Appendix L – Marine Assessment

Hunter Water Corporation

Belmont Drought Response Desalination Plant
Marine Environment Assessment Amendment Report

July 2020

Table of contents

Table index

Figure index

Appendices

1. Introduction

1.1 Background

Hunter Water Corporation (Hunter Water) is seeking approval to construct and operate a drought response desalination plant (the 'Project'), adjacent to the Belmont Wastewater Treatment Works (WWTW) in Belmont South, a suburb of Lake Macquarie Local Government Area (LGA) of New South Wales (NSW) (the 'Project area'); (see Figure 1-1).

Like much of NSW, the Lower Hunter region continues to experience ongoing drought conditions. In response to the drought, Hunter Water is rolling out a program of drought response measures as outlined in the 2014 Lower Hunter Water Plan (LHWP). Measures include the staged introduction of water restrictions, implementation of a broad range of water conservation and water loss initiatives as well as various operational measures. The 2014 LHWP identified the implementation of emergency desalination as a measure of last resort in response to a severe drought, and would only be implemented if water storage levels reached a critical point and all other measures have been implemented.

GHD Pty Ltd (GHD) were engaged by Hunter Water to prepare an Environmental Impact Statement (EIS) (GHD, 2019a) to support a development application for the Project as State Significant Infrastructure (SSI) under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The EIS was prepared in accordance with the provisions of the EP&A Act and the EP&A Regulation and addresses the Secretary's Environmental Assessment Requirements (SEARs) issued by the Department of Planning, Industry and Environment (DPIE) for the Project on 12 December 2017 and revised on 24 January 2018. The EIS was publicly exhibited by DPIE for 28 days from 21 November 2019 to 19 December 2019.

The Project described in the EIS included the construction and operation of a desalination plant, designed to produce up to 15 megalitres per day (ML/day) of potable water, with two sub-surface intake structures.

Since commencing this Project, Hunter Water has begun a major review of the 2014 LHWP, now referred to as the Lower Hunter Water Security Plan (LHWSP). The LHWSP seeks to determine the preferred portfolio of supply and demand side options to ensure a sustainable and resilient supply for the region, over the long term as well as during drought. This work indicates that a drought response portfolio including a desalination plant at Belmont with a nominal production capacity of up to 30 ML/day would provide the best balance of meeting the community's needs should a severe drought occur, while still providing value for money.

In addition to the proposed increase in plant capacity, further design development and assessment following completion of the EIS has identified that a direct ocean intake would perform considerably better than a sub-surface option across key criteria including, reliability, efficiency and scalability.

1.2 Purpose and structure of this report

This Report has been prepared as a supporting document to the Amendment Report and addresses the requirements for the SEARs in considering the revised impacts of the amended Project. The purpose of this report is to assess the likely impacts of the future construction and operation of an ocean intake pipe and intake structure 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 Report also assesses the impacts from increase in brine discharge associated with the increased production volumes onto the marine environment.

This report should be read in conjunction with GHD reports titled: *Belmont Drought Response Desalination Plant – Environmental Impact Statement (GHD, November 2019)* and *Belmont Drought Response Desalination Plant – Marine Environment Assessment Report (GHD, November 2019)*.

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, 2020a).

Paper Size ISO A4

0 110 220 330 440

Metres

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

N

GHD

Hunter Water Corporation
Belmont Drought Response Desalination Plant
Marine Environment Assessment Amendment Report

Project No. **22-19573**
Revision No. **0**
Date **29/06/2020**

Project Location

Figure 1-1

G:\22\19573\Design\04 Deliverables\02 Other\2219573_AR_MEAR_0.aprx
Print date: 29 Jun 2020 - 10:05

Data source: LPI: DTDB / DCDB, 2017; public_NSW_Imagery: © Department of Customer Service 2020. Created by: fmackay

2. Project changes

2.1 Overview

In addition to the proposed increase in plant capacity, the amended Project includes the following design changes:

- Seawater intake: Further design development and liaison with Hunter Water's construction partners following completion of the EIS identified reliability and construction risks with the proposed horizontal sub-surface intake system as described in the EIS. An assessment of the horizontal sub-surface intake system was undertaken against alternative intake options. This assessment found that a direct ocean intake would perform considerably better than a sub-surface option across key criteria including reliability, efficiency and scalability (see Section 2.2).
- Power supply: The EIS proposed to meet power requirements for the Project via a minor upgrade to the existing 11 kV power supply network in the vicinity of Hudson and Marriot Street. The amendment to the capacity of the water treatment process plant means this is now unfeasible, due to inability to meet energy requirements. Instead, the Project will connect to Ausgrid's 33 kV network in the vicinity of the Project (see Figure 2-1).

2.2 Key features of the amended Project

The amended Project for the construction and operation of a drought response desalination plant, designed to produce up to 30 ML/day of potable water, includes the following key components (as shown in Figure 2-1):

- ***Sea Water Pump Station (On-shore)***, including a central well, screening and pump housing, proposed to be a concrete structure (referred to as a wet well) of approximately nine to 11 m diameter, installed to a depth up to 20 m below existing surface levels.
- ***Intake pipeline***, the indicative pipeline alignment is approximately 1000 m in length, extending outwards from the central housing to the off-shore intake structure. Construction of the intake pipeline would be determined during detailed design; however, the following construction methodologies/considered and assessed included Construction method 1 (CM1) Horizontal directional drilling (HDD) and (CM2) Pipejacking/micro-tunnelling.
- ***Intake structure (Off-shore)***, the intake structure would be in the form of a horizontal intake with a velocity cap structure and low through-screen velocity to minimise impacts on marine species and habitat. The intake structure would be 5 m in diameter, have a minimum of 5 m clearance from the seabed and a depth of approximately 18 m of water.
- **Water treatment process plant** – The water treatment process plant would not significantly change from that described in the EIS. The inclusion of buildings to house equipment rather than the installation of containerised equipment is the primary change. The buildings would be placed above ground level and located to allow incremental installation, if required. Services to and from the process equipment (e.g. power, communications, and raw feed water (seawater)) would comprise a mix of buried and overhead 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 raw feed water.

  - 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 up to 56 ML/d 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 a brine pump station at the Belmont WWTW for disposal via the existing ocean outfall pipe.
- **Power supply** – Power requirements of the amended water treatment process plant would require connection to Ausgrid's 33 kV line to the north-west of the water treatment process plant site, with new private power line connecting to a substation within the plant site.
- **Ancillary facilities** – Including a tank farm, equipment housing buildings, chemical storage and dosing, hardstand areas, stormwater and cross drainage, access roads, parking areas, and fencing, signage and lighting.

Each of these elements are described further in Appendix D of the Amendment Report.

The desalination plant would be connected to Hunter Water's potable water network via a potable water pipeline proposed to be constructed to augment the existing water network. The pipeline does not form part of the Project and would be part of a separate design and approvals process.

Paper Size ISO A4

0 60 120 180 240

Metres

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

N

Hunter Water Corporation
Belmont Drought Response Desalination Plant
Marine Environment Assessment Amendment Report

The Amended Project

Project No. **22-19573**
Revision No. **0**
Date **29/06/2020**

Figure 2-1

G:\22\19573\Design\04 Deliverables\02 Other\2219573_AR_MEAR_0.aprx\2219573_MEA004_TheProject_0
Print date: 29 Jun 2020 - 10:04

Data source: HWC: Aerial Imagery, Existing outfall: 2019; LPI: DTDB / DCDB, 2017; public_NSW_Imagery: © Department of Customer Service 2020. Created by: fmackay

3. Methodology

A desktop assessment has been undertaken to confirm the existing legislative framework and environmental conditions relevant to marine ecology associated with the proposed Belmont Desalination Plant ocean intake pipe and intake structure (hereto referred to as the 'proposed intake pipe'). 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.

A desktop assessment was undertaken specifically for the outfall pipe structure. Details of this were presented in GHD's *Belmont Drought Response Desalination Plant – Marine Environment Assessment Report (GHD, 2019)*.

3.1 Review of relevant legislation

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

- *NSW Environmental Planning and Assessment Act 1979* (EP&A Act 1979)
- *NSW Fisheries Management Act 1994* (FM Act 1994)
- *NSW Biodiversity Conservation Act 2016* (BC Act 2016)
- *Commonwealth 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 direct ocean intake (DOI). 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

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 in the vicinity of the existing 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 the area up to 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-current; 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).
Burwood Beach Marine Environmental Assessment Program (MEAP)	Hunter Water, 2014	The Burwood Beach MEAP was undertaken from 2011-2013 and 2017-2019, approximately 12 km north of the Belmont WWTW. Importantly, the Burwood WWTW outfall discharges biosolids in addition to effluent, while Belmont WWTW discharges effluent only. Given the relatively close proximity of the Burwood WWTW outfall to the Belmont WWTW outfall, some of the results of the monitoring program's reference locations were utilised to review ambient marine environmental conditions.
Belmont WWTW outfall videos	Hunter Water, 2018	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.

3.4 Review of recent marine ecology reports

Advisian undertook targeted fish and benthic surveys along the Belmont WWTW ocean outfall in February 2020 (Advisian, 2020) (Appendix A). Results of the surveys were reviewed and incorporated into this report (refer to Section 4.1.3) to define the existing environment along and around the WWTW ocean outfall.

3.5 Updated brine discharge modelling

The brine discharge modelling for the EIS design (capacity of 15 ML/d) indicated that a discharge of 28.2 ML/day brine would result in a salinity of 65 psu (GHD, 2020b). The design has since been amended to a capacity of 30 ML/d and 56.6 ML/day brine discharge with a salinity of 58.3 psu (GHD, 2020b). This report has been reviewed to inform potential impacts on water quality from discharge of the brine into the marine environment.

3.6 Intake pipeline area benthic survey

To support the environmental impact assessment, two GHD marine ecologists undertook a survey of the proposed ocean intake area on 12 and 13 December 2019. The purpose of the survey was to identify benthic habitat features and species present within the survey area. This was achieved by deployment of an underwater remotely operated vehicle (ROV) to record video footage of the benthic environment at a number of grid-mapped survey points. Results of this assessment are presented in Section 4.1.

4. Existing environment

4.1 Benthic habitat and species assessment

4.1.1 Benthic environment

The benthic environment within the proposed DOI area was assessed to provide an understanding of seabed characteristics (Figure 4-1).

The benthic environment throughout the proposed DOI area is comprised of open homogenous sand substrate (Plate 4-1 to Plate 4-3) interspersed by small sand ripples associated with nearshore wave-action. Observations of survey footage indicate that sand substrate consisted primarily of coarse grained sand, interspersed with patches of shell grit/shell fragments. There was little evidence of burrowing or mound-building activity associated with infauna.

4.1.2 Species assessment within the DOI area

A number of species were observed both prior to and during the surveys. Schools of unidentified fish were observed at the surface during transit to the survey area and exhibited predatory-like behaviour, breaking the water surface, although the predating species was not observed. Several marine species were observed during the survey as listed below:

- A small (approximately 1 m length) unidentified shark species was observed on the surface however was not able to be identified or photographed
- Numerous jellyfish (*Carybdea sp*.) throughout the survey area (Plate 4-1; Plate 4-3)
- Octocorals (*Cavernularia sp.*) were occasionally observed on the benthos during the surveys (Plate 4-2)
- Four Southern Eagle Rays (*Myliobatus tenucaudatus*) (Plate 4-2)
- Flathead (*Platycephalus* sp.)
- School of fish, possible perch (*Lutjanus* sp.) (Plate 4-3)

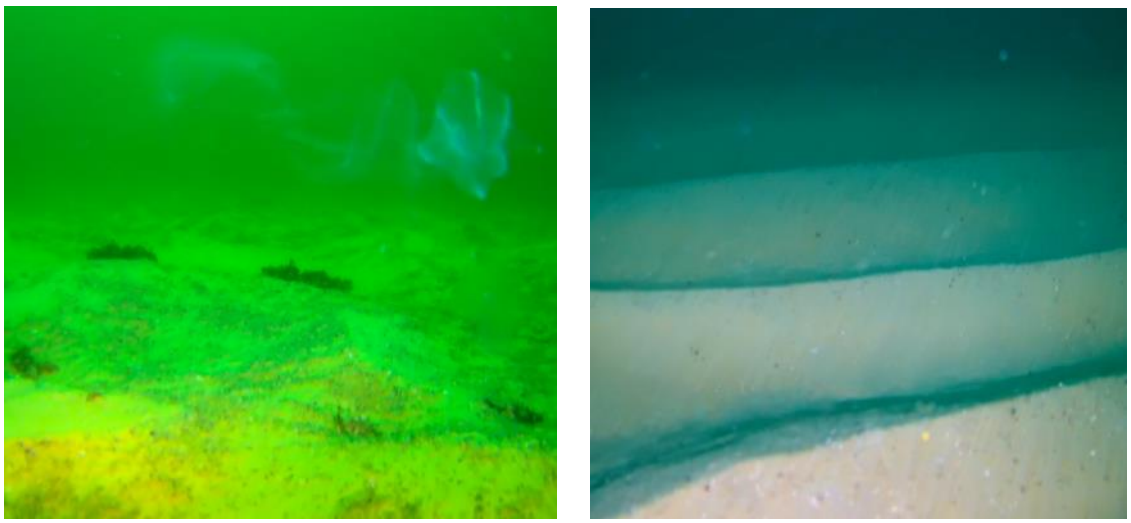


Plate 4-1 Jellyfish (*Carybdea sp.*) with drifting seaweed and coarse sand patches (left); sand ripples (right)

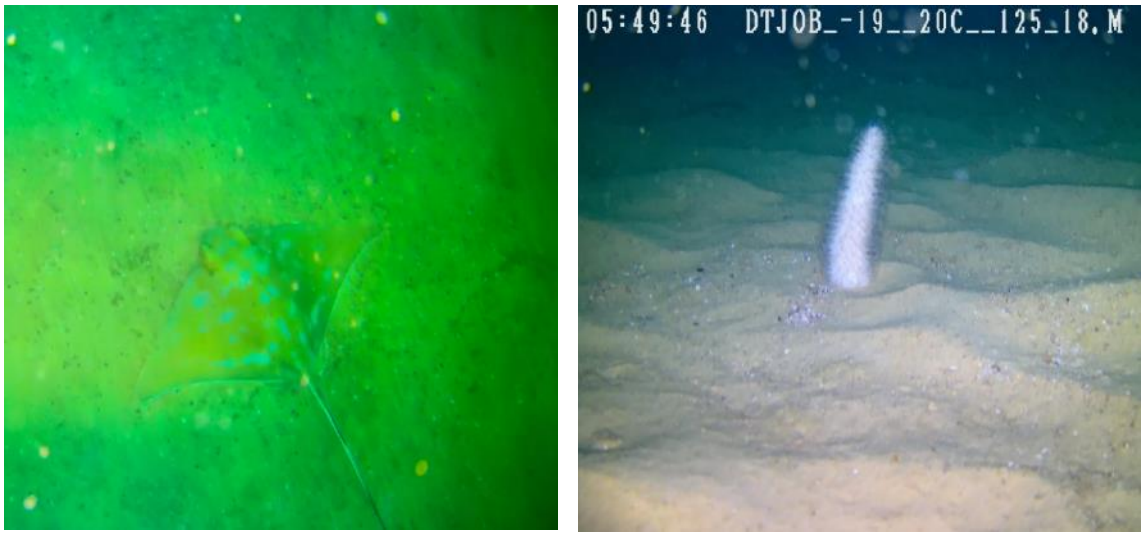
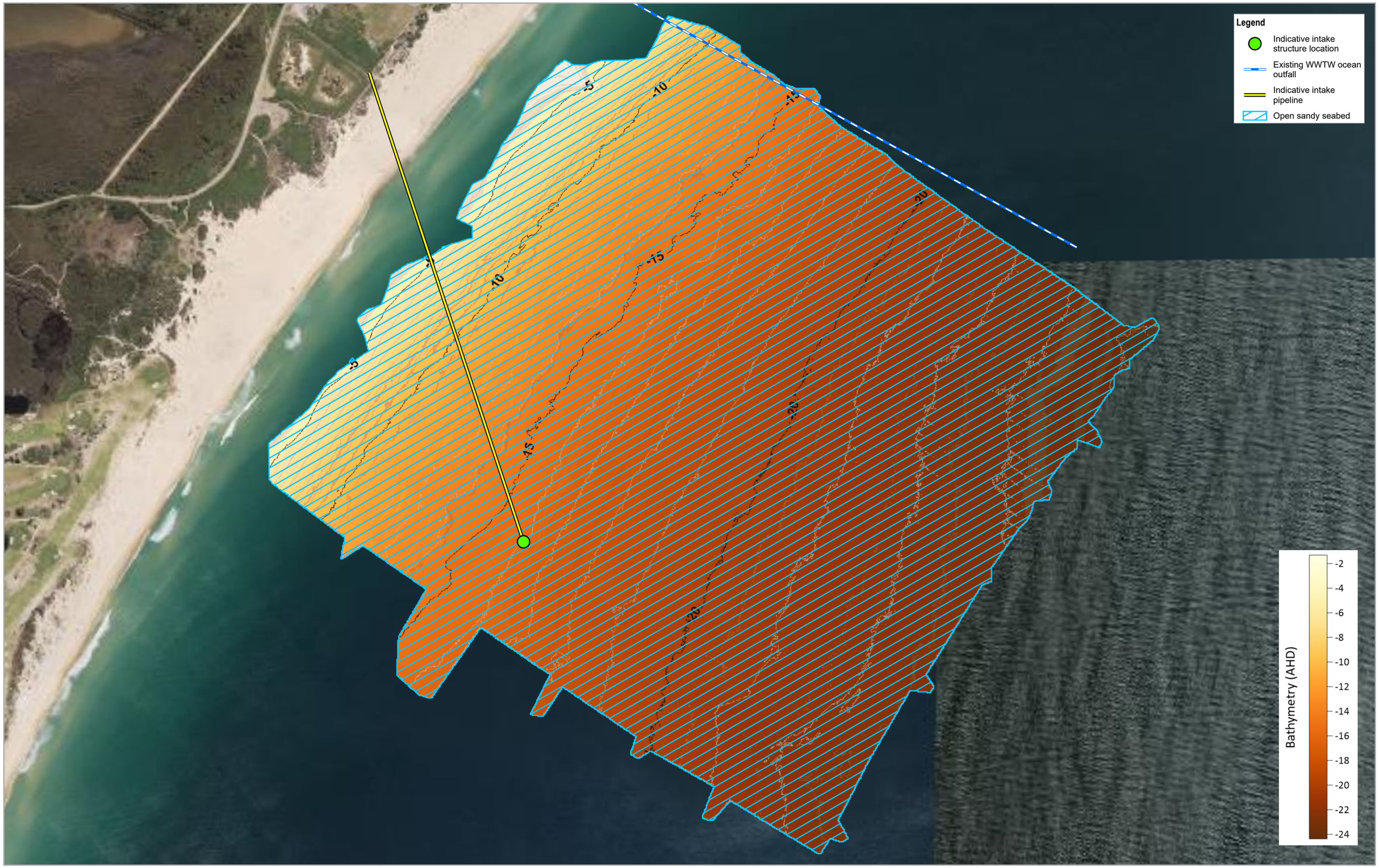


Plate 4-2 Southern eagle ray (*Myliobatis tenucaudatus*) (left) observed; octocoral (*Cavernularia sp.*) (right) observed

Plate 4-3 Jellyfish (left); school of fish, possibly perch (*Lutjanus sp.*) (right)



Paper Size ISO A3

0 0.05 0.1 0.15 0.2

Kilometres

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

N

GHD

Hunter Water Corporation
Belmont Drought Response Desalination Plant
Marine Environment Assessment Amendment Report

Seafloor habitat observed from benthic and geophysical survey

Project No. **22-19573**
Revision No. **0**
Date **29/06/2020**

Figure 4-1

G:\22\19573\Design\04 Deliverables\02 Other\2219573_AR_MEAR_0.aprx\2219573_MEA001_SeaFloorHabitat_0
Print date: 29 Jun 2020 - 10:05

Data source: public_NSW_Imagery: © Department of Customer Service 2020. Created by: fmackay

4.1.3 Species assessment within the Belmont WWTP ocean outfall

Advisian undertook a targeted fish survey along the Belmont WWTW ocean outfall (Advisian, 2020) (Appendix A). The following provides a summary of findings from the fish survey:

- The fish assemblages on the Belmont outfall was similar to fish assemblages observed in the area and they were consistent across the 2019 and 2020 surveys.
- The most abundant fish were the yellowtail mackerel (*Trachurus novaezelandiae*) which were present in the lower half of the water column above the pipeline.
- Mado (*Atypichthys latus*) were the most abundant fish at the pipe.
- Two species of wrasse were observed during both surveys; crimson banded wrasse (*Notolabrus gymnogenis*) and southern maori wrasse (*Ophthalmolepis lineolate*). Old wife (*Enoplosus armatus*) were also observed in both years.
- The red scorpionfish (*Scorpaena* spp.) and half-banded seaperch (*Hypoplectrodes maccullochi*) were common on the pipe's surface.
- A green moray *Gymnothorax prasinus* was observed in February 2020.
- Several shark and ray species were observed in the vicinity of the pipe: crested hornshark, (*Heterodontus galeatus*), spotted wobbegong (*Orectolobus maculatus*), stingaree (*Trygonoptera* sp.), fiddler ray (*Trygonorrhina fasciata*), small hammerhead sharks (potentially *Sphyrna zygaena*).

A targeted benthic ecology survey was also undertaken along the outfall in February 2020, results of which are summarised below (Advisian, 2020):

- Sponges (*Clathrinid* sp, *Chondropsis* sp,, *Holopsamma laminaefavosa* and *Darwinella* sp.).
- Corals (soft coral and sun coral), anemone (*Phlyctenanthus australis*), sea pen (*Sarcoptilus grandis*).
- Marine worm (fan worm, *Sabellastarte australiensis*).
- Molluscs (squid, *Sepioteuthis australis*).
- Echinoderms (feather stars, *Ptilometra australis* and *Cenolia trichopteran*; brittle star, *Ophiotix* sp).
- Ascidians (Polycitor giganteus, Pyura spinifera, Herdmania grandis and Didemnid sp.).

4.2 Protected matters desktop review

4.2.1 Overview

4.2.1.1 EPBC Act - Threatened and migratory species

The EPBC Act Protection Matters Search Tool (PMST) provides opportunity to identify MNES protected under the EPBC Act that are predicted to occur in, or be related to, a defined area. To inform MNES that may occur within the project area a PMST search was completed using a 10 km buffer from a centroid of the proposed DOI infrastructure, to fully encompass the Project area (Figure 4-2) and surrounding environmental receptors. This defines the project extent for the purposes of this MNES assessment. The output of the PMST is provided in Appendix B.

As the focus of this assessment is the marine environment, exclusively terrestrial species have been omitted from further consideration.

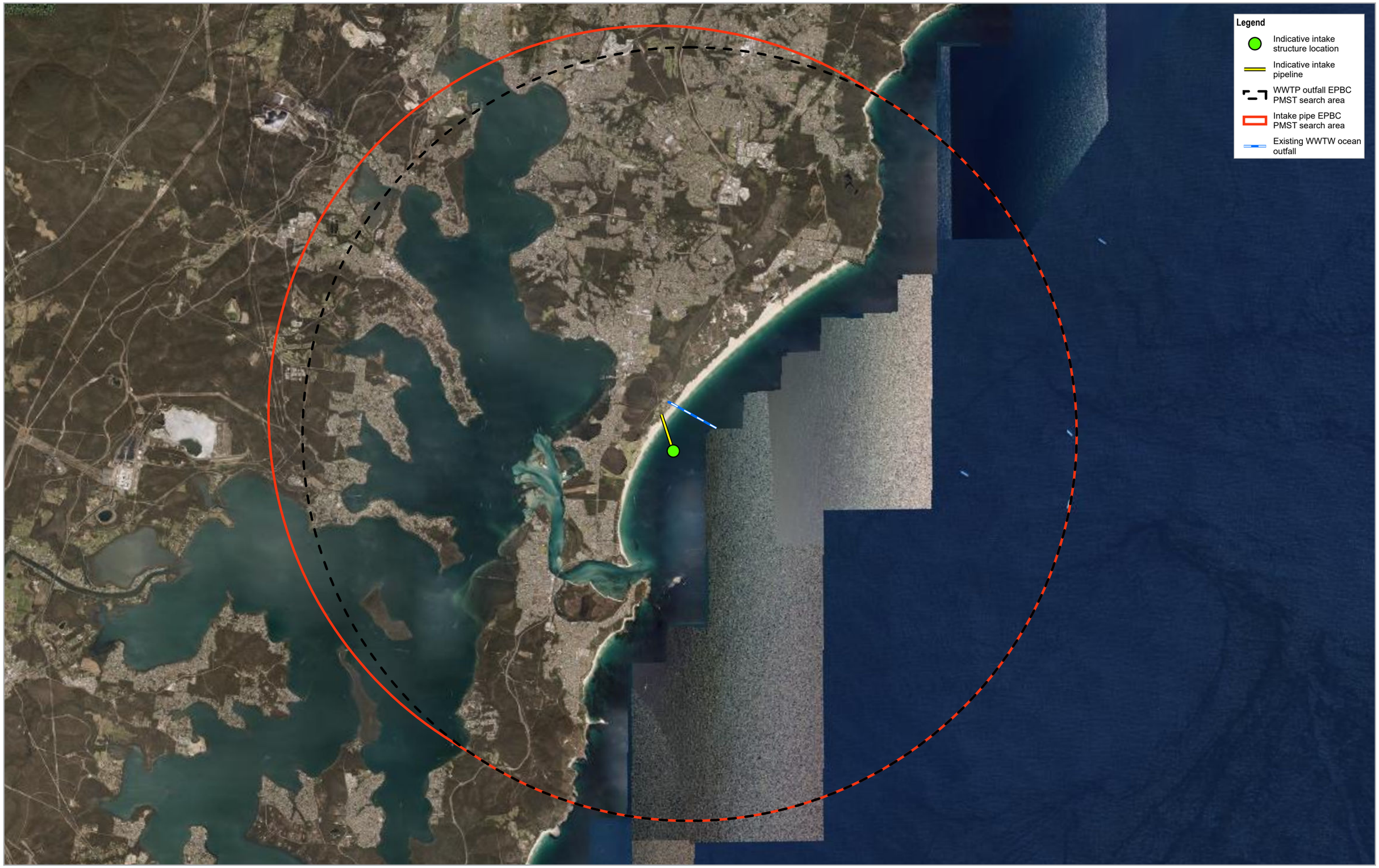
This process has identified 53 listed threatened species, and a further 51 listed migratory species of relevance to the project area. The likelihood of these species occurring within the project area has been assessed; a summary of which is provided in Section 4.2.3 and a full assessment provided in Appendix C.

4.2.1.2 EPBC Act – Additional MNES

The PMST search also identified the following additional MNES as potentially relevant to the Project area:

- One Wetland of International importance - The Hunter estuary wetlands, which is located approximately 16 km north of the Project area.
- One Commonwealth Marine Area - The Hunter Marine Park, which is located approximately 70 km north of the Project area.
- Five Threatened Ecological Communities (TECs), including:
  - Central Hunter Valley eucalypt forest and woodland (critically endangered), approximately 53 km north-west of the Project area.
  - Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community (endangered), approximately 30 km north north-east of the Project area.
  - Littoral Rainforest and Coastal Vine Thickets of Eastern Australia (critically endangered); not present within the Project area.
  - Posidonia australis seagrass meadows of the Manning-Hawkesbury ecoregion (endangered). The closest meadow of this TEC is located approximately 2 km from the Project area, within Lake Macquarie.
  - Subtropical and Temperate Coastal Saltmarsh (vulnerable); not present within the Project area.

Given the distance and nature of the works within the marine environment, these MNES have been omitted from further assessment here (Appendix D).



Paper Size ISO A3

0 0.65 1.3 1.95 2.6

Kilometres

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

N

GHD

Hunter Water Corporation
Belmont Drought Response Desalination Plant
Marine Environment Assessment Amendment Report

Intake pipe and outfall location Field Surveys Search Buffers

Project No. **22-19573**
Revision No. **0**
Date **29/06/2020**

Figure 4-2

G:\22\19573\Design\04 Deliverables\02 Other\2219573_AR_MEAR_0.aprx\2219573_MEA005_Buffers_0
Print date: 29 Jun 2020 - 10:04

Data source: public_NSW_Imagery: © Department of Customer Service 2020. Created by: fmackay

4.2.1.3 BC and FM Act

The Office of Environment and Heritage (OEH) BioNet Atlas (licensed) for records of threatened species, populations and endangered ecological communities listed under the BC Act and FM Act was interrogated to identify records relevant to the Project area (OEH, 2019) (Appendix E). As for EPBC listed species, exclusively terrestrial species have been omitted from further consideration. The majority of identified matters protected by State legislation relevant to the Project area are also listed as MNES. An additional two seals, two dolphins, one whale and 45 bird species listed solely under State legislation were identified through the BioNet assessment as relevant to the Project area. Eleven bird species from the BioNet search protected under MNES were also considered in this desktop assessment.

Two additional hammerhead shark species protected under the FM Act 1994 were not picked up from the BioNet or PMST searches. These species have been incorporated into the assessment given they represent biodiversity values relevant to the project protected under the FM Act 1994.

The likelihood of these State protected matters occurring within the project area has been assessed, and a summary provided following.

4.2.2 Likelihood of occurrence

A likelihood of occurrence assessment was conducted to determine the likelihood of relevant species identified by the desktop searches (or their important habitat) as occurring within the project area. This process used understanding of habitat requirements, species migratory behaviours and distribution to understand whether species identified by the PMST as potentially occurring in the area were likely to occur at the time of project activity.

A 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.

The following table presents the findings of this assessment for threatened species (Table 4-1) with migratory species subsequently summarised.

Potential for impact from the proposed intake pipe has been reviewed for those species that are considered likely to occur in the Project area at the time of work (Section 5).

Table 4-1 Threatened species relevant to the project area

Species	Common Name	Scientific Name	EPBC Act Status	BC/FM Act Status	Likelihood of occurrence
Marine mammals	Sei whale	*Balaenoptera borealis*	V, Mig		Unlikely to occur
	Blue whale	*Balaenoptera musculus*	E, Mig	E1	Unlikely to occur
	Fin whale	*Balaenoptera physalus*	V, Mig		Unlikely to occur
	Southern right whale	*Eubalaena australis*	E, Mig	E1, P	**Likely to occur**
	Dugong	*Dugong dugon*	Mig	E1, P	**Likely to occur**
	Humpback whale	*Megaptera novaeangliae*	V, Mig	V, P	**Likely to occur**
	New Zealand fur seal	*Arctocephalus forsteri*		V	**Likely to occur**
	Australian fur seal	*Arctocephalus pusillus doriferus*		V	May occur
	Common dolphin	*Delphinus delphis*		P	May occur
	Bottlenose dolphin	*Tursiops truncatus*		P	**Likely to occur**
	Gray's beaked whale	*Mesoplodon grayi*		P	Unlikely to occur
Marine reptiles	Loggerhead turtle	*Caretta caretta*	E, Mig	E1, P	**Likely to occur**
	Green turtle	*Chelonia mydas*	V, Mig	V, P	**Likely to occur**
	Leatherback turtle	*Dermochelys coriacea*	E, Mig	E1	May occur
	Hawksbill turtle	*Eretmochelys imbricata*	V, Mig	P	**Likely to occur**
	Flatback turtle	*Natator depressus*	V, Mig		Unlikely to occur
Sharks and Rays	Grey nurse shark	*Carcharias taurus*	CE	CE	May occur
	Great white shark	*Carcharodon carcharias*	V, Mig	V	**Likely to occur**
	Whale shark	*Rhincodon typus*	V, Mig		May occur
	Great hammerhead shark	*Sphyrna mokarran*		V	May occur
	Scalloped hammerhead shark	*Sphyrna lewini*		E	May occur
Fish	Black rock cod	*Epinephelus daemelii*	V	V	Unlikely to occur
Marine birds	38 EPBC listed species 83 State listed species				Shorebirds likely to occur on foreshore
Syngnathids	White's Seahorse	*Hippocampus whitei*	Marine	E	Unlikely to occur
	Other species				**Likely to occur**

Key: CE - Critically Endangered; E/E1 – Endangered; V – Vulnerable; P – Protected; Mig – Migratory

The 51 listed migratory species predicted to occur in the project area include:

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

Migratory shorebirds are likely to occur along the foreshore within the Project area however, other migratory species are considered unlikely to occur in the project area. These species have therefore been omitted from further consideration.

4.2.3 Summary

Overall, eleven groups of species listed under either the EPBC Act or BC Act and considered **likely to occur** in the Project area, these are:

- One shark (Great White Shark)
- Three reptiles (Loggerhead Turtle, Green Turtle, Hawksbill Turtle)
- Five mammals (Southern Right Whale, Dugong, Humpback Whale, New Zealand Fur Seal and Bottlenose Dolphin)
- Protected marine shorebirds
- Syngnathids

Additionally, migratory shorebirds are also likely to occur in the Project area. The potential for the proposed survey to impact on these species is considered following.

4.3 Intake pipe larval study desktop review

Larvae, eggs, juvenile fish and small species, such as syngnathids, have the potential to be at risk to impacts from the proposed DOI, due to their small size and low mobility. As such, a desktop study was conducted to determine if any species of relevance to the assessment had the potential to be impacted by the intake pipe during various life stages. This included an assessment of State and Commonwealth listed species, commercial fishery species that are likely to occur within the intake pipe area and species know to occur on the existing WWTW outfall pipe.

4.3.1 Protected species

No Commonwealth or State listed threatened species that are considered likely to occur in the Project area undergo larval life stages. As described in Table 4-1, the black rock cod (*Epinephelus daemelii*) is considered unlikely to occur however, this species does has a larval stage which, if present in the area during intake operation, may be impacted. The species produce eggs which float freely in the water column with the pelagic larval stage lasting up to 60 days (Francis *et al.,* 2016). Larvae usually disperse following oceanic currents, with dispersal along the NSW central/southern coast (~32 – 35°S) guided by the East Australian Current (EAC) (Francis *et al.* 2016).

Under the EPBC Act, syngnathids are not listed as threatened, however are listed as Marine species; these species are also protected under the NSW Fisheries Management Act 1994 (FM Act), including White's Seahorse (*Hippocampus whitei*) which is listed Endangered under the Act however, is unlikely to occur due to a lack of suitable habitat in the project area (preference for shallow estuarine habitats) (FSC, 2019). However, suitable hard substrate habitat for many syngnathid species is present at the existing Belmont WWTW outfall pipe, approximately 500 m north of the indicated intake pipe location (Figure 4-1). Once constructed the intake pipe itself will also provide suitable hard substrate habitat for syngnathids, similar to the existing WWTW outfall pipe.

Male syngnathids carry broods of 20-1,500 eggs, depending on species, with hatching occurring within 20-40 days (Browne *et al.,* 2008). While eggs are held within the brood-pouch, hatchlings may be free-swimming larvae or juveniles as much as 12 mm in length (DPI, 2019). Juveniles of some species adopt the habitat of their parents almost immediately, while juveniles and larvae of other species continue to live within the water columns for some time (Browne *et al.,* 2008).

A study of fish larvae within the nearby Swansea Channel identified 3,367 fish larvae within 22,000 m^3 of filtered seawater, of which, larvae of five syngnathid species were identified, representing 9.54% of the total (Trnski, 2001). However, it is worth noting that extensive syngnathid habitat, namely seagrass meadows, exist within the Channel as well as within Lake Macquarie itself, which may contribute to local larval abundance compared to the relative absence of suitable habitat within the Project area. The author also notes that within-tide variability and temporal variability of larvae was high (Trnski, 2001). Syngnathid larvae and juveniles may therefore be present within the water column in the vicinity of the proposed DOI.

4.3.2 Commercial fishery species

The Department of Primary Industries (DPI) is the legislative body that manages the commercial fishing industry in NSW. NSW DPI has listed the following as the operational fisheries in NSW waters:

- Abalone Fishery
- Estuary General Fishery
- Estuary Prawn Trawl Fishery
- Inland Restricted Fishery
- Lobster Fishery
- Ocean Hauling Fishery
- Ocean Trap & Line Fishery
- Ocean Trawl Fishery
- Sea Urchin and Turban Shell Restricted Fishery

A list of targeted species from the above commercial fisheries known to have a larval life stage is provided in Table 4-2. Additionally, the table summarises the spawning regions and likelihood of occurrence of the larvae of each species in the vicinity of the proposed DOI. Likelihood of occurrence for larvae of these species is determined by the following criteria:

- Likely to occur – Spawning region overlaps the Project area
- May occur – Spawning region adjacent to the Project area
- Unlikely to occur – Spawning region is not adjacent to, or does not overlap, the Project area

Table 4-2 NSW commercial fishery catch species with a larval stage

Common name	Scientific name	Spawning region*	Larvae likelihood of occurrence
Fish			
Bonito	*Sarda australis*	Coastal reefs and estuaries	Likely to occur
Bar cod	*Epinephelus ergastularius*	Coastal to oceanic waters	Likely to occur
Silver trevally	*Pseudocaranx georgianus*	Coastal waters and estuaries	Likely to occur
Yellowtail kingfish	*Seriola lalandi*	Coastal, inshore and offshore. Also bays, harbours, jetties and pylons.	Likely to occur
Rubberlip (grey) morwong	*Nemadactylus douglasii*	Continental shelf waters around reefs and adjacent sandy areas	Unlikely to occur
Yellowfin bream	Acanthopagrus australis	Estuaries	May occur
Dusky flathead	Platycephalus fuscus	Estuaries	May occur
Tiger flathead	Platycephalus richardsoni or Neoplatycephalus richardsonii	Estuaries	May occur
Leatherjackets	Family Monacanthidae	Estuaries and coastal waters as juveniles	Likely to occur
Silver biddy	*Gerres subfasciatus*	Estuaries and coastal waters	Likely to occur
Yellowtail scad	*Trachurus novaezelandiae*	Estuaries and coastal waters	Likely to occur
Sand whiting	Sillago ciliata	Estuaries and coastal waters, with development occurring in estuaries	Likely to occur
Stout whiting	Sillago robusta	Estuaries and coastal waters, but develop in estuaries	Likely to occur
Red spot whiting	Sillago flindersi	Estuaries and coastal waters, but develop in estuaries	Likely to occur
Pilchards	*Sardinops sagax*	Estuaries to continental shelf waters	Likely to occur
Snapper	*Pagrus auratus*	Estuaries, harbours and bays	May occur
Sea mullet	Mugil cephalus	Nearshore marine waters	Likely to occur
Luderick	Girella tricuspidata	Surf zone, estuaries	Likely to occur
Crustaceans			
School prawns	*Metapenaeus macleayi*	Oceanic. But returns to estuaries when still less than 10 mm	Likely to occur
Eastern king prawns	*Penaeus plebejus*		
Spanner crab	*Ranina ranina*	Coastal areas	Likely to occur
Mud crab	*Scylla serrata*	Oceanic. But returns to coastal areas at 4 – 5 mm	Likely to occur
Blue swimmer crab	*Portunus pelagicus*	Lower estuaries, coastal and oceanic waters	Likely to occur

Common name	Scientific name	Spawning region*	Larvae likelihood of occurrence
Eastern rock lobster	*Sagmariasus verreauxi*	Coastal areas	Likely to occur
Tropical rock lobster	*Panulirus longipes*		
Tropical rock lobster	*Panulirus ornatus*		
Bugs (smooth and eastern Balmain bug)	*Ibacus* spp.	Coastal areas	Likely to occur
Echinoids			
Long-spined sea urchin	*Centrostephanus rodgersii*	Coastal rocky reefs	Likely to occur
Purple sea urchin	*Heliocidaris erythrogramma*	Coastal rocky reefs, seagrass beds and sandy mud bottoms.	
Red sea urchin	*Heliocidaris tuberculata*		
Molluscs			
Pipi	*Donax deltoides*	Surf zone and coastal areas	Likely to occur
Blacklip abalone	*Haliotis rubra*	Coastal rocky reefs	Likely to occur
Sydney turban snail	*Turbo torquatus*	Coastal to oceanic	Likely to occur
Military turban snail	*Turbo militaris*		
	Turbo undulatus		
Others			
Gould's Squid	*Notodarus gouldi*	Usually open ocean, but can spawn from eggs attached to hard substrates in coastal areas	Likely to occur
Octopus spp.		Spawn from eggs attached to hard substrates in coastal areas	

* - Species spawning regions identified from Stewart *et al.* 2015

4.3.3 Epi-benthic species and associated fish assemblages

Since the installation of the existing WWTW outfall pipe, a variety of filter feeding organisms have recruited to the pipe, such that there is now a locally dense and diverse community established. It is anticipated that the proposed intake structure will attract a similar assemblage as the nearby WWTW outfall pipe, due to recruitment of sessile organisms on the newly available hard substrate.

The existing WWTW outfall pipe has identified a community dominated by a variety of sponges, ascidians, algae and sea pens. Together, these sessile organisms form a diverse biogenic habitat that supports an array of invertebrate and fish species. Fish assemblages associated with the pipeline include those that are utilise the benthic habitat as refugia and feeding grounds, as well as higher order predators.

Species with a larval lifecycle stage and observed in the previous studies or during the benthic survey of the proposed ocean intake area are summarised in Table 4-3. The epi-benthic species observed at the WWTW outfall pipe generally produce and release nektonic and planktonic eggs and larvae to the water column. Generally, the fish found at the WWTW outfall pipe do not migrate to spawning grounds, and will spawn in nearby inshore/coastal environments. However, some species may also spawn in estuaries, inlets, bays, open water or upper continental slopes.

Table 4-3 Species with larval lifecycle observed in previous studies in the region

Type	Species observed	Spawning region
Epibenthic organisms		
Sponges	*Tethya sp.; Halopsamma sp.; Cliona sp.; Callyspongia sp.; Ircinia sp.*	Local area
Ascidians	*Pyura spinifera*	Local area
Algae	Encrusting and erect algal species.	Local area
Sea pens	Pennatulacea spp.	Local area
Crinoids	Crinozoa	Local area
Octocoral^	*Cavernularia sp.*	Local area
Fish assemblages		
Mado	*Atypichthys latus*	Inshore/coastal
Australian Salmon	*Arripis sp.*	Open water or inshore/coastal
Stripey	*Microcanthus strigatus*	Inshore/coastal
Striped catfish	*Plotosus lineatus*	Inshore/coastal
Eastern fortescue	*Centropogon australis*	Estuaries and bays
Wrasse	*Notolabrus tetricus*	Inshore/coastal
Gobies	Gobiidae	Inshore/coastal
Leatherjackets	Monacanthidae	Open water or inshore/coastal
Moray eel	Muraenidae	Open water or inshore/coastal
Sergeant baker	*Latropiscis purpurissatus*	Bays, inlets, inshore/coastal to upper continental slope
Flathead^	*Platycephalus fuscus*	Estuaries and bays
Perch^	*Lutajnus sp.*	Inshore/coastal
Jellyfish^	*Carybdea sp.*	Inshore/coastal

^ Species observed during benthic surveys of proposed ocean intake

5. Impact assessment and mitigation measures

5.1 Construction

Construction of the intake pipeline and intake structure has the potential to harm the marine environment through activities that would disturb the seabed such as drilling and installation of the intake structure and supporting infrastructure. Vessels would be required to support the construction activities. The risks to the environment from these activities are:

- Seabed disturbance and associated turbidity and water quality impacts
- Light and noise pollution from vessel platforms and drilling activities
- Release of potential wastes, contaminants or pollutants (including hydrocarbon spills) from construction activities
- Atmospheric emissions
- Interference with other users of the area affected

Other unplanned events may also arise during construction activities. The risks to the environment from these are:

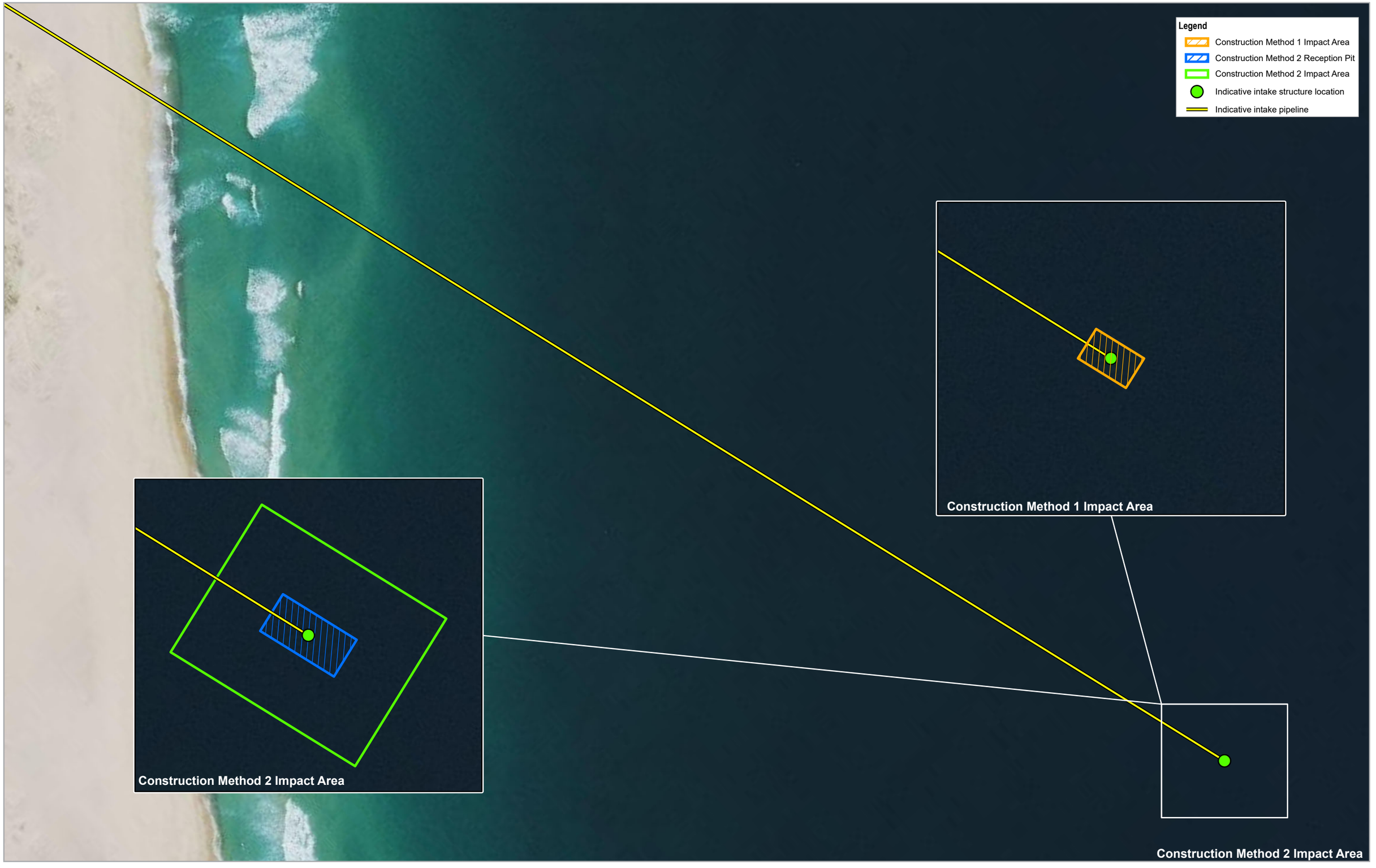
- Pest introduction and proliferation
- Accidental release of solid waste
- Impacts to the seabed from dropped objects
- Marine fauna collisions
- Hydrocarbon, chemicals and other liquid waste
- Damaged fuel tank associated with vessel collision

The following sections provide a detailed assessment of the identified risks from construction of the intake pipe to the marine environment. Mitigation measures are considered against the impacts and environmental outcomes described.

5.1.1 Seabed disturbance

5.1.1.1 Impact description

Two construction methods have been proposed for installation of the intake pipe (refer to Appendix D of the Amendment Report for details on each): CM 1 horizontal directional drilling (HDD) and CM 2 micro-tunnelling (or pipe-jacking). These methods would have varying degrees of disturbance to the seabed. An area of disturbance has been estimated for each of the proposed methods in Table 5-1 with a discussion provided in the sections thereafter (Figure 5-1). This estimate also takes into consideration the area of disturbance for the intake structure which is common for all construction methods.



Paper Size ISO A3

0 0.015 0.03 0.045 0.06

Kilometres

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

N

GHD

Hunter Water Corporation
Belmont Drought Response Desalination Plant
Marine Environment Assessment Amendment Report

Project No. **22-19573**
Revision No. **0**
Date **29/06/2020**

Construction Method Impact Areas

Figure 5-1

G:\22\19573\Design\04 Deliverables\02 Other\2219573_AR_MEAR_0.aprx\2219573_MEA002_ImpactArea_0
Print date: 29 Jun 2020 - 10:08

Table 5-1 Estimated seabed disturbance areas for each construction method

Pipeline construction method	Area of impact	Estimated area* of seabed disturbance	Dominant sediment type
CM 1 Horizontal Directional Drilling	Pipeline exit point at seabed and construction of intake head	104 m^2	Sandy sediment
CM 2 Pipe jacking/micro tunnelling with reception pit	Reception pit (20 m x 10 m) with buffer for spoil deposition (600 m^3)^	2,200 m^2	Sandy sediment

*The estimated area considers a DN1200 pipe

^ *An average dredge depth of 3 m has been assumed in calculation of spoil volumes*

5.1.1.2 Impact analysis

CM1 Horizontal Directional Drilling

HDD requires drilling of an initial pilot drill hole (approximately 200-300 mm diameter) from the shore-side location to the proposed exit point where a short length of pipe on the seabed will connect to the intake structure. This is likely to occur between chainage -370 m and 230 m, subject to the detailed design (WSP, 2020). The pilot hole is then back reamed to the outer diameter of the pipe to allow the pipe to be pulled through the hole. Once pulled through, the pipe would be laid on the seabed for approximately 5 m before connection to the intake head. An estimated 104 m^2 of the seabed would be impacted via the HDD operations at the exit point.

The underlying geology through which the conduit would be constructed generally consists of sand material. The conduit may therefore need to be supported through the injection of drilling fluid to avoid collapse. There is therefore a risk that break-through of the drill head into the water column from the seabed may result in the release of drilling fluids into the environment. Drilling fluids used in the marine environment are generally water-based fluids with a mixture of polymers and additives. Water-based drilling fluids are considered the most environmentally acceptable drilling fluids because of their low toxicity and their ability to disperse easily and degrade rapidly (Swan *et al.,* 1994). The composition of the water-based fluid proposed for use for the Project could not be confirmed at the time of this assessment. The use of additives may be necessary depending on the water quality and the varying types of materials encountered during the drilling process. Site based conditions would inform use of these additives and the required dosage at the time of drilling. The following therefore provides an overview of common polymers and additives used in the drilling industry with an assessment of their toxicity and behaviour in the environment.

Xanthan gum, a common polymer in drilling fluids, aids in gelling the drill fines into a suitable cake for extraction. Xanthan gum is a cellulose, plant based material which is largely of little risk to fish with a lethal concentration of 50 % of the population (LC50) of rainbow trout at 420 m/L (Curtin University of Technology, 2009).

Additives may include bentonite and soda ash. Bentonite, a commonly used additive, aids in the extraction of excavated material, acts as a lubrication agent and reduces fluid loss to the underlying formations. Bentonite is a natural clay and is considered to be inert with very low toxicity however may be harmful to filter feeding animals such as corals when in suspension (Hinwood *et al.,* 1994 *In* Swan *et al.*, 1994). Soda ash or sodium carbonate, another common additive, may be used to adjust the pH of the water for efficient use of the bentonite and polymers. Soda ash may be toxic in relatively high concentrations. The ecotoxicological profile of sodium carbonate reports LC50 for fish as 300 mg/L (Schlumberger, 2014), which presents little risk to fish. During the break-out process, the volume of drilling fluid that enters the marine environment depends on the exit methodology and the time delay between the drill exiting the seabed and commencement of the back-reaming activity. It is estimated that 50 to 200 m^3 and 120 to 500 m^3 of fluid will enter the environment for the slanted pile construction method and the direct open to seafloor method, respectively (pers comm Hunter Water, 2020). Depending on the composition of the drilling fluids and condition of currents on site, the break-out process may result in a semi-solid, gelatine like area of sand a few meters in diameter which will likely disperse with local currents within a few days (Curtain University of Technology, 2009). Given the location of the Project in an open sandy environment, the break-out process from the drilling process is therefore not expected to significantly impact on epi-benthic and benthic fauna in an otherwise de-pauperate seabed (seabed with little fauna and flora present).

If any localised increase in suspended sediment occurs during installation works associated with the intake pipe structure, it would be temporary in nature, with sediment settling and dispersing quickly out of suspension as a result of the predominantly sandy nature of the sediment.

CM 2 Micro-tunnelling/pipe jacking

Micro-tunnelling requires the excavation of a 20 m x 10 m x 3 m reception pit for receiving the pipeline and constructing the vertical riser shaft. An estimated 2,200 m^2 of seabed would be impacted via the micro-tunnelling operations at the reception pit. The excavated material is expected to be placed in the vicinity of the pit to enable the re-spreading of the material over the pipe and across the area once it has been put in place. The thin layer of sandy sediment is not expected to significantly impact on an otherwise de-pauperate seabed.

Similar to HDD, micro-tunnelling also utilises a water-based drilling fluid. Potential impacts from this operation are discussed under CM 1 section.

If any localised increase in suspended sediment occurs during installation works associated with the intake pipe structure, it would be temporary in nature, with sediment settling and dispersing quickly out of suspension as a result of the predominantly sandy nature of the sediment.

5.1.1.3 Management controls

To reduce or eliminate the impact of seabed disturbance, a number of design and management controls can be implemented when possible.

- Construction method would consider option with least disturbance to seabed area and break out of drilling fluids
- Speed of drilling would be reduced prior to breakthrough to surface to minimise the volume of drilling fluids released into the marine environment
- Visual observations during drilling for signs of increased turbidity and sedimentation
- Emergency Management Plan in place to support drilling activities

5.1.1.4 Environmental outcome

The activities associated with the pipe laying would disturb an estimated area of 104 m^2 or 2,200 m^2 of seabed and benthic habitats for the CM 1 HDD and CM 2 micro-tunnelling construction options, respectively. The seabed to be disturbed consists largely of open sandy substrate.

The pipe laying activities would occur in/over benthic habitats that are widely represented at a regional scale. Once the pipe has been installed, further disturbance or damage to soft sediment habitats and benthic communities is not anticipated.

The environmental risks would be limited to the immediate surrounds of the pipe, and are expected to be short term in nature, with low risk on existing species. Additionally, disturbance and impacts to habitats from the construction phase are not likely to be detrimental to the overall quality of the region as the habitat is considered to be well represented locally and regionally. As such, risks associated with planned seabed disturbance are considered to be acceptable and as low as reasonably practicable.

5.1.2 Artificial light emissions

5.1.2.1 Impact description

Artificial light emissions are likely to occur during the use of safety lighting on vessels and support barges.

5.1.2.2 Impact analysis

Artificial light from vessels may attract and disorientate fauna such as birds, marine turtles, fish, and other pelagic species in the locality, particularly during peak breeding and migratory periods.

Seabirds

Birds may be attracted or deterred either directly or indirectly by the light source. Studies conducted between 1992 and 2002 in the North Sea confirmed that artificial light was the reason that birds were attracted to and accumulated around illuminated offshore infrastructure (Marquenie *et al*., 2008). Structures in deep water environments tend to attract marine life at all trophic levels, creating food sources and shelter for seabirds (Surman, 2002), and providing enhanced capability for night foraging. Birds may also use light as a cue for migration.

However, seabirds can also be deterred by artificial light and all species are known to be vulnerable to artificial lighting, but more particularly fledglings (DoEE, 2020). Birds most active at night can be disorientated by artificial lighting, causing collision, entrapment, stranding, grounding and interference with navigation. These behavioural responses to artificial light can yield injury or death for seabirds and light is known to impact seabirds up to 18 km from the light source (DoEE, 2020).

Marine reptiles

Turtles use light for navigation. The attraction of turtles to artificial lighting occurs as the light source has a highly directed light field in comparison to the disparate light of natural navigational light sources (e.g. moonlight) (Witherington and Martin, 1996; Witherington, 1997). The magnitude of impact has been shown to vary between species and in relation to light wavelength and intensity. Some lights are understood not to affect nesting densities (which excludes wavelengths below 540 nm) (DoEE, 2020).

Dedicated environmental monitoring from drilling rigs revealed that very few, if any, turtle hatchlings approached lit drill rigs at night while those that did approach did not remain around the drill rig for very long (usually less than 30 minutes) (Apache, 2007). Therefore, artificial lighting from vessels is not likely to impact on hatchlings even though they may transit through the project area during installation activities.

Artificial lighting is known to disrupt the normal behaviour of nesting female turtles, as well as hatchlings attempting to orient towards the ocean (Salmon, 2006). Beaches in the vicinity of the Project area are not known to host nesting turtles however, there have been intermittent reports of individuals nesting in the wider region, including as far south as Manly (Thomas, 2020). It is therefore considered that nesting females and hatchlings may occur and would be affected by artificial lighting should works overlap with the nesting season. However, noting that some light types do not appear to affect nesting (Low Pressure Sodium, LPS and High Pressure Sodium HPS), which excludes wavelengths below 540 nm (DoEE, 2020). Artificial light impacts turtle species up to 18 km away from the light source (DoEE, 2020).

Fish and other pelagic species

The response of fish to light emissions varies according to species and habitat. According to Meekan *et al.* (2001), light trap experiments have shown that some fish and zooplankton species are attracted to light sources, with traps drawing catches from up to 90 m away (Milicich *et al*., 1992). A study of larval fish populations by Lindquist *et al.* (2005) around an oil and gas platform in the Gulf of Mexico found that an enhanced abundance of clupeids (herring and sardines) and engraulids (anchovies), both of which are highly photopositive, was caused by platforms' light fields.

The concentration of organisms attracted to light causes an increase in food source for predatory species; marine predators are known to aggregate at the edges of artificial light halos. Shaw *et al.* (2002), in a similar light trap study, noted that juvenile tunas (Scombridae) and jacks (Carangidae), which are highly predatory, might have been preying upon concentrations of zooplankton attracted to the light field from platforms. This could lead to increased predation rates compared to unlit areas.

The vessels used during construction of the DOI will require lighting for safe navigation, security and illumination of work areas during any night works. The potential impacts from artificial lighting on fish and other coastal species are, therefore, considered temporary and mobile across the pipe route. Chance of encounter with susceptible species during installation activities is considered minimal with a temporary period of exposure. Hence, lighting is not considered likely to have long term influence on behaviour of species encountered during the intake pipe and intake structure installation activities.

Cetaceans

Currently there is no evidence to imply that artificial light sources negatively impacts on the migratory, feeding or breeding behaviours of cetaceans. According to Simmonds *et al.* (2004), cetaceans predominantly utilise acoustic senses to assess their environment rather than visual stimuli and light sources. However, these species may be indirectly impacted by artificial lighting should their food sources be attracted to light. Migrating species may also be impacted by artificial lighting through changes to their migration patterns.

Such impacts are temporary and not considered likely to have long term influence on behaviour of species encountered during the intake pipe and intake structure installation activities.

5.1.2.3 Management controls

To reduce or eliminate the impact of artificial lighting, the following management controls can be implemented when possible:

- Employ Best Practice Lighting Design for infrastructure such as vessels and barges that require to be lit at night in accordance with DoEE (2020) National Light Pollution Guidelines. Measures could include modification of light wavelengths, prevention of upward light spill and limiting light intensity for seabirds and maintaining a dark zone between any turtle nesting beach and infrastructure, avoiding direct lighting onto nesting beach or screen barriers for marine turtles (DoEE, 2020).
- Light spill from the nearshore vessel operations will be minimised where possible using directional lighting. Light shields could be considered to avoid spill if sensitive receptors are determined during activities to be negatively affected.
- Lighting on vessel decks will be managed to reduce direct light spill onto marine waters, unless such actions do not comply with navigation and vessel safety standards (AMSA Marine Orders Part 30: Prevention of Collisions; AMSA Marine Orders Part 21: Safety and Emergency Arrangements).

5.1.2.4 Environmental outcome

Minimum lighting is required for safety purposes on board the vessels, and for navigational purposes. Vessel presence is required to undertake the activities and therefore environmental consequences due to lighting are possible.

It is necessary for all vessels in Australian waters to comply with the navigation safety requirements prescribed within the *Navigation Act 2012* and the subordinate Marine Orders concerning workplace safety equipment (e.g. lighting) and navigation. While light spill will be reduced wherever possible, the elimination of deck lighting on vessels would result in:

- Increased probability for vessel collisions and accidents
- Presenting new safety risks to crew members
- Non-compliance with marine codes and regulations

Turtles and shorebirds are identified as being the most sensitive to artificial light sources. Beaches in the vicinity of the intake pipe are not known to host turtle nesting. It is, therefore, unlikely that artificial light generated by the construction activities will interfere with species breeding success and population longevity. Indirect impacts on these and other marine species could include changes in migration patterns; nonetheless, such impacts would be temporary and mobile across the intake pipe route and are not considered to pose a significant risk.

5.1.3 Artificial noise emissions

5.1.3.1 Impact descriptions

The activities associated with the installation of the intake pipe will generate standard shipping noise associated with vessel movements between port environments and additional noise generated from the use of construction machinery.

Disturbance to marine fauna (including avifauna) from above ground and underwater noise may occur in response to noise generated by vessel movement as well as intake pipe laying activities.

5.1.3.2 Impact analysis

The proposed intake pipe laying and intake structure activities will generate above ground and underwater noise related to installation of the pipe, engine and general vessel operations. Vessels are also expected to use sounders and other navigational equipment to support vessel positioning and pipe laying operations.

Acoustically dependent cetaceans and other fauna with potential to overlap with the intake pipe route include dolphins, humpback whales, southern right whales, dugongs and fur seals (Table 4-1).

Aquatic fauna are known to vocalise across a wide range of frequencies; e.g. 1 kHz – 160 kHz (McCauley, 1994; Southall *et al.,* 2007). According to McCauley (1994) and Richardson *et al.* (1995), the sound pressure threshold for direct physical trauma to occur in cetaceans is typically viewed to be >200 dB re 1Pa. Kongsberg Maritime Ltd (2010) report non-injury limits for cetaceans (both permanent or temporary) and fish at 183 dB.

As such, desktop review indicates that physiological damage, such as the loss of hearing, would only be probable if fauna are exposed to strong sounds from higher energy sources (e.g. > 180 dB). Noise measurements during pipe trenching works reported in Nedwell *et al.* (2003) indicate source levels similar to general commercial shipping operations, ranging between 152 to 192 dB (re 1 µPa at 1 m) while JASCO Research (2006) demonstrated that noise levels associated with pipe laying reduced to 130 dB and 120 dB at a distance 380 m and 3.03 km from the source, respectively. Noise from standard commercial shipping operations ranges from 176 to 186.6 dB (re 1 µPa at 1 m) and 118 to 124.9 dB (re 1 µPa) at 3 km (McKenna *et al.,* 2012).

Marine fauna which are known to use the area and that utilise acoustics for communication and navigation may be particularly sensitive to excessive noise, potentially suffering from temporary or permanent threshold shift (TTS or PTS) in hearing ability if exposed to higher energy sources (Table 5-2).

While there are no quantitative national guidelines on acceptable exposure levels for megafauna to underwater noise generated by construction activities, the *Underwater Piling Noise Guidelines* (2012) are the accepted guide on relevant behavioural and physiological noise criteria for some megafauna species (Table 5-2).

Table 5-2 Behavioural and physiological noise criteria for some megafauna (DPTI, 2012)

Species	Impact	Noise exposure criteria for impact piling
Cetaceans and pinnipeds	Behavioural	SPL 160 dB re: 1 µPa
Low frequency cetaceans (All baleen whales, including southern right whale and humpback whale)	Physiological (TTS)	Peak 224 dB re: 1 µPa SEL 183 dB (Mlf) re: 1 μPa_2-s
	Physiological (PTS)	Peak 230 dB re: 1 µPa SEL 198 dB (Mmf) re: 1 μPa_2-s
Mid frequency cetaceans (Majority of toothed whales including dolphins and killer whale)	Physiological (TTS)	Peak 224 dB re: 1 µPa SEL 183 dB (Mmf) re: 1 μPa_2-s
	Physiological (PTS)	Peak 230 dB re: 1µPa SEL 198 dB (Mmf) re: 1 μPa_2-s
High frequency cetaceans (Other toothed whales)	Physiological (TTS)	Peak 224 dB re: 1 µPa SEL 183 dB (Mhf) re: 1 μPa_2-s
	Physiological (PTS)	Peak 230 dB re: 1 µPa SEL 198 dB (Mhf) re: 1 μPa_2-s

Species	Impact	Noise exposure criteria for impact piling
Pinnipeds (seals and sea lions including Australian fur seal)	Physiological (TTS)	Peak 212 dB re: 1 µPa SEL 171 dB (Mpw) re: 1 μPa_2-s
	Physiological (PTS)	Peak 218 dB re: 1 µPa SEL 186 dB (Mpw) re: 1 μPa_2-s

Observations by the US National Research Council (2003) of responses by cetaceans to artificially generated sound identified behavioural reactions that include changes to diving, surface and breathing, avoidance, swimming direction, swim speed and shock reactions However, while cetaceans are likely to transit the region, larger species such as whales are unlikely to be present within the shallow waters of the Project area.

Smaller cetaceans such as dolphins may be present within the project area but it is expected that these species will exhibit avoidance behaviour during construction activities.

The New Zealand fur seal is likely to occur in the project area during construction activities. The impact of artificially generated sound on pinnipeds is poorly understood however the DPTI guidelines indicate that TTS and PTS occur at 171 dB (re 1 μPa_2-s) and 186 dB (re 1 μPa_2-s), respectively (Table 5-2). It is expected that like dolphins these species will avoid the project area during construction activities.

Turtles are thought to be highly sensitive to low frequency sound and are able to detect frequencies in the 100 to 700 Hz (Bartol and Musick, 2003). Literature on the impacts of sound on turtles is currently in its infancy and the topic poorly understood however, observations by McCauley et al (2002) report erratic swimming behaviour and increased swimming activity in response to increased levels of artificial sound. As such, the planned construction activities have the potential to impact these species and risk associated with these activities should therefore be managed.

The majority of fish are classified as having poor hearing and reduced sensitivity to noise, with some species having no known sensitivities to noise (Nedwell *et al.* 2016). The acoustic sensitivity of syngnathids is not currently known however, Anderson (2009) has observed them to exhibit physiological stress under noisy conditions. It is expected that impacts on fish during construction will be short-term in nature, potentially resulting in avoidance behaviour and are not expected to be significant at the population level. It is therefore considered that fish species are unlikely to be impacted by noise and frequencies generated during the project works.

A variety of migratory birds are likely to occur on the foreshore of the Project area, with populations and species being highly dependent upon the time of year. Construction activities have the potential to disturb birds in residence via the generation of artificial noise, which may cause a local reduction in shorebird use of the project area during construction.

5.1.3.3 Management controls

The following controls will be implemented for the purposes of decreasing or mitigating the impact of noise on marine fauna:

- Activities that generate underwater noise could be timed to occur outside of peak migration months to reduce overlap with migratory movements and therefore reduce the potential threat to both migratory marine mammals and migratory marine birds. Where this is not possible, the need for Marine Fauna Observers will be determined on the basis of construction timeframes.
- Acoustic harassment/deterrent devices could be sounded prior to commencement of any underwater activity to provide opportunity for sensitive marine fauna to relocate temporarily.

- Vessel machinery will be maintained in accordance with the manufacturer specifications to reduce noise emissions.
- The interaction of all vessels with cetaceans and whale sharks will be compliant with Part 8 of the Environment Protection and Biodiversity Conservation (EPBC) Regulations (2000). The Australian Guidelines for Whale and Dolphin Watching (Commonwealth of Australia, 2017)) for sea-faring activities will be implemented across the entire project. This includes the implementation of the following guidelines:
  - Caution zone (300 m either side of whales and 150 m either side of dolphins) – vessels must operate at no wake speed in this zone.
  - Caution zone must not be entered when calf (whale or dolphin) is present.
  - No approach zone (100 m either side of whales and 50 m either side of dolphins) – vessels should not enter this zone and should not wait in front of the direction of travel or an animal or pod, or follow directly behind.
  - If there is a need to stop, reduce speed gradually.
  - Do not encourage bow riding.
  - If animals are bow riding, do not change course or speed suddenly.

5.1.3.4 Environmental outcome

Above ground and underwater noise generated by the installation of the intake pipe and intake structure within the Project area may result in localised influences on fauna.

Noise emissions generated by the vessels and proposed pipe installation would be similar to that of other marine vessels which cross through the region (e.g. commercial shipping vessels and recreational vessels) and would be unbroken rather than pulsed noise emissions. The vessels are required in the field for the intake pipe installation activities, therefore, vessel elimination is not considered to be a practicable alternative on this basis.

Underwater background noise levels, inclusive of biological, wind, wave and shipping movements, differ across locations. As an example, background noise levels ranging between 100-138 dB and 100-120 dB have been reported in Gladstone and South Australia, respectively (SLR, 2019 and DPTI, 2012). As such, noise levels associated with construction of the intake pipe and intake structure are expected to be consistent with background conditions and not surpass the acoustic noise limits identified for marine fauna protection. It is expected that noise emissions associated with construction of the intake pipe and intake structure are unlikely to result in significant impacts.

There is potential for migratory species to be present within the area during installation works if works proceed during the whale migration season. Whales generally head north to warm waters to breed and give birth from late April to August and return south from September to November (NSW Government, 2020). Due to the transitory nature of the marine fauna are able to move away from noise sources without disruption to feeding and breeding ranges and therefore, it is not anticipated that construction noise would have a significant impact on marine fauna. Behavioural impacts (e.g. avoidance patterns and swimming movements away from the area) are the most probable form of impact to marine fauna as a result of anthropogenic noise generated by this activity, particularly for sensitive species such as cetaceans. Vessel noise is anticipated to only induce temporary and localised behavioural impact if species are encountered, with afflicted marine species expected to adopt normal behavioural patterns within a short time frame in the open waters surrounding the pipe route and intake structure.

Due to the short-term nature of the activity, exposure of sensitive marine receptors to noise would not occur over extended periods of time. The mobility of marine fauna also supports their ability to behaviourally avoid unfavourable habitats; this also reduces the probability of inflicting any impact to marine fauna as a result of anthropogenic noise sources.

5.1.4 Planned discharges

5.1.4.1 Impact description

The possible discharges to the surrounding marine environment are sewage and food waste, brine, cooling water and deck drainage.

Discharge of drilling fluid into the marine environment during CM 1 HDD or CM 2 micro-tunnelling works is discussed separately in Section 5.1.1.

5.1.4.2 Impact analysis

All wastes are expected to be disposed on land at an identified licensed waste management facility and transported in accordance with its waste type classification and category.

It is envisaged that non-hazardous planned vessel discharges will be minimal and continuous. This will also be dependent on the total number of people on board the construction vessel and any rainfall received during the construction period. A reduction in water quality in associated waters is one consequence of non-hazardous substances discharge. Such effects are short-lived, lasting hours, and are typically localised and restricted to surface water layers (< 5 m). Short-term changes to existing environmental conditions are not anticipated for waters 100 m away from the source of discharge as a result of the rapid dispersion and dilution of the discharge with increasing distance from the discharge origin.

The following provides a description of possible planned discharges associated with the intake pipe and intake structure installation activities. It is noted that any planned discharge is to be undertaken in accordance with state and international obligations.

Water turbidity and oleaginous discharge

Increases in water turbidity could be a possible consequence of food waste or sewage discharge into surrounding waters. The discharge of water from deck drainage and vessel discharge could lead to increases in turbidity and induce toxic effects in marine organisms within the surrounding area. Hazardous substances stored on deck with potential to influence discharge quality (e.g. hydrocarbons and other contaminants) should be contained within bunds avoiding risk of impact to surrounding water quality in the event if deck runoff.

Water temperature

Water used for cooling of vessel engines and other equipment will be discharged at temperatures above surrounding seawater. The cooling water discharge will transmit heat to the surrounding waters while also mixing with the larger body of water into which it is released.

Temperature dispersion modelling has indicated that receiving waters rapidly mix with released waters; with discharge waters less than 100 m horizontally away from the discharge point measured at less than less than 1°C above ambient water temperature levels (Woodside, 2011). The corresponding distance for discharge waters to reach this level in the vertical axis is within 10 m.

While vessel design does vary, all vessels maintain the same discharge design, where cooling water is emitted into the surrounding waters above the water line. This discharge mechanism allows for the cooling and oxygenation of the heated discharge water before it is released into the immediate marine environment. It is anticipated that the impact of cooling water discharge on the water quality of the surrounding environment will be minimal, given the relatively low quantities of discharge, minor differences in temperature, release above water line, rapid mixing and expanse of the ocean's water around the vessel.

Brine wastewater

Brine discharge, particularly that with marginally higher salinity, with typically 10% higher salt content than that of seawater, is an output of the seawater desalination process from onboard vessel operations. Due to the higher density of desalination brine relative to seawater, the brine discharge will sink and diffuse into the ocean currents. Brine discharge volume is proportional to the fresh/potable water demands of the vessel and people on board.

Temporary fluctuations of 20 to 30 % in salinity can be tolerated by majority of marine species, with most pelagic species, in the short-term, anticipated to tolerate exposure to the marginal increases in salinity resulting from desalination brine (Walker and McComb, 1990). Released brine will, similar to cooling waters, mix into the surrounding environment rapidly such that differences are minor within 100 m of release point. It is therefore expected that the impact of brine discharge on the surrounding water quality of the activity zone will be minimal, given that the discharge volume and increase in salt concentration is low in comparison to the volume of water in the open sea in the area.

Nutrient enrichment

Eutrophication can be a consequence of food waste and sewage discharge. Eutrophication can lead to changes to plankton within the affected zone, affecting the marine species in the area, which feed on plankton. According to Costello and Read (1994), discharge into the sea typically dilutes to 1 in 1000 dilution levels within half an hour. These findings indicate that it is unlikely for acute toxicity to develop at ecologically significant locations nor is it likely that detectable levels would be achieved at discharge locations. On this basis, no impacts to the environment, including nutrient enrichment, from sewage management are expected. Relevant legislative requirements regarding waste release to the environment will be followed by the vessel during all operations.

Management controls

In order to mitigate or lessen planned discharges, the following management plans would be implemented:

- Sewage and food waste will be collected, stored, processed and disposed of in accordance with NSW (*Protection of the Environment Operations Act* 1997 and Marine Pollution Regulation 2006), Australian (AMSA) and international regulations (MARPOL).
- Liquid substances will be discharged in compliance with MARPOL, including:
  - Untreated sewage will be stored onboard and disposed of onshore at a reception facility or to a carrier licensed to receive the waste, or discharged at a distance of more than 12 nautical miles from the nearest land in accordance with Regulation 11 of MARPOL Annex IV.
  - Treated sewage will be discharged in compliance with Regulation 11 of MARPOL Annex IV.
  - Sewage system will be compliant with Regulation 9 of MARPOL Annex IV and be maintained in accordance with the vessels planned maintenance system.

  - As per MARPOL Annex IV/AMSA Marine Order 96, any vessel licensed to carry more than 15 persons will have an International Sewage Pollution Prevention Certificate.
  - Vessels may discharge oily water after treatment to 15 ppm in an oily water filter system as required by MARPOL Annex I Regulations (for the prevention of pollution by oil). To discharge, the vessels will require a current International Oil Pollution Prevention (IOPP) certificate for oily water filtering equipment, and a current calibration certificate for the bilge alarm.
- Vessel masters will ensure that the maximum carrying capacity of the sewage system is not exceeded. All wastes will be disposed on land at an identified licensed waste management facility and transported in accordance with its waste type classification and category.
- Scupper plugs or equivalent will be available on vessel decks where chemicals and hydrocarbons are stored and frequently handled (i.e.' high risk' areas). Non-hazardous, biodegradable detergents will be used for deck washing.
- The vessel operator will record the quantity, time and onshore location of the oily water disposal in the vessel Oil Record Book.

5.1.4.3 Environmental outcome

In order to undertake the activities, vessel presence is required and no alternative is available. Therefore, food, brine, cooling water, sewage and oleaginous discharge will be produced during the course of these activities. Under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*, a representation of MARPOL Annex IV, V and I requirements respectively, permits the disposal of these non-hazardous substances into the sea by vessels within Australian waters.

Another possible course of action is to retain untreated sewage and food in storage until it can be disposed of at an onshore reception facility. This alternative would require one vessel, additional or currently available, to conduct regular trips to transfer and return wastes to shore.

This process would involve increases in fuel consumption and port movements, as well as the need for a licensed onshore waste treatment facility. Due to these factors, the onshore disposal option would result in an increase in environmental risk which, given the relatively small quantities of discharge involved, would be unjustifiable in comparison to the planned discharge option which is considered environmentally acceptable and preferred due to the minimal volumes of waste involved over a brief duration. The strong coastal currents and well-mixed waters that characterise the majority of the site would also enhance the dilution and dispersion of any discharge, further reducing the effects of any waste released into the surrounding waters.

The waste retention and discharge options both have minimal impact on the environment and comply with the conditions of MARPOL. Considering the operational factors mentioned previously, the onboard treatment of waste is considered more feasible and more likely to be adopted for most cases during the course of this activity. Given the international acceptance and industry-wide adoption of the MARPOL standards, it is accepted that compliance with the corresponding MARPOL requirements would translate into diminished environmental impacts from planned discharges to as low as reasonably practicable.

5.1.5 Atmospheric emissions

5.1.5.1 Impact description

Greenhouse gases (GHG) (including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O)) and non-GHG (such as sulphur oxides (SO_X) and nitrous oxides (NO_X)) are emitted as a result of the burning of fuel to power vessel engines, generators and mobile and fixed plant and equipment, as well as on-board waste incinerators. The fuel predominantly used for these activities would be diesel.

Ozone-depleting substances (ODS) may also be in use by closed-system rechargeable refrigeration systems on-board these vessels.

5.1.5.2 Impact analysis

Short-term reduction in air quality in the immediate region around the Project area may occur due to the burning of hydrocarbons. This would occur throughout the pipe laying and intake structure activity.

Humans and seabirds in the immediate region would be affected by the localised decline in air quality accompanying the emission of non-GHG and GHG. It would also be noted that the emissions would contribute to the national GHG count.

The combustion of fuels from activities is not expected to affect the air quality of coastal communities, as the majority of the pipe-laying activities will occur offshore, away from population areas. In addition, the gaseous emissions are of relatively low quantities and it is expected that under normal conditions these emissions would undergo rapid dissipation into the surrounding environment.

The likelihood of accidental emission of significant quantities of ODS is deemed to be rare due the maintenance of ODS-containing refrigeration systems on vessels. Despite this, there is potential for the unintentional discharge and brief emission of ODS to contribute to the depletion of the ozone layer. Maintenance of refrigeration systems containing ODS is on a routine, but infrequent basis, and with controls implemented, the likelihood of an accidental ODS release of material volume is considered rare.

5.1.5.3 Management controls

A variety of management controls will be implemented in order to mitigate or eliminate the occurrence of gaseous discharge:

- All equipment will be properly maintained in good working order.
- Catalytic converters and exhaust filters will be correctly fitted where appropriate and available to minimise diesel exhaust emissions.
- Idling time of diesel engines should be limited and engines should not be overloaded.
- Fuel oil will meet regulated sulphur content levels in order to control SO_X and particulate matter emissions.
- Engines will be operated in a manner so that regulated NO_X emission levels are achieved.
- Compliance with MARPOL Annex VI (as implemented in Commonwealth waters by the Commonwealth *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* (PSPPS Act); and Marine Order 97: Marine pollution prevention - air pollution). In particular:
  - Optimisation of fuel use to increase efficiency and minimise emissions.
  - Use of low sulphur fuel (0.5% m/m) to minimise emissions from combustible sources.
  - Implementation of a planned servicing/maintenance system to manage emissions.

– Vessel engines will hold a valid and current International Air Pollution Prevention Certificate (IAPPC).
– ODS will not be deliberately discharged during the maintenance, service, repair or disposal of systems or equipment, and through good maintenance, fugitive emissions will be minimised.

5.1.5.4 Environmental outcome

As the proposed pipe-laying activities under all construction options require the presence of vessels, there is no potential for the elimination of gaseous emissions from vessels. The proposed construction methods, are expected to have approximately similar emissions. Vessel gaseous emissions resulting from the combustion of hydrocarbons and waste incineration is permitted on Australian waters under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*. This Act meets the requirements and obligations outlined in the MARPOL Annex VI. In addition, since the activity is predominantly situated in coastal waters of some distance from populated areas, air emissions will experience rapid dissipation into the surrounding environment and are unlikely to extend to onshore communities.

Other feasible and reliable fuel types for vessels have not been found. However, in order to reduce emissions, low sulphur-oxide marine-grade diesel would be used to fuel the vessels, as opposed to heavy fuel oil. For the purposes of controlling sulphur oxide and particulate matter emissions into the atmosphere, the applicable fuel will satisfy standardised sulphur content quantities. Under the MARPOL Annex VI requirements, ODS use in closed-system refrigeration systems is considered acceptable. Inadequate workplace conditions (e.g. the lack of air conditioning) and unacceptable food hygiene standards would result from the lack of such systems on vessels.

As such, the removal of ODS closed-system refrigeration systems is not considered feasible. Assuming that the risk of unintentional release of ODS has been mitigated by the consistent maintenance of such systems by qualified staff it can be considered that all feasible measures have been considered and implemented, and that the anticipated environmental impacts of gaseous emissions are acceptable. Given the international acceptance and industry-wide adoption of the MARPOL standards, it is accepted that compliance with the corresponding MARPOL requirements would translate into diminished environmental impacts from atmospheric emissions to as low as reasonably possible.

5.1.6 Interference with other users

5.1.6.1 Impact description

A number of different impacts may arise from unrelated shipping traffic crossing the path of the construction vessels. Given intake pipe route is a planned alignment and the intake structure location which may cross navigational waters and areas utilised for recreational fishing, this activity may result in the temporary reduction of accessibility to these areas, or require other vessel operators to re-route vessel movements to avoid crossing paths with construction vessels or Project area.

5.1.6.2 Impact analysis

The potential impact of the interim occupation of an area by construction vessels is the temporary loss of access to fishing grounds and navigational waters within the Project area. There is potential that fishing would be disrupted, that fishing apparatus may be damaged upon catching onto the subsea infrastructure or that vessels may be required to change navigational course to avoid collision risk.

The visible vessel presence at the site during the pipe-laying phase may prove a reasonable and recognisable obstacle to regional shipping traffic. Vessels involved in the laying of intake pipe and intake structure have limited manoeuvrability, meaning that all other maritime traffic may need to avoid these vessels and their associated in-water equipment.

Additionally, navigation charts (Admiralty Charts) are updated with locations of subsea pipes, as such maritime users are alerted to the presence of the pipes. Normal maritime procedures are followed by all vessels for communications that assist with mitigation of interference risks.

Interference or entanglement risk associated with fishing activities post installation would be minimised by burial of the pipe within soft sediment along the length of the route to the intake structure however, the intake structure itself will result in a small level of risk that cannot be eliminated.

5.1.6.3 Management controls

The following management controls have been considered for all construction methods and will be implemented in order to mitigate or remove interference issues between activity-related vessels and other users of the sea:

- Pipe-laying related activities will be undertaken in accordance with all marine navigation and vessel safety requirements under the International Convention of the Safety of Life at Sea (SOLAS) 1974 and *Navigation Act 2012*. For the vessels, this requires equipment and procedures to comply with AMSA Marine Order - Part 30: Prevention of Collisions, and Marine Order - Part 21: Safety of Navigation and Emergency Procedures.
- Stakeholder consultation (local councils, fishing bodies, etc.).
- Notification to the following Australian Government agencies will be made prior to moving the pipe laying vessel on location:
  - The Australian Hydrographic Office of proposed activity, location (i.e. vessel location) and commencement date to enable a Notice to Mariners' to be issued
  - The Australian Maritime Safety Authority (AMSA) Rescue Coordination Centre (RCC) of proposed activities, location (i.e. vessel location) and commencement date to enable an AusCoast warning to be issued
- Vessels will also be equipped with all navigational and safety requirements for operation in Australian waters. These may include an automatic identification system (AIS) and an automatic radar plotting aid (ARPA) system capable of identifying, tracking and projecting the closest approach for any vessel (time and location) within radar range (up to approximately 70 km).
- Visual observations will be conducted by trained watch keepers on all vessels 24 hours per day to support management of collision risk or entanglement/interference with other users.

5.1.6.4 Environmental outcome

As pipe-laying activities cannot be undertaken without vessel presence, the vessels may not be removed to eliminate the associated issues. However, there is potential for disruption to marine vessel operations, with recreational fishing activities likely to be temporarily affected via need to adjust course to avoid collision/overlap risk during construction. As such, stakeholder consultation and marine user notifications, which are industry standard processes, will be implemented for the activity in order to inform and mitigate the impacts on vessels. Notifications will also be undertaken to inform all maritime users of action (including location and duration) to support management of collision risk. Inshore, pipe will be passed through a sub-surface conduit to avoid interference with other users post installation.

Apart from engagement and consultation with other vessels under both construction methods, and use of sub-surface conduits for installation of the intake pipeline, no other management controls have been identified to mitigate the possibility of disruption to commercial vessel operations. Because of this, the impacts of marine vessel disruption have been deemed reasonable and controlled to keep the effects of vessel operation to existing maritime traffic as low as reasonably possible.

5.1.7 Pest introduction and proliferation

5.1.7.1 Impact description

Invasive marine pests (IMPs) are identified as marine plants, animals and algae, which have been introduced into a location that is not within their natural dispersal range but which provides conditions that support their survivorship (DAFF, 2009). Vessels carrying IMPs may unintentionally but successfully introduce these species to the region where the activity is occurring. IMPs may be carried within the external biological fouling on the vessel hull, within seawater pipes (e.g. cooling water) and associated infrastructure or on submersible marine instruments and equipment. Ballast water exchange may also allow for the transportation and proliferation of IMPs within the area of activity.

Before vessels can proceed to the site location, quarantine obligations may have to be fulfilled by all vessels, particularly for vessels sourced from overseas, if any. Ballast water exchange record requirements will need to be complied with. Internationally-sourced vessels will also be required to maintain possession of Australian Quarantine and Inspection Service (AQIS) Clearance documentation in order to verify compliance with Mandatory Ballast Water Requirements or verify biofouling management measures outlined by the AQIS.

5.1.7.2 Impact analysis

IMPs at risk of introduction to the Project area predominantly originate from Southeast Asian countries and from established IMP populations within many NSW ports.

Ecosystem health, biodiversity, fisheries, aquaculture, human health and waterway industries including tourism are at potential risk from the impacts of IMPs (DAFF, 2009; Wells, 2009). The extent of the detrimental effects introduced marine pests may have includes depletion of viable fishing areas and aquaculture stock, out-competing native flora and fauna, over-predation of native flora and fauna, reduction of coastal aesthetics and increased maintenance costs, human illness through released toxins, reduction in vessel performance, damage to vessel engines and propellers and damage to industrial infrastructure.

The introduction of new species is not a rare occurrence. However, the physical, chemical and biological circumstances of the environment into which the species has been introduced are important determining factors as to whether the species will successful establish and become an invasive pest.

Flora and fauna species atypical to the region can be attracted to newly created hard substrate habitats; such as those that would be provided by the presence of the intake structure. It is anticipated that this would be minimised by burial of the pipe, with only a small area of new hard substrate made available by the intake structure. The new habitat provided by the intake structure is however, expected to accommodate native species as demonstrated on the WWTW outfall, which had previously limited access to available hard substrate habitats.

5.1.7.3 Management controls

The following controls and processes may be employed when possible in order to mitigate or eliminate the risk of introducing pests:

- Vessels should be sourced locally wherever possible.
- All vessels working on the Project, whether internationally or locally sources, will adhere to Australian quarantine requirements.
- The management of ballast water prior to entry to Australian waters must follow AQIS guidelines and compliance requirements in relation to marine pest introduction risk management for any internationally sourced vessel.

5.1.7.4 Environmental outcome

Organisms from the natural environment collect on vessels and submersible equipment as biofouling. Vessels also require ballast water for safe operational purposes. As such, these occurrences and risks are difficult or impractical to eliminate.

To mitigate the possibility of introducing IMPs, the planned activities will be conducted with equipment and vessels, which would ideally have been operational and active within New South Wales State waters, or Commonwealth waters since their last dry-dock inspection or cleaning session. Where possible, equipment should not be obtained from higher risk areas in Southeast Asia susceptible to IMPs.

Shallow water environments are the predominant preferred habitat for the successful introduction of most known marine pests. As the location of the installation activities are within shallow coastal waters, there is potential that an IMP would be able to adapt and develop a successful translocation to the project area or surrounding region.

Successful marine pest establishment is known to be more prevalent in regions of disturbance and new hard substrate, which provide more opportunities for effective translocation by these species. Burial of the pipe via the HDD and micro-tunnelling construction methods greatly reduces the availability of hard substrate and reduces the zone of disturbance to the small area in the vicinity of the intake structure, thereby reducing the risk of translocation. Additionally, with the adherence of construction vessels to biofouling regulations, the chance of a successful translocation for IMPs is considered unlikely.

Furthermore, Commonwealth government quarantine requirements and practices consistent with the National Biofouling Management Guidance for Petroleum Production and Exploration Industry (MPSC, 2018) will be observed and adhered to by internationally sourced vessels as is the industry standard. Biofouling legislation undergoes intermittent revision and as such, Commonwealth quarantine requirements and practices along with industry standards may change in the near future. If amendments to legislation occur, relevancy of these controls should be undertaken. At time of writing all controls applied are considered leading practice for biosecurity management such that the risk of the successful introduction of an IMP is considered as low as reasonably practicable.

5.1.8 Accidental release of solid wastes

5.1.8.1 Impact description

A variety of hazardous (i.e. petroleum based products, solvents, batteries, heavy metals) and non-hazardous (i.e. general municipal wastes) solid waste may be released unintentionally into the environment from overfull and/or uncovered bins or if blown off the deck of a vessel. Accidental spillage of waste from vessels, and incorrectly disposed items, may also cause the unintentional release of solid waste into the surrounding environment.

The structural design of the intake pipe, materials and construction methodologies considered are such that it is not expected to break into pieces that could be released to the environment in the event of contact damage.

Non-hazardous solid waste includes plastics, packaging and paper materials and products while examples of hazardous solid wastes include oily and contaminated wastes, aerosol products, fluorescent tubes, batteries and medical waste.

5.1.8.2 Impact analysis

There is capacity for non-hazardous solid waste such as plastic bags to detrimentally affect the environment and cause entanglement or be ingested by fauna. The entanglement and ingestion of non-hazardous solid waste is a risk particularly prevalent for seabirds and marine turtles. The ingestion of solid wastes like plastic bags can consequently result in internal tissue damage, prevention of normal feeding behaviours and potentially death of the affected fauna.

The pollution of the immediate environment with the release of hazardous solid waste has the likely consequence of negatively affecting the health of flora and fauna within the area. Particular fish, cetaceans, seabirds and reptiles are susceptible to chemical impacts, including disease or physical injury after ingesting or absorbing the waste.

The pipe is not expected to break such that segments would be released to the marine environment. As such, the pipe is not expected to present a waste or entanglement risk during operations.

5.1.8.3 Management controls

The following management controls have been considered and will be implemented in order to mitigate or remove the risk of accidental solid waste release:

- Appropriate waste containment facilities will be included on the vessel as well as onshore and managed to avoid overflow or accidental release to the environment.
- No waste materials will be disposed of overboard; all non-biodegradable and hazardous wastes will be collected, stored, processed and disposed of in accordance with Regulation 9 of MARPOL Annex V.
- Hazardous wastes will be separated, labelled and retained in storage onboard within secondary containment (e.g. bin located in a bund).
- All recyclable and general wastes to be collected in labelled, covered bins (and compacted where possible) for appropriate disposal at regulated waste facility.
- Solid non-biodegradable and hazardous wastes will be collected and disposed of onshore at a suitable waste facility or to a carrier licensed to receive the waste if required by legislation.
- Intake pipe design is such that in the unlikely event of contact damage, the pipe does not break apart into segments or fragments, instead remaining intact to support recovery and repair of the affected segment.

5.1.8.4 Environmental outcome

Small amounts of solid non-biodegradable and hazardous wastes will be generated during the pipe-laying activities. Storage of these wastes on board in fully enclosed containers is considered good (and common) practice within this industry. During the activities, removal of these wastes from the activity area to appropriate regulated waste facilities onshore should be implemented on a regular basis.

During the activities, given the adoption of the industry standard management controls listed above, it is considered that all practicable measures have been implemented and the likelihood of solid wastes being discharged to the environment has been reduced to as low as reasonably practicable.

The unplanned release of non-hazardous and hazardous solid wastes through inadequate containment and practices is unlikely to have any significant environmental effects, as impacts would be temporary and localised. The management controls are considered effective in reducing the potential environmental impact to the marine environment. As such, the risk associated with unplanned releases of non-hazardous and hazardous solid wastes is considered as low as reasonably practicable.

5.1.9 Dropped objects

5.1.9.1 Impact description

Damage to benthic habitats can occur due to an object being dropped overboard (e.g. equipment falling from vessel deck). Any marine organisms associated with the affected benthic habitat within the dropped object's footprint may also be harmed.

5.1.9.2 Impact analysis

Disruption of habitats

Disturbance of marine biota within the affected habitat would occur although the habitat itself would not be permanently destroyed. Due to the gradual infill process of such seabed disturbances, the effects on the seabed caused by a dropped object may persist for a length of time even if the object was retrieved.

Physical damage of any sessile or slow moving fauna and epibenthos may occur within the area of disturbance caused by the dropped object however the marine survey of the Project area indicates that the area is characterised by open sandy substrate.

Direct impacts from dropped objects to the seabed can include smothering/disturbance or damage of habitat and epibenthos. Objects that are not retrieved (where that action would cause significant disturbance or safety risk) would be expected to be colonised by epifauna (primary fouling will occur within weeks to months). Eventually dropped objects will degrade, but that may take years. Immediate localised and short term impacts would be related to increased suspended sediment and turbidity; however sands are predicted to settle quickly and the impacts to water quality will be so localised and short term they are not predicted to have any effect on filter feeders.

Where objects are dropped to, and remain on, the seabed, damage to habitat will be long term until the object degrades. By providing a hard substrate on previously soft sediment, this will also result in a localised change in biodiversity with fouling communities settling on the object. As such, it will take an extensive period (decades) for the localised environment to return to a state similar to prior to impact.

The current indicative alignment of the intake pipe is within predominantly coarse sandy stretches; the risk from dropped object on marine fauna is therefore considered minor.

Additional environmental implications

Injury to fauna (e.g. entanglement or ingestion) and deterioration of the habitat or water quality in the immediate area are also potential indirect consequences of dropped objects.

As noted under Section 5.1.4, pollution and contamination caused by the discharge of hazardous solid waste into the marine environment can have direct and indirect effects on the marine biota. Physiological injury from ingestion or absorption and other chemical impacts may affect individual organisms.

5.1.9.3 Management controls

The following management controls will be implemented to reduce or eliminate the impact of dropped objects on the environment:

- All equipment and gear on the vessels should be securely fastened during mobilisation/demobilisation.
- Lifting is to be carried out by competent personnel using equipment that is suitable, certified and maintained.
- Waste management controls are to remain effective to reduce risk of release of wastes that could be ingested or cause entanglement.
- During the activities, detailed records of equipment lost overboard or dropped will be maintained and reviews will be undertaken to reflect on methods to mitigate repetition of the incident.

5.1.9.4 Environmental outcome

Procedures have been implemented for each specific lifting/handling requirement and would be performed should any equipment lifting be needed. The equipment used for lifting operations is to be maintained as specified in the planned maintenance system.

The chance of a dropped object affecting the environment is deemed to be reduced to levels as low as reasonably possible with the adoption of these industry accepted controls and procedures.

5.1.10 Marine fauna collision and entanglement

5.1.10.1 Impact description

There is potential for collision to occur between marine fauna and vessels associated with the proposed activities. This risk is particularly pronounced concerning possible collision between large slowly moving cetaceans like whales and a vessel or deployed equipment.

The consequences to fauna of this risk ranges from changes to fauna behavioural patterns to injury or death of the animal as a result of a direct collision with construction vessels or of being entangled in equipment during construction.

5.1.10.2 Impact analysis

Due to their inquisitive nature, cetaceans (e.g. dolphins) are frequently attracted to vessels and offshore facilities.

A number of instances of vessel collisions resulting in the death of the involved cetacean have occurred in Australian waters though data suggests that these instances are commonly associated with fast ferries and container ships (WDCS, 2006). Some cetaceans are known to be capable of detecting and manoeuvring to avoid collision with vessels (WDCS, 2006).

There are a variety of whale responses to the advance of vessels, with some whale species known to be inquisitive and approach vessels that are slow moving or stationary, while other whale species dive or stay motionless in the presence of vessels. However, whales typically do not approach vessels and are more likely to adapt evasive behaviours to avoid nearby ships, including the employment of longer dives.

The risk of potential vessel strike is considered low for all marine species, including cetaceans, marine turtles, sirenians, pinnipeds, fish and seabirds. This risk accounts for the avoidance behaviour marine fauna species adopt to evade vessels until the vessel disruption has elapsed.

Works will occur where recreational and commercial fishing vessels currently traverse. The risk that the additional vessel presence in the activity location will have considerable effect on marine fauna within the area is relatively small. This is due to the relatively low vessel speeds during the activity, with vessel speeds and associated barges during marine construction activities typically ranges between 6-10 knots.

The timing of construction activities is currently unknown, therefore there is potential that construction may overlap with the migratory windows of shorebirds and marine species, such as Humpback whales. Even if whales are present, construction vessels and the construction activity is not considered a direct threat as the average service speed of construction vessels are expected to range between 6-10 knots during transit to the project area, and largely stationary during construction. Humpback whales cruise at 3.7 knots (NSW OEH, 2014) and are considered relatively able to navigate away from vessels undertaking these construction activities. As such, the impact of this activity on (migratory) cetaceans is expected to be minor, as interactions with whale pods can be avoided or minimised through available operational controls.

5.1.10.3 Management controls

The following controls will be adopted and executed for all construction methods to mitigate or eliminate the risk of collision between vessels and marine fauna:

- Operations of vessels will be commensurate with Part 8 of the EPBC Regulations (Interacting with Cetaceans and Whale Watching).
- A member of the vessel crew will act as a marine fauna observer (MFO) at all times during daylight works and will maintain vigilant watch in support of Part 8 of the EPBC Regulations to manage risk of vessel collision with any other vessels or marine fauna. The MFOs will be trained and experienced in whale identification and behaviour, distance estimation, and be capable of making accurate identifications and observations of whales in Australian waters. The MFO will provide advice on appropriate actions to be taken to mitigate risks should whales be encountered.
- The Australian Guidelines for Whale and Dolphin Watching (Commonwealth of Australia, 2017) for sea-faring activities will be implemented across the entire project. This includes the implementation of the following guidelines:
  - Caution zone (300 m either side of whales and 150 m either side of dolphins) – vessels must operate at no wake speed in this zone.
  - Caution zone must not be entered when calf (whale or dolphin) is present.
  - No approach zone (100 m either side of whales and 50 m either side of dolphins) – vessels should not enter this zone and should not wait in front of the direction of travel or an animal or pod, or follow directly behind.
  - If there is a need to stop, reduce speed gradually.
  - Do not encourage bow riding.
  - If animals are bow riding, do not change course or speed suddenly.

5.1.10.4 Environmental outcome

As these activities require the presence of vessels, there is no potential for the elimination of vessels from the locality. Vessel speeds typically range between 6-10 knots during pipe-laying operations, with vessels expected to be largely stationary during construction. In order to reduce the chance of vessel interaction with marine fauna, the identified management and legislative control measures would be implemented. Vessels will be largely stationary or very slow moving during construction so collision risk will, therefore be limited. On this basis the potential risks associated with collision and interference with marine animals from vessel activities is considered to be as low are reasonably practical.

5.1.11 Hydrocarbon, chemicals and other liquid waste

5.1.11.1 Impact description

Note that release of hydrocarbons from vessel collision is addressed in Section 5.1.12 below.

Vessels, plant and other construction equipment require a wide variety of liquids, chemicals and hydrocarbon compounds to operate and to be maintained. Vessel engines and equipment such as cranes and generators operate on diesel fuel while hydraulic and lubricating oils are required for the operation and continual maintenance of mechanical components. Fuel drums may also be retained in dedicated storage areas while some vessel engines adopt independent storage tanks. Examples of hazardous liquids include corrosion inhibitors, biocide and miscellaneous chemicals like cleaning agents and lubricating oils.

Various scenarios may result in the accidental release of liquid wastes into the surrounding marine environment. Tank pipework failure or inadequate bunding are two examples. However, the quantity of hydrocarbons that can be accidentally discharged during operations is relatively small and restricted by the quantity available stored on the deck of the vessel.

If refuelling is required during the pipe-laying activity, then refuelling events have the potential to cause environmental impacts through reduction in water quality and/or contamination of marine flora and fauna. Spills during refuelling can occur through several pathways, including fuel hose breaks, coupling failure or tank overfilling.

In the event the refuelling pipe is ruptured, the fuel bunkering activity will cease by turning off the pump. Any fuel remaining in the transfer line will be discharged to the environment, inclusive of any fuel released prior to the transfer operation being stopped.

If multiple failures occur on the vessel e.g. failure of multiple barriers and unwatched by crew members, then it is possible that up to 10 m^2 spill of marine diesel could be released into the marine environment. This is expected to mix into the surrounding surface water within a relatively short period of time. Within a few hours, dispersion of the hydrocarbons into the natural environment would be anticipated.

Marine diesel

Marine diesel currently being used on vessels has a sulphur content of maximum 0.50% m/m. In the marine environment, diesel has the following characteristics:

- Diesel spills will extend rapidly in the direction of prevailing wind and waves.
- Evaporation is the dominant process contributing to the fate of spilled diesel from the sea surface and will account for 60–80% reduction of the net oil balance.
- Warmer air and sea temperatures result in increases to the evaporation rate of diesel.
- Diesel residues are typically comprised of heavy compounds that may remain longer and will tend to disperse as oil droplets into the upper layers of the water column.

Lubricating fluids and hydraulic oils

When spilt into the marine environment, hydraulic oils and lubricating fluids behave similarly to diesel. However, the spreading rate of a slick of lubricating oils would be slightly slower despite these oils being more viscous. In comparison, hydraulic oils have light to moderate viscosity and spills of these oils tend to disperse rapidly during high sea conditions.

Dispersion behaviour

If a spill involved a light, refined hydrocarbon of volumes such that the hydrocarbon would spread quickly, a thin film of approximately (~1 g/m^2) would develop over the water surface. The slick would be visible during calm sea conditions, though for more adverse sea conditions, the spilt hydrocarbons would not be as visible in the environment.

5.1.11.2 Impact analysis

There is a low likelihood that a leak or spill of hydrocarbons or other liquids (including environmentally hazardous chemicals and wastes) may occur at the site. Such an occurrence would result in the localised reductions in water quality and contamination of marine fauna at water depths of less than 1 m in the proximity of the source vessel. The potential impacts would be restricted to the immediate vicinity of the spill. However, contamination to intertidal and benthic communities may also occur as any spill would be in close proximity to these environments.

Due to the characteristics of the hydrocarbons and chemicals on-board the vessels, the small volumes that may contribute to such a spill and the nature of the marine environment within the Project area; unplanned hydrocarbon and chemical spills are not considered likely to result in major spatial or ecological impacts. As a result of the short exposure times, any effects from the toxic components of the diesel fuel to receptors would be minor.

The effects on water quality would disperse quickly, due to predominant wind and current mixing at the sea surface. Temporary changes to water quality from the rapid spill dilution and dispersion can translate into short-term effects on marine fauna if the spill occurs in ocean waters. Similarly, temporary effects on marine fauna may occur if the spill was in the vicinity of shallow coastal environments.

At the sea surface with concentrations expected of <1 g/m^2, oiling of wildlife is not predicted to occur either through fauna entering the water from above (e.g. seabirds) or fauna surfacing through the hydrocarbon layer at the sea surface (e.g. cetaceans, fish, marine reptiles).

There are a number marine and migratory bird species expected to occur in the area; impacts to these birds are not predicted.

5.1.11.3 Management controls

The following controls will be adopted in order to mitigate or eliminate the potential for the spillage of hydrocarbons, environmentally hazardous chemicals and liquid-waste to the marine environment for all construction methods:

- Chemicals and hydrocarbons will be packaged, marked, labelled and stowed in accordance with MARPOL Annex I, II and III regulations. These include provisions for all chemicals (environmentally hazardous) and hydrocarbons will be stored in closed, secure and appropriately bunded areas.
- A Material Safety Data Sheet (MSDS) will be available for all chemicals and hydrocarbons in locations nearby to where the chemicals/wastes are stored.

- Vessel operators will have an up to date Shipboard Oil Pollution Emergency Plan (SOPEP) and Shipboard Marine Pollution Emergency Plan (SMPEP). All shipboard chemical and hydrocarbon spills will be managed in accordance with these plans by trained and competent crew. Related mitigation measures in place:
  - Spill exercises will be conducted at minimum of every three months and recorded in the vessel log.
  - Spill kit will be located near high risk spill areas.
  - Spills will be cleaned up immediately, spill kits re-stocked and clean up material contained, and not washed overboard.
  - Vessel decks will be bunded. Scupper plugs should be available to prevent liquid discharges from decks.
- Any contaminated material collected will be contained on board for appropriate onshore disposal.
- Spill clean-up equipment will be located where chemicals and hydrocarbons are stored and frequently handled (i.e. 'high risk' areas). The quantity of spill recovery materials will be appropriate to the quantity of stored chemicals.
- Transfer deck run off discharges to the sea via the scuppers. Scupper plugs or equivalent will be available on vessel decks where chemicals and hydrocarbons are stored and frequently handled (i.e.' high risk' areas). Plugs will be utilised during handling of large quantities of hydrocarbons or hazardous chemicals.
- Any equipment or machinery with the potential to leak oil will be enclosed in continuous bunding or will have drip trays in place where appropriate.
- Following rainfall events, bunded areas on open decks of the vessels will be cleared of rainwater.
- All hoses for pumping and transfers will be maintained and checked as per the PMS.
- On board oily water disposal will be managed in accordance with the Marine Pollution Regulation 2006. The vessel operator will record the quantity, time and onshore location of the oily water disposal in the vessel Oil Record Book.
- If vessels are equipped with an oily water filter system, they may discharge oily water after treatment to 15 ppm in an oily water filter system (providing they have a current calibration certificate for the bilge alarm) as required by MARPOL Annex I Regulations (for the prevention of pollution by oil). To discharge, the vessels will require a current IOPP certificate for oily water filtering equipment, and a current calibration certificate for the bilge alarm.

The following controls will be implemented for the purposes of mitigating or eliminating the risk of the spillage of hydrocarbon from refuelling of vessels or machinery onboard:

- Refuelling operations will be a manned operation. In the event the refuelling pipe is ruptured, fuel bunkering will cease.
- Spill clean-up equipment will be located where hydrocarbons are stored and frequently handled (i.e. 'high risk' areas).
- Refuelling of a vessel will only occur in port and in suitable weather conditions.
- Dry-break refuelling hose couplings and hose floats can be installed on the refuelling hose assembly.

5.1.11.4 Environmental outcome

Removal of the use of chemicals or hydrocarbons on-board vessels is not an option for the operation of the vessel and associated intake pipe construction activities. Similarly, since open deck drainage is an essential safety feature of any marine vessel, the risk of discharge from deck drainage cannot be eliminated. However, it is anticipated that any impacts to water quality resulting from a hydrocarbon or chemical spillage would be temporary and constrained to the immediate vicinity, if such an incident did occur.

In such cases, spillage of hydrocarbons or environmentally hazardous chemicals may be attributed to machinery, engines and tanks leaking these liquids into the marine environment. Due to these limited impacts and the management controls implemented to reduce the risk of contaminants reaching the surrounding environment to levels as low as reasonably possible, the risks of a small hydrocarbon spill are considered to be environmentally acceptable.

Vessels will only operate with, process and/or retain in storage low quantities of chemicals and hydrocarbons suitable to support operations. The vessels will also adopt safety measures consistent with the requirements of the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* and MARPOL Annex I, II and III. These safety precautions and safeguards may entail, among other measures, the assignment of correct stowage and designation of appropriate storage and handling areas. The risks of discharge to the aquatic environment are mitigated by the adoption of these safety control measures, resulting in the reduction of these risks to levels as low as reasonably possible. A variety of measures have been implemented to prepare for spill response should any incident occur.

The risks and measures adopted to address any potential spill resulting from hydrocarbon refuelling are similar to those outlined for spills as a result of discharge. Refuelling of vessels may only be allowed within ports. As obligated under the requirements of MARPOL Annex III and the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*, vessels will execute safety measures when necessary. Dry break refuelling hoses, keeping equipment well serviced and maintaining spill clean-up and containment equipment are some of the safeguards that will be adopted. The most suitable and relevant standard to observe in this environment is the internationally accepted MARPOL standard due to the scope, extent and character of the activity and its use by the wider industry. The measure outlined in MARPOL would be adopted in the event of a spill.

No refuelling would occur in coastal waters and if required, would only occur, at port which would reduce the effects of an accidental spill. In coastal waters with a high level of mixing of the water column, it is anticipated that a low volume spill would dilute and disperse quickly into the surrounding waters. In port, containment procedures would be deployed to avoid significant spill dispersal. Since only minor physical and/or chemical impacts are expected, sensitive receptors in near-surface waters would not be greatly affected, thereby justifying that the risks and impacts of a potential spill have been reduced to levels as low as reasonably practicable.

5.1.12 Damaged fuel tank associated with vessel collision

5.1.12.1 Impact description

During the activities, there is a possibility that vessels could collide. The rupture of a vessel's fuel tank is the predominant risk resulting from a potential vessel collision. The significance of the risk is attributed to the release of marine diesel into the aquatic environment from the damaged fuel tank. Collision between vessels and other obstacles is unlikely, with no additional sub-surface hazards found in the vicinity. Such obstacles would typically be infrastructure or regions of shallow seabeds; none of which overlap with the proposed pipe laying route.

As a consequence of a tank rupture from vessel collision, a standard tank is expected to empty into the marine environment within hours.

5.1.12.2 Impact analysis

Fauna receptors

Marine mammals

Geraci (1990) cited studies that suggested that marine mammals have the capacity to identify and avoid oil slicks. In contrast, other sources indicate that this is not evident (Etkin, 1997) with examples of marine mammals observed surfacing and feeding in oil affected areas (Matkin *et al.,* 2008).

Understanding of the effects of surface oil on marine mammals has not been fully developed. The impact of oil on marine wildlife is influenced by the characteristics of the oil and the extent to which it has been weathered. Through direct contact and ingestion, organisms oiled in the early stages of a spill experience higher levels of toxicity than those exposed to weathered oil. As the project area lies within migratory routes for several marine species, the surface oil released from a vessel collision is likely to have severe effects on animals in the afflicted areas. No known key breeding, feeding or rest areas are located in the Project area, where any potential surface spill may occur. Therefore, it is unlikely that numerous species would be exposed in the event of a spill.

Marine mammals may be affected by oil slicks via the following mechanisms, as outlined by Geraci (1990):

- Ingestion and accumulation
- Skin contact
- Interference with feeding
- Vapour inhalation
- Baleen fouling

Ingestion and accumulation

Feeding behaviours that rely on surface skimming are especially susceptible to the ingestion of surface oil condensate. The following effects may occur as a consequence of oil condensate ingestion:

- Acute effects include neurological damage and liver disorders (Geraci, 1990), gastrointestinal ulceration, haemorrhaging and secondary organ dysfunction due to ingestion of oil (Etkin 1997)
- Chronic poisoning via ingestion of components that have entered the food web (Neff *et al*., 1976)

There is no observed evidence from studies or records to indicate that a whale may consume enough hydrocarbons by feeding in/near a hydrocarbon spill to suffer the above acute impacts. Additionally, mysticetes (baleen whales) are less exposed to chronic poisoning risk as they typically feed on biota that can accumulate and dispose of hydrocarbons from their systems in a relatively short period.

Exposure to hydrocarbon pollution, the ingestion of oil from the water column, via contaminated food and the potential subsequent effects is discussed in following sections.

Skin contact

Hydrocarbon's material characteristics mean they readily adhere to rough surfaces on fauna, e.g. fur, calluses and hair. Due to their hairless and smooth-skinned features, hydrocarbons typically do not stick to whales and dolphins, with testing conducted by Geraci *et al*. (1985) confirming that cetacean skin is a suitable barrier to oil. However, Etkin (1997) reported the development of eye and skin lesions on cetaceans as a result of prolonged exposure to oil.

Interference with feeding

The loss of food species and loss of access to feeding areas due to the surface condensate coupled with the species selective diet can result in substantial decrease in body mass in marine mammals exposed to oil spills. The stress associated with oil spill exposure also has an effect on the body mass of marine mammals (UNEP, 2013).

Baleen feeders rely on a sieve-like mechanism called a baleen to filter nutrient-rich water for food such as plankton and small fish. The whale's tongue then shifts the food to the oesophagus. This feeding mechanism is vulnerable to a heavy oil spill inclusive of exposure to weathered oil, as indicated by the combined evidence of studies conducted by Geraci *et al*. (1985). Oil can potentially disrupt the efficiency of the feeding mechanism for days by blocking the baleen plates. As such whales, which skim food from surface waters, are therefore more susceptible to impacts from surface oil than other species.

Vapour inhalation

Congested lungs, damaged airways or emphysema are possible consequences of vapour inhalation of surface oil, depending on the inhalation concentration. The inhalation of oil vapours is also known to cause irritation and harm to soft tissue e.g. the mucous eye membranes. The damage to an individual is greatest when it is trapped, panicked and exposed continuously or for prolonged periods to the oil (Geraci, 1990).

Fish

According to Kennish (1997) and Hayes *et al*. (1992), open sea fish typically have the ability to identify and avoid surface slicks. Compared to other marine organisms, fish are unlikely to experience as much exposure to surface oil since diesel would remain on the sea surface.

However, since eggs, larvae and fish in their early juvenile stages are likely to inhabit the planktonic sea surface waters, recruitment success could be affected. The surface oil would predominantly have lethal or near-lethal impacts on the future growth and development of exposed larvae/eggs/juvenile fish (Kennish, 1997).

Marine reptiles

Surface diesel may impact marine turtles via a variety of direct and indirect means, including:

- Ingestion and accumulation
- Consumption of contaminated food
- Skin contact
- Vapour inhalation

Hydrocarbon spills are particularly detrimental to marine turtles since they are vulnerable to the impacts of such spills in all stages of its life cycle from eggs to adults, onshore or offshore (NOAA, 2010). This is compounded by indications that turtles show no avoidance behaviours to zones affected by oil spills. Ingestion and inhalation of surface hydrocarbons is also likely as marine turtles rise to the surface to breathe.

Skins infections, impacts on internal organs and the occurrence of respiratory issues are likely effects of marine turtle's exposure to surface hydrocarbons. Given the open coastal environ of the Project area, turtles within the activity zone would be transiting through the area afflicted by the surface spill. It is not anticipated that affected marine turtles would have any significant impact on overall turtle numbers in the region as evaporation and entrainment would mean toxic constituents of hydrocarbons did not linger on the surface for long periods.

Birds

The feeding and resting behaviours of birds on surface waters renders them exposed to surface oil condensate. The primary impact mechanisms faced by seabirds include:

- Ingestion of oil
- Impact on feeding areas
- Fouling of plumage

Seabird fouling can occur when contact is made between the seabirds and floating hydrocarbons. According to Michel and Hayes (1992), seabirds may experience fouling during feeding and diving for prey, wading in shallower waters or during roosting on the surface of waters affected by surface condensate.

The structural integrity, performance and function of a seabird's plumage are affected by oil fouling. Fouling can consequently cause the loss of buoyancy, inability to fly and loss of waterproofing properties of plumage resulting in hyperthermia in affected seabirds.

Preening and feeding/diving actions on the surface of affected waters can lead to the ingestion of surface oils by seabirds. Changes in blood characteristics and intestinal irritation are some of the consequences of oil ingestion by bird species (Michel and Hayes, 1992). The extent of impacts on seabirds is dependent on the type of hydrocarbon they are exposed to, duration of exposure and the type of seabird affected.

As noted above, hydrocarbon condensate on the water surface can affect a wide number of prey species occupying the surface water environments, e.g. krill and baitfish. These disruptions to the food chain through the reduced availability of suitable prey caused by surface condensate may be detrimental to the behaviour and survival of certain bird species, which feed on surface water biota.

The predominant feeding behaviours of seabird species within the Project area are either by skimming surface water or by dive bombing. These birds are therefore exposed to surface oil condensate while feeding and resting on the water surface.

The quantity of marine wildlife affected and the extent of surface oil's impact is reliant on a variety of factors including the weather, season and biological productivity of the afflicted region.

Habitat receptors

Rocky shorelines

The oiling of rocky shorelines (such as Swansea Heads and Green Island, approximately 4 km south of Project area and Redhead Point approximately 8 km north of project area) is likely in the event that vessel collision occurs within the vicinity of shallow coastal waters. A spill in shallow waters from collision and tank rupture may subsequently lead to the suffocation of marine organisms and potentially toxic effects. High water movement and water energy may eventually remove oil from rocky shoreline substrates while lower energy water environments would result in oil persisting on substrates. In such cases, loss or toxicity of biofouling taxa inhabiting the shoreline would likely occur. Re-establishment of hard substrate surfaces by organisms is often a reasonably rapid process lasting between weeks to months after the removal of oil from platform surfaces.

Rocky reefs

An oil spill in near-shore environments as a consequence of vessel collision and rupturing of a fuel tank close to shore and or in shallow waters may result in impacts upon a wide variety of organisms inhabiting shallow water rocky reefs. There are several rocky reefs in the region in (such as at Green Island). Such an oil spill could subsequently hinder the photosynthesis processes for some of these reef-inhabiting organisms and impart toxic effects to affected species.

Sandy beaches

An oil spill close to shore resultant from a vessel collision in shallow waters can result in oil being trapped on sandy beaches around the project area such as Blacksmith Beach, Nine Mile Beach and Redhead Beach. It is likely that some of the oil will result in the contamination of sand deeper in the beach profile. This may be facilitated by the melting of oil into the beach profile, the suspension of sediments within the surf zone or the infiltration of oil condensate to sediments located deeper in the beach profile. It is noted that sandy beaches are vital environments to various protected shorebirds for feeding and roosting.

Sensitive benthic habitats

Rocky reef species

Rocky reefs and coral reefs are not found in the Project area however rocky reefs are present in the surrounding region and coralline species are known to occur on the existing WWTW outfall pipe. There is a general absence of information on the long-term effects of hydrocarbons in the water column on reefs. Some impacts on coralline species are temporary while others may persist for longer periods, with variations of extent and duration dependent on the coral type, health of the reef and reproduction period of the coral (NOO, 2001).

The effect of hydrocarbon exposure resulting from vessel collision or ruptured fuel tank includes diminished feeding, fertilisation and larval settlement. Decreased growth rates and the demise of larvae and tissue may also be consequences of hydrocarbon exposure (Villanueva *et al.* 2008). These impacts would occur not only to any corals present but toxicity affects would also affect filter feeding epifauna such as ascidians or sponges. The extent of impact is dependent on the length of time the environment is exposed to dissolved hydrocarbons. The photosynthetic ability of marine flora could also be affected.

Macroalgal and seagrass beds

Seagrass beds are known to occur within Lake Macquarie and the Swansea Channel, south of the Project area and could thus be impacted if an oil spill were to occur.

The occurrence of oil captured within the water column could affect light qualities and the ability for macroalgae to photosynthesize. Studies conducted by Burns *et al*. (1998) and Dean *et al.* (1998) reveal that rapid recovery rates are possible despite heavy oiling. Periods ranging from weeks to months may, however, be needed for benthic habitats exposed to oil within the water column to recover to original water quality conditions.

Phytotoxic effects caused by absorption from the water column may be experienced by macroalgae. Reduced photosynthetic efficiency has been indicated by aquatic plants where hydrocarbon compounds have concentrated within the membranes of the plant (Runcie and Durako, 2004). A recovery duration ranging from weeks to months is required for habitats to return to original water quality conditions after experiencing long-term effects.

Soft sediments

Even though soft sediment benthic environments may not be impacted by residue oil, shallower regions are susceptible to accumulation of oil, as noted above in discussion of beach environs.

5.1.12.3 Management controls

The following management controls will be adopted and executed for the purposes of mitigating or eliminating the risk of hydrocarbon spillage as a result of vessel collision:

- Visual observations will be maintained by watch keepers on all vessels.
- Regular notification to the following Australian Government agencies before and during operations:
  - The AMSA RCC of proposed activity, location and commencement date to enable an AusCoast warning to be issued.
  - The Australian Hydrographic Office of proposed activity, location and commencement date to enable a 'Notice to Mariners' to be issued.
  - In the event of a spill resulting in notification to AMSA, other sea users (e.g. fishing industry) will be informed of the incident via Marine Notices to prevent vessels entering an area where hydrocarbons have been released.
- Vessel will operate in compliance with all marine navigation and vessel safety requirements in the International Convention of the SOLAS 1974 and the *Navigation Act 2012*. This includes the requirement for all equipment and procedures to comply with the following AMSA Marine Orders:
  - Marine Order 30: Prevention of Collisions.
  - Marine Order 21: Safety and Emergency Arrangements.
  - Marine Order 27: Safety of Navigation and Radio Equipment: sets out ship requirements regarding radio installations, equipment, watch keeping arrangements, sources of energy, performance standards, maintenance requirements, personnel and recordkeeping.
  - Vessels will be equipped with appropriate navigational systems which may include an automatic identification system (AIS) and an automatic radar plotting aid (ARPA) system capable of identifying, tracking and projecting the closest approach for any vessel (time and location) within the operational area and radar range (up to approximately 70 km).

- Marine diesel oil compliant with sulphur content of maximum 0.5% m/m) is the only engine fuel to be used by the vessels, compliant with MARPOL Annex VI.
- Oil spill responses will be executed in accordance with the vessel's SOPEP, as required under MARPOL.

5.1.12.4 Environmental outcome

In order to undertake the activities, vessel presence is required and no alternative is available. Navigation and safety instruments and equipment can be found on vessels, as prescribed by the International Convention of the SOLAS 1974 and actioned through the *Navigation Act 2012*. These are necessary for the safe navigation of the vessel to avoid potential vessel collisions.

In order to combat the possible eventuality of a spill from collision risk, measures have been implemented to respond to spills and minimise their effects. Marine user notifications (as governed by NSW *Marine Safety Regulations 2016*) and stakeholder consultation for affected parties within the activity zone might help reduce the risk of vessel collision which could result in ruptured fuel tanks and oil slicks. At a national level, oil spill response is managed by Australian Maritime Safety Authority (AMSA) who administer the National Plan to Combat Pollution of the Sea by Oil and other Noxious and Hazardous Substances.

These standards and controls are considered to reduce the likelihood of a vessel collision. With all controls in place risk of vessel collision is considered managed to as low as reasonably practicable.

5.2 Operation and maintenance

5.2.1 Intake pipe: Impingement and entrainment

5.2.1.1 Impact description

Large volumes of seawater will be sucked into the intake structure and associated pipe into the desalination plant onshore. There is potential for marine biota to be impacted via impingement or entrainment through this process. The concept design report (WSP, 2020) has identified using a cap intake structure with low through screen velocity of 0.15 m/s.

Entrainment occurs when organisms that are small enough to pass through the intake screens, are caught within the current and drawn into the intake system (WRA, 2011). Entrainable organisms are defined by the United States Environmental Protection Agency (US EPA) as "small organisms with limited to no swimming ability. Some these organisms (or life stages of organisms), such as fish eggs, may be fully passive, lacking the ability to avoid intake flow regardless of velocity" (Missiver and Maliva, 2018).

Impingement occurs when organisms of sufficient size to avoid passing through intake screens become trapped against the screen by the force of water flowing through and are unable to escape (WRA, 2011). The US EPA defines impingable organisms to be "large enough to be retained by a mesh with a maximum opening of 14.2 mm, including 9.5 mm mesh and 6.35 by 12.7 mm mesh. The group includes larger, actively moving juvenile and adult organisms" (Missiver and Maliva, 2018).

Therefore it is necessary to understand whether any of the organisms identified in Section 4.3 have potential to be impacted. This section aims to identify the extent of current knowledge on impingement and entrainment of marine organisms from seawater intake facilities, and provide high-level assessment of risks to marine biota populations that may be impacted.

5.2.1.2 Impact analysis

A comprehensive review of impingement at US and United Kingdom (UK) power plants with ocean intakes by Barnthouse *et al.* (2013) is summarised in Table 5-3. The model-based studies summarised from the review suggest that impacts to biota from entrainment may occur. However, Barnthouse *et al*. (2013) indicates that there is no empirical evidence to support a conclusion that reducing entrainment and impingement would result in measureable improvements in fish populations.

Table 5-3 Summary of entrainment and impingement model-based studies (adapted from Barnthouse *et al.* 2013)

Location	Species/population monitored	Summary of impact
Connecticut Yankee Power Station, Connecticut, USA	Fish eggs; larvae	4% of fish eggs and larvae could be entrained. No inferences on impact to adult populations.
Connecticut Yankee Power Station, Connecticut, USA	Fish eggs; larvae	37 years of data showed no evidence of long-term impact on ecology of Connecticut River.
Monroe Power Plant, Michigan, USA	Yellow perch	2-3 % impact on the equilibrium biomass of the yellow perch population, contrasting to 50% for fishing.
Michigan Power Plants, USA	Various species	0.28 % to 0.86 % impact on species biomass.
Millstone Nuclear Power Station, USA	Winter flounder	Reducing entrainment by 50% would result in an increase in spawning population of only 9%.
Salem Generating Station, New Jersey, USA	Various fish populations	Trends analysis found no evidence of reduction of diversity or abundance to key fish populations.
Fawley Power Station, Hampshire, UK	Local fish population	Impingement found to have no measureable effect on long-term stability of the population.
Ohio River Power Plants, Ohio, USA	Local fish populations	6 of 22 populations may have been measurably higher if there was no entrainment.
Poletti Power Station, USA	Winter flounder; Atlantic menhaden	Reductions in abundance of only 0.09% for winter flounder and 0.01% for Atlantic menhaden.
San Onofre Power Station, California, USA	Queenfish; White croaker	The standing stock of local queenfish and white croaker populations could be reduced by about 13% and 6%, respectively.

Environmental impacts of impingement and entrainment were assessed in a white paper by the Water Reuse Desalination Committee and identified a comprehensive multi-year study of 19 power station intakes by the California State Water Resources Control Board. This study estimated that a 50 Mega-gallon per day (equivalent to 189 ML/day) desalination plant would result in a daily impingement of 2 lbs (0.9 kg) of biomass per day with the comparison given that the daily food intake of one pelican can be as much as 4 lbs (1.8 kg) per day (WRA, 2011). Similarly, a pilot scale biological evaluation for a proposed 30 mega-gallon/day (113 ML/day) desalination facility in California tested a 2.4 mm wedge-wire screen with 0.09 m/s through-screen velocity and observed an entrainment-related mortality between 0.02-0.06 % (Missimer *et al.,* 2015).

The Sydney Desalination Plant was estimated to entrain approximately 2% of the total population of fish larvae in the local area (approximately 300 m^2) around an intake for an productive capacity of 500 ML/day, while entrainment of larvae for a 125 ML/day productive capacity would be significantly less (Sydney Water, 2005). The conclusions of WRA (2011) indicate that the impacts of impingement and entrainment from larger seawater desalination plants with open ocean intakes than the proposed Belmont plant is not significant and would not have a measureable impact on the natural environment.

Specific impingement and entrainment literature for small desalination plants of similar intake volumes and velocities to this project were not available. However, desktop review of literature at other larger direct ocean intakes (Sydney Water, 2005; WRA, 2011) revealed that impacts of impingement and entrainment from larger seawater desalination plants with open ocean intakes than the amended Project is not significant. These were due to a combination of intake structure design with screen apertures of 100-300 mm allowing fish to swim freely (Sydney Water, 2005) and low flow velocities 0.15-0.3 m/s reducing entrainment of eggs and larvae (Missimer *et al*, 2015). As such impacts from impingement and entrainment associated with the amended Project are unlikely to be significant.

Impingement and entrainment is dependent on the screen slot aperture, flow velocity, and current passing the screen (Missimer *et al.* 2015). Screen apertures are typically in the range of 50-300 mm, which allow fish to move freely across the screen at low flow velocities, reducing impingement (Missimer *et al.* 2015). Furthermore, an environmental assessment by Sydney Water for the Kurnell desalination project suggests that an intake velocity of less than 0.6 m/s would assist in minimising impingement (Sydney Water, 2005). Missimer *et al.* (2015) indicate that restricting entrance velocities to below 0.15-0.3 m/s did not significantly affect impingement however did result in a significant reduction in the entrainment of eggs and larvae.

The conclusions of Sydney Water (2005) and Missimer *et al.* (2015) indicate that an ocean intake with screen aperture of 100 mm or 300 mm would allow fish to swim freely across the screen with minimal impingement, particularly at low flow velocities.

Larvae from a wide range of species are likely to be present within the water column in the vicinity of the proposed intake pipe (Section 4.3). As such, the intake of seawater during operation as the potential to entrain larvae of species that are known to spawn larvae in the vicinity, including larvae of protected species such as the black rock cod and syngnathids, larvae of commercial fishery species and larvae of species confirmed present within the Project area.

In addition to potential impact from biota, impingement may also have significant impacts on intake operations. For example, jellyfish blocking seawater cooling intakes, such as at the Birka Power and Desalination Plant and Ghubra Desalination Plant in Oman, where 300 tonnes of jellyfish damaged intake screens causing a 50 percent reduction in output (Kress and Galil, 2018). Similarly, for entrainment, outbreaks of invasive dinoflagellates in 2008-2009 caused the closure of desalination plants in the Gulf of Oman (Kress and Galil, 2018).

5.2.1.3 Management controls

The proposed Belmont intake structure and pipe are designed with consideration for low flow velocity and volume and reducing impacts on larvae and fish in the surrounding environment.

5.2.1.4 Environmental outcome

A low through screen velocity of 0.15 m/s will minimise entrainment of eggs and larvae, whilst coarse screens would minimise impingement of marine life. A horizontal intake would eliminate vertical vortices and avoid withdrawal of productive habitat which is usually located closer to the surface (WSP, 2020). As such the risk of impingement and entrainment from this Project is considered to be as low as reasonably practicable.

5.2.2 Intake pipe: Maintenance activities

5.2.2.1 Impact description

Throughout operation, the intake structure will attract encrusting communities and may develop into a localised ecosystem similar to that established on the WWTW outfall. Regular maintenance activities will be required within the pipes and at the intake structure for cleaning and removal of the biofouling to maintain optimal flow velocities. This may involve replacement of screens, mechanical scraping or high pressure water jetting of surfaces to remove encrusting biota.

5.2.2.2 Impact analysis

Intake maintenance operations (including associated vessel movements) have the potential to disturb the established benthic habitat and associated communities. This will include direct disturbance to communities established on the structure and nearby seabed, or indirect disturbance associated with increased suspended sediment and turbidity and increased noise levels from the scraping or jetting activities. Impacts are expected to be localised to the intake structure and immediate vicinity, and temporary, with recovery timeframes dependant on water depth, sediment type and characteristics of the in situ benthic communities. Noise impacts are expected to be negligible when compared to noise generated from construction activities and are therefore not expected to present any acoustic risk to established benthic habitat and associated communities.

The intake structure will provide suitable hard substrate habitat for syngnathids, which may result in colonisation of the structure. Intake maintenance may impact on these species through the mechanical clearing of the substrate; their slow moving nature may put them at risk from such activities.

5.2.2.3 Management controls

To reduce or eliminate the risk of habitat disturbance from planned pipe maintenance activities, the following management controls will be implemented:

- The pipeline will be buried or contained within a subsurface conduit to reduce the potential for third party damage (and thus required maintenance) to the pipe.
- The intake structure will be inspected prior to undertaking any maintenance activities particularly for those slow moving species such as syngnathids.
- In the event that syngnathids are confirmed, syngnathids and the substrate they are attached to will be safely relocated prior to maintenance activities commencing.

5.2.2.4 Environmental outcome

Any intake maintenance will be performed by a specialist group who have established targeted procedures to manage identified risks. Localised, short-term disturbances to sediments and/or epibenthos living on the intake structure/within the disturbance footprint are expected to occur as a result of planned maintenance activities. Design considerations such as wider inlet pipe diameter would allow for encrusting of marine life within the pipe whilst maintaining optimum flow conditions and reducing need for regular maintenance. Chlorine dosing within the intake pipe would control growth within the intake pipe and reduce need for regular maintenance (WSP, 2020).The likelihood of maintenance adversely impacting marine habitats in and around the pipe and associated structures is considered to be reduced to as low as reasonably practicable.

5.2.3 Intake pipe: Habitat creation

5.2.3.1 Impact description

Construction of the intake structures will create artificial hard substrate habitat for marine encrusting and biofouling communities on the intake structure.

5.2.3.2 Impact analysis

Colonisation of the intake structure is expected to commence following installation, after which, the biofouling community will undergo a long-term natural recruitment succession process (Hamer and Mills, 2015). It is expected that a mature community, comparable to that currently present on the WWTW outfall may be achieved within a few years on the intake structure. The assemblages that will occur on the infrastructure are expected to support species which are currently not represented within the direct footprint of the intake.

Communities are expected to be dominated by a variety of sponges, ascidians, algae and sea pens supporting an array of invertebrate and fish species, similar to the ecology on and around the Belmont WWTW outfall (Advisian, 2020). Whilst habitat creation may be perceived as a positive impact, the colonisation of the intake structure will require regular maintenance activities to maintain adequate flow velocities. Such activities come with risks associated with vessel movement (refer to Sections 5.1.2 to 5.1.12) and maintenance activities on slow-moving marine species (Section 5.2.2).

Artificial structures may also facilitate pest proliferation through provision of habitat for establishment of non indigenous species (Glasby *et al*., 2007), particularly in the project area which is characterised by stretches of open sandy substrate (refer to Section 5.1.7).

5.2.3.3 Management controls

To manage the effects of habitat creation on the marine environment, the following controls will be implemented:

- The pipe will be buried or contained within a subsurface conduit to reduce the area of exposure for encrusting communities, where possible.
- The intake structure will be inspected during scheduled maintenance activities for any slow moving species such as syngnathids.

5.2.3.4 Environmental outcome

Habitat creation may be considered as a positive outcome in comparison to risks associated with seabed disturbance. Habitat creation following the installation of the existing WWTW outfall shows an abundance of marine life and rich habitat. It is expected that the provision of hard substrate from the intake structure would create habitat opportunities that would not otherwise be available.

5.2.4 Outfall pipe: Species abundance and diversity

Operational impact assessment at the WWTW outfall has been undertaken for the original sub-surface intake structure proposal (refer to Section 7.4.3.3 of the EIS). Recent literature from the Sydney Desalination Plant has highlighted some interesting research outcomes on species abundance and diversity associated with the operations of the plant. This has been included below as relevant to both the original and the amended design.

5.2.4.1 Impact description

Following commencement of operations of the Sydney Desalination Plant and associated discharge, the abundance of demersal fish around the outlet was found to have increased by 329% (Kelaher *et al.,* 2020). Additionally, an increase in abundance of 135% and 315% were observed for targeted recreational and commercial species, and non-target species, respectively (Kelaher *et al.,* 2020). The study further observed that fish abundance generally returned to pre-discharge levels following the cessation of desalination operations with the exception of benthic fauna.

The effective dilution of brine discharge to approximately 1 psu of background levels were found to be highly unlikely to harm sessile invertebrates in earlier studies at the Sydney Desalination Plant (Clark *et al.,* 2018). However, the authors also suggested that discharge velocities achieved by the high pressure diffusers increased near-bed flow away from the outfall such that it impacted the settlement, growth and survivorship of invertebrates. This was based on a discharge of 365 ML/day of brine with an estimated near-bed velocity of 0.25 m/s at 30 m from the pipe compared to a pre-discharge velocity of 0.05 m/s. They supported this conclusion with change pattern observations in taxonomic groups in relation to the settlement ability, suspension feeding ability, and evolved settlement preferences of marine invertebrate larvae to the new flow conditions.

In contrast however, long term monitoring of benthic infaunal assemblages at the Gold Coast Desalination Plant, assessed the potential long term impacts of brine discharge. Since beginning operation in March 2009, the environmental impact of the discharge of brine on benthic infauna was found to be minimal (Viskovich *et al*., 2014).

5.2.4.2 Impact analysis

Long-term marine monitoring at existing large-scale desalination plants, such as the Sydney Desalination Plant and Gold Coast Desalination Plant, indicate that potential impacts to species abundance and diversity may be dependent on the local assemblages and benthic characteristics at each outfall pipe.

As the existing WWTW outfall is expected to be an order of magnitude smaller than these plants, it is likely that any potential adverse impacts, such as changes to benthic community structures in the vicinity of the outfall, will be contained to the immediate area of the outfall. Additionally, unlike the Sydney and Gold Coast Plants, brine discharge will be pre-mixed with the existing wastewater outflow, resulting in a discharge salinity of 47.9 psu compared to 65 psu at the Sydney outfall site (GHD, 2020b; Sydney Water, 2005). Furthermore, salinity is expected to rapidly decrease as the near-seabed flow of brine away from the outfall becomes diluted through natural entrainment of seawater.

The increase in discharge volume at the existing WWTW outfall is expected to increase the turbulence and mixing within the area. The presence of such turbulence within the water column may attract various marine species, resulting in an increase in abundance of marine species in the vicinity of the outfall, as observed at the Sydney Desalination Plant. It is not expected that there will be much difference in species abundance and diversity between the original (15 ML/day) and amended (30 ML/day) proposals.

The benthic environment in the immediate vicinity of the outfall is also well-represented throughout the region therefore, significant impacts to benthic communities due to brine discharge are unlikely to occur.

5.2.4.3 Management controls

To manage the effects of increased brine discharge on marine communities at the WWTW outfall pipe, the following is recommended:

- Continuation of the Ocean Outfall Benthic Monitoring Program (as part of EPL 1771) throughout operation of the project.
- Integration of pipeline ecology and fish assemblage monitoring into the Ocean Outfall Benthic Monitoring Program for better understanding of potential changes in the species abundance and diversity.

5.2.4.4 Environmental outcomes

Brine discharge modelling undertaken for both the original (15 ML/day) and amended (30 ML/day) proposals for the Belmont desalination plant indicates that impacts to water quality at the outfall will meet the required Water Quality Objectives and are likely to have the same or smaller area of impact compared to the existing WWTW outflow (GHD, 2020b). Ongoing monitoring of outfall benthic communities in accordance with EPL 1771 and integration of pipeline ecology and fish assemblage into that monitoring will allow for better understanding of existing communities and active management of any impacts to species abundance and diversity that may occur through operation. As such, the risk of impact to species abundance and diversity at the outfall is considered to be as low as reasonably practicable.

5.2.5 Outfall pipe: Water quality

5.2.5.1 Impact description

Chemical assessment

Desalination of seawater requires the addition of a number of chemicals during the pre-treatment, desalination process and cleaning process in order to combat marine growth, remove suspended solids, maintain pH levels and preserve the reverse osmosis (RO) membranes. These chemicals may have the potential to contaminate the marine environment if present in discharge water and their impacts must therefore be assessed. Increasing the capacity of the plant from 15 ML/day to 30 ML/day will require a proportionally larger amount of chemicals for the efficient operation of the plant. Ultimately, more chemicals may be expected within the comingled brine effluent discharge.

Water quality objectives

Operation of the desalination plant will release brine discharge comingled with the WWTW effluent. The following assessment was made in relation to the water quality impacts of the release of the comingled brine-effluent discharge from the 30 ML/day plant vs the original 15 ML/day plant into the marine environment via the existing diffuser system (GHD, 2020b):

- 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. This is due to the greater pre-dilution of treated wastewater by the larger volume of brine discharge.
- The spatial area of effect of the marine ecosystem WQO for NOx is predicted to be similar across dry and wet season periods and for the existing conditions, 15 ML and 30 ML scenarios.
- The spatial area to meet the near-surface salinity WQO is predicted to be substantially smaller for the 30 ML scenario relative to 15 ML scenario. The dilution factor for the near-bed salinity WQO is readily met within 5 m of the diffuser.
- Because of the higher salinities of the comingled discharge for the 30 ML vs the 15 ML/day scenario, positively buoyant (rising) plume mixing is less vigorous. However, the near-field dilution factors for the 30 ML scenario (68-310) are still substantially greater than the WQOs for human health (22 dry season, 15 wet season) and near-surface salinity (18) when rising plumes breach the surface.
- Dilution factors are similar between the 30 ML and 15 ML scenarios over the short distance that negatively buoyant (sinking) plumes fall. The near-field dilution factors for the amendment scenario are substantially greater for higher currents (24-36) or similar during low currents (9-11) than the WQO for near-seabed salinity (13).

5.2.5.2 Impact analysis

Chemical assessment

An assessment of the chemicals that are typically used in the reverse osmosis treatment process is provided in Table 5-4. These chemicals are anticipated to have minimum impacts on marine water quality for both the 15 and the 30 ML/day scenario due to the nature of the chemicals, dilutions to be achieved and decomposition of the chemicals in seawater. This is largely due to the neutralisation, removal or dilution of these chemicals before release.

Table 5-4 Typical chemicals required for reverse osmosis treatment process. Adapted from Sydney Water (2005)

Additive	Use	Fate
Ferric chloride	Pre-treatment of intake water as coagulant to aid removal of suspended solids.	Binds to solid matter and is removed during the pre-treatment process.
Polyelectrolyte polymer	Pre-treatment of intake water to enhance coagulation and removal of particles.	Binds to solid matter and is removed during the pre-treatment process.
Sulphuric acid	Added to prevent scaling of RO membranes.	Neutralised during RO cleaning process and discharged to marine environment.
Anti-scalants	Anti-scalants are typically sodium salts of poly carboxylic acid dosed continuously to RO feedwater to prevent scaling of RO membranes.	Discharged to marine environment.

Additive	Use	Fate
Sodium hypochlorite	Intermittent dosing of seawater intake to control marine growth.	Removed by sodium bisulphite during pre-treatment process.
Lime	Used for pH and alkalinity adjustment and corrosion control. Lime sludge is produced in lime water separators.	Discharged to marine environment during potabilisation process.
Acidic detergent	Added intermittently to clean membranes. Chemical used is dependent on membrane operating requirements.	Neutralised during RO cleaning process and discharged to marine environment.
Sodium bisulphate	Added to preserve RO membranes during membrane shutdowns. Neutralises residual chlorine in feed water.	Discharged to marine environment.
Biocide	May be added intermittently to the RO system to aid control of marine growth.	Discharged to marine environment.

The findings of the long-term marine monitoring program conducted at the Sydney Desalination plant confirmed there was no impact from these chemicals at outfall due to very low concentrations and dilution proportional to that of the brine (Clark *et al.,* 2018). The Sydney Desalination Plant has a productive capacity of 500 ML/day, which is considerably greater than the design capacity of the proposed Belmont desalination (productive capacity of 30 ML/day), with the impact from the Belmont plant likely to be substantially smaller. As the long-term monitoring program for Sydney indicates that there has been no impact to the marine environment as a result of these chemicals, it is considered unlikely that the chemicals within discharge from the Belmont WWTW outfall will result in measureable impacts to the marine environment.

If chlorine is used as an anti-foulant during the reverse osmosis process then all discharges will need to comply with appropriate marine guidelines for chlorine and chlorine produced oxidants. Recent work by Batley and Simpson (2020) proposed a short term guideline of 7.2µg/L for chlorine produced oxidants in marine waters.

Water quality objectives

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 (GHD, 2020b). 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. Near-bed salinity WQO is met within 5 m of the diffuser.

The Sydney Desalination Plant outfall resulted in an increase in local salinity of 1 psµ within 30 m of the outlet with no detectable influence on temperature (Clark *et al*., 2018). This change in salinity was found to have no effect on the abundance or diversity of fish assemblages. 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.

5.2.5.3 Management controls

To reduce or eliminate the risk of reduced water quality from operation activities, the following management controls will be implemented:

- Water quality monitoring program will be developed and implemented to identify long-term impacts from the discharge of brine concentrate on water quality or the marine environment.
- Volume of chemicals in the aggregate, concentrations and discharge regimes (frequency) (inclusive of chlorine) that will be used during the desalination process will need to be adjusted and dosed in a manner so as to achieve desalination objectives and minimise harm to the marine environment to as low as reasonably practicable and/or as required by regulators.

5.2.5.4 Environmental outcomes

Discharge from the Belmont desalination plant under the amended scenario 30 ML/day is unlikely to result in significant impacts to water quality at the outfall beyond the near field mixing zone, similar to the 15 ML/day scenario. Examples from operation of much larger capacity plants indicate that increases in salinity are unlikely to have significant effect on the benthic communities and the existing fish assemblages. The same is expected for the Belmont desalination plant.

5.3 Decommissioning

5.3.1 Impact description

When desalination operations cease, there are two options for decommissioning: retaining the intake pipe and structure in place or partially removing the intake pipe and/or intake structure from the seabed.

If the intake pipe and intake structure is kept in place, there is no further disturbance impact predicted on the environment as it would already have been present in the environment for a nominated period of time. Rather, the intake structure will continue to provide hard substrate for recruitment of sessile organisms, forming biogenic habitat likely to support an array of invertebrate and fish species, similar to the ecology on and around the Belmont WWTW outfall (Advisian, 2020).

If the intake structure is to be removed, the impacts to the environment would be considered similar to the impacts of installation. This would include resuspension of sediments, disturbance of established benthic habitats and organisms, entanglement of marine fauna and other potential risks associated with vessel operations previously discussed in this report may be realised.

5.3.2 Impact analysis

Leaving the intake structure in the environment will enable the habitat which established post installation to remain as is, with no further disturbance expected. The intake structure provides a settlement substrate and will be heavily encrusted with marine life.

It is considered likely that removing the intake structure would directly impact on the habitats and encrusting organisms that have developed on and around the intake structure, resulting in disturbance to that benthos. Removal would also resuspend and disturb sediments, carrying risk of burying nearby sedentary species and slow moving marine fauna. However, turbidity increases would be considered to be localised with only short-term effects from which the system would recover rapidly.

Operation of vessels and barges to remove the intake structure would also result in additional impacts from generation of shipping related artificial light, artificial noise, planned discharges and atmospheric emissions. It would also carry risk of unplanned impacts discussed earlier in this report occurring as a result of liquid and solid waste spills and marine fauna collisions/entanglements.

5.3.3 Management controls

Current industry practice is that disused pipes are left in-situ but may be removed by future projects seeking to install overlapping new infrastructure.

To ensure any decommissioning planning is current for the time of decommissioning, requirements for this action will be reviewed in future at the time of pipe decommissioning. That review will take into account the most cost effective, environmentally friendly and best practicable methods, legal requirements and industry practices at that time. The following management controls will be considered to mitigate potential disturbance from decommissioning:

- There are no management controls required for the option of retiring the intake pipe and intake structure pipe in place. Removal of structures that are above the seabed would provide benefits in safety in navigation and recreational/commercial fisheries operations.
- If the intake structure is to be removed, it will be recovered with options to be salvaged in accordance with relevant environmental legislation. Management controls proposed for all other impacts associated with pipe construction/laying activities will also apply here.

5.3.4 Environmental outcome

If the intake pipe and intake structure is to remain, the environment will be maintained in the same condition as it was for the lifespan of its operation.

The activities associated with removal of the intake structure would be expected to disturb the seabed and benthic habitats. The area of disturbance would be dependent on methods to be applied for retrieval of the intake structure at the time of decommissioning. The intake structure removal activities would occur in/over benthic habitats that are currently widely represented at a regional scale. Localised, short term disturbances to sediments would therefore be expected to occur. More permanent impacts would be expected to the established sessile organisms living on the intake structure as a result of habitat removal.

Any future decommissioning review will take into account potential risks at the time of the proposed action adopting leading industry practices and identify measures/strategies for any proposed action that have the lowest practical environmental impact risk.

6. Conclusion

This report was developed to assess the potential impacts on the marine environment from construction of an ocean intake pipe south of the existing Belmont WWTW. The assessment also considers the potential impacts from increased brine discharge at the outfall associated with the amended water treatment process plant design.

The EIS design included a sub-surface seawater intake structure which did not require the construction of an ocean intake pipe, therefore the risks on the marine environment from such infrastructure were not relevant for the EIS. The impacts from the discharge of the comingled effluent and brine discharge from the WWTW outfall were the key risks assessed as part of the EIS design. The Amended design to the water treatment process plant necessitated sourcing raw feed water through construction of the ocean intake pipe and intake structure.

Construction of this intake pipe and structure has the potential to harm the marine environment through activities that will disturb the seabed such as drilling. Vessels will be required to support the construction activities. The risks to the environment from these activities are listed below and summarised in Table 6-1:

- Seabed disturbance causing benthic and epi-benthic mortality
- Disruption of fish and marine mammal movement
- Increased turbidity and water quality impacts in isolated areas
- Light and noise pollution from vessel platforms and drilling activities
- Release of potential wastes, contaminants or pollutants (including hydrocarbon spills)
- Atmospheric emissions
- Interference with other users of the area affected

Other unplanned events may also arise during construction activities. The risks to the environment from these unplanned activities are listed below and summarised in Table 6-1:

- Pest introduction and proliferation
- Accidental release of solid waste
- Impacts to the seabed from dropped objects
- Marine fauna collisions
- Release of hydrocarbon, chemicals and other liquid waste
- Damaged fuel tank associated with vessel collision

Operation of the amended water treatment process plant and maintenance activities at the intake and outfall pipes have potential to harm the marine environment. The risks to the environment from these activities are:

- Impingement and entrainment (Table 6-2)
- Clearing activities associated with maintenance of the intake and outfall pipes (Table 6-2)
- Environmental impacts from brine discharge at the WWTW outfall (Table 6-3)

The management and mitigation measures detailed in the *Belmont Drought Response Desalination Plant – Environmental Impact Statement* (GHD, November 2019) and *Belmont Drought Response Desalination Plant – Marine Ecology Assessment Report* (GHD, November 2019) are still appropriate and will be implemented where reasonable and feasible.

The following provides a summary of those key management and mitigation measures proposed for the Project of relevance to the marine environment:

- Vessels used in construction activities to adhere to relevant AMSA Marine Orders; Part 8 of the EPBC Regulations (Interacting with Cetaceans and Whale Watching); The Australian Guidelines for Whale and Dolphin Watching (Commonwealth of Australia, 2017) for sea-faring activities.
- Continuation of the Ocean Outfall Benthic Monitoring Program (as part of EPL 1771) throughout operation of the project including water quality, benthic infauna and sediment quality. Integration of pipeline ecology and fish assemblage monitoring into the program.
- Mitigation measures as outlined in the Construction Environmental Management Plan (CEMP) (refer to Section 8 of the EIS).

Risks associated with construction, operation and maintenance of the drought response desalination plant are considered to be acceptable and as low as reasonably practicable with the implementation of the management and mitigation measures.

Table 6-1 Summary of environmental impacts and proposed management and mitigation measures associated with each potential intake pipeline construction method

Impact	Construction Method 1 (HDD)	Construction Method 2 (Micro-tunnelling)
Seabed disturbance	Estimated disturbance footprint 104 m^2	2,200 m^2
Artificial light emissions	It is unlikely that artificial light generated by the construction activities associated with CM1 and CM2 will interfere with species breeding success and population longevity. Indirect impacts on these and other marine species could include changes in migration patterns however, such impacts would be temporary and mobile across the intake pipe route (Section 5.1.2). **Artificial light emissions associated with CM1 and CM2 are not considered to pose a significant impact.**	
Artificial noise emissions	Maximum sound pressure (117 dB(A)) is less than that generated by standard shipping operations. Management controls described in Section 5.1.3 are expected to mitigate the risk to as low as reasonably practicable. **Noise emissions associated with CM1 are unlikely to result in significant impacts.**	Maximum sound pressure (120 dB(A)) is less than that generated by standard shipping operations. Management controls described in Section 5.1.3 are expected to mitigate the risk to as low as reasonably practicable. **Noise emissions associated with CM2 are unlikely to result in significant impacts.**
Planned discharges	Non-hazardous planned vessel discharges are expected to be minimal and continuous. Impacts to water quality such as temperature changes, oleaginous discharges, turbidity and nutrient enrichment may occur (Section 5.1.4). Implementation of management controls and compliance with MARPOL requirements are expected to translate into diminished environmental impacts from planned vessel-based discharges (Section 5.1.4).	Non-hazardous planned vessel discharges are expected to be minimal and continuous. Impacts to water quality such as temperature changes, oleaginous discharges, turbidity and nutrient enrichment may occur (Section 5.1.4). Implementation of management controls and compliance with MARPOL requirements are expected to translate into diminished environmental impacts from planned vessel-based discharges (Section 5.1.4).
	Additional discharge of drilling fluids from HDD operations may also occur. These fluids are considered non-toxic within the marine environment (Section 5.1.1). **Impacts from planned discharges from CM1 are considered to be as low as reasonably practicable.**	Additional discharge of drilling fluids from micro-tunnelling operations may also occur. These fluids are considered non-toxic within the marine environment (Section 5.1.1). **Impacts from planned discharges associated with CM2 are considered to be as low as reasonably practicable.**
Atmospheric emissions	Short-term reduction in air quality in the immediate region around the project area may occur due to the burning of hydrocarbons. Implementation of management controls and compliance with MARPOL requirements are expected to translate into diminished environmental impacts from atmospheric emissions (Section 5.1.5). **Impacts from atmospheric emissions from CM1 and CM2 are considered to be as low as reasonably practicable.**	

Impact	Construction Method 1 (HDD)	Construction Method 2 (Micro-tunnelling)
Interference with other users	A number of impacts may arise from unrelated shipping traffic crossing the path of the construction vessels. Given the intake pipe route and intake structure is a planned alignment which may cross navigational waters and areas utilised for recreational fishing, this activity may result in the temporary reduction of accessibility to these areas (Section 5.1.6). Recreational fishing equipment may also become entangled in the small length of surface-laid pipe between the exit point and intake structure, as well as the intake structure itself (Section 5.1.6). Burial of the pipe along the entire alignment in addition to implementation of management controls are expected to minimise the risk of interference with other users (Section 5.1.6). **Impacts from interference with other users have been deemed reasonable and as low as reasonably practicable**.	A number of impacts may arise from unrelated shipping traffic crossing the path of the construction vessels. Given the intake pipe route and intake structure is a planned alignment which may cross navigational waters and areas utilised for recreational fishing, this activity may result in the temporary reduction of accessibility to these areas (Section 5.1.6). Recreational fishing equipment may also become entangled in the intake structure (Section 5.1.6). Burial of the pipe along the entire alignment in addition to implementation of management controls are expected to minimise the risk of interference with other users (Section 5.1.6). **Impacts from interference with other users have been deemed reasonable and as low as reasonably practicable**.
Pest introduction and proliferation	Vessels carrying invasive marine pests (IMP) may unintentionally introduce these species to the project area. Ecosystems, fisheries, aquaculture, human health, etc. are at potential risk from the impacts of IMPs (Section 5.1.7). Implementation of management controls described in Section 5.1.7 are expected to minimise the risk of pest introduction. Additionally, burial of the pipe minimises the availability of hard substrate for IMP translocation and recruitment. **The risk of the successful introduction of an IMP is considered as low as reasonably practicable.**	Vessels carrying invasive marine pests (IMP) may unintentionally introduce these species to the project area. Ecosystems, fisheries, aquaculture, human health, etc. are at potential risk from the impacts of IMPs (Section 5.1.7). Implementation of management controls described in Section 5.1.7 are expected to minimise the risk of pest introduction. Additionally, burial of the pipe minimises the availability of hard substrate for IMP translocation and recruitment. **The risk of the successful introduction of an IMP is considered as low as reasonably practicable.**
Accidental release of solid wastes	A variety of solid waste may be released unintentionally into the environment from the deck of a vessel (Section 5.1.8). Implementation of management controls described in Section 5.1.8 are expected to minimise the risk of accidental release of solid wastes. **The risk associated with unplanned release of solid wastes is considered to be as low as reasonably practicable.**	A variety of solid waste may be released unintentionally into the environment from the deck of a vessel. Implementation of management controls described in Section 5.1.8 are expected to minimise the risk of accidental release of solid wastes. **The risk associated with unplanned release of solid wastes is considered to be as low as reasonably practicable.**

Impact	Construction Method 1 (HDD)	Construction Method 2 (Micro-tunnelling)
Dropped objects	Damage to benthic habitats and organisms can occur due to an object being dropped overboard (e.g. equipment falling from vessel deck) (Section 5.1.9). Implementation of management controls described in Section 5.1.9 are expected to minimise the risk of dropped objects. **The chance of a dropped object affecting the environment is deemed to be reduced to levels as low as reasonably possible.**	Damage to benthic habitats and organisms can occur due to an object being dropped overboard (e.g. equipment falling from vessel deck) (Section 5.1.9). Implementation of management controls described in Section 5.1.9 are expected to minimise the risk of dropped objects. **The chance of a dropped object affecting the environment is deemed to be reduced to levels as low as reasonably possible.**
Marine fauna collisions and entanglement	There is potential for collision to occur between marine fauna and vessels associated with the proposed activities across all construction methods (Section 5.1.10). Implementation of management controls described in Section 5.1.10 are expected to minimise the risk of marine fauna collisions and entanglement. **The potential risks associated with collision and interference with marine animals from vessel activities is considered to be as low are reasonably practicable.**	
Hydrocarbon, chemicals and other liquid waste	Vessels, plant and other construction equipment require a wide variety of liquids, chemicals and hydrocarbon compounds to operate and to be maintained. Localised reductions in water quality and contamination of marine fauna at water depths of less than 1 m in the proximity of the source may occur (Section 5.1.11). The potential impacts would be restricted to the immediate vicinity of the spill however, contamination to intertidal and benthic communities may also occur as any spill would be in close proximity to these environments. Implementation of management controls and adherence to MARPOL regulations described in Section 5.1.11 are expected to minimise the risk of spill from hydrocarbon, chemicals and other liquid waste. **The risks and impacts of a potential spill of hydrocarbons, chemicals and other liquid waste have been reduced to levels considered to be as low as reasonably practicable.**	
Damaged fuel tank associated with vessel collision	There is a possibility that vessels could collide. The rupture of a vessel's fuel tank is the predominant risk resulting from a potential vessel collision. The significance of the risk is attributed to the release of marine diesel into the aquatic environment from the damaged fuel tank (Section 5.1.12). Implementation of management controls described in Section 5.1.12 are considered to reduce the likelihood of a vessel collision. **The risks of vessel collision and likelihood of fuel tank rupture are considered to be as low as reasonably practicable.**	

Table 6-2 Summary of environmental impacts and proposed management and mitigation controls associated with the operation of the ocean intake structure

Impact	Summary	Relevant management and mitigation measures	Environmental outcome
Impingement and entrainment	As large volumes of seawater will be sucked into the intake pipe, there is potential for marine biota to be impacted via impingement or entrainment (Section 5.2.1). Marine organisms of sufficient size to avoid passing through intake screens may become trapped against the screen by the force of water flowing through and are unable to escape (impingement). Small marine organisms with limited to no swimming ability, such as fish eggs and larvae, lack the ability to avoid the intake flow and are drawn into the intake system (entrainment).	The following management controls have been considered and will be implemented in order to mitigate or remove the risk of impingement and entrainment of organisms (Section 5.2.1): • Intake pipe design is such that the maximum intake approach velocity of 0.15 m/s • Intake screen mesh aperture size should be greater than 100 mm diameter • Further screening technologies such as wedge-wire screens should also be considered to reduce entrainment of ichthyoplankton.	The proposed Belmont intake pipe is designed with relatively low flow volume (30 ML/day productive capacity) while implementing similar management measures as those described for the 500 ML/day Sydney Desalination Plant (Section 5.2.1). **The risk of impingement and entrainment from the ocean intake is considered to be as low as reasonably practicable.**
Maintenance activities	Throughout operation the pipe and associated structures will attract encrusting communities and may develop into a localised ecosystem similar to that established on the WWTW outfall (Section 5.2.2). Regular maintenance activities will be required within the pipes and at the intake structure for cleaning and removal of the biofouling to maintain optimal flow velocities. This may involve replacement of screens and mechanical scraping of surfaces to remove encrusting biota.	To reduce or eliminate the risk of habitat disturbance from planned pipe maintenance activities, the following management controls will be implemented (Section 5.2.2): • The pipe will be contained within a subsurface conduit to reduce the potential for third party damage (and thus required maintenance) to the pipe. • The pipe and associated structures will be inspected prior to undertaking any maintenance activities particularly for those slow moving species such as syngnathids. • In the event that syngnathids are confirmed, syngnathids and the substrate they are attached to will be safely relocated prior to maintenance activities commencing.	Any pipe maintenance will be performed by a specialist group who have established targeted procedures to manage identified risks. Localised, short-term disturbances to sediments and/or epibenthos living on the intake structure/within the disturbance footprint are expected to occur as a result of planned maintenance activities (Section 5.2.2). **The likelihood of maintenance adversely impacting marine habitats in and around the pipe and associated structures is considered to be reduced to as low as reasonably practicable.**

Impact	Summary	Relevant management and mitigation measures	Environmental outcome
Habitat creation	Construction of the intake structures will create artificial hard substrate habitat for marine biofouling communities (Section 5.2.3). Communities are expected to be dominated by a variety of sponges, ascidians, algae and sea pens supporting an array of invertebrate and fish species. Habitat creation is perceived as a positive impact however, colonisation of the intake structure will require regular maintenance to maintain adequate flow velocities, which will entail risks described under the maintenance section (Section 5.2.3).	To manage the effects of habitat creation on the marine environment, the following controls will be implemented (Section 5.2.3): • The pipe will be contained within a subsurface conduit to reduce the area of exposure for encrusting communities. • The intake structure will be inspected during scheduled maintenance activities for any slow moving species such as syngnathids.	Habitat creation may be considered as a positive outcome in comparison to risks associated with seabed disturbance (Section 5.2.3). **The provision of hard substrate from the intake structure is expected to result in greater species abundance and diversity compared to existing conditions.**

Table 6-3 Comparison of environmental impacts at the ocean outfall for the amended 30 ML and 15 ML scenarios

Impact	Summary of Amendment Scenario (30 ML)	Summary of EIS Scenario (15 ML)	Environmental outcome
Water Quality Objectives			
Marine toxicity (NHx)	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. This is due to the greater pre-dilution of treated wastewater by the larger volume of brine discharge (GHD, 2020b).	The marine toxicity WQO is met within approximately 1 m of the diffuser because of the low dilution factor of <1. Near-field modelling predicts this dilution factor is met immediately upon release into the marine environment (GHD, 2019).	Near-field modelling indicates that the marine toxicity WQO is met immediately upon release into the marine environment for the 30 ML scenario, similar to the 15 ML scenario. No new mitigation measures are proposed.
Marine ecosystem (NOx)	The spatial area of effect of the marine ecosystem WQO for NOx is predicted to be similar across dry and wet season periods and existing conditions, for the 15 ML and 30 ML scenarios. The WQO is met within approximately 1 km of the diffuser (GHD, 2020b).	The spatial area of effect of the marine ecosystem WQO is predicted to be similar across dry and wet season periods and baseline and proposed scenarios (~1 km of the diffuser for 95% of the time) (GHD, 2019).	Far-field modelling indicates that the spatial area to meet marine ecosystem WQO for the 30 ML scenario during both the dry and wet periods have similar sized predicted mixing zones relative to the 15 ML scenario. No new mitigation measures are proposed.

Impact	Summary of Amendment Scenario (30 ML)	Summary of EIS Scenario (15 ML)	Environmental outcome
Salinity	The spatial area to meet the near-surface salinity WQO is predicted to be substantially smaller for the 30 ML scenario relative to 15 ML scenario. The dilution factor for the near-bed salinity WQO is readily met in the immediate vicinity of the diffusers (GHD, 2020b). Far-field modelling indicates that the spatial area to meet ambient marine salinity WQO (DS of 1 PSU) has substantially reduced the predicted mixing zone during both the dry and wet periods relative to the 15 ML scenario (GHD, 2020b).	The spatial area to meet the ambient marine salinity WQO (DS 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 (GHD, 2019). For proposed 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 (GHD, 2019).	The spatial area to meet the near-surface salinity WQO is predicted to be substantially smaller for the 30 ML scenario relative to 15 ML scenario. No new mitigation measures are proposed.
Human health	The spatial area to meet the human health WQO dilution factor is predicted to decrease because of pre-dilution by the increased brine discharge (GHD, 2020b). Far-field modelling indicates that the spatial area to meet human health WQO (DS of 1 PSU) has substantially reduced the predicted mixing zone during both the dry and wet periods relative to the 15 ML scenario (GHD, 2020b). Exceedances of the human health WQO are greater than ~1 km from the nearest beach, and thereby do not pose a material risk to swimmers (GHD, 2020b).	The spatial area to meet the human health WQO dilution factor for human health is predicted to be similar between the existing and proposed scenario (15 ML) during the representative dry (~300 m for 95% of the time) and wet (up to ~500 m of the diffuser for 95% of the time) periods (GHD, 2019). Exceedances of the human health WQO are greater than ~1 km from the nearest beach, and thereby do not pose a material risk to swimmers (GHD, 2019).	Far-field modelling indicates that the spatial area to meet human health WQO (DS of 1 PSU) has substantially reduced the predicted mixing zone during both the dry and wet periods relative to the 15 ML scenario. No new mitigation measures are proposed.
Species abundance & diversity			
	The benthic environment in the immediate vicinity of the outfall is well-represented throughout the region therefore, significant impacts to benthic communities due to brine discharge under the 30 ML scenario are unlikely to occur.	The benthic environment in the immediate vicinity of the outfall is well-represented throughout the region therefore, significant impacts to benthic communities due to brine discharge under the 15 ML scenario are unlikely to occur.	The risk of impact to species abundance and diversity at the outfall under the 15 ML and 30 ML scenarios are considered to be similar and as low as reasonably practicable. Integration of fish and pipeline ecology monitoring into the existing benthic monitoring program is recommended as an early detection tool for identification of change.

Impact	Summary of Amendment Scenario (30 ML)	Summary of EIS Scenario (15 ML)	Environmental outcome
Chemical assessment			
	Increasing the capacity of the plant from 15 ML/day to 30 ML/day will require a proportionally larger amount of chemicals for the efficient operation of the plant. These chemicals are not anticipated to have impacts on marine water quality for the 30 ML/day scenario due to the nature of the chemicals, dilutions to be achieved and decomposition of the chemicals in seawater. This is largely due to the neutralisation, removal or dilution of these chemicals before release.	Chemicals are required during the desalination process for the efficient operation of the plant. These chemicals are not anticipated to have impacts on marine water quality for the 15 ML/day scenario due to the nature of the chemicals, dilutions to be achieved and decomposition of the chemicals in seawater. This is largely due to the neutralisation, removal or dilution of these chemicals before release.	Discharge of chemicals from the Belmont desalination plant is unlikely to result in significant impacts to water quality at the outfall beyond the near field mixing zone for both the 15 ML and 30 ML scenarios.

7. References

Advisian. (2020). Proposed Belmont Desalination Plant: Marine Ecology Impact Assessment (Fish, Infauna and Pipeline Epibenthic Ecology) Report. Unpublished report prepared for Hunter Water Corporation.

Barnthouse, L. (2013). Impacts of entrainment and impingement on fish populations: A review of the scientific evidence. *Environmental Science & Policy,* 31, 149-156.

Browne, R., Baker, J., Connolly, R. (2008). Chapter 13: Syngnathids: Seadragons, Seahorses, and Pipfishes of Gulf St Vincent. *Natural History of Gulf St Vincent, The University of Adelaide, Royal Society of South Australia (Inc.),* Adelaide, 162-176.

Clark, G., Knott, N., Miller, B., Kelaher, B., Coleman, M., Ushiama, S., Johnston, E. (2018). First large-scale ecological impact study of desalination outfall reveals trade-offs in effects of hyper salinity and hydrodynamics. *Water Research,* 145, 757-768.

Curtain University of Technology (2009) Environmental Assessment of drilling fluids and viscocifiers, Botany Bay Cable Project Available at: https://majorprojects.accelo.com/public/97c2863f38b8363a2d0dcb776a1b0ee5/07%20Appendix%20D%20-%20Environmental%20assessment%20of%20drilling%20fluids.pdf

Department of Environment and Energy (DoEE) (2020). Light Pollution Guidelines: National Light Pollution Guidelines for Wildlife – including marine turtles, seabirds and migratory shorebirds. Australian Government. Available at: https://www.environment.gov.au/system/files/resources/2eb379de-931b-4547-8bcc-f96c73065f54/files/national-light-pollution-guidelines-wildlife.pdf

Department of Primary Industries (DPI) (2019). Syngnathiformes. Department of Primary Industries, NSW Government. Available at: https://www.dpi.nsw.gov.au/fishing/closures/identifying/marine-or-estuarine-species/syngnathiformes

ERMS (2006). Toxicity of Drilling Discharges. Environmental Risk Management System.

Evans, W.E. (1994). Common dolphin, White-bellied Porpoise *Delphinus delphis* Linnaeus, 1758. **In:** Ridgway, S.H. & R. Harrison, eds. *Handbook of Marine Mammals Vol 5: The First Book of Dolphins*. Page(s) 191-224. Academic Press, London.

GHD (2019). Brine Discharge Modelling Report: Belmont Drought Response Desalination Plant. Prepared for Hunter Water Corporation. GHD

GHD (2020a). Biodiversity Development Assessment Report: Belmont Drought Response Desalination Plant. Prepared for Hunter Water Corporation. GHD.

GHD (2020b). Amendment Report – Brine Discharge Modelling: Belmont Drought Response Desalination Plant. Prepared for Hunter Water Corporation. GHD.

GHD (2020c). Noise and Vibration Amendment Report: Belmont Drought Response Desalination Plant. Prepared for Hunter Water Corporation. GHD.

Glasby, T.M., Connwell, S. D., Holloway, M.G., Hewitt, C. L. (2007) Nonindigenous biota on artificial structures: could habitat creation facilitate biological invasions. *Marine Biology* 151, 887–895.

Environmental implications of offshore oil and gas development in Australia – Drilling activities Chapter 3. The findings of an independent Scientific Review. In Swan, J., Neff JM, Young PC (eds.) (1994). *Environmental Implications of Offshore Oil and Gas Development in Australia, the*

Findings of an Independent Scientific Review. Australian Petroleum Exploration Association (APEA), Energy Research and Development Corporation (ERDC), Australia

Fisheries Scientific Committee (FSC) (2019). White's Seahorse *Hippocampus whitei* – Final Determination. Fisheries Scientific Committee, NSW Government.

Forcada, J. & P. Hammond (1998). Geographical variation in abundance of striped and common dolphins of the western Mediterranean. *Journal of Sea Research*. 39:313-325.

Francis, M., Harasti, D., Malcolm, H. (2016). Surviving under pressure and protection: a review of the biology, ecology and population status of the highly vulnerable grouper *Epinephelus daemelii*. *Marine and Freshwater Research,* 67, 1215-1228.

Hale, P.T., A.S. Barreto & G.J.B. Ross (2000). Comparative Morphology and Distribution of the *aduncus* and *truncatus* forms of Bottlenose Dolphin *Tursiops* in the Indian and Western Pacific Oceans. *Aquatic Mammals*. 26.2:101-110.

Hamer, P. and Mills, K. (2015). *Trial of nearshore artificial reefs to enhance pier based recreational fishing. Recreational Fishing Grants Program Research Report.* The State of Victoria Department of Economic Development, Jobs, Transport and Resources

Kelaher, B., Clark, G., Johnston, E., Coleman, M. (2020). Effect of Desalination Discharge on the Abundance and Diversity of Reef Fishes. *Environmental Science and Technology*, 54, 735-744.

Kress, N and Galil, B. (2018). Chapter 8: Impact of seawater desalination by reverse osmosis on the marine environment. Efficient Desalination by Reverse Osmosis. Israel Oceanographic and Limnological Res., National Institute of Oceanography.

Missimer, T., Jones, B., Maliva, R (eds) (2015). Intakes and outfalls for Seawater Reverse-Osmosis Desalination Facilities: Innovations and Environmental Impacts. *Environmental Science, Springer.*

Missimer, T., and Maliva, R. (2018). Environmental issues in seawater reverse osmosis desalination: Intakes and outfalls. *Desalination,* 434, 198-215.

Pitman, R.L. (2002). Mesoplodont Whales *Mesoplodon* spp. **In:** Perrin, W.F., Wursig, B. & Thewissen, J.G.M., eds. *Encyclopaedia of Marine Mammals*. Page(s) 738-742. London, Academic Press.

Quayle DB (1988) Pacific oyster culture in British Columbia. Can Bull Fish Aquat Sci 218:1–24

Ross, G.J.B. (2006). *Review of the Conservation Status of Australia's Smaller Whales and Dolphins*. Page(s) 124. Report to the Australian Department of the Environment and Heritage, Canberra. Available from: http://www.environment.gov.au/resource/review-conservation-status-australias-smaller-whales-and-dolphins.

Schlumberger (2014). Safety Data Sheet: Soda Ash M3.

Stewart, J., A. Hegarty, C. Young, A. M. Fowler and J. Craig, (eds) 2015. Status of Fisheries Resources in NSW 201314. NSW Department of Primary Industries, Mosman: 391pp.Swan, J., Neff JM, Young PC (eds.) (1994). *Environmental Implications of Offshore Oil and Gas Development in Australia, the Findings of an Independent Scientific Review*. Australian Petroleum Exploration Association (APEA), Energy Research and Development Corporation (ERDC), Australia

Sydney Water (2005). Summary of the Environmental Assessment. Proposed Kurnell Peninsula Desalination Plant and Associated Infrastructure. Sydney Water.

Thomas, K. (2020). Green sea turtle eggs transported from manly more than 500km to hatch near Coffs Harbour. Australian Broadcasting Corporation (ABC). Available at:

https://www.abc.net.au/news/2020-01-13/green-turtle-eggs-relocated-from-manly-to-coffs-coast/11862364. Accessed 17/02/2020.

Trnski, T. (2001). Diel and tidal abundance of fish larvae in a barrier-estuary channel in New South Wales. *Marine Freshwater Resources,* 52, 995-1006.

Viskovich, P., Gordon, H., and Walker, S. (2014). Busting a salty myth: long-term monitoring detects limited impacts on benthic infauna after three years of brine discharge. *IDA Journal of Desalination and Water Reuse*, 6, 3-4, 134-144.

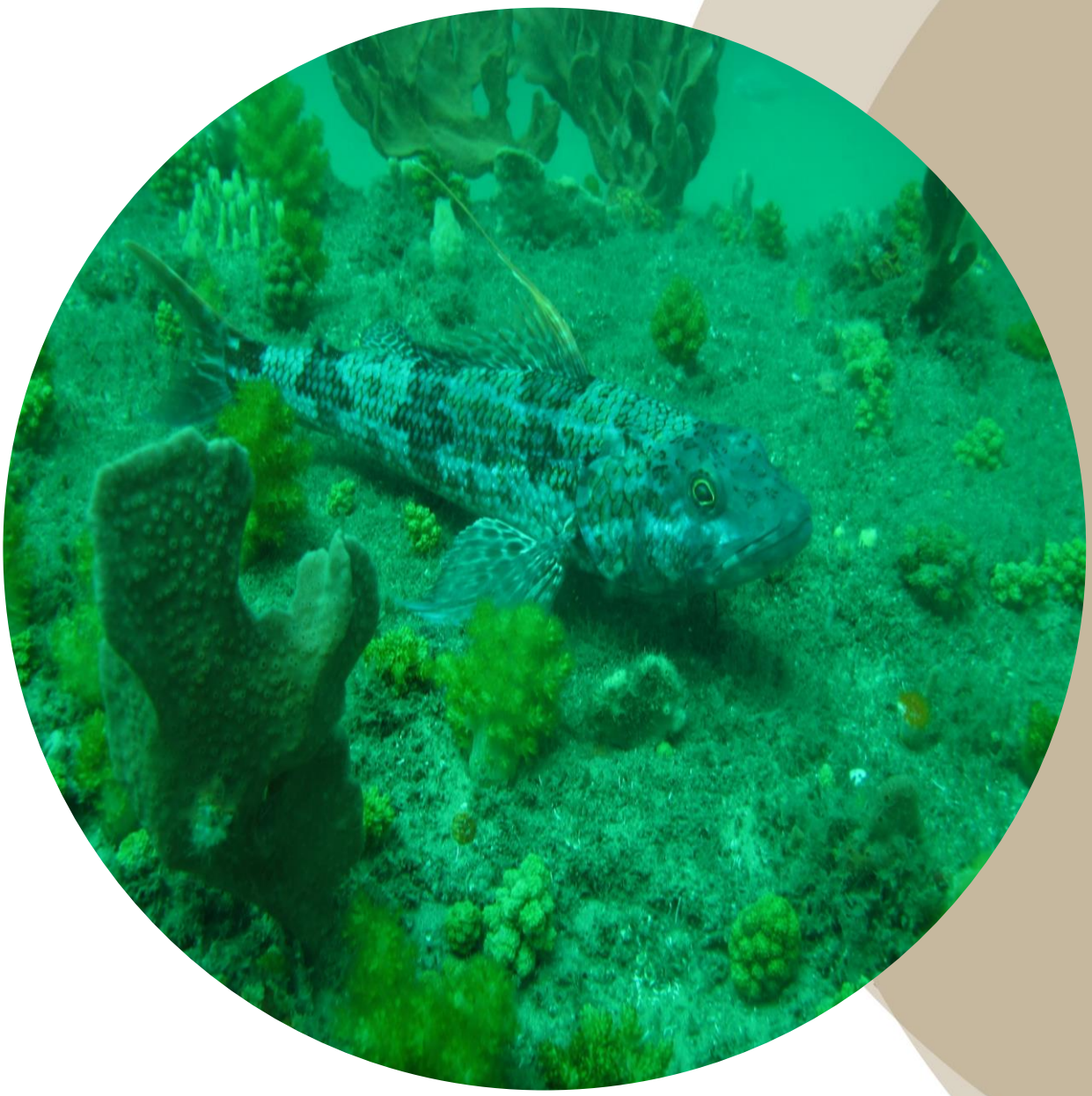
Water Reuse Association (WRA) (2011). Desalination Plant Intakes: Impingement and Entrainment – Impacts and Solutions. Water Reuse Association Desalination Committee.

WSP (2020). Belmont Desalination Plant. Direction Ocean Intake Concept Design.

York, P.H., Booth, D.J., Glasby, T.M. and Pease, B.C. 2006. Fish assemblages in habitats dominated by *Caulerpa taxifolia* and native seagrasses in south-eastern Australia. *Marine Ecology Progress Series* 312:223-234.

Appendices

Appendix A – Proposed Belmont Desalination Plant: Marine Ecology Impact Assessment (Fish, Infauna and Pipeline Epibenthic Ecology) Report.



Proposed Belmont Desalination Plant

Marine Ecology Impact Assessment (Fish, Infauna and Pipeline Epibenthic Ecology)

Hunter Water Corporation

9 June 2020

301015-04040 – Final Report_3

Advisian
Worley Group

advisian.com

Disclaimer

Company details

Advisian Pty Ltd
8-14 Telford Street
Newcastle East
NSW

PROJECT 301015-04040 – Final Report_3: Proposed Belmont Desalination Plant - Marine Ecology Impact Assessment (Fish, Infauna and Pipeline Epibenthic Ecology)

Rev	Description	Author	Review	Advisian approval	Revision date	Client approval	Approval date
A	Draft Report	K. Newton, T. Kane, H. Houridis, K. Stewart	H. Houridis	H. Houridis	13/3/2020		
B	Draft 2 Report	H. Houridis	H. Houridis	K. Newton	10/04/2020		
O	Final Report				11/04/2020		11/04/2020
O	Final Report_2	 K. Newton	 H. Houridis	 K. Newton	4/6/2020	M. Priestley	4/06/2020
O	Final Report_3	 K. Newton	 H. Houridis	 K. Newton	9/6/2020	M. Priestley	9/06/2020

Table of contents

Appendices

Table list

Figure list

Executive summary

Hunter Water Corporation is planning to construct a drought response desalination plant (DRDP), adjacent to the Belmont Wastewater Treatment Works (WWTW). The DRDP would be implemented as a last resort if water storage levels reach a critical point to ensure water security.

This report is a supporting document to the EIS that provides detailed information on the fish ecology, benthic reef ecology and benthic infauna of the Belmont study area, using existing data that had been collected from ongoing monitoring surveys and investigations at the existing WWTW. The report also includes a detailed impact assessment on fish and benthic ecology for proposed works associated with construction and operation of the proposed desalination plant intake structure and pipeline, and operational brine discharges to the marine environment. The impact assessment also considers a range of DRDP capacity options including 15ML, 30ML and 65ML/day.

The receiving environment surrounding the WWTW is primarily soft sediment habitat with limited hard substrate that is provided by the outfall pipeline. The soft sediment habitat is monitored periodically as part of EPA licence conditions that require ecological investigation of benthic sediments in and around the vicinity of the ocean outfall diffusers at Belmont (this has occurred since 2016). The most recent monitoring survey, for which data is currently available, was completed in 2019 which found that the habitat was dominated by polychaetes, arthropods (primarily cumaceans, isopods and amphipods) and to a lesser extent nematodes and phoronids. Natural variability is responsible for changes in community structured observed annually and between monitoring sites, however a potential zone of impact was also noted during the 2019 survey from the outfall where results for Shannon diversity (which was lower at sites closer to the outfall) and polychaete ratio and abundance (which were both higher at sites located closer to the outfall). A survey was also undertaken in February 2020, but these samples are still being identified.

The taxa on the vertical and horizontal surfaces of the outfall pipeline were similar and dominated by a range of species including sponges, sea anemones, echinoderms and soft corals. Several fish and shark species were also observed around the pipe, likely feeding or utilising the relatively complex habitat offered by the outfall structure for shelter. The species present are neither unique or significant and are typically found in coastal reefs elsewhere in the region.

A diverse range of fish species are also known to occur within the vicinity of the WWTW, some of which are listed as threatened or protected under the FM Act 1994 and/or the EPBC Act 1999 and others which are of commercial and/or recreational importance. The likelihood of occurrence, potential impacts and assessments of significance for these species have been addressed by GHD in the Marine Assessment for the Belmont Drought Desalination Plant, Environmental Impact Statement (GHD 2020).

Construction impacts are primarily related to installation of the intake riser and intake pipeline. Potential impacts on the marine environment will vary depending on the method of installation (e.g. HDD or micro-tunnelling). Construction impacts are primarily related to direct seabed disturbance and underwater noise and will not be significant in terms of spatial extent and duration.

Operational impacts are primarily related to the potential for entrainment at the inlet and the discharge of effluent at the outfall. Discharge of brine has the potential to impact the soft sediment habitat surrounding the outfall where poor mixing and dilution could result in the accumulation of brine over the seabed. Detailed modelling undertaken by GHD (2020) has concluded that:

- The marine toxicity water quality objective (WQO) is met within ~1 m of the diffuser because of the low required dilution factor of <1. Near-field modelling predicts this dilution factor is met immediately upon release into the marine environment.
- The spatial area to meet the near-surface salinity WQO is very localised as the dilution factor for the near-seabed salinity WQO is readily met in the immediate vicinity of the diffusers.
- The spatial area of effect of the marine ecosystem WQO is predicted to be similar across dry and wet season periods for all scenarios.

As a result, the modelling has confirmed that the 15ML and 30ML options will have minimal impacts to fish and benthic habitat surrounding the outfall, however the 65ML option will require modifications to the existing diffuser outlet to ensure that potential impacts to fish and benthic fauna can be mitigated.

1 Introduction

1.1 Scope of Report

As part of their drought response, Hunter Water is proposing a desalination plant adjacent to the existing Belmont Wastewater Treatment Works (WWTW) in Belmont South, NSW. Advisian Pty Ltd has been engaged by Hunter Water Corporation to:

1. Undertake a background review of fish ecology, benthic pipeline reef ecology and benthic infauna in the local area, and;
2. Undertake an impact assessment on fish, benthic pipeline reef ecology and benthic infauna for proposed works associated with construction and operation of the proposed desalination plant intake structure and pipeline, and operational brine discharges to the marine environment.

The location of the Belmont WWTW and general study area is shown in Figure 1-1.

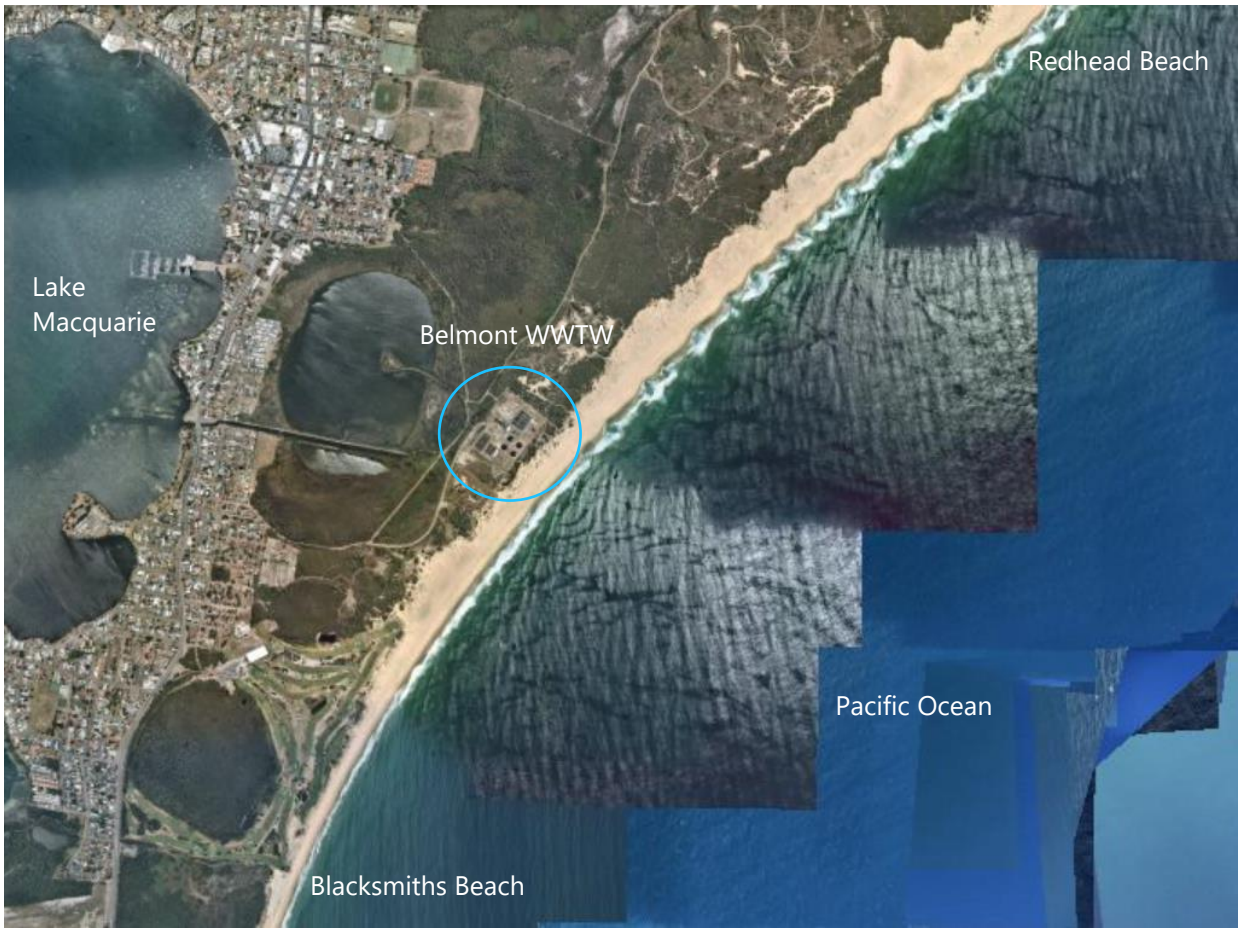


Figure 1-1 Location of the Belmont WWTW.

1.2 Proposed Works

The design basis for the concept development of the proposed desalinated direct seawater intake and associated infrastructure has been prepared by WSP (2019). The assessment is based on a plant capacity of 15ML/day and 30ML/day (WSP 2019). The desalination plant is currently planned to have an initial operating life of 20 years (WSP 2019).

1.2.1 Design Assumptions

General Design Assumptions

Design flows of 1,054L/s (30ML/day, 90ML day intake) with intake over 24 hours form the basis of the concept design. Design flows of 527L/s (15ML/day capacity, 45ML/day intake) were also included as part of the design and assessment. The project infrastructure is divided into three parts, which include the intake structure, intake pipeline and the pump station wet well and rising main. The intake pipeline and structure are discussed as their construction and operation have the potential to impact on the marine environment. The pump station wet well and rising main are located on land and are not discussed for purposes of this report.

Intake Structure Design Assumptions

The proposed intake location is based on the following assumptions:

- Sufficient clearance (500 m minimum) from the WWTW brine outfall with a minimum clearance from the edge of the 1% human health buffer.
- Sufficient distance from the beach to ensure the intake is clear of the surf zone.
- Sufficient intake depth to prevent contamination of intake water in terms of oil spills or algae (5 m assumed for this application).
- Sufficient height above the seafloor to prevent seafloor sediments being drawn into the intake pipes (5 m assumed for this application), this is subject to the water quality (turbidity and silt density index) which was not known at the time of the development of the concept.
- Using a velocity cap intake structure with low through screen velocity of 0.15 m/s to minimise impingement and entrainment of marine life with a horizontal intake to eliminate vertical vortices and avoids withdrawal of productive aquatic habitat which is usually located closer to the surface (Desalination Plant Intakes Impingement and Entrainment Impacts and Solutions White Paper, June 2011, WaterReuse Association).
- Installation of coarse screens assuming 50% effective screen area to allow for bars and blockages.
- Bottom portion of intake structure to be designed for velocity of 0.8 m/s (Desalination Engineering Planning and Design, Nikolay Voutchkov 2013).
- Taper to be installed between top screen structure and vertical riser to ensure smooth transition and to avoid significant turbulence at inlet into vertical riser pipe/pipeline.

- Vertical shaft to be oversized by 50% to allow for potential accumulation of shellfish on the walls, a DN1500 vertical shaft was therefore selected (Desalination Engineering Planning and Design, Nikolay Voutchkov, 2013).
- Dosing at the intake may need to be considered to control marine growth in the intake system in which case smaller dosing pipes will need to be installed along the pipeline.

1.2.2 Intake Structure Concept Design

Intake Features

Based on the assumptions above and the allowable velocity of 0.15 m/s through 50% blocked screens, the intake structure will be based on the following parameters (refer Table 1-1):

Table 1-1 Intake screen parameters (reproduced from WSP 2019).

INTAKE SCREEN FEATURE	DIMENSION 15ML/DAY	DIMENSION 30ML/DAY
Height of screen	1m	1m
Intake velocity	0.15m/s	0.15m/s
Required area assuming 50% blockage	7.0m^2	14.1m^2
Diameter of intake structure	2.2m	4.4m
Select intake structure diameter of 4.5m		
Velocity if 50% blocked	0.07m/s	0.13m/s
Velocity if unblocked (new)	0.03m/s	0.07m/s

To allow for opportunity to increase plant capacity to 30ML/day, a 4.5 m diameter intake structure is assumed. With the selected screen size, velocities will vary between 0.07 m/s and 0.13 m/s for plant capacities of 15ML/day and 30ML/day respectively (assuming 50% blockage).

The intake structure will be 5 m high, 4.5 m diameter installed on the seabed.

The general arrangement of the intake structure which would occur above the seabed is shown in Figure 1-2.

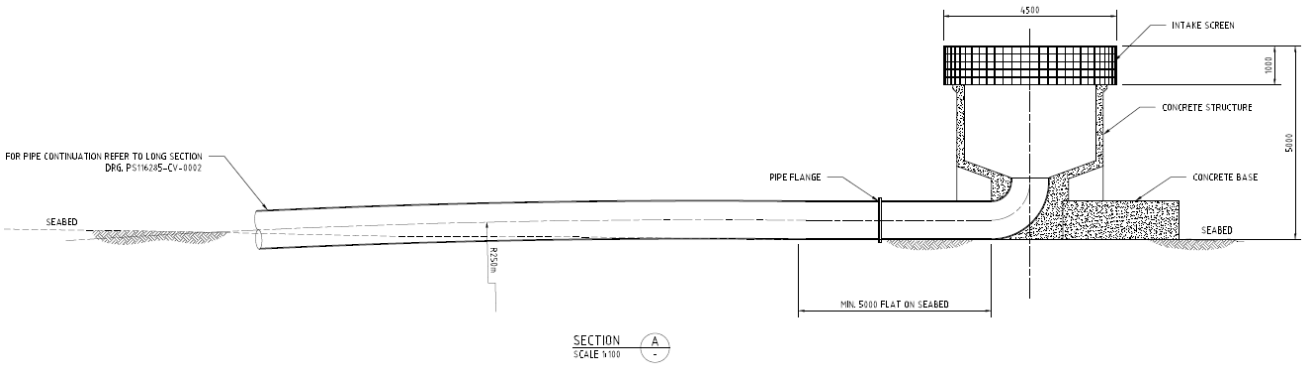


Figure 1-2 General arrangement of the proposed intake structure above the seabed (WSP 2019).

Intake Pipeline

The proposed intake pipeline alignment (shown in Figure 1-3) is based on the following assumptions:

- Total distance between intake structure and pump station wet well is approximately 1000 m.
- This alignment was selected to avoid shallow rock and maintain a vertical alignment where rock may be minimised.
- Sufficient installation depth to avoid scouring and erosion which increase the risk of damage to the pipeline, this is especially important along the surf zone (15 m installation depth assumed for the concept, to be confirmed with relevant geotechnical data).
- As an initial assessment, prior to material selection, polyethene pipe (PE100 PN16) was used to calculate the pipe sizes. The pipe sizes were calculated on the basis of the following:
    - Roughness values of 0.3 mm and 1.5 mm for new and aged pipe respectively.
    - Reduction of 100 mm in internal diameter to allow for marine growth.
- Given the uncertainty of the plant capacity at this stage an OD1000 PE PN16 pipe is deemed to be the most suitable for the purpose.

Figure 1-3 shows the proposed intake pipeline alignment over the seismic survey results and indicative depth of bedrock.

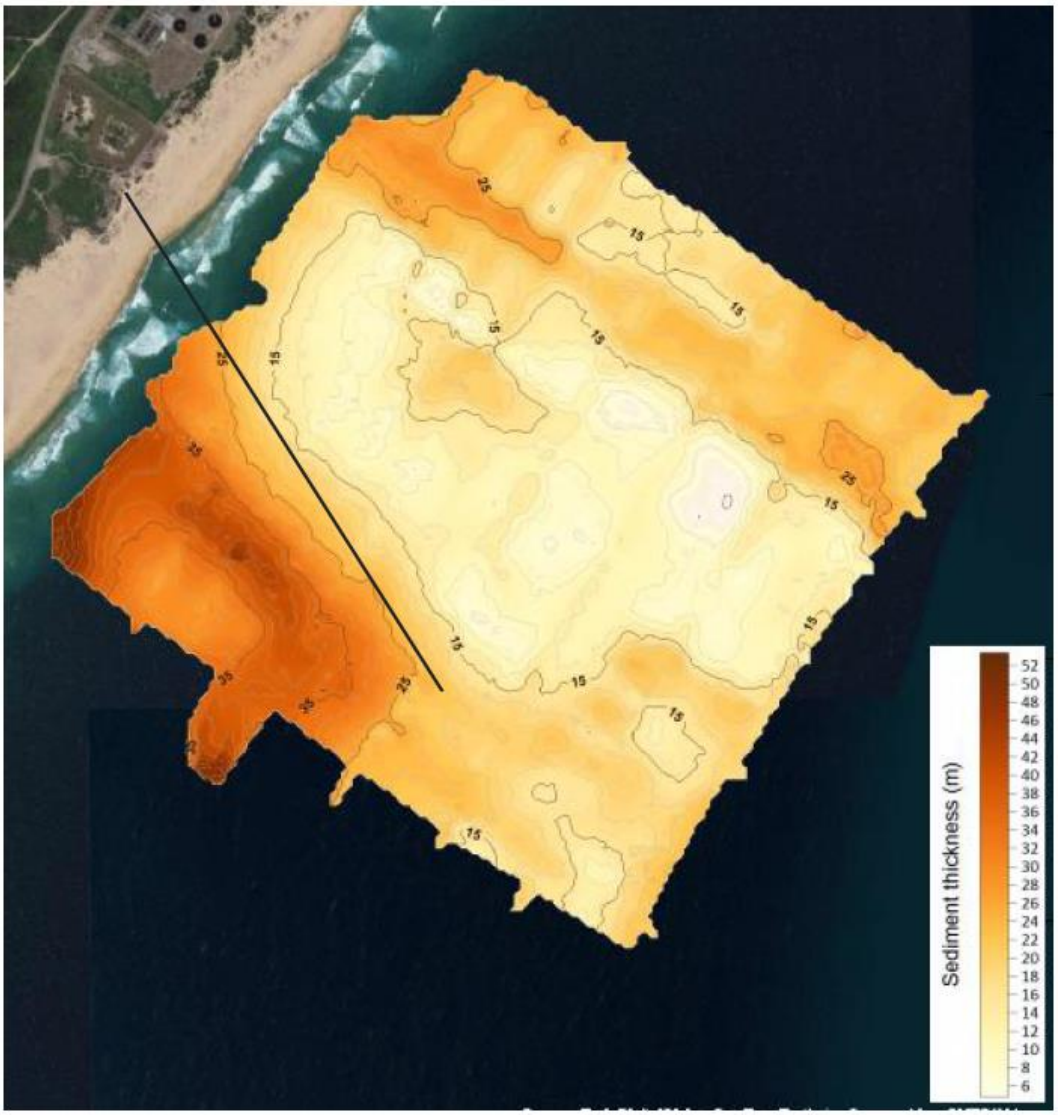


Figure 1-3 Intake pipeline alignment and bedrock level (reproduced from WSP 2019).

1.2.3 Potential Construction Methods

Two different construction methods were assessed which include Horizontal Directional Drilling (HDD) and Microtunnelling (or Pipejacking) (WSP 2020).

Horizontal Directional Drilling (HDD)

- The internal diameter of the tunneled pipeline must be minimum 1000mm as discussed above (internal diameter of 715mm allowing 100mm reduction in diameter for marine growth) or two OD800 PE PN16 parallel mains (internal diameter of 551mm allowing 100mm reduction in diameter for marine growth).
- If the pipeline is to be installed via HDD, the following parameters are to be met:
    - Entry angle ≤15°

- Curvature of pull ≥250m radius

- The connection to the intake structure is to be made on the sea surface where the drilled pipeline exists the seabed.

Microtunnelling / Pipejacking

- The internal diameter of the tunneled pipeline must be minimum 715mm as discussed above (assuming 100mm reduction in diameter to account for marine growth). Pipe selection for microtunnelling / pipejacking is to be confirmed through the trenchless procurement process once geotechnical information is available, market availability is considered, and Contractor involvement may have been obtained.
- The tunneling process will require an onshore shaft and launch chamber.
- The tunnel will terminate at a rise shaft, constructed from an offshore platform.
- The connection to the intake structure is to be made at the tunnel depth. A caisson shaft (or similar) will be installed to a depth of 15m with a GRP connector between the tunneled pipeline and the GRP riser shaft.

2 Local Fish Ecology

A number of sources were reviewed to determine the fish species which are known to occur or have the potential to occur in the coastal marine environment of the proposed Belmont Desalination Plant intake and outfall. These included local fisheries database records, searches of threatened and protected species under State and Commonwealth legislation (with search results provided in **Appendix A**), local commercial and recreational fishing targets / catch, a review of the fish surveys undertaken for the Burwood Beach and Boulder Bay WWTW Ocean Outfalls between 2011-2014 and a targeted fish survey undertaken along the Belmont WWTW Ocean Outfall Pipeline in February 2020.

2.1 Threatened and Protected Fish Species

Searches of threatened and/or protected fish species listed under the *NSW Fisheries Management (FM) Act* 1994, *NSW Biodiversity Conservation (BC) Act* 2016 and *Commonwealth Environmental Protection and Biodiversity Conservation (EPBC) Act* 1999 were made (see **Appendix A**). Search results are summarised below.

2.1.1 Fisheries Management Act 1994

The NSW FM Act 1994 lists threatened and protected fish under the following schedules:

- Schedule 4 Endangered species, populations and ecological communities
- Schedule 4A Critically endangered species and ecological communities
- Schedule 5 Vulnerable species and ecological communities

Full current listings of threatened and protected species under the FM Act 1994 were obtained (NSW Government 2020) and are included in GHD (2020). Marine fish species (including bony fishes, sharks and syngnathids) which have the potential to occur within the coastal marine study area are listed below.

2.1.1.1 Schedule 4 Endangered species, populations and ecological communities

Endangered fish species include:

- *Hippocampus whitei*, White's Seahorse
- *Sphyrna lewini*, Scalloped Hammerhead Shark
- *Thunnus maccoyii*, Southern Bluefin Tuna

2.1.1.2 Schedule 4A Critically endangered species and ecological communities

Critically endangered fish species include:

- *Carcharias taurus*, Grey nurse Shark

2.1.1.3 Schedule 5 Vulnerable species and ecological communities

Vulnerable fish species include:

- *Carcharodon carcharias*, White Shark, Great White Shark
- *Epinephelus daemelii*, Black Rockcod, Black Cod
- *Sphyrna mokarran*, Great Hammerhead Shark

2.1.1.4 Protected Species

Protected fish species include:

- Syngnathids (seahorses, seadragons, pipefish, pipehorses, seamoths): all species of the families Syngnathidae, Solenostomidae and Pegasidae
- Ballina angelfish, *Chaetodontoplus ballinae*
- Bluefish, *Girella cyanea*
- Eastern blue devil fish, *Paraplesiops bleekeri*
- Elegant wrasse, *Anampses elegans*
- Estuary cod, *Epinephelus coioides*
- Giant Queensland groper, *Epinephelus lanceolatus*
- Herbsts nurse shark, *Odontaspis ferox*

2.1.2 Biodiversity Conservation Act 2016

The BioNET Atlas of NSW Wildlife (DoEH 2020) was used to identify any threatened and/or protected fish species listed under the BC Act 2016 with the potential to occur in the study area. A search area of 10 km radius around the proposed intake/discharge location is automatically adopted by this search tool and was considered suitable considering the highly mobile nature of marine fish and their larvae. Search results for marine species listed under the BC Act 2016 are provided in GHD (2020).

The BC Act 2016 lists a number of threatened marine species including mammals (seals, dolphins, whales and dugongs), birds (little penguin) and reptiles (marine turtles) but does not list any fish species. The likelihood of occurrence, potential impacts and assessments of significance for these species have been addressed by GHD in the Marine Assessment for the Belmont Drought Desalination Plant, Environmental Impact Statement (GHD 2020).

2.1.3 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act 1999 Protected Matters Search Tool (DoEE 2020) was used to determine the fish species listed as threatened or protected under the EPBC Act 1999 with the potential to occur in the study area. Due to the highly mobile nature of marine fish and their larvae a search area of within a 10 km radius of the proposed intake/discharge location was adopted. Search results are provided in GHD (2020). Along with fish species, a large number of marine mammals, reptiles are listed. These have been assessed by GHD (2020).

Fish species listed under the EPBC Act 1999 with the potential to occur in the study area include:

- Black Rockcod, *Epinephelus daemelii* – Vulnerable. Species or species habitat likely to occur within area.
- Grey Nurse Shark (east coast population), *Carcharias taurus* - Critically Endangered. Species or species habitat likely to occur within area.
- Great White Shark, *Carcharodon carcharias* - Vulnerable. Species or species habitat known to occur within area.
- Whale Shark, *Rhincodon typus* - Vulnerable. Species or species habitat may occur within area.
- Shortpouch Pygmy Pipehorse, *Acentronura tentaculata* - Protected. Species or species habitat may occur within area.
- Girdled Pipefish, *Festucalex cinctus* - Protected. Species or species habitat may occur within area.
- Tiger Pipefish, *Filicampus tigris* - Protected. Species or species habitat may occur within area.
- Upside-down Pipefish, *Heraldia nocturna* - Protected. Species or species habitat may occur within area.
- Beady Pipefish, *Hippichthys penicillus* - Protected. Species or species habitat may occur within area.
- Eastern Potbelly Seahorse, *Hippocampus abdominalis* - Protected. Species or species habitat may occur within area.
- White's Seahorse, *Hippocampus whitei* - Protected. Species or species habitat likely to occur within area.
- Crested Pipefish, *Histiogamphelus briggsii* - Protected. Species or species habitat may occur within area.
- Javelin Pipefish, *Lissocampus runa* – Protected. Species or species habitat may occur within area.
- Sawtooth Pipefish, *Maroubra perserrata* – Protected. Species or species habitat may occur within area.
- Red Pipefish, *Notiocampus ruber* - Protected. Species or species habitat may occur within area.
- Weedy Seadragon, *Phyllopteryx taeniolatus* – Protected. Species or species habitat may occur within area.
- Spiny Pipehorse, *Solegnathus spinosissimus* - Protected. Species or species habitat may occur within area.
- Robust Ghostpipefish, *Solenostomus cyanopterus* - Protected. Species or species habitat may occur within area.
- Ornate Ghostpipefish, *Solenostomus paradoxus* - Protected. Species or species habitat may occur within area.

- Spotted Pipefish, *Stigmatopora argus* - Protected. Species or species habitat may occur within area.
- Widebody Pipefish, *Stigmatopora nigra* - Protected. Species or species habitat may occur within area.
- Double-end Pipehorse, *Syngnathoides biaculeatus* - Protected. Species or species habitat may occur within area.
- Bentstick Pipefish, *Trachyrhamphus bicoarctatus* - Protected. Species or species habitat may occur within area.
- Hairy Pipefish, *Urocampus carinirostris* - Protected. Species or species habitat may occur within area.
- Mother-of-pearl Pipefish, *Vanacampus margaritifer* - Protected. Species or species habitat may occur within area.

2.2 Recreational and Commercial Fishing Targets

2.2.1 Recreational Target Species

2.2.1.1 NSW DPI Listing

Recreational fishing targets in NSW are highly diverse. NSW DPI (2020) lists the following recreationally targeted saltwater (including estuarine and marine) species. Their general habitat is also provided (as identified by NSW DPI and/or the Australian Museum).

- Albacore (longfin tuna), *Thunnus alalonga* – pelagic species.
- Amberjack, *Seriola dumerili* – pelagic, reef associated.
- Australian Bass, *Macquaria novemaculeata* – coastal rivers and streams.
- Australian Salmon, *Arripis trutta* - coastal inshore waters such as beaches, rocky head lands and shallow off shore reef.
- Australian Sawtail, *Prionurus microlepidotus* - schools around coastal reefs.
- Balmain Bug, *Ibacus peronii* - soft sand and muddy environments in water depths ranging from 15 to 650 m, but found most commonly at depths of 150 m.
- Banded Rock Cod (Bar Cod), *Epinephelus ergastularius* - deep water species and is usually caught in depths of 110-370 m.
- Bass Groper, *Polyprion moeone* - inhabits deep offshore waters of Australia's southern coast. It can be found in the deep water (100 m +) off the NSW coast.
- Beach Worm - burrowed in sandy areas throughout the south-eastern Australian coast at the low water mark.
- Bigeye Tuna, *Thunnus obesus* – offshore oceanic waters, typically in deeper water.

- Black Bream, *Acanthopagrus butcheri* - found in brackish and fresh waters of estuaries and rivers (occasionally found in coastal waters of southern and western Australia in times of flood).
- Blacklip Abalone, *Haliotis rubra* – adhere to rocky surfaces and inhabit crevices and caves on reefs. They generally inhabit waters between 5 and 10 m in depth but can be found in deeper waters up to 40 m in depth.
- Blue-Eye Trevalla (Cod), *Hyperoglyphe antarctica* - occurs over rocky bottoms in deep offshore waters of southern Australia (except for WA). It occurs at depths of 400-600 m.
- Blue Groper, *Achoerodus viridis* - rocky reef areas.
- Blue Swimmer Crab, *Portunus pelagicus* – adults are frequently found in large numbers in shallow bays and estuaries, found in coastal waters.
- Bluefish, *Girella cyanea* - occasionally found on coastal reefs of NSW but preferring offshore areas such as Lord Howe Island.
- Bonito, *Sarda australis* - found in schools in bays, large estuaries and coastal waters.
- Cobia (black kingfish), *Rachycentron canadum* – pelagic, shallow coral reefs and off rocky shores, occasionally in estuaries.
- Cockles, *Katelysia scalarina* and *Anadara trapezius* - *A. trapezius*, inhabits estuaries, mud flats and seagrass beds. Sand Cockle, *K. scalarina*, inhabits tidal flats and estuary mouths on protected or sandy subtidal sediment underlying seagrass beds to about 5 m depth.
- Commercial Scallop, *Pecten fumatus* - buried in soft sand or muddy sediments at depths from 1-120 m.
- Cunjevoi, *Pyura stolonifera* - forms large mats, covering intertidal rock platforms and wharf pylons, to a depth of approximately 12 m.
- Cuttlefish - several species of cuttlefish inhabit NSW waters ranging from the shallow inshore reefs and weeds beds to deep offshore areas.
- Eastern Red Scorpionfish (Red Rock Cod), *Scorpaena jacksoniensis* - coastal reefs - often found with sponges and in rocky areas covered with algae.
- Eastern Rock Lobster, *Jasus verreauxi* – continental shelf of NSW - they hide in holes and crevices around rocky areas and reefs, preferring vegetative cover such as weed/kelp.
- Eastern School Whiting, *Sillago flindersi* - benthic species found from shallow tidal flats down to depths of 180 m on the continental shelf, usually associated with sandy substrates.
- Eels (Short and Long-finned), *Anguilla reinhardtii* - freshwater rivers, streams, dams, lagoons and lakes on the coastal side of the Great Dividing Range.
- Estuary Perch, *Macquaria colonorum* - coastal rivers and lakes.
- Flathead (Bluespotted), *Platycephalus arenarius* - commonly found along beaches and in estuaries of northern NSW.

- Flathead (Dusky), *Platycephalus fuscus* - found in estuaries and coastal bays - they occur over sand, mud, gravel and seagrass and can inhabit estuarine waters up to the tidal limit.
- Flathead (Tiger), *Neoplatycephalus richardsoni* - predominantly found offshore but also inhabit shallow coastal bays.
- Flounder, various species inhabit NSW waters including the large-toothed and small-toothed Flounder that are found throughout as well as long-snouted and greenback flounder, found in southern NSW - commonly found in bays and estuaries on sandy or silty bottoms.
- Garfish (Eastern Sea Garfish), *Hyporhamphus australis* - live in sheltered bays, clear coastal waters and some estuaries to waters about 20 m deep. These fish school near the surface at night and over weed and seagrass beds during the day.
- Gemfish, *Rexea solandri* - bottom dwelling fish which inhabit deep water, generally found in large schools at depths of 100-800 m.
- Grey Morwong (Rubber Lip / Blue Morwong), *Nemadactylus douglasii* - inhabit the continental shelf waters, usually seen over sand near rocky reefs, commonly caught on or near reefs in water depths of 10-100 m.
- Hairtail, *Trichiurus lepturus* – occur in tropical and temperate continental shelf and slope waters from inshore to a depth of at least 350 m.
- Hapuku (New Zealand Groper), *Polyprion oxygeneios* – inhabit deep offshore waters to about 200 fathoms (365 m) in southern NSW, VIC, TAS, SA and southern WA.
- Leatherjacket, various species inhabit NSW waters to depths of 250 m or more. Leatherjacket are found in estuarine (artificial structures such as pylons and wharfs or seagrass), coastal and offshore (rocky reefs, sand/mud bottoms or sponge beds) waters.
- Longtail Tuna (Northern Bluefin Tuna), *Thunnus tonggol* – frequently occur in the southern waters of Australia's east and west coasts during summer.
- Luderick, *Girella tricuspidata* – inhabit coastal and estuarine waters to a depth of 20 m. Often found in large schools around rocky outcrops and jetties.
- Mackerel (Narrow-barred Spanish), *Scomberomorus commerson* – inhabits coastal waters.
- Mackerel (Spotted), *Scomberomorus munroi* – endemic to Australasian waters and are most common in offshore waters away from reefs and shoals.
- Mahi Mahi (Dolphinfish), *Coryphaena hippurus* – found in tropical and warm temperate waters. Typically preferring offshore conditions and can be found near floating objects such as fish trap buoys and weed rafts.
- Mangrove Jack, *Lutjanus argentimaculatus* – inhabit coastal waters and rivers. Juveniles typically inhabit estuaries and freshwater streams whilst adults inhabit deeper offshore reefs down to depths of at least 100 m.
- Marlin (Black), *Makaira indica* – inhabit tropical and subtropical waters and are occasionally found in waters off Australia's southern areas during summer. Usually prefer areas well offshore but can inhabit almost any ocean depth.

- Marlin (Indo-Pacific Blue), *Makaira mazara* – inhabit tropical and subtropical waters and are rarely found in ocean waters less than 100 m deep.
- Marlin (Striped), *Tetrapturus audax* – inhabit tropical to temperate waters.
- Morwong (Banded), *Cheilodactylus spectabilis* – inhabit exposed rocky headlands and coastal reefs down to a depth of 50 m.
- Morwong (Jackass), *Nemadactylus macropterus* – generally occur as individuals or large schools and inhabit deep coastal waters, between 25 m to a depth of more than 200 m, and occasionally found in large coastal bays.
- Morwong (Red), *Cheilodactylus fuscus* – occur in warm temperate waters. Commonly found in NSW waters, occurring in shallow coastal waters and on rocky reefs to a depth of about 30 m.
- Moses Snapper (Perch), *Lutjanus russellii* – generally inhabit coastal reefs and estuaries. Adult fish are more common in deeper offshore water. Found at depths from 3 m to 80 m.
- Mud Crab, *Scylla serrata* – inhabit tropical to warm temperate waters and prefer soft muddy bottoms below the low tide level and generally live in sheltered estuaries, mud flats, mangrove forests and the tidal reaches of some rivers.
- Mullet (Poddy), refers to the juvenile of various species of Mullet such as the Head of the Sea (bully) Mullet and the Sand Mullet. Found in estuaries and coastal waters of NSW.
- Mullet (Sea), *Mugil cephalus* – commonly found in estuaries and coastal waters of NSW.
- Mulloway, *Argyrosomus japonicus* or *hololepidotus* – inhabit temperate marine waters and are usually seen on offshore reefs but may also inhabit shallow estuaries.
- Native Oyster (Flat), *Ostrea angasi* – found throughout the marine and estuarine habitats, typically attaching themselves to hard substrates prior to breaking free and settling on sand or soft mud. Typically inhabit the subtidal zone between 2 m and 20 m deep.
- Octopus, various species inhabit NSW waters from shallow intertidal rock ledges to deep offshore areas.
- Pacific Oyster, *Crassostrea gigas* – the species settles on any hard substrate in the intertidal and shallow subtidal zones, to a depth of about 3 m. They are typically found in brackish waters in sheltered estuaries.
- Pearl Perch, *Glaucosoma scapulare* – found in small schools on deep offshore reefs in coastal waters to a depth of 90 m.
- Prawn (Black Tiger), *Penaeus monodon* – most are produced by Aquaculture; however, they are occasionally trawled off the coasts of WA, NT and QLD to a depth of 150 m.
- Prawn (School and Eastern King), refers to the School (*Metapenaeus macleaya*) and Eastern King (*Penaeus plebejus*) Prawn – estuarine and coastal waters off the east coast of Australia. Juveniles inhabit estuaries, generally near seagrass beds. Adults are commonly found in ocean waters but may also occur in estuaries.

- Purple Sea Urchin, *Heliocidaris erythrogramma* – inhabit coastal waters up to 35 m deep but are most common in waters shallower than 10 m deep. Often found attached to rocky reefs, stones, seagrass beds, in crevices and burrows and on sandy mud bottoms. Areas somewhat protected from wave motion are preferred.
- Rock Blackfish (Black Drummer or Eastern Rock Blackfish), *Girella elevata* – Juveniles are found in rockpools, estuaries and shallow rocky reefs. Adults prefer the exposed rocky reefs/shoreline from the surf zone to a depth of about 25 m. They are also found in caves or under ledges.
- Sailfish, *Istiophorus platypterus* – rarely found outside the tropics, but has been found in the southern waters of Australia's east and west coasts during summer. The species approaches continental coasts, islands and reefs.
- Samsonfish, *Seriola hippos* – inhabits coastal and inshore waters of NSW, commonly in and around rocky reefs.
- Sand Whiting, *Sillago ciliata* – inhabit inshore waters of eastern Australia including coastal beaches, sand bars, bays, coastal lakes, estuaries and rivers as far as the tidal limits. They favour sandy or muddy sand substrates in shallow water to about 6 m deep.
- Shark (Blue), *Prionace glauca* – inhabits tropical and subtropical waters from the surface to at least 150 m deep.
- Shark (Hammerhead), various species inhabit NSW waters including Smooth Hammerheads, Great Hammerheads and Scalloped Hammerheads. They range in depth from the surf zone out to sea and from the surface down to at least 275 m.
- Shark (Shortfin Mako), *Isurus oxyrinchus* – found in tropical and warm temperate seas occurring from the surface to a depth of at least 150 m.
- Shark (School), *Galeorhinus galeus* – found in temperate continental waters including southern NSW from the surf zone to well offshore.
- Shark (Whaler), various species inhabit NSW waters from the upper reaches of estuarine rivers to offshore areas.
- Shark (Wobbegong), various species, commonly the Banded Wobbegong and Spotted Wobbegong inhabit NSW waters. They inhabit shallow, inshore waters less than 100 m deep where rock and weed are common.
- Shortbill Spearfish, *Tetrapturus angustirostris* – the species is rarely seen in coastal waters as it prefers oceanic conditions.
- Slipper Lobster (Flat), refers to the Aesop Slipper Lobster (*Scyllarides haanii*) and Blunt Slipper Lobster (*Scyllarides squammosus*) found in Australian waters on the east and west coasts in depths up to 135 m but can be found as shallow as 10 m.
- Snapper, *Pagrus auratus* – commonly found in coastal and offshore waters.
- Sole, various species inhabit NSW water including the Black Sole and Lemon Tongue Sole. They are commonly found in bays and estuaries on sandy or silty bottoms.

- Southern Bluefin Tuna, *Thunnus maccoyii* – found in NSW waters and typically form large surface schools in offshore waters off southern Australia at certain times of the year.
- Southern Rock Lobster, *Jasus edwardsii* – inhabit a variety of reef habitats in waters ranging between 1 m to about 200 m deep.
- Spanner Crab, *Ranina ranina* – inhabit coastal waters. They prefer a sandy habitat to depths of more than 100 m, but may be found in other environments, from sheltered bays to surf zones.
- Squid, various species inhabit NSW waters from shallow inshore reefs and weed beds to the offshore, open water areas. Southern Calamari Squid are usually found to a depth of less than 100 m. Arrow Squid live anywhere from estuaries to offshore areas 500 m deep.
- Swordfish, *Xiphias gladius* – generally inhabit Australian waters beyond the continental shelf and occur infrequently in the coastal waters of southern Australia. Typically found down to a depth of 650 m.
- Oyster (Sydney Rock), *Saccostrea glomerata* – inhabit sheltered estuaries and bays.
- Oyster (Pacific), *Crassostrea gigas* – introduced species now found throughout most of the range of the Sydney Rock Oyster.
- Tailor, *Pomatomus saltatrix* – occurs in oceanic waters as well as estuarine and inshore waters.
- Tarwhine, *Rhabdosargus sarba* – found in bays, harbours and coastal areas.
- Teraglin, *Atractoscion aequidens* – Juveniles occur in inshore waters whilst adults inhabit offshore reefs.
- Tropical Rock Lobster (Painted and Ornate), X – inhabits depths between 1 m and 200 m (most common depth of 20 m), inhabiting a range of reef habitats along the continental shelf, often in caves, holes and crevices.
- Turban Snail, *Turbo undulata* – found in intertidal and shallow reef areas to depths of about 20 m. They can also be found in tidal pools and weed-covered reefs.
- Wahoo, *Acanthocybium solandri* – tropical species found in Australian waters.
- Yellowfin Bream, *Acanthopagrus australis* - inhabit estuaries up to the brackish water limit and inshore rocky reef habitats near ocean beaches and rocky headlands.
- Yellowfin Tuna, *Thunnus albacares* – oceanic fish which may also be found in the brackish waters of estuaries. Fish weighing less than 15 kg regularly form schools whilst those over 15 kg inhabit deeper waters above the thermocline and tend not to school.
- Yellowtail Kingfish, *Seriola lalandi* – generally inhabit rocky reefs and adjacent sandy areas in coastal waters and occasionally enter estuaries. They are found in shallow water down to about 50 m deep.

2.2.1.2 Local Recreational Charter Operation

Information regarding local recreational fish catch in coastal waters off Swansea, specifically at depths of <30 m, was obtained from Sandy Bottom Boat Charters, a recreational fishing charter operation running out of Swansea (in January 2020). The following species were identified as being caught or seen regularly in these inshore coastal waters (with many other fish caught but not as commonly).

- Australian salmon, *Arripis trutta* – coastal inshore waters such as beaches, rocky head lands and shallow off shore reef.
- Bonito, *Sarda australis* – found in schools in bays, large estuaries and coastal waters.
- Black Bream, *Acanthopagrus butcheri* – found in brackish and fresh waters of estuaries and rivers (occasionally found in coastal waters of southern and western Australia in times of flood).
- Yellowfin Bream, *Acanthopagrus australis* - inhabit estuaries up to the brackish water limit and inshore rocky reef habitats near ocean beaches and rocky headlands.
- Rock Blackfish (Black Drummer or Eastern Rock Blackfish), *Girella elevata* – Juveniles are found in rockpools, estuaries and shallow rocky reefs. Adults prefer the exposed rocky reefs/shoreline from the surf zone to a depth of about 25 m. They are also found in caves or under ledges.
- Eastern Red Scorpionfish (Red Rock Cod), *Scorpaena jacksoniensis* – coastal reefs - often found with sponges and in rocky areas covered with algae.
- Flathead (Sand), *Platycephalus bassensis* - occurs primarily on sandy seabeds in temperate marine waters. It is found in bays and coastal areas down to about 100 m in depth.
- Flathead (Dusky), *Platycephalus fuscus* – found in estuaries and coastal bays - they occur over sand, mud, gravel and seagrass and can inhabit estuarine waters up to the tidal limit.
- Flathead (Tiger), *Neoplatycephalus richardsoni* – predominantly found offshore but also inhabit shallow coastal bays.
- Flounder, various species inhabit NSW waters including the Large-Toothed and Small-Toothed Flounder that are found throughout as well as Long-Snouted and Greenback Flounder, found in southern NSW - commonly found in bays and estuaries on sandy or silty bottoms.
- Grouper (red).
- (Eastern) Blue Groper, *Achoerodus viridis* –inhabit coastal reefs, in depths of 1-60+ m. Juveniles often shelter in seagrass beds in estuaries.
- Luderick, *Girella tricuspidata* – inhabit coastal and estuarine waters to a depth of 20 m. Often found in large schools around rocky outcrops and jetties.
- Grey Morwong (Rubber Lip / Blue Morwong), *Nemadactylus douglasii* – inhabit the continental shelf waters, usually seen over sand near rocky reefs, commonly caught on or near reefs in water depths of 10-100 m.
- Morwong (Banded), *Cheilodactylus spectabilis* – inhabit exposed rocky headlands and coastal reefs down to a depth of 50 m.

- Morwong (Jackass), *Nemadactylus macropterus* – generally occur as individuals or large schools and inhabit deep coastal waters, between 25 m to a depth of more than 200 m, and occasionally found in large coastal bays.
- Morwong (Red), *Cheilodactylus fuscus* – occur in warm temperate waters. Commonly found in NSW waters, occurring in shallow coastal waters and on rocky reefs to a depth of about 30 m.
- Mulloway, *Argyrosomus japonicus* or *hololepidotus* – inhabit temperate marine waters and are usually seen on offshore reefs, but may also inhabit shallow estuaries.
- Octopus, various species inhabit NSW waters from shallow intertidal rock ledges to deep offshore areas.
- Sharks (gummy, Port Jackson, banjo, hammerhead, bronze whaler, mako, great white, bull).
- Blue Mackerel (Slimy Mackerel), *Scomber australasicus* – schooling pelagic fish inhabiting tropical and temperate marine waters.
- Snapper, *Pagrus auratus* – commonly found in coastal and offshore waters.
- Squid, various species inhabit NSW waters from shallow inshore reefs and weed beds to the offshore, open water areas. Southern Calamari Squid are usually found to a depth of less than 100 m. Arrow Squid live anywhere from estuaries to offshore areas 500 m deep.
- Tailor, *Pomatomus saltatrix* – occurs in oceanic waters as well as estuarine and inshore waters.
- Tarwhine, *Rhabdosargus sarba* – found in bays, harbours and coastal areas.
- Teraglin, *Atractoscion aequidens* – Juveniles occur in inshore waters whilst adults inhabit offshore reefs.
- Wrasse.
- Yellowtail Kingfish, *Seriola lalandi* – generally inhabit rocky reefs and adjacent sandy areas in coastal waters and occasionally enter estuaries. They are found in shallow water down to about 50 m deep.
- Yellowtail Scad, *Trachurus novaezelandiae* – schooling species found in a range of habitats from the surface to 500 m deep.

2.2.2 Commercial

Commercial fishers operate throughout NSW state waters including estuaries, beaches, bays and ocean. The key wild species harvested by NSW commercial fisherman include snapper, yellow fin bream, flathead, king and school prawns, sea mullet, mulloway, whiting, yellowtail kingfish, crabs, eastern rock lobsters and deep water reef fish such as blue eye trevalla (NSW DPI 2008, 2020). However, numerous other species are targeted. Commercial fisheries have historically been defined by the method of capture (e.g. prawn trawl and fish trap); however, some fisheries with one target species are defined by the species itself (e.g. the lobster fishery). The NSW commercial fisheries operating in estuarine or marine waters which include species that have the potential to occur in the proposed intake/outfall locations include:

- **Abalone Fishery** - Abalone is commercially harvested from rocky reefs by licenced divers.

- **Developmental Commercial Fisheries** - From time to time individuals and groups express an interest in exploring opportunities to harvest fisheries resources they perceive to be under-utilised in NSW waters, or using unique fishing methods not authorised under the State's existing Fisheries Management Strategies. Currently proposed fisheries can be found here (https://www.dpi.nsw.gov.au/fishing/commercial/fisheries/developmental-commercial-fisheries).

- **Estuary General Fishery** - The Estuary General Fishery is a diverse multi-species multi-method fishery that may operate in 76 of the NSW's estuarine systems. It is the most diverse commercial fishery in NSW. The Fishery includes all forms of commercial estuarine fishing (other than estuary prawn trawling which comprises the Estuary Prawn Trawl Fishery) in addition to the gathering of pipis and beachworms from ocean beaches. The most frequently used fishing methods are mesh and haul netting. Other methods used include trapping, hand-lining and hand-gathering. On average, the 10 species that make up over 80% of landings by weight are sea mullet (*Mugil cephalus*) 40%, luderick (*Girella tricuspidata*) 8%, yellowfin bream (*Acanthopagrus australis*) 8%, school prawn (*Metapenaeus macleayi*) 5%, blue swimmer crab (*Portunus pelagicus*) 4%, dusky flathead (*Platycephalus fuscus*) 4%, sand whiting (*Sillago ciliata*) 3%, pipi (*Donax deltoides*) 3%, mud crab (*Scylla serrata*) 3% and silver biddy (*Gerres subfasciatus*) 2%.

- **Estuary Prawn Trawl Fishery** - The Estuary Prawn Trawl Fishery uses otter trawl nets to target school prawns and eastern king prawns in three estuaries in NSW (the Clarence, Hawkesbury and Hunter Rivers). Overall, school prawns comprise a major part of the total fishery catch, with the proportion of non-target species contributing to the catch varying between estuaries. Squid is also an important species for some Hawkesbury River fishers.

- **Lobster Fishery** - The Fishery extends from the Queensland border to the Victorian border and includes all waters under jurisdiction of NSW to around 80 miles from the coast. Eastern rock lobster (*Sagmaraisus verreauxi*) is the main species harvested but occasionally, southern rock lobster, *Jasus edwardsii*, and tropical rock lobster, *Panulirus longipes* and *P. ornatus*, are also caught. It is characterised by inshore and offshore sectors. Inshore fishers use small beehive or square traps in waters up to 10 m in depth, whilst offshore fishers use large rectangular traps.

- **Ocean Hauling Fishery** - The Ocean Hauling Fishery is broken up into 7 regions along the NSW coast and targets approximately 20 finfish species using commercial hauling and purse seine nets from sea beaches and in ocean waters within 3 nautical miles of the NSW coast. The catch is mainly made up of Pilchards (*Sardinops sagax*) 34%, sea mullet (*Mugil cephalus*) 30%, Australian Salmon (*Arripis trutta*) 17%, blue mackerel (*Scomber australasicus*) 8%, Yellowtail Scad (*Trachurus novaezelandiae*) 5% and Yellowfin Bream (*Acanthopagrus australis*) 2% of the total catch.

- **Ocean Trawl Fishery** - There are two sectors to the NSW Ocean Trawl Fishery: the prawn trawl sector and the fish trawl sector. Both sectors use similar gear, the otter trawl net, and many of the fishers endorsed for fish trawling are also endorsed for prawn trawling. The major species taken in the Ocean Trawl Fishery include school whiting (comprising of stout whiting and red spot whiting), eastern king, school and royal red prawns, tiger flathead, silver trevally, various species of sharks and rays, squid, octopus and bugs.

- **Ocean Trap and Line Fishery** - The Ocean Trap and Line fishery is a multi-method, multi species fishery targeting demersal and pelagic fish along the entire NSW coast, in continental shelf and slope waters. Snapper, yellowtail kingfish, leatherjackets, bonito and silver trevally form the bulk of the commercial catch. Other key species include rubberlip (grey) morwong, blue-eye trevalla, sharks, bar cod and yellowfin bream. This fishery uses a variety of traps or lines with hooks. The methods used (and the key species taken by each method) include: fish trap (snapper, silver trevally, grey morwong and leatherjackets); setlines (snapper and sharks); driftlines (spotted and Spanish mackerel, yellowtail kingfish, and sharks); hand-held lines (mulloway, yellowtail kingfish and bonito); droplines (blue-eye trevalla and hapuku); leadlining (yellowtail kingfish, mackerel and tuna); and spanner crab traps, known as 'dillies'.
- **Sea Urchin and Turban Shell Restricted Fishery** - Sea urchins (*Centrostephanus rodgersii, Heliocidaris erythrogramma* and *Heliocidaris tuberculata*) are the main target species in this fishery with small quantities of turban shell landed at times. Fishing for sea urchins is generally undertaken when the roe is well developed. Purple urchins are harvested primarily from October to March when the quality of their roe is best. Red urchins have an extended spawning period (from February to October) and specimens with firm roe of marketable volume and quality are found year-round. Turban shells are harvested year-round for their fleshy foot. A minimum legal length of shell has been set for the Sydney turban snail (*Turbo torquatus*) and Military turban snail (*Turbo militaris*) (NSW DPI 2020).

2.3 Burwood Beach Ocean Outfall Fish Study 2011-2014 (WorleyParsons 2014)

The Burwood Beach MEAP Fish Study was undertaken 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 Burwood Beach WWTW Ocean Outfall (off Newcastle) and at a number of reference locations to the north and south. The UVC method was based on four replicate 5 m x 25 m belt transects (for larger and more mobile species) and one 1 m x 25 m belt transect (for smaller cryptic species) per event. The BRUVS method was based on three replicate deployments per site which were spaced 200 m from each other.

The southernmost reference sites for the BRUVS and UVC surveys included “South 2” and “Reference South - Redhead” – these sites were close to Redhead, located ~ 6 km north of the Belmont WWTW Ocean Outfall and occurred over low-profile rocky reefs surrounded by sand. Site details are included in Table 2-1. Data collected from the Redhead reference sites is considered appropriate to inform local fish community data with similar fish communities also likely to inhabit the immediate Belmont WWTW receiving environment. A summary of species data was collated for the southernmost (Redhead) reference sites (Table 2-2).

Table 2-1 Burwood Beach Ocean Outfall fish survey southern site details.

Site	GPS Co-ordinates	Survey Method	Sampling Events	Depth
South 2 – NC15	33°00.4881/ 151°44.7859	BRUVS	December 11	22 m
South 2 – NC16	33°00.5838/ 151°44.8236	BRUVS	December 11	22 m
South 2 – NC17	33°00.5069/ 151°44.8580	BRUVs	December 11	22 m
Reference South - Redhead	33°01.605'/ 151°42.980'	UVC	Dec 11, Apr 12, Oct 12 & Apr 13	23 m

Table 2-2 Summary of fish assemblage data near Redhead NSW (WorleyParsons 2014).

Fish Species		Total Abundance	Survey Dates	Method	Site
Scientific Name	Common Name				
Austrolabrus maculatus	Black Spot Wrasse	10	Apr-12 and Apr-13	UVC	South Reference
Acanthistius ocellatus	Eastern Wirrah	1	Dec-11	BRUVS	South Reference
Acanthopagrus australis	Bream	43	Dec-11, Apr-12 and Apr-13	UVC & BRUVS	South Reference
Achoerodus viridis	Eastern Blue Groper	9	Dec-11, Apr-12 and Apr-13	UVC & BRUVS	South Reference
Atypichthys strigatus	Australian Mado	3	Apr-13	UVC	South Reference
Aulopus purpurissatus	Sergeant Baker	3	Dec-11	BRUVS	South Reference
Cheilodactylus fuscus	Red Morwong	12	Dec-11, Apr-12 and Apr-13	UVC & BRUVS	South Reference
Chelmonops truncatus	Eastern Talma	2	Dec-11	BRUVS	South Reference
Cleidopus gloriamaris	Pineapple Fish	4	Apr-12	UVC	South Reference
Dinolestes lewini	Longfin Pike	13	Dec-11 and Apr-12	UVC & BRUVS	South Reference
Enoplosus armatus	Old Wife	23	Dec-11, Apr-12 and Apr-13	UVC & BRUVS	South Reference
Heterodontus portusjacksoni	Port Jackson Shark	2	Dec-11 and Apr 13	UVC & BRUVS	South Reference

Fish Species		Total Abundance	Survey Dates	Method	Site
Scientific Name	**Common Name**				
Hypoplectrodes maccullochi	Halfbanded Perch	2	Apr-12	UVC	South Reference
Hypoplectrodes nigroruber	Banded Sea Perch	1	Apr-13	UVC	South Reference
Lotella rhacina	Large Tooth Beardy	2	Apr-13	UVC	South Reference
Meuschenia freycineti	Sixspine Leatherjacket	4	Dec-11	BRUVS	South Reference
Nemadactylus douglasii	Grey Morwong	3	Dec-11	BRUVS	South Reference
Notolabrus gymnogenis	Crimson-banded Wrasse	14	Dec-11, Apr-12 and Apr-13	UVC & BRUVS	South Reference
Ophthalmolepis lineolata	Maori Wrasse	28	Dec-11, Apr-12 and Apr-13	UVC & BRUVS	South Reference
Pagrus auratus	Australasian Snapper	7	Dec-11 and Apr-13	UVC & BRUVS	South Reference
Paraplesiops sp.		1	Apr-12	UVC	South Reference
Parma microlepis	White Ear	29	Dec-11, Apr-12 and Dec-11	UVC & BRUVS	South Reference
Parupeneus signatus	Blackspot Goatfish	1	Apr-13	UVC	South Reference
Parupeneus spilurus	Blacksaddle Goatfish	2	Dec-11	BRUVS	South Reference
Pempheris multiradiata	Big scale Bullseye	2	Apr-13	UVC	South Reference
Phyllacanthus parvispinus	Eastern Slate-Pencil Urchin	9	Apr-13	UVC	South Reference
Pseudocaranx dentex	White Trevally	25	Dec-11	BRUVS	South Reference
Rhabdosargus sarba	Eastern Pomfred	5	Dec-11	BRUVS	South Reference
Scorpis lineolata	Silver Sweep	48	Dec-11 and Apr-13	UVC & BRUVS	South Reference
Trachichthys australis	Southern Roughy	2	Apr-12	UVC	South Reference

Fish Species		Total Abundance	Survey Dates	Method	Site
Scientific Name	Common Name				
Trachurus novaezelandiae	Yellowtail	138	Apr-12 and Dec-11	UVC & BRUVS	South Reference
Upeneichthys lineatus	Stingaree	2	Dec-11 and Apr-13	UVC & BRUVS	South Reference

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.

2.4 Belmont WWTW Pipeline Fish Surveys

2.4.1 February 2019 Opportunistic Observations

In February 2019 (Advisian 2019), opportunistic observations of fish species associated with the Belmont WWTW Ocean Outfall Pipeline were made during the annual benthic infauna survey with the following species identified:

- Port Jackson shark (*Heterodontus portusjacksoni*)
- Mado (*Atypichthys latus*)
- Yellowtail mackerel (*Trachurus novaezelandiae*)

2.4.2 February 2020 Fish Survey

In February 2020, a targeted fish survey was undertaken along the Belmont WWTW Ocean Outfall Pipeline by divers. Fish species' presence and abundance were assessed by visual census along a 25 m section of the pipe. A diver, swimming slightly above and to one side of the pipe and then back along the other side, recorded the fish observed over four separate dives (on two separate days). Infield diver observation and underwater video were used to record fish data. Due to the limited underwater visibility at the time of the survey (10 cm - 0.5 m) a quantitative measurement of fish abundances was not possible. A semi-quantitative assessment of abundance therefore was made using the A.C.F.O.R. scale (Table 2-3, Peters 1995). Video of the Belmont pipeline outfall from March 2019 was also reviewed and fish abundance assessed on the same scale. The 2019 video was collected by Gray Diving Services during cleaning operations (supplied by Hunter Water). This allowed for a high-level comparison of fish abundance between years.

Table 2-3 ACFOR abundance scale.

A	Species observed is "Abundant" within the given area.
C	Species observed is "Common" within the given area.
F	Species observed is "Frequent" within the given area.
O	Species observed is "Occasional" within the given area
R	Species observed is "Rare" within the given area.

Results

The fish assemblage on the Belmont outfall pipe was similar to fish assemblages observed on reef habitats in the region (WorleyParsons 2014). The assemblage was generally consistent across the 2019 and 2020 surveys, with the same common species occurring at similar abundances.

The most abundant fish were yellowtail mackerel, *Trachurus novaezelandiae*, which occurred in a large school (100s) in the lower half of the water column above the pipeline. Mado, *Atypichthys latus*, were the most abundant fish (10s-100) at the pipe, approaching and following the diver. A similar fish from the same family, stripey *Microcanthus strigatus*, was also present but in lower numbers.

Two species of wrasse were observed on both occasions; crimson banded wrasse *Notolabrus gymnogenis* and southern maori wrasse *Ophthalmolepis lineolata*. Old wife *Enoplosus armatus* were also observed in both years.

On the pipe's surface, red scorpionfish (rock cod; *Scorpaena* spp.) were common, as were half-banded seaperch *Hypoplectrodes maccullochi*. A green moray *Gymnothorax prasinus* was observed in February 2020.

Several shark and ray species have been observed on a single occasion. A crested hornshark, *Heterodontus galeatus*, was previously observed on the pipe during sediment sampling work at this site in February 2019. A spotted Wobbegong *Orectolobus maculatus* and a stingaree *Trygonoptera* sp. were seen in March 2019, and a fiddler ray *Trygonorrhina fasciata* in 2020. Small hammerhead sharks, presumably smooth hammerhead, *Sphyrna zygaena*, were observed at the surface near the pipe in 2020.

The absence of eastern blue groper *Achoerodus viridis* and morwong species, such as the red morwong *Cheilodactylus fuscusz*, was a distinct difference to fish assemblages observed on local reef habitats.

All results with their ACFOR abundance from 2019 and 2020 are provided in Table 2-4.

Table 2-4 Fish survey results and ACFOR abundance 2019 and 2020.

Species	Scientific Name	ACFOR March 2019	ACFOR February 2020
Yellowtail mackerel	*Trachurus novaezelandiae*	A	A
Mado	*Atypichthys latus*	A	A
Stripey	*Microcanthus strigatus*	F	F
Maori wrasse	*Ophthalmolepis lineolate*	C	F
Crimson banded wrasse	*Notolabrus gymnogenis*	F	O
White ear	*Parma microlepis*	C	F
Girdled Scalyfin	*Parma unifasciata*	O	-
Red scorpionfish	*Scorpaena spp*	C	C
Half-banned seaperch	*Hypoplectrodes maccullochi*	C	F
Old wife	*Enoplosus armatus*	O	O
Green moray	*Gymnothorax prasinus*	-	O

Silver sweep	*Scorpis lineolate*	O	-
Sergeant baker	*Latropiscis purpurissatus*	O	-
Spotted Wobbegong	*Orectolobus maculatus*	O	-
Stingaree	*Trygonoptera sp.*	O	-
Fiddler ray	*Trygonorrhina fasciata*	-	O

3 Local Benthic Infauna

Benthic infauna in the local receiving environment has been described by a number of sources since 2003. A summary of findings is provided in the following sections.

3.1 Belmont WWTW Infauna and Sediment Studies (BioAnalysis 2006 and 2007)

Benthic biodiversity and sediment quality investigations were undertaken in 2006 and 2007 by BioAnalysis, respectively, as part of broader impact assessments for Hunter Water's major marine outfalls at Boulder Bay, Burwood Beach and Belmont WWTWs. These studies were based on a control impact study design.

Infauna sampling locations included Belmont Outfall (with 3 nested sites) and 2 Reference Locations (Swansea Heads and Redhead – 3 nested sites at each). For the infauna study, five random benthic grabs were taken at each site. Samples were sieved to 0.5 mm and sorted infauna identified to family level.

The main findings of the 2006 infauna study were as follows:

- Crustaceans were the most diverse and abundant fauna within soft sediment habitats at Belmont Outfall and Reference locations.
- ANOVA detected no significant differences between total richness and total abundance of infauna between the Outfall and Reference locations.
- ANOVA showed that there were significantly smaller numbers of individual polychaetes detected at the Outfall location compared to Reference locations.
- ANOVA showed there was significantly greater variability among sites at the Outfall compared to variability at sites within Reference locations.
- Multivariate MDS analysis suggested that most variability was at the scale of sites, while differences between locations were also apparent. Pairwise comparisons showed that the Outfall was significantly different to Swansea Heads and to Redhead, while the two Reference locations were also significantly different from each other.
- In general, no consistent patterns were identified at the Outfall location that could be attributed to the discharge of sewage.

3.2 Belmont WWTW Ocean Outfall Benthic Monitoring (Advisian 2016, 2017, 2018, 2019 and 2020)

The 2016, 2017, 2018, 2019 and 2020 benthic monitoring undertaken by Advisian adopted a combined gradient and control/impact style study 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 at > 2 km).

The objective of these studies was to assess if there was any significant impact from the outfall on marine sediment contaminants and infauna assemblages. Specific aims were to:

- Establish and document the extent and spatial scales over which organic solids and metals from the outfall effluent accumulate in soft sediment around the outfall and along the effluent dispersion pathways,
- Establish any spatial impacts on benthic infauna communities potentially affected by the discharges, including possible consequence of smothering, contaminant accumulation or alteration of habitat, and
- Establish any temporal impacts on benthic infauna communities potentially affected by the discharges, by comparison with previous investigations, where possible.

All raw infauna data from the 2016 – 2019 sampling years is provided in **Appendix B**. Data from February 2020 was not available at the time of reporting.

3.2.1 Summary of Infauna Taxa 2016-2019

A total infauna richness of 111 taxa (families), consisting of 17688 individual organisms (i.e. total abundance), was recorded in the 2019 survey (see Table 3-1 and **Appendix B**). Overall, taxa richness in 2019 was slightly higher than in any of the previous sampling years (i.e. 97 in 2016, 84 in 2017 and 100 in 2018). Total abundance in 2019 (17688 individuals) was much higher than in any previous year (8104 in 2016, 6885 in 2017 and 5903 individuals in 2018) (Table 3-1).

A summary of the total number of families (richness) and total number of individuals (abundance) for all Phyla identified during the 2019 survey is provided in Table 3-1. This table also provides the comparative data for all taxa identified in the 2016, 2017 and 2018 surveys. Figure 3-1 shows the total abundance of each Phylum recorded for all four surveys.

Infauna richness varied slightly between years for some Phyla while others remained the same. Overall, the richness of individual taxa was quite similar between the four sampling years from 2016 to 2019. Infauna taxa identified in 2019 included 29 families from the Phylum Annelida (compared to 31 in 2016, 24 in 2017 and 31 in 2018), 35 families from Arthropoda (with 28 in 2016, 23 in 2017 and 35 in 2018), no Bryozoa (one family was recorded in 2016 and 2017 and none in 2018), one Chaetognatha (one taxa was identified in 2016, none in 2017 and one in 2018), four families from Chordata (none were recorded in either 2016 or 2017 and four families in 2018), two Cnidarians (two families were recorded in 2016 and 2017 and one in 2018), six families from Echinodermata (five were recorded in 2016 and 2017 and four in 2018), 26 Mollusca (23 were recorded in 2016, 24 in 2017 and 19 in 2018), one family of Nematoda, Phoronida, Platyhelminthes and Sipuncula (one family of each was also identified in 2016 to 2018 for all these taxa), two Nemertia (compared to one family in all previous sampling years) and two Porifera (one family was identified in 2016 and none in either 2017 or 2018) (Figure 3-1 and Table 3-1).

Annelida were by far the most abundant taxa in 2019 with a total abundance of 10620. The total number of Annelida in 2018 was also high compared to other taxa with 2825 individuals, similar to in 2017 with 2786 individuals, and in 2016 the total number recorded was 4943 individuals (Figure 3-1 and Table 3-1).

Arthropoda, Nematoda and Phoronida were next most abundant taxa. Arthropoda had 2085 individuals in 2019, compared to 968 in 2018, 2487 in 2017 and 1376 in 2016. Nematodes were much more abundant in 2019 than other sampling years with 2025 individuals, with 405 in 2018, 109 in 2017 and 164 in 2016. Phoronida was also very abundant in 2019 with 2163 individuals. These organisms

were also highly abundant in previous years (with 222 recorded in 2018, 935 in 2017 and 1127 in 2016), but 2019 did have much higher abundance than any of these years (Figure 3-1 and Table 3-1).

Mollusca and Sipuncula were next most abundant. There were 357 molluscs identified in 2019 (a significant drop from the 1297 individuals in 2018 but more similar to the 340 recorded in 2017 and 221 in 2016). A total of 240 Sipuncula were identified in 2019, which was much higher than any previous year (at 42 in 2018, 22 in 2017 and 23 in 2016) (Figure 3-1 and Table 3-1).

The abundance of Echinoderms and Nemertia were similar to previous sampling years. In 2019, 60 echinoderms were recorded (with 64 in 2018, 114 in 2017 and 115 in 2016). There were 77 Nemertia identified in 2019 (with 61, 59 and 73 in 2018, 2017 and 2016 respectively). The abundance of the remaining taxa (i.e. Bryozoa, Chaetognatha, Chordata, Cnidaria and Porifera) were typically quite low, with below 22 individuals (for Platyhelminthes). In most cases the total numbers of these taxa were slightly higher than or very similar to previous sampling years (Figure 3-1 and Table 3-1).

Table 3-1 Summary of infauna Phylum identified in 2019 including the number of families (richness) and total number of individuals (abundance). The 2016 – 2018 comparative values are also provided.

Phylum	Richness 2019	Abundance 2019	Richness 2018	Abundance 2018	Richness 2017	Abundance 2017	Richness 2016	Abundance 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**

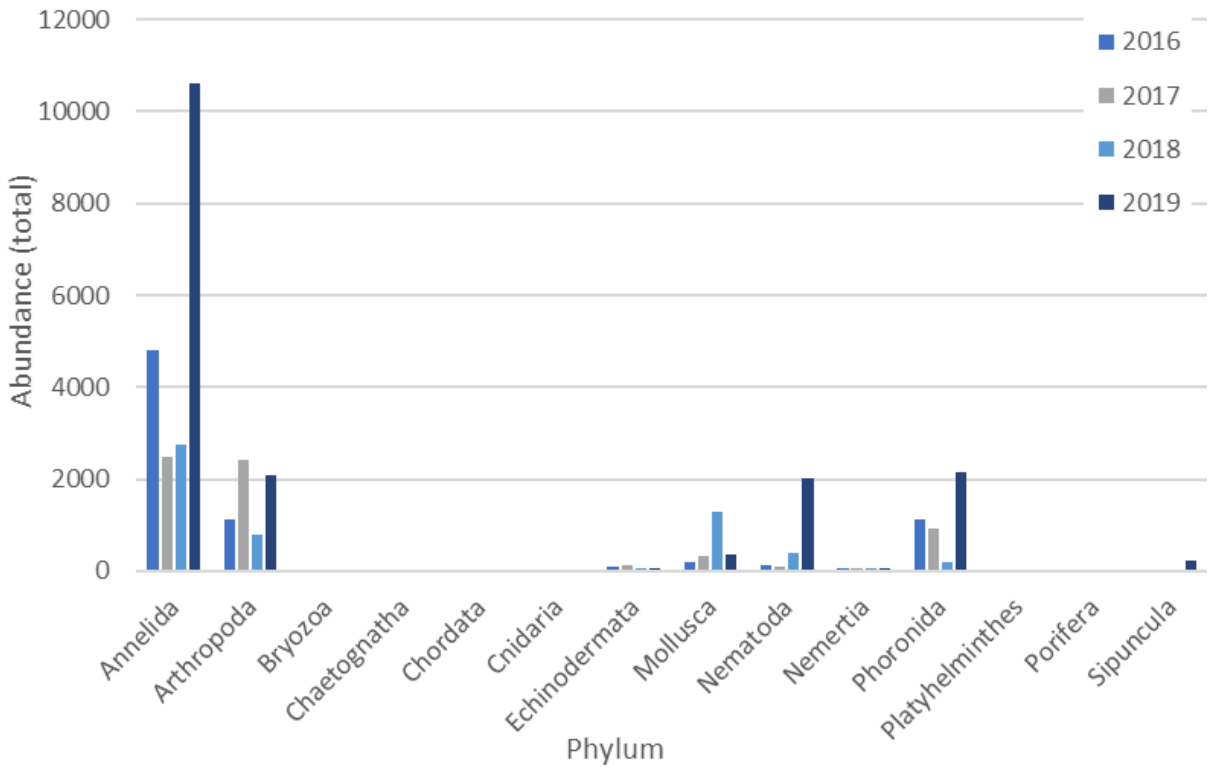


Figure 3-1 Total abundance of individuals for each Phylum identified from 2016-2019.

The raw infauna data for 2018 shows that the vast majority of Annelida identified were from the family Polygordiidae (7526 individuals), with Spionidae (1897 individuals) and Syllidae (305 individuals) being the next most common in this Phylum. The total abundance of different annelid families has varied quite widely between sampling years; however, the most abundant families do tend to stay the same, albeit with changes in abundance between years.

In 2019 the most abundant Arthropod family was Bodotriidae (Bodotriid cumaceans), with 430 individuals. Anthuridae isopods were also quite abundant with 272 individuals, as were a number of amphipod families including Phoxocephalidae (259 individuals), Caprellidae (213 individuals), Platyischnopidae (193 individuals) and cf Aoridae (186 individuals).

The most abundant families within the Phylum Molluscs in 2019 were Macrtidae (Mactrid clams) and Heterodonta (Heterodont clams (juveniles)) with abundances of 98 and 96 respectively. The family of Trochidae, which had been very abundant in 2018 (1071 individuals) only had 22 individuals in 2019.

The Phylum Nematodes (as Nematoda spp.) had very high abundance in 2019 with 2025 individuals (compared to 405 individuals in 2018). The family Phoronidae (horseshoe worms) from the phylum Phoronida had 2163 individuals in 2019. This family was also quite abundant in 2016 and 2017 (but not as much in 2018). Sipunculiformes spp. (peanut worms) from the phylum Sipuncula had 240 individuals in 2019, however, was not found to be particularly abundant in any previous sampling year.

Four years of survey have shown there is a continual and significant shift in the most dominant infauna Phylum and families, their comparative richness and total abundance between sampling years. While some Phylum remain most dominant (e.g. Arthropods and Annelids), the abundance of individual families within these Phylum differs between years. In 2019 some Phylum became more dominant than

they had been previously (e.g. Nematoda, Phoronida and Sipuncula) or showed a shift back to abundances more similar to those seen in earlier sampling events (e.g. Mollusca).

3.2.2 2016 Results

For benthic infauna assemblages, a total richness of 97 infauna taxa (families) were identified. Annelids were the most abundant Phyla, followed by Arthropods and Phoronids. Various analyses found there were significant differences between the majority of sites for all of the response variables (abundance, richness, diversity and polychaete ratio). Replicates within sites were most often more similar to each other than to replicates from other sites. The data suggested that a few prevalent taxa varied with increasing distance from the outfall. These taxa were mainly Polygordiidae, Phoronidae and Spionidae. The infauna study found only minor evidence of an effect from the outfall as evidenced by an elevated polychaete ratio at sites closer to the outfall and the very low abundance of infauna recorded from the two sites closest to the outfall. Infauna richness was also relatively low at the two outfall sites but not as low as values recorded at sites further away. When compared to the previous investigations, there was evidence indicating a possible shift in infauna assemblages, from crustaceans, being the most common taxa near the outfall in 2006, to polychaetes, being most common near the outfall in 2016.

3.2.3 2017 Results

Overall, infauna assemblages in 2017 were similar to in 2016, although there were some new taxa recorded as well as some previously reported families that were not present. A total richness of 84 infauna taxa (families), consisting of 6885 individual organisms (i.e. total abundance), was identified in 2017, a slight reduction from the 97 taxa and total abundance of 8104 recorded in 2016. Annelida, Arthropoda (Crustaceans) and Phoronida were the most abundant taxa (Phylum) in 2017, as previously recorded in the 2016 survey. Of note was the slight reduction in the number of families and significant reduction in the number of individuals of the Phylum Annelida. In addition, the slight reduction in the number of families but significant increase in number of individuals of Arthropoda.

The families Spionidae and Polygordiidae of the Phylum Annelida, the families of Amphipoda and an undifferentiated family of the Phylum Arthropoda (Copepods), and family Phoronidae from the Phylum Phoronida, were especially abundant. This was similar to in 2016.

The Shannon diversity index (based on family level data) was lowest at the sites located nearest the outfall (5 m and 20 m sites) and there was also some indication of an impact out to 100 m from the outfall (which was not evident for Shannon diversity in the 2016 study).

Polychaete ratio was highest at the outfall sites 5N and 5S, was low and relatively consistent at all sites located between 20 m and 500 m from the outfall and rose again slightly at the two reference sites. A highly localised zone of impact in terms of polychaete ratio was seen in 2017, more localised than in the 2016 survey where polychaete ratio was highest at sites between 20 m and 100 m.

Infauna abundance generally decreased with distance from the outfall, in both directions, with highest abundance found at the outfall site 5S and both the 20 m sites. In 2016 patterns of infauna abundance differed, with levels of abundance low at the two outfall sites.

Taxa richness (based on family level data) was lowest at the outfall site 5N and there were no other consistent or strong patterns of richness with distance from the outfall. This was also similar to results recorded in 2016.

Univariate analysis of variance (ANOVA) on family level data found that there were significant differences between sites for all the response variables (i.e. diversity, polychaete ratio, abundance and richness). Multivariate multidimensional scaling (MDS) analysis provided a weak indication of differences between sites and between years. Further multivariate analysis using PERMANOVA identified statistically significant differences between sites and between sampling years at individual sites. No statistically significant impact of direction (i.e. north or south) on infauna assemblages was found indicating that the prevailing northward current was not having any measurable impact on infauna to the north of the outfall.

SIMPER analysis suggested that a few prevalent taxa vary with increasing distance from the outfall in 2017. These taxa are mainly Arthropoda, Phoronidae and Spionidae, the same as in 2016.

Polychaetes and crustaceans were highly abundant around the outfall (i.e. at the 5 m and 20 m sites) in 2017. In 2016, Advisian reported that when compared to the previous investigations, there was evidence indicating a possible shift in infauna assemblages, from crustaceans being the most common taxa near the outfall in 2006, to polychaetes being the most common taxa near to the outfall in 2016. Results from the 2017 survey further confirmed temporal variability in the dominance of the most common taxa around the outfall.

3.2.4 2018 Results

Overall, infauna assemblages in 2018 were similar to previous years (2016 and 2017), with some variability in the families within Phyla and their relative abundances recorded. A total richness of 100 taxa (families) consisting of 5903 individual organisms (i.e. total abundance) was recorded in 2018. Richness was slightly higher, and abundance lower, than in previous years. The most abundant infauna Phylum in 2018 were Annelida, Arthropoda, Mollusca and Nematoda, which was somewhat similar and somewhat different to the previous sampling years. The families Polygordiidae (polychaete worms of the Phylum Annelida) and Trochidae (of the Phylum Mollusca) were particularly abundant in 2018 and were found to contribute strongly to the significant differences detected between sites. Polygordiid worms were most common at sites close to the outfall whereas Trochids were most common at sites located further away from the outfall.

No strong patterns for Shannon diversity (at the family level) with distance from the outfall were detected in 2018 (which was similar to in 2016). This was dissimilar to in 2017 where the Shannon diversity index was lowest at the sites located nearest the outfall (5 m and 20 m sites) and there was also some indication of an impact out to 100 m from the outfall.

As found in all previous surveys, polychaete ratio in 2018 was significantly higher (and had higher within site variability) at sites located near to the outfall and was low (with much lower variability) at most other sites (although levels were slightly higher at 20S and Swansea). A highly localised zone of impact in terms of polychaete ratio was seen in 2017 (highest at sites 5N and 5S), more localised than in the 2016 survey where polychaete ratio was highest at sites between 20 m and 100 m.

In 2018, infauna abundance tended to decrease with distance from the outfall, in both directions, which was similar to the findings of 2017 and was likely associated with the high numbers of polychaetes present. In 2016, patterns of infauna abundance differed slightly, with levels of abundance low at the two outfall (5N and 5S) sites.

Taxa richness (based on family level data) fluctuated considerably between sites in 2018 with peaks at 100N and Outfall S and lowest richness values at 200N and 500N. No strong patterns in richness

relating to distance from the outfall could be detected, however, a very weak indication of increased richness within 100 m of the outfall was evident. In 2016 and 2017 no consistent or strong patterns of richness with distance from the outfall were recorded.

SIMPER analysis on the 2018 data suggested that the abundance of two prevalent taxa varied with increasing distance from the outfall, contributing highly to the differences seen between sites. These were Polygordiidae (polychaete worms) and Trochidae (molluscs). In 2016 and 2017 SIMPER analysis also suggested that a few prevalent taxa varied with increasing distance and these taxa were mainly Arthropoda, Phoronidae and Spionidae.

3.2.5 2019 Results

The 2019 benthic infauna study again showed some temporal changes in infauna assemblages from the previous surveys. The overall taxa richness in 2019 (111 families) was slightly higher than previous sampling years and total abundance was considerably higher in 2019 with 17688 individuals identified. The most abundant Phylum identified in 2019 were Annelida (with much higher abundance than any other taxa), Arthropoda, Nematoda and Phoronida, similar to previous years.

In 2019, Shannon diversity values were typically lowest at sites within 100 m of the outfall (and at 500N) and diversity values were highest at the sites North Ref and 200N. There were significant differences detected between sites for Shannon diversity in 2019. Two-way ANOVA found that there was a significant interaction between distance and year, indicating that differences in Shannon diversity which occurred between distances differed between years.

In 2019 polychaete ratio was higher around the outfall sites, indicating a highly localised zone of impact related to this index as has been seen previously. In 2019, polychaete ratio was highest at the site 20N. There was no strong consistent gradient effect seen with distance from the outfall, however, a zone of impact (increased polychaete ratio) out to around 100 m in the southern direction was apparent. Two-way ANOVA found that there was a significant interaction between distance and year, indicating that differences in polychaete ratio which occurred between distances differed between years.

In 2019, infauna abundance was highest in close proximity to the outfall, particularly at the site 20S. Abundance was also very high at the two outfall sites, 20N and 100N, and was much higher than all previous years. There were significant differences between sites for abundance (family level) in 2019. Two-way ANOVA for abundance found that there was a significant interaction between distance and year, indicating that differences in abundance which occurred between distances differed between years.

In 2019, levels of richness fluctuated considerably between sites, with peaks at 100N and North Ref and lowest richness values seen at 500N, 200S, 500S and Swansea. There was some indication of increased richness at sites around the outfall. Significant differences between sites were found for taxa richness. The two-way ANOVA undertaken for infauna richness found significant differences for the fixed factor of year and the random factor of site (distance) but no significant interactions between factors. This indicates that the patterns in richness seen were similar between years.

Multidimensional scaling also showed differences between the four sampling years, with samples from each year being somewhat grouped together. It also showed that the 2016 and 2017 data and the 2018 and 2019 data were more similar to each other. The n-MDS plots did not show any strong

gradient effect of impact with distance from the outfall, however, they both showed a weak grouping of samples from sites located closer to the outfall.

PERMANOVA results for all four sampling years showed here was a significant interaction between Year x Distance and Year x Site (Distance). These results suggest that there are differences in infauna assemblages between distances, but these are not consistent between years. The results suggest that there is significant natural variability which changes between years.

SIMPER analysis undertaken on the 2019 data indicated that a few prevalent taxa contributed most to the differences seen between sites. These included Polygordiidae (polygordiid worms, Phylum Annelida) and Phoronidae (horseshoe worms, Phylum Phoronida) (both particularly prevalent around the outfall), Spionidae (spionid worms, Phylum Annelida) (most abundant at sites 100S, 500N and North Ref, with lowest abundance at 100N) and Amphipoda spp. (amphipods, Phylum Arthropoda).

3.2.6 Summary

Spatial and temporal variation is common in infauna communities, even in the absence of a potential impact. As for previous years, impacts on infauna in 2019 were generally found to be localised to within around 100 m of the outfall. Given the data provided in the current and previous years' reports, yearly shifts in the abundance of infauna are occurring in the Belmont Ocean Outfall area, with high numbers of some organisms fluctuating between surveys. The significant interactions between distance and year detected for most indices (abundance, diversity and polychaete ratio) indicate that the significant differences between distances are not consistent between years. However, the lack of an interaction between these factors for richness, and significant results for the fixed factor of year and random factor of site (distance), shows more consistency in these results over time.

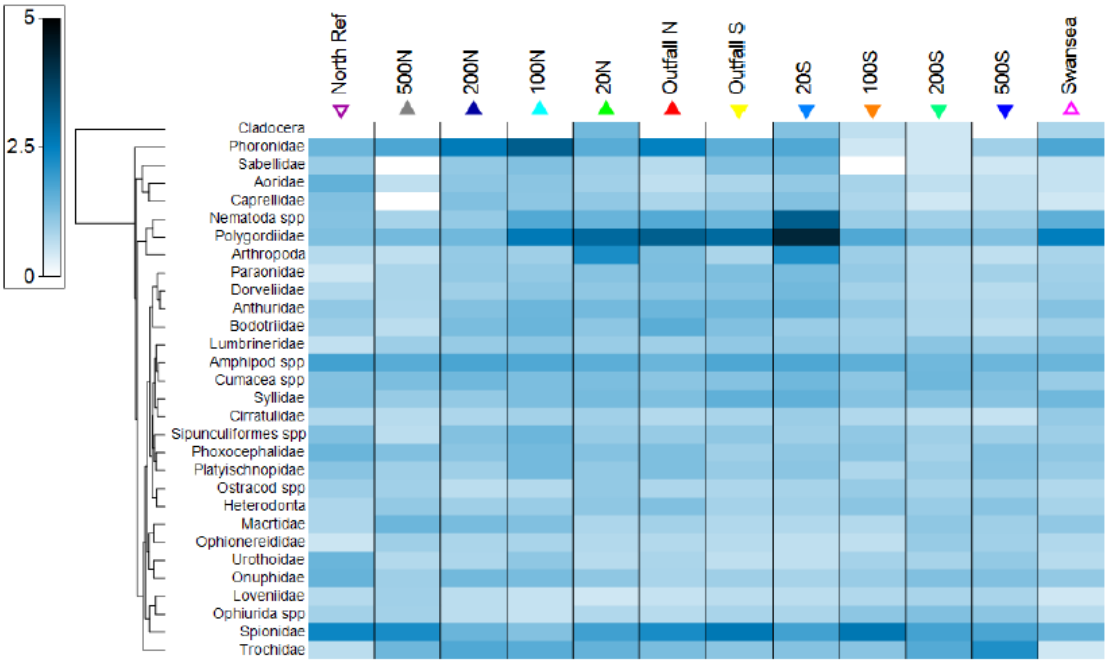


Figure 3-2 Shade Plot of the relative abundance of infauna taxa groups (fourth square root transformed)) for all sampling events among sites (pooled sampling events) from 2016-2019 (where abundance is represented by a spectrum of shades of blue, from white (absent) to dark blue (most abundant).

The results of the four annual surveys undertaken by Advisian to date (2016 to 2019) indicate that discharge of effluent from the Belmont outfall has a small (localised) and variable effect on infauna adjacent to the point of discharge (Figure 3-2). While a localised 'zone of impact' has been detected for several indices in multiple years, typically extending to 100 m, a consistent 'gradient' of impact with distance from the outfall is not typically seen beyond this distance. In addition to this impact, natural variability within the system is also occurring and may also be responsible for some of the differences observed. Overall however, the magnitude of impact (on benthic infauna) is small and the extent of impact is localised.

4 Local Benthic Epifauna

4.1 Belmont WTW Ocean Outfall Pipeline

The benthic ecology of the Belmont WWTW Ocean Outfall Pipeline was described using observational data collected during a 2018 survey (GHD 2018) the February 2019 benthic infauna survey (Advisian 2019) and a targeted benthic ecology survey undertaken by divers in February 2020 (Advisian 2020).

4.1.1 Opportunistic Observations 2018

A review of the 2018 footage of the pipe 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. Other sessile organisms present within the sponge garden include encrusting and solitary ascidians e.g. *Pyura spinifera*, and a variety of encrusting and erect algal species (GHD 2018).

Together, these sessile organisms form a diverse biogenic habitat that supports an array of invertebrate and fish species. Crinoids were also 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 (Figure 4-3).

4.1.2 Opportunistic Observations 2019

In February 2019, a number of still photographs were taken of the horizontal (top) and vertical (sides) surfaces of the Belmont WWTW Ocean Outfall Pipeline during the benthic infauna survey. Identifications of the sessile flora and fauna observed on the pipeline were made from these photographs and are provided in Table 4-1. The taxa identified on the vertical and horizontal surfaces of the pipeline were very similar. Invertebrate organisms included sponges, sea anemones, echinoderms and soft corals. Several fish and shark species were also observed around the pipeline (refer to Section 2.4), likely feeding or utilising the relatively complex habitat (in a typically bare sand environment) for shelter. Some representative images of the horizontal pipeline surface from February 2019 are provided in Figure 4-1 and vertical surface in Figure 4-2.

Table 4-1 Identifications of Belmont Outfall pipeline taxa, February 2019.

Taxa Group	Species Identified
Sponges	Class Demospongiae, various species particularly: ▪ Genus Chondropsis ▪ Genus Dactylia ▪ Genus Holopsamma Class Calcarea, Order Clathrinida
Anemones	White-striped anemone (*Anthothoe albocincta*)
Corals	Soft coral (Order Alcynacea) – Capnella sp.?
Echinoderms	Feather star (*Ptilometra australis*)

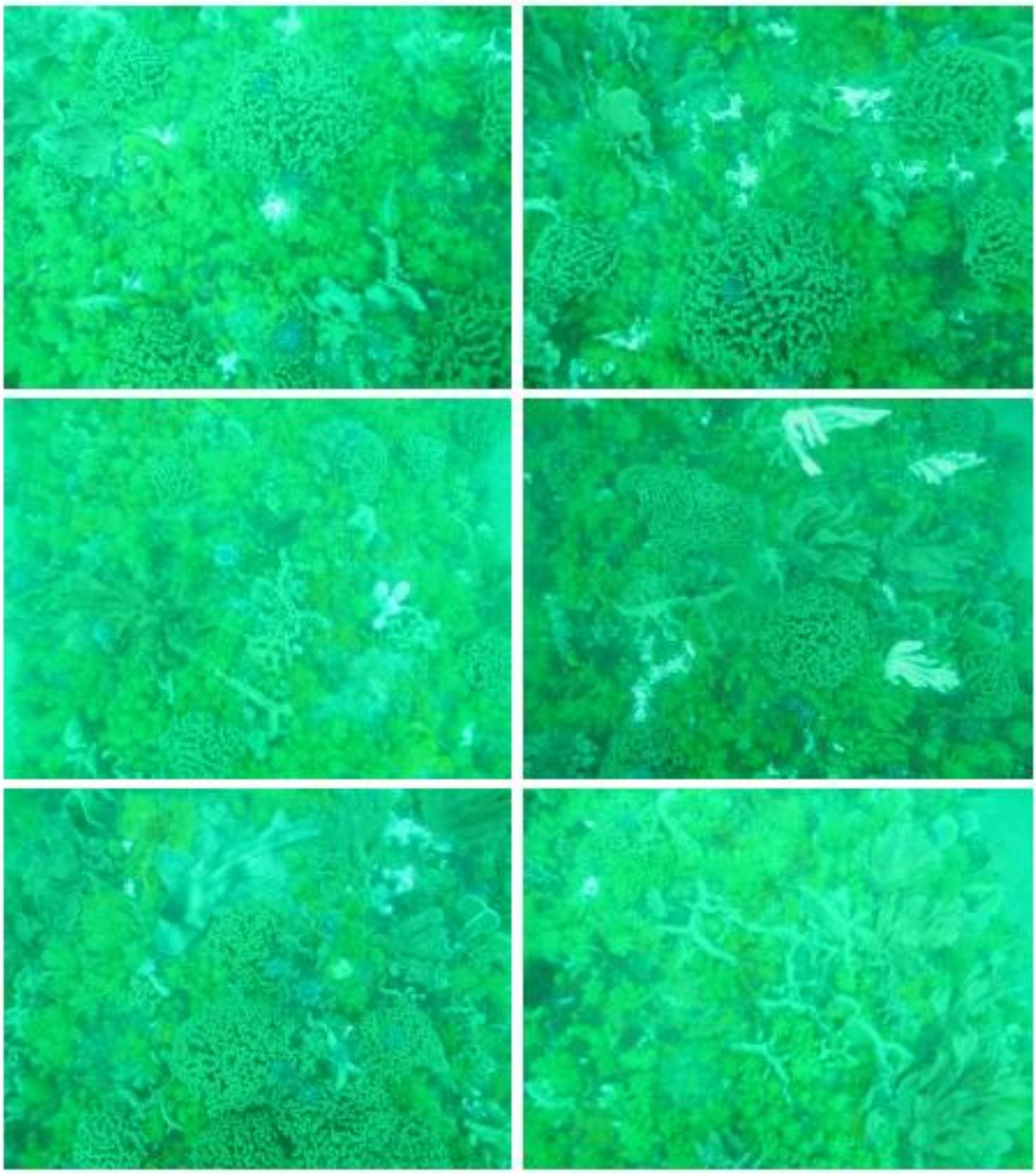


Figure 4-1 Horizontal (upper) surface of the Belmont pipeline, February 2019.

Figure 4-2 Lateral view - Vertical (side) surface of the Belmont pipeline, February 2019.

4.1.3 Benthic Pipeline Survey 2020

During February 2020, four dives were made specifically to qualitatively identify benthic organisms inhabiting the Belmont WWTW Pipeline. Photographs were taken of as many organisms as possible and later identified. Underwater visibility during all these dives was very poor, despite retrying surveys over two separate weeks (10 cm - 0.5 m) and therefore the ability to obtain images was limited. Images from this survey are shown in Figure 4-3 and identifications from this survey in Table 4-2.

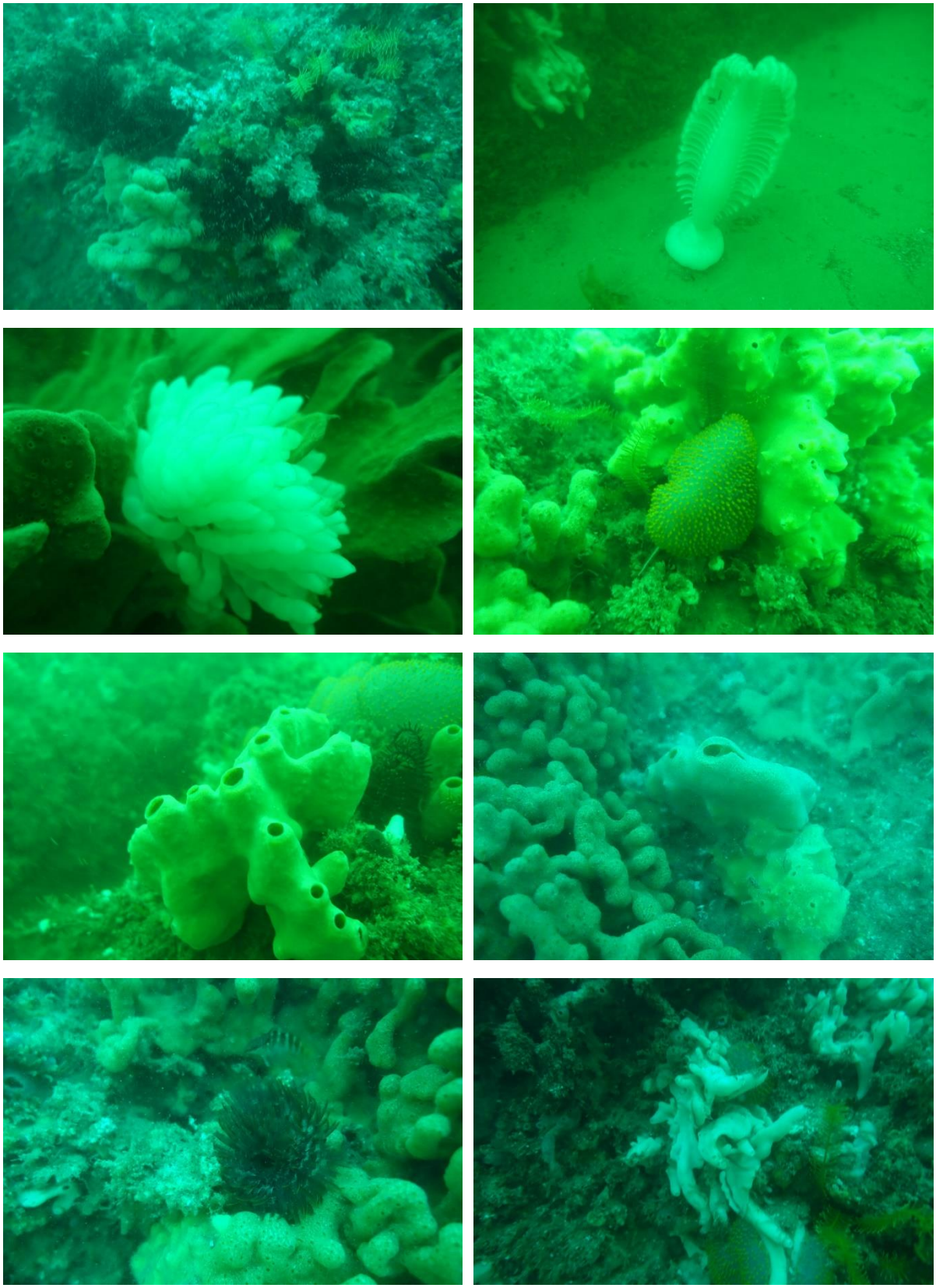


Figure 4-3 Benthic organisms inhabiting the outfall pipeline in February 2020.

Table 4-2 Identifications of Belmont Outfall pipeline taxa, February 2020.

Taxa Group	Species Identified
Sponges	Class Demospongiae, various species particularly: ▪ *Clathrinid* sp ▪ *Chondropsis* sp ▪ *Holopsamma laminaefavosa* ▪ Darwinella sp.
Corals, anemones and sea pens	Sea pen (*Sarcoptilus grandis*) Red anemone (*Phlyctenanthus australis*) Soft coral (*Capnella* sp.) Sun coral (*Tubastrea* sp.)
Marine worms	Fan worm (*Sabellastarte australiensis*)
Molluscs	Squid egg mass (*Sepioteuthis australis*)
Echinoderms	Feather star (*Ptilometra australis*) Feather star (*Cenolia trichopteran*) Brittle star (*Ophiotix* sp.)
Ascidians	*Polycitor giganteus* *Pyura spinifera* *Herdmania grandis* Potential – Didemnid sp.

5 Assessment of Potential Impacts

5.1 Construction Activities

Two different construction methods for installing the intake pipeline were assessed by WSP (2020); Horizontal Directional Drilling (HDD) and Microtunnelling (or Pipejacking) as summarised in Section 1.2.3.

Construction impacts are primarily related to installation of the intake structure and intake pipeline. Potential impacts will vary depending on the method of installation. The HDD and microtunnelling methods both involve drilling or tunnelling from land, with very little direct interaction with the seabed, except at the point where the pipeline exits the seabed (HDD method) or where the rise shaft connects to the intake structure. The main impacts associated with installation of the pipeline and riser, relates to the physical disturbance of the seabed caused by the drilling and the disposal of cuttings from the drilling activity. There will also be a small direct loss of seabed habitat where the drilling and construction activities occur, and indirect impacts associated with turbidity, and increases in light attenuation and potential smothering caused by plumes. Turbid plumes associated with construction activity will tend to be localised and short-term in duration, resulting in only minor environmental impact. Other potential impacts relating to grouting discharge are also considered minor. A summary of construction related impacts is provided in Table 5-1.

Table 5-1 Summary of Key Construction Related Impacts

Potential Impact	Description
Underwater Noise	Transient noise during construction associated with drilling and/or tunneling. Micro-tunneling is expected to generate the least noise.
Pollution (water pollution)	HDD and tunneling usually require the use and recirculation of drilling fluids which have the potential to leak into the environment. A small volume of cuttings may also be released to the environment where drilling and tunneling exit the seabed.
Habitat disturbance (sandy habitat)	Physical disturbance to the environment. The installation of the pipeline will require disturbance to marine habitat on the seabed. Construction methods will result in minor habitat disturbance as they occur below the seabed. A minor disturbance is likely with the HDD method at the location where pipeline exists the seabed. Installation of the riser will also require minor disturbance to the seabed at the end of the pipeline.
Interference with other users	Interference with human activities, including commercial and recreational fishing; proposed construction methods will result in minor interference, except during the period of riser installation.
Impact to protected species	There are no threatened or protected species that will be impacted significantly by the construction of the intake.

5.1.1 Impacts on Fish

Installation of the intake pipeline is expected to cause very localised and minor disturbance to a very small area further offshore which may be used by demersal fish species. With all construction options, the disturbance represents a very small area of equivalent total habitat available along Nine Mile Beach and impacts to fish are considered highly unlikely.

Some minor and temporary noise impacts on fish in the immediate vicinity of the proposed works may occur during construction. This will likely result in avoidance behavior, but these effects are likely to be very short term in duration.

The turbidity generated by the construction activities is also unlikely to be of a threshold high enough to impact on fish as the medium to coarse grained sand in the construction zone is likely to generate only very minor turbid plumes when disturbed.

Overall, it is not considered that any potential construction impacts on fish species identified as having the potential to occur within the study area would be significant (specifically on sand dwelling / demersal fish species which may occur around the intake location, as identified in Section 2). While formal Assessments of Significance under the FM Act 1994, BC Act 2016 and EPBC Act 1999 have been made by GHD (2020), it can be assumed from the impact assessment above that there would be no significant impacts on any threatened or protected fish species with the potential to occur in the study area which would significantly threatened their livelihood, disrupt breeding cycles, fragment populations or place any local threatened population at risk of extinction.

5.1.2 Impacts on Benthic Infauna

Installation of the intake pipeline using the proposed methods i.e. drilling and tunneling, will result in minimal disturbance to benthic infauna as there is minimal potential interaction with the seabed. A small area of seabed containing infauna will be lost where the riser is constructed, and this will be an area no greater than 65 m^2.

With all construction options, the disturbance represents a very small area of equivalent total habitat available along Nine Mile Beach and impacts to infauna are considered negligible.

5.1.3 Impacts on Benthic Epibiota (Flora and Fauna)

The only significant epibiota present within the study area are the species present along the existing ocean outfall pipeline as outlined in Section 4.1.3.

No direct impact from construction activities or indirect impacts through noise or turbidity are expected on the epibenthic species present on the existing pipeline.

5.2 Operational Activities

Operational impacts are primarily related to the presence of the intake structure and its operation and the presence of the outfall pipeline and its operation. To address the key issue associated with operation of the outfall, detailed brine dispersion modelling was commissioned to assess impacts associated with each of the TDP options. The impact assessment associated with brine discharge is based on the following modelling reports:

- Belmont Drought Response Desalination Plant – Brine Modelling Assessment (GHD 2019) and
- Belmont Drought Response Desalination Plant – Amendment Report, Brine Modelling Assessment (GHD 2020).

The extent of impact on the marine environment from brine discharge can vary depending on the discharge method, source water salinity and quality, site conditions and ecosystem type (NAS, 2008). Accordingly, the detailed modelling undertaken by GHD (2019, 2020) confirmed the following for both the 15ML and 30ML/day TDP options:

- The marine toxicity WQO is met within ~1 m of the diffuser because of the low required dilution factor of <1. The near-field modelling predicts this dilution factor is met immediately upon release into the marine environment.
- The spatial area to meet the near-surface salinity WQO is predicted to be relatively smaller as the dilution factor for the near-seabed salinity WQO is readily met in the immediate vicinity of the diffusers.
- The spatial area of effect of the marine ecosystem WQO is predicted to be similar across dry and wet season periods for the proposal and amendment scenarios.

A summary of additional potential effects was provided in Clark et al. (2018). Other potential effects of brine on water quality include changes in temperature and dissolved oxygen, although these are generally only issues for thermal plants (Lattemann and Hopner 2008). Brines can also contain toxic contaminants, such as metals, anti-scalants, coagulants and coagulant aids, antifoaming agents and cleaning chemicals (Roberts et al. 2010), which can accumulate in sediments around outfalls (Muhammad 2002; Romeril 1977) or in marine organism tissues (Lin et al., 2011). Additionally, brine can lower pH, which can negatively impact calcifying marine organisms (Fabricius et al. 2013).

The amount of near-field dilution will depend primarily on the receiving water currents, the discharge velocity, and angle of discharge (Chin 1987). Without proper dilution, a plume of elevated salinity discharge may extend for a considerable distance beyond the mixing zone resulting in impacts to marine ecosystems. Even after dilution, concentrate will be of higher salinity than receiving water and tend to sink and settle along the bottom of the marine environment, making benthic habitat and communities the most vulnerable to potential impacts.

RO desalination plants also require substantial intake of sea water, which can result in impingement (i.e. trapping of organisms on screens) and entrainment (i.e. organisms being drawn into the plant), (Latterman & Hopner 2008). Studies conducted for Sydney desalination found that flow rates of 0.1 m/s do not impinge larger fish and animals but smaller species including phytoplankton, zooplankton and icthyoplankton are likely to be impinged or entrained (Ecology Lab 2005).

Table 5-2 Summary of Key Operation Related Impacts

Potential Impact	Description
Entrainment from Seawater Intake	Removal of larval and adult fish and invertebrates from the ecosystem. The larvae of fish and a great number of invertebrate species spend variable amounts of time as part of the planktonic community and may be unable to escape predicted intake current speeds of 0.15 m sec -1. This current speed is less likely to pose a threat to most of the larger (i.e. non-larval) fishes and mobile invertebrates. There is currently little information on which to base estimates of the range of species or biomass that could be entrained from offshore intakes and how this compares with the total number of larvae occurring within the nearshore areas of Belmont. Biota entrained into the desalinisation plant would have a mortality rate of 100%. Any biota unable to escape a current speed of 0.15 m sec -1 could become drawn into the plant (entrained) and would need to be removed during the pre-treatment process.
Impingement (i.e. marine biota caught on screens by the speed and force of the intake current).	Generally, larger animals such as fish can swim away from intake currents, but smaller fish, jellyfish and other floating biota could become trapped on intake screens, potentially clogging screens and requiring more power to maintain intake current speeds. The survival of biota impinged on intake screens depends on the design of the screens, speed of the intake current, size, age and species of organism and water conditions.
Brine Discharge	Brine discharge from seawater desalination can have variable impact on the marine environment depending on the discharge method, source water salinity and quality, site conditions and ecosystem type. Under the 15ML/day and 30ML/day options, minimal impacts to benthic habitat are anticipated with only a very small area of seabed that could be exposed to an effluent plume of 1PSU (13 fold dilution, equivalent). The GHD (2020) modelling confirmed that dilution factor for the near-seabed salinity WQO is readily met in the immediate vicinity of the diffusers. The 65 ML/day TDP option has the greatest potential to impact the existing seabed (including pipeline epibenthic fauna) as the modelling shows a much larger area of seabed that will be influenced by above 1PSU effluent-brine salinity. Infauna (and existing pipeline epibiota) are the most vulnerable to these effects as they have limited mobility and are the dominant community type in the vicinity of the existing outfall. Larger, mobile animals such as adult fish are likely to be able to avoid the plume in the immediate vicinity of the discharge, but smaller invertebrates

	(and some species of fish) living in or near reefs (or along the existing pipeline) would be unable to escape its influence.
Water Quality (Chemicals in Brine)	Brines can also contain toxic contaminants, such as metals, anti-scalants, coagulants and coagulant aids, antifoaming agents and cleaning chemicals (including chlorine and biproducts) some of which can accumulate in sediments around outfalls or in marine organism tissues. Brine can lower pH, which can negatively impact calcifying marine organisms. There are therefore multiple pathways by which brine can impact the marine environment, including changes in salinity, temperature, water quality, hydrology, and pollution with contaminants. These are unlikely to be an issue with the 15ML/day and 30ML/day TDP options, however improvements to diffuser performance are recommended for the 60ML/day option to ensure that dilution and dispersion of contaminants is sufficient to minimize any potential for impact.

5.2.1 Impacts on Fish

The potential impacts of desalination on fishery productivity include changes caused by habitat creation or destruction, barriers to movement (from a layer of brine), impingement and entrainment and changes in nutrient loads (RPS 2009). Modelling undertaken by GHD (2020) has confirmed that for both the 15ML and 30 ML options, the spatial area to meet the near-surface salinity threshold to minimise effects on marine biota is predicted to be of limited spatial extent as the dilution factor for the near-seabed salinity thresholds is readily met in the immediate vicinity of the diffusers. Similarly, the relevant marine toxicity threshold is met within ~1 m of the diffuser because of the low required dilution factor of <1. Near-field modelling predicts this dilution factor is met immediately upon release into the marine environment from the diffuser. Impacts on fish are therefore determined to be unlikely as discussed in the sections below.

Intake

The extent of environmental impact associated with the intake is site-specific and varies depending on design of the intake system (screen size, intake velocity rate, position, depth). The volume of intake water and the flow rate is also likely to influence the level of impingement and entrainment of fish and fish larvae as does the intake location, ambient hydraulics (low currents produce a higher risk), water quality (temperature and dissolved oxygen impact mobility) (Missimer and Maliva 2018). Options to mitigate impingement and entrainment include installation of mesh screens, reducing flow velocity and ensuring the source water is drawn from an area of relatively low fish productivity (Latterman and Hopner 2008).

Entrained organisms are killed by pressure and velocity changes caused by circulating pumps in the plant, chlorine and other chemicals used to prevent corrosion and fouling, and predation by filter feeders (mussels, barnacles) that line the intake pipes (Missimer and Maliva 2018). The GHD (2020) report also refers to use of an intake structure be in the form of a horizontal intake with a velocity cap structure and low through-screen velocity to minimise impacts on marine species and habitat.

In contrast, the physical presence of the riser will most likely have a positive effect as it is likely to be colonized by reef fish and species similar to that already present along the outfall pipeline. Artificial structures, like that of the desalination outlet infrastructure, is generally associated with greater abundances of fish. They provide a habitat for colonization, changing water flow, light, and refuge (Kelaher et al. 2019).

Outfall

The extent of impact associated with discharge from the outfall can also vary and will likely depend on a range of factors including the salinity of the discharge and its toxicity, which is largely dependent on the extent of dilution and mixing by the diffusers.

A seven year study of the Sydney desalination plant by Kelaher et al. (2019) identified the following changes to fish populations:

- An increase of fish abundance by 279% at the outlet site.
- Hypersaline discharge positively influenced abundances of pelagic and demersal fish, whose numbers increased by 218% and 329% respectively following the commencement of discharge.
- On average there was 32% more herbivorous fish near the outlet compared to reference sites away from the outlet.
- A trend for greater fish species richness at the outfall compared to reference areas.
- Hypersaline discharge did not significantly influence benthic or herbivorous fish abundances at the outlet.

As no significant structural modifications are proposed at the existing outfall to accommodate the desalination discharge, no significant changes to the existing habitat or the fish species present is anticipated. Some changes could be expected if there is a significant change to the (volume) flow and composition of the effluent, however this is also unlikely to have a negative impact on fish species and abundance as outlined by Kellaher et al. (2019).

Fish have the potential to be impacted by toxic chemicals and additives that are used in pre-treatment and the desalination process. Chemicals include coagulants (ferrous chloride and aluminum chloride, used to remove suspended matter from source water), anti-scalants (polyphosphates and phosphonates, used to prevent formation of scale precipitates and salt deposits on equipment), biocides, anti-foaming additives and detergents.

Chlorine is also routinely used to neutralize some of the cleaning chemicals prior to discharge and is also used as a biocide to inhibit biofouling of internal pipework. It is therefore potentially toxic to marine species at low concentrations. Chlorine is rapidly converted to hypochlorous acid (HOCl) and hydrochloric acid (HCl) in receiving waters. The term' free chlorine' refers to Cl_2, HOCl and hypochlorite ion OCl- in equilibrium. The relative amounts of the different forms in equilibrium are governed by pH, temperature and ionic strength (ANZG 2018). The free, chlorine-based oxidants (Cl2, HClO, ClO-) are very short-lived (t1/2 ~ 0.2 s) in seawater and are mostly converted to back chloride ions in the marine environment (ANZECC 2000, Saeed et al. 2015, Wahab 2012). As a result, most of the chlorine-based oxidants convert the bromide (Br-) in the seawater to the equivalent bromine oxidants HBrO and BrO- which are as equally (or more) toxic than the chlorine equivalents (CEE 2018). Most modern RO plants

include dosing with sodium metabisulphite to neutralise chlorine ensuring low concentrations in waste brine (refer to RPS 2009).

Section 3 of ANZECC National Water Quality Guidelines provide trigger values for "Chlorine" (free chlorine) to protect freshwater aquatic environments. The guidelines provide a trigger value of 3 µg Cl/ L (0.003 mg/L) for 95 % ecosystem protection and 1 µg Cl/L (0.001 mg/L) for 99 % ecosystem protection. However, there is not a trigger for chlorine in marine (seawater) environments. ANZECC explains that: *"In seawater, reaction with bromine results in formation of chloride ion and HOBr"* A recent study has developed a short term guideline of 7.2 µg/L for chlorine-produced oxidants in marine waters and in the process of being included in the ANZG 2018 guidelines (Batley and Simpson 2020). The discharge from the desalination plant will need to comply with the relevant water quality guideline or interim values provided by Batley and Simpson (2020).

Heavy metal leaching into the waste stream can occur from corroding equipment (copper, zinc, nickel) which is not generally a problem for reverse osmosis plants, whilst small amounts of iron, chromium, nickel and molybdenum may be present in their concentrate from stainless steel (Pacific Institute 2013).

Some of these chemicals are toxic to marine organisms even at low concentrations but can be effectively managed through ensuring efficient dilution of the effluent prior to discharge, as recommended by GHD (2019).

Overall, it is not considered that any potential operational impacts on fish species identified as having the potential to occur within the study area would be significant (specifically on sand dwelling / demersal fish species which may occur around the intake location, and reef associated and sand dwelling / demersal species which are known to occur around the outfall - as identified in Section 2). While formal Assessments of Significance under the FM Act 1994, BC Act 2016 and EPBC Act 1999 have been made by GHD (2020), it can be assumed from the impact assessment above that there would be no significant impacts from operation on any threatened or protected fish species with the potential to occur in the study area which would significantly threatened their livelihood, disrupt breeding cycles, fragment populations or place any local threatened population at risk of extinction.

5.2.2 Impacts on Benthic Infauna

Intake

From an operational perspective, no impact on benthic infauna is anticipated from the operation or presence of the seawater inlet.

Outfall

There are a number of field studies that have assessed the impacts from desalination discharges to a range of marine habitats, including seagrass (Gacia et al. 2007), corals (Hammond et al. 1998) and benthic infauna (Pilar Russo et al 2007). The latter study involved monitoring of the brine discharge (68PSU) from a 50ML reverse osmosis plant in Alicante, Spain at 4 m, 10 m and 15 m water depths. The study measured significant changes in infaunal communities closest to the discharge where the community became dominated by nematodes after 9 months of operational discharges. During the 2 years after commencement, the change in dominance extended over a much larger area. The results from Pilar Russo et al. (2007) are not directly comparable to Belmont due to the significant differences

between the receiving environments and the concentration of the brine discharge but the study does highlight some of the potential impacts that may occur.

More recently, detailed assessments have been undertaken of the operational effects of desalination plants in Australia, in particular the published work by Clark et al. (2018) of the Sydney desalination plant. Monitoring confirmed that diffusers were highly effective in reducing salinity to 1 PSM above ambient within 100 m of the outfall discharge. The study found that polychaetes, bryozoans and sponges reduced in cover as far as 100 m from the outfall, while barnacles showed the opposite pattern and were more abundant near the discharging outfall. Ecological impacts were disproportionate to the relatively minor change in salinity (~1 psm), with authors hypothesising that impacts were primarily driven by changes in hydrodynamics caused by the diffusers, such as higher near-bed flow away from the outfall. This is consistent with flow preferences of various taxonomic groups, which differ due to differences in settlement and feeding abilities.

The study found that impacted communities were characterised by increased cover of the barnacle *Megabalanus coccopoma* and bivalves, and reduced cover of polychaetes, bryozoans and sponges. There were no significant impacts of brine discharging on species richness, Shannon-Wiener diversity, evenness, or bare space (a proxy for resource availability), at either near or far outfall locations (Clark et al. 2018).

Several major taxonomic groups responded strongly to outfall operation. The strongest negative impact was for polychaete tubeworms, which decreased in cover at both near and far outfall locations while the plant was discharging. The effect was most prominent in the first months of the discharging period, when polychaetes were almost absent at near outfall locations. On average, polychaete cover reduced by approximately 60% at near outfall locations while brine was being discharged, and effects were weaker but still significant at far outfall locations. Both bryozoan and sponge cover were negatively impacted at the near outfall location.

On temperate reefs, the covers of polychaetes, bryozoans, and sponges may be reduced out to 100 m from desalination discharge outlets, although this pattern is reversed for barnacles. There may also be fewer polychaetes, molluscs and crustaceans in soft sediments adjacent to desalination discharge outlets compared to areas further away. In some instances, however, the invertebrate and fish assemblages associated with sediment habitats may not be significantly influenced by hypersaline brine from desalination plants.

As mentioned previously, typical brine concentrate will be of higher salinity than receiving water and tend to sink and settle along the bottom of the marine environment, making benthic habitat and communities the most vulnerable to potential impacts. As the existing outfall at Belmont will discharge a blended effluent containing sewage effluent and brine, the resultant concentrate will contain a much lower concentration of salt and is therefore much less likely to form a "heavy" layer over the seabed. Modelling by GHD (2020) has predicted that the salinity of the brine-effluent mixture for both the 15ML and 30ML/day options will be lower than ambient marine salinity and therefore have minimal effect on the seabed habitat. The spatial area to meet the near-surface salinity threshold to minimise effects on marine biota is predicted to be small as the dilution factor for the near-seabed salinity thresholds is readily met in the immediate vicinity of the diffusers. In contrast, the 65ML/day TDP option has the potential to impact a substantially larger area of seabed (~300 m of diffuser) because the existing diffuser configuration would not be able to dilute this volume of effluent sufficiently. The GHD (2019) report provides recommendations for minimizing the effects of the 65ML/day option.

Design generally plays a major role in the extent to which the brine discharge affects benthic communities. From a review of literature, studies showed that when brines were released into well-flushed environments, impacts tend to be small. Furthermore, outfalls with diffusers also demonstrated lower impacts on benthic infaunal communities. (Roberts et al. 2010).

5.2.3 Impacts on Benthic Epibiota (Flora and Fauna)

Intake

From an operational perspective, no impact on benthic epibiota is anticipated from the operation or presence of the seawater inlet.

Outfall

Whilst benthic habitat and communities are the most vulnerable to potential impacts from discharge of brine, the modelling undertaken by GHD (2020) has confirmed that impacts are highly unlikely. Under the 15ML/day and 30ML/day options, minimal impacts to benthic habitat are anticipated as the dilution factor for the near-seabed salinity thresholds is readily met in the immediate vicinity of the diffusers. The 65 ML/day TDP option has the greatest potential to impact the existing pipeline epibenthic fauna as the modelling shows a much larger area of seabed that will be influenced by above 1PSU effluent-brine salinity. This is likely to result in potential changes to the pipeline community unless modifications to the diffuser are undertaken to improve dilution. Effects to benthic epibiota will be limited to the pipeline ecosystem as the seabed surrounding the outfall is predominantly sandy seabed with few epibenthic species present.

5.3 Summary

Construction impacts are primarily related to installation of the intake riser and intake pipeline. Potential impacts on the marine environment will vary depending on the method of installation (e.g. HDD or micro-tunnelling). Construction impacts are primarily related to direct seabed disturbance and underwater noise and will not be significant in terms of spatial extent and duration.

Operational impacts are primarily related to the potential for entrainment at the inlet and the discharge of effluent at the outfall. Discharge of brine has the potential to impact the soft sediment habitat surrounding the outfall where poor mixing and dilution could result in the accumulation of brine over the seabed. Detailed modelling undertaken by GHD (2020) has concluded that:

- The marine toxicity WQO is met within ~1 m of the diffuser because of the low required dilution factor of <1. Near-field modelling predicts this dilution factor is met immediately upon release into the marine environment.
- The spatial area to meet the near-surface salinity WQO is very localised as the dilution factor for the near-seabed salinity WQO is readily met in the immediate vicinity of the diffusers.
- The spatial area of effect of the marine ecosystem WQO is predicted to be similar across dry and wet season periods for all scenarios.

As a result, the modelling has confirmed that the 15ML and 30ML options will have minimal impacts to fish and benthic habitat surrounding the outfall, however the 65ML option will require modifications to the existing diffuser outlet to ensure that potential impacts to fish and benthic fauna can be mitigated. By co-locating the desalination plant with the wastewater treatment facility, the potential for salinity

stress can be greatly reduced and furthermore, if concentrate is released in a way that can maximise dispersion of the effluent as recommended in the modelling report these effects could be further reduced.

6 References

ABC News (2019). Sydney desalination plant discharge boosts fish numbers by almost 300 per cent. https://www.abc.net.au/news/2019-12-19/sydney-desalination-plant-discharge-boosts-fish-numbers/11811650.

Advisian (2019). Belmont Ocean Outfall Benthic Monitoring 2019 Report. Report prepared for Hunter Water Corporation, 7 August 2019 – FINAL.

Batley, G and Simpson, S. (2020) Short-Term Guideline Values for Chlorine in Marine Waters. Environmental Toxicology and Chemistry, 39, pp. 754-764.

Brendan P. Kelaher, Graeme F. Clark, Emma L. Johnston, and Melinda A. Coleman (2020). Effect of Desalination Discharge on the Abundance and Diversity of Reef Fishes Environmental Science & Technology 2020 54 (2), 735-744 DOI: 10.1021/acs.est.9b03565.

CEE (2018). Chlorine in seawater heat exchange process at Crib Point. AGL Gas Import Jetty Project Crib Point, Western Port. Draft Report 27th February 2018 for Jacobs.

Clark, G., Knott, N., Miller, B., Kelaher, B., Coleman, M., Ushiama, S. and Johnston, E. (2018). First large-scale ecological impact study of desalination outfall reveals trade-offs in effects of hypersalinity and hydrodynamics. Water Research, 145, pp.757-768.

Clarke et al. (2018). First large-scale ecological impact study of desalination outfall reveals trade-offs in effects of hypersalinity and hydrodynamics. Water Research, Volume 145, 15 November 2018, Pages 757-768. https://www.sciencedirect.com/science/article/abs/pii/S0043135418307012

Department of Environment and Heritage (DoEH) (2020). BioNET Atlas of NSW Wildlife. http://www.bionet.nsw.gov.au/. Accessed 20 January 2020.

Department of the Environment and Energy (DoEE) (2020). Protected Matters Search Tool. (http://www.environment.gov.au/webgis-framework/apps/pmst/pmst.jsf). Accessed 20 January 2020.

Environmental Assessment of Sydney Desalination Plant (2005). GHD, Sydney Water.

Gacia, E., O. Invers, Manzanera, M., Ballesteros, E> and Romero, J. (2007). Impact of the brine from a desalination plant on a shallow seagrass (Posidonia oceanica) meadow. Estuarine, Coastal and Shelf Science 72:579-590

GHD (2020). Marine Assessment for the Belmont Drought Desalination Plant, Environmental Impact Statement. Report Prepared for Hunter Water, March 2020.

Graeme F. Clark, Nathan A. Knott, Brett M. Miller, Brendan P. Kelaher, Melinda A. Coleman, Shinjiro Ushiama, Emma L. Johnston (2018). First large-scale ecological impact study of desalination outfall reveals trade-offs in effects of hypersalinity and hydrodynamics. Water Research 145 (2018) 757-768

Hammond, M.A., Blak, N.J., Dye, C.W., Hallock-Muller, P., Luther, M.E., Tomasko, D.A and Vargo, G. (1998). Effect of disposal of seawater desalination discharges on nearshore benthic communities, Phase 2 report Southwest Florida Water Management District, University of South Florida.

Jones, G. and Candy, S. (1981). Effects of dredging on the macrobenthic infauna of Botany Bay. Marine and Freshwater Research, 32(3), p.379.

Kelaher et al. (2020). Effect of Desalination Discharge on the Abundance and Diversity of Reef Fishes. Environ. Sci. Technol. 2020, 54, 2, 735-744. https://pubs.acs.org/doi/full/10.1021/acs.est.9b03565

Kelaher, B., Clark, G., Johnston, E. and Coleman, M. (2019). Effect of Desalination Discharge on the Abundance and Diversity of Reef Fishes. Environmental Science & Technology, 54(2), pp.735-744.

Kuiter, R.H. (2000). Coastal Fishes of South-eastern Australia. Gary Allen.

Missimer, T. and Maliva, R. (2018). Environmental issues in seawater reverse osmosis desalination: Intakes and outfalls. Desalination, 434, pp.198-215.

Morris, Peter (1995). Methods of Environmental Assessment. University College London Press. p. 236.

NAS (2008). Desalination: A National Perspective. National Academy of Sciences. National Academies Press, Washington DC, USA.

NSW Department of Primary Industries (NSW DPI) (2008). Commercial fishing in New South Wales – Primefact 825. https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0009/631098/Commercial-fishing-in-New-South-Wales.pdf.

NSW Department of Primary Industries (NSW DPI) (2020). Commercial fishing – our fisheries. https://www.dpi.nsw.gov.au/fishing/commercial/fisheries.

NSW Department of Primary Industries (NSW DPI) (2020). Condition of fish communities in NSW. https://www.dpi.nsw.gov.au/fishing/habitat/your-catchment/condition-of-fish-communities-in-nsw. Accessed 20 January 2020.

NSW Department of Primary Industries (NSW DPI) (2020). Fishing: Fish species. https://www.dpi.nsw.gov.au/fishing/fish-species.

NSW Government (2020). NSW Legislation - Fisheries Management Act 1994 No 38 - Current version for 5 December 2019 to date. https://www.legislation.nsw.gov.au/#/view/act/1994/38. Accessed 20 January 2020.

Olympic Dam Expansion EIS, Appendix O: Desalination Plant Construction, 2009.

Pacific Institute (2013). Key Issues in Seawater Desalination in California: Marine Impacts. Oakland, California.

Petersen, K., Heck, N., Reguero, B., Potts, D., Hovagimian, A. and Paytan, A. (2019). Biological and Physical Effects of Brine Discharge from the Carlsbad Desalination Plant and Implications for Future Desalination Plant Constructions. Water, 11(2), p.208.

Pilar Russo, Y.D., Ossa Carretero, J.A. Giminez Casalduero, F.G. and Sanchez Lizaso, J.L. (2007). Spatial and temporal changes in infaunal communities inhabiting soft bottoms affected by brine discharges. Marine Environmental Research 64: 492-503.

Popper, A. and Hastings, M. (2009). The effects of anthropogenic sources of sound on fishes. Journal of Fish Biology, 75(3), pp.455-489.

Riera, R., Tuya, F., Ramos, E., Rodríguez, M. and Monterroso, Ó. (2012). Variability of macrofaunal assemblages on the surroundings of a brine disposal. Desalination, 291, pp.94-100.

Roberts, D., Johnston, E. and Knott, N. (2010). Impacts of desalination plant discharges on the marine environment: A critical review of published studies. Water Research, 44(18), pp.5117-5128.

Ruso, Y., la Ossa Carretero, J., Casalduero, F. and Lizaso, J. (2007). Spatial and temporal changes in infaunal communities inhabiting soft-bottoms affected by brine discharge. Marine Environmental Research, 64(4), pp.492-503.

Sánchez-Lizaso, J., Romero, J., Ruiz, J., Gacia, E., Buceta, J., Invers, O., Fernández Torquemada, Y., Mas, J., Ruiz-Mateo, A. and Manzanera, M. (2008). Salinity tolerance of the Mediterranean seagrass Posidonia oceanica: recommendations to minimize the impact of brine discharges from desalination plants. Desalination, 221(1-3), pp.602-607.

School of Biological Sciences, Flinders University (2011). Fourth Quarter Report. Adelaide Desalination Infauna Monitoring. Adelaide.

Seqwater (2020). Fact Sheet -About the Gold Coast Desalination Plant. https://s3-ap-southeast-2.amazonaws.com/ehq-production-australia/c563351449b4e20d7aee4217b221649f7b9b1e1e/documents/attachments/000/088/636/original/2017_A4_Fact_sheet_Gold_Coast_Desalination_Plant_FINAL.pdf?1538024494

Shao, D. and Law, A. (2009). SALINITY BUILD-UP DUE TO BRINE DISCHARGES INTO SHALLOW COASTAL WATERS. Modern Physics Letters B, 23(03), pp.541-544.

Southern Seawater Desalination Plant. Performance and Compliance Report 14 April 2018 – 13 April 2019. https://www.watercorporation.com.au/-/media/files/residential/water-supply/desalination/ssdp/ssdp-performance-compliance-report-2018-2019.pdf

Sustainability Matters (2018). Major desalination study finds minimal marine impact. https://www.sustainabilitymatters.net.au/content/water/news/major-desalination-study-finds-minimal-marine-impact-759394468

Sydney Desalination Plant (2020). Marine Environment. https://www.sydneydesal.com.au/caring-for-the-environment/marine-environment/

Sydney Water (2006). Sydney's Desalination Project - Marine & Estuarine Monitoring Program. Detailed Design https://www.sydneydesal.com.au/media/1092/marine-and-estuarine-monitoring-program.pdf

Veolia (2017). Marine Water Quality and Ecosystem Management Plan for Sydney's Desalination Plant. https://www.sydneydesal.com.au/media/1211/marine-wq-and-ecosystem-env-mgmt-plan-2017-00047487xce34f.pdf

Viskovich, P., Gordon, H. and Walker, S. (2014). Busting a salty myth: long-term monitoring detects limited impacts on benthic infauna after three years of brine discharge. IDA Journal of Desalination and Water Reuse, 6(3-4), pp.134-144

Wenger, A., Harvey, E., Wilson, S., Rawson, C., Newman, S., Clarke, D., Saunders, B., Browne, N., Travers, M., Mcilwain, J., Erftemeijer, P., Hobbs, J., Mclean, D., Depczynski, M. and Evans, R. (2017). A critical analysis of the direct effects of dredging on fish. Fish and Fisheries, 18(5), pp.967-985.

Appendix A
Threatened Species Searches

Fisheries Management Act 1994 No 38

Current version for 5 December 2019 to date (accessed 20 January 2020 at 10:37)

Schedule 4

Schedule 4 Endangered species, populations and ecological communities

(Section 220C)

Part 1 Endangered species

Fish

Archaeophya adamsi Fraser, 1959	Adam's Emerald Dragonfly
Austrocordulia leonardi	Sydney Hawk Dragonfly
Hippocampus whitei (Bleeker, 1855)	White's Seahorse
**Maccullochella ikei* Rowland	Eastern Freshwater Cod
**Maccullochella macquariensis* (Cuvier)	Trout Cod
**Macquaria australasica* (Cuvier, 1830)	Macquarie Perch
Mogurnda adspersa (Castelnau, 1878)	Southern Purplespotted Gudgeon, Purple Spotted Gudgeon
Nannoperca australis Günther, 1861	Southern Pygmy Perch
**Nannoperca oxleyana* Whitley	Oxleyan Pygmy Perch
**Prototroctes maraena* (Günther, 1864)	Australian Grayling
Sphyrna lewini (Griffith & Smith, 1834)	Scalloped Hammerhead Shark
Thunnus maccoyii	Southern Bluefin Tuna

Marine vegetation

Part 2 Endangered populations

Fish

Ambassis agassizii Steindachner, 1866, Agassiz's glassfish, olive perchlet, western New South Wales population

Craterocephalus amniculus (Crowley and Ivanstoff, 1990), Darling River Hardyhead, Hunter River population

Gadopsis marmoratus, river blackfish, Snowy River population

Tandanus tandanus (Mitchell, 1838), freshwater catfish, eel tailed catfish, Murray-Darling Basin population

Marine vegetation

**Posidonia australis* Hook.*f.* (1858), seagrass, Port Hacking, Botany Bay, Sydney Harbour, Pittwater, Brisbane Waters and Lake Macquarie populations

Part 3 Endangered ecological communities

Aquatic ecological community in the natural drainage system of the lower Murray River catchment (as described in

the recommendation of the Fisheries Scientific Committee to list the ecological community)

Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River (described in the recommendation of the Fisheries Scientific Committee to list that aquatic ecological community, as the area covered by that recommendation)

Aquatic ecological community in the natural drainage system of the lowland catchment of the Lachlan River (described in the recommendation of the Fisheries Scientific Committee to list that aquatic ecological community, as the area covered by that recommendation)

Aquatic ecological community in the catchment of the Snowy River in NSW (as described in the final determination of the Fisheries Scientific Committee to list that aquatic ecological community)

Part 4 Species presumed extinct

Fish

Hadrachaeta aspeta Hutchings, 1977	Marine Worm
**Pristis zijsron* Bleeker, 1851	Green Sawfish
Metaprotella haswelliana Mayer, 1882	Haswells Caprellid

Marine vegetation

**Vanvoorstia bennettiana* (Harvey) Papenfuss (1956)	Bennetts Seaweed

Fisheries Management Act 1994 No 38

Current version for 5 December 2019 to date (accessed 20 January 2020 at 10:38)

Schedule 4A

Schedule 4A Critically endangered species and ecological communities

(Section 220C)

Part 1 Critically endangered species

Fish

**Carcharias taurus* Rafinesque, 1810	Greynurse Shark
**Craterocephalus fluviatilis* (McCulloch, 1913)	Murray Hardyhead
Euastacus dharawalus (Morgan, 1997)	Fitzroy Falls Spiny Crayfish
Galaxias rostratus	Flathead Galaxias
Galaxias tantangara (Raadik, 2014)	Stocky Galaxias
Notopala hanleyi (Frauenfeld, 1864)	Hanley's River Snail
Notopala sublineata (Conrad, 1850)	Darling River Snail
Smeagol hilaris Tillier & Ponder, 1992	Marine Slug

Marine vegetation

Nereia lophocladia J. Agardh (1897)	Marine Brown Alga

Part 2 Critically endangered ecological communities

Fisheries Management Act 1994 No 38

Current version for 5 December 2019 to date (accessed 20 January 2020 at 10:39)

Schedule 5

Schedule 5 Vulnerable species and ecological communities

(Section 220C)

Part 1 Vulnerable species

Fish

Austropetalia tonyana (Theischinger, 1995)	Alpine Redspot Dragonfly
Bidyanus bidyanus (Mitchell, 1838)	Silver Perch
Branchinella buchananensis Geddes, 1981	Buchanans Fairy Shrimp
**Carcharodon carcharias* (Linnaeus, 1758)	White Shark, Great White Shark
Epinephelus daemelii (Günther, 1876)	Black Rockcod, Black Cod
Euastacus armatus (von Martens 1866)	Murray Crayfish
Microrchestia bousfieldi Lowry & Peart, 2010	Bousfields Marsh-hopper
Sphyrna mokarran Ruppell, 1837	Great Hammerhead Shark

Marine vegetation

Part 2 Vulnerable ecological communities

Australian Government
Department of the Environment and Energy

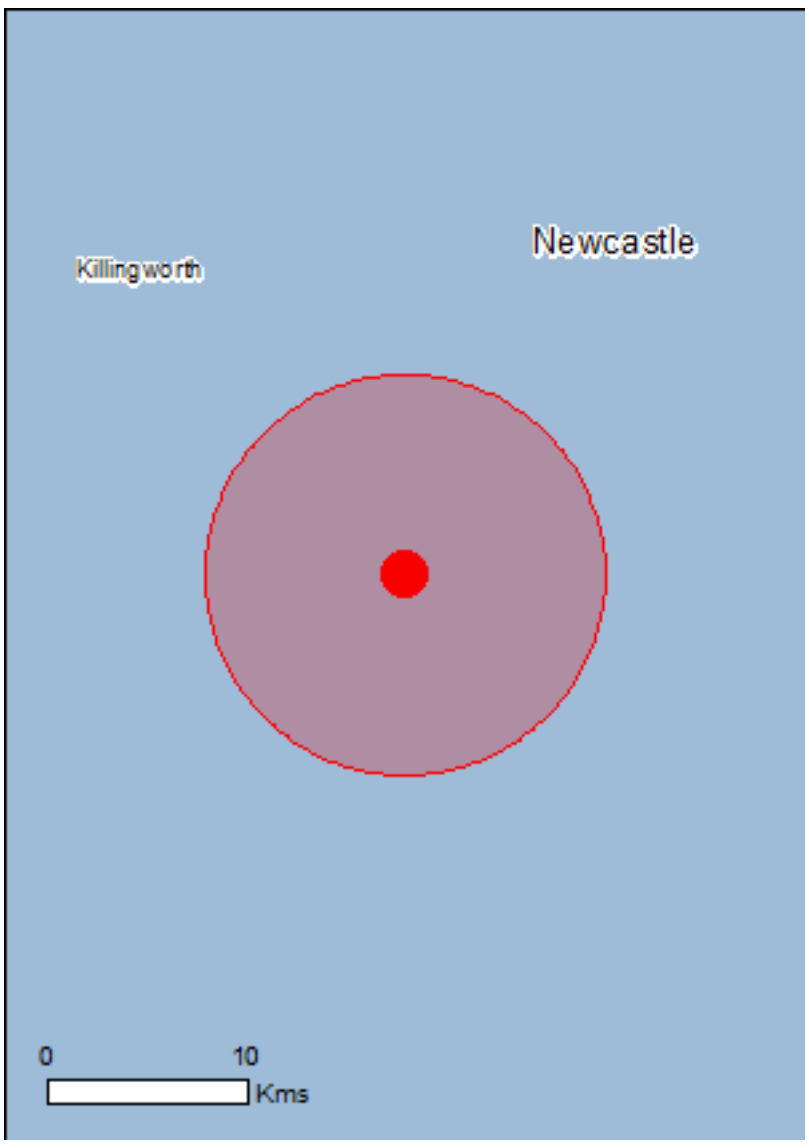
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

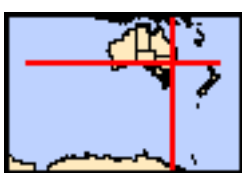
Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 20/01/20 11:38:53



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 10.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	5
Listed Threatened Species:	79
Listed Migratory Species:	72

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	7
Commonwealth Heritage Places:	None
Listed Marine Species:	97
Whales and Other Cetaceans:	16
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	7
Regional Forest Agreements:	1
Invasive Species:	47
Nationally Important Wetlands:	2
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Hunter estuary wetlands	Within 10km of Ramsar

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
Temperate East

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Central Hunter Valley eucalypt forest and woodland	Critically Endangered	Community may occur within area
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	Endangered	Community likely to occur within area
Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	Critically Endangered	Community likely to occur within area
Posidonia australis seagrass meadows of the Manning-Hawkesbury ecoregion	Endangered	Community likely to occur within area
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Species or species habitat known to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat known to occur within area
Dasyornis brachypterus Eastern Bristlebird [533]	Endangered	Species or species habitat likely to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea antipodensis gibsoni Gibson's Albatross [82270]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Fregetta grallaria grallaria White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian) [64438]	Vulnerable	Species or species habitat likely to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat known to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Pterodroma leucoptera leucoptera Gould's Petrel, Australian Gould's Petrel [26033]	Endangered	Species or species habitat may occur within area
Pterodroma neglecta neglecta Kermadec Petrel (western) [64450]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Species or species habitat may occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche bulleri platei Northern Buller's Albatross, Pacific Albatross [82273]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta cauta Shy Albatross [82345]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta steadi White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thinornis rubricollis rubricollis Hooded Plover (eastern) [66726]	Vulnerable	Species or species habitat likely to occur within area
Fish		
Epinephelus daemelii Black Rockcod, Black Cod, Saddled Rockcod [68449]	Vulnerable	Species or species habitat likely to occur within area
Frogs		
Heleioporus australiacus Giant Burrowing Frog [1973]	Vulnerable	Species or species habitat may occur within area
Litoria aurea Green and Golden Bell Frog [1870]	Vulnerable	Species or species habitat known to occur

Name	Status	Type of Presence
		within area
Litoria littlejohni		
Littlejohn's Tree Frog, Heath Frog [64733]	Vulnerable	Species or species habitat may occur within area
Mammals		
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat may occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Chalinolobus dwyeri		
Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat likely to occur within area
Dasyurus maculatus maculatus (SE mainland population)		
Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat known to occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Petauroides volans		
Greater Glider [254]	Vulnerable	Species or species habitat known to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)		
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Potorous tridactylus tridactylus		
Long-nosed Potoroo (SE Mainland) [66645]	Vulnerable	Species or species habitat likely to occur within area
Pseudomys novaehollandiae		
New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat known to occur within area
Pteropus poliocephalus		
Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Plants		
Acacia bynoeana		
Bynoe's Wattle, Tiny Wattle [8575]	Vulnerable	Species or species habitat likely to occur within area
Angophora inopina		
Charmhaven Apple [64832]	Vulnerable	Species or species habitat likely to occur within area
Caladenia tessellata		
Thick-lipped Spider-orchid, Daddy Long-legs [2119]	Vulnerable	Species or species habitat likely to occur within area
Corunastylis insignis		
Wyong Midge Orchid 1, Variable Midge Orchid 1 [84692]	Critically Endangered	Species or species habitat known to occur within area
Cryptostylis hunteriana		
Leafless Tongue-orchid [19533]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat known to occur within area
Cynanchum elegans White-flowered Wax Plant [12533]	Endangered	Species or species habitat known to occur within area
Diuris praecox Newcastle Doubletail [55086]	Vulnerable	Species or species habitat known to occur within area
Eucalyptus camfieldii Camfield's Stringybark [15460]	Vulnerable	Species or species habitat known to occur within area
Eucalyptus parramattensis subsp. decadens Earp's Gum, Earp's Dirty Gum [56148]	Vulnerable	Species or species habitat likely to occur within area
Grevillea parviflora subsp. parviflora Small-flower Grevillea [64910]	Vulnerable	Species or species habitat known to occur within area
Grevillea shiressii [19186]	Vulnerable	Species or species habitat likely to occur within area
Melaleuca biconvexa Biconvex Paperbark [5583]	Vulnerable	Species or species habitat may occur within area
Persicaria elatior Knotweed, Tall Knotweed [5831]	Vulnerable	Species or species habitat likely to occur within area
Pterostylis gibbosa Illawarra Greenhood, Rufa Greenhood, Pouched Greenhood [4562]	Endangered	Species or species habitat may occur within area
Rutidosis heterogama Heath Wrinklewort [13132]	Vulnerable	Species or species habitat likely to occur within area
Syzygium paniculatum Magenta Lilly Pilly, Magenta Cherry, Daguba, Scrub Cherry, Creek Lilly Pilly, Brush Cherry [20307]	Vulnerable	Species or species habitat known to occur within area
Tetratheca juncea Black-eyed Susan [21407]	Vulnerable	Species or species habitat known to occur within area
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or

Name	Status	Type of Presence
		related behaviour known to occur within area
Sharks		
Carcharias taurus (east coast population) Grey Nurse Shark (east coast population) [68751]	Critically Endangered	Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area
Ardenna grisea Sooty Shearwater [82651]		Species or species habitat likely to occur within area
Ardenna pacifica Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat likely to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Sternula albifrons Little Tern [82849]		Breeding likely to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta Shy Albatross [89224]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area

Name	Threatened	Type of Presence
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Dugong dugon Dugong [28]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat may occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat likely to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat may occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat likely to occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius phaeopus Whimbrel [849]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Pluvialis fulva		
Pacific Golden Plover [25545]		Species or species habitat known to occur within area
Thalasseus bergii		
Crested Tern [83000]		Breeding known to occur within area
Tringa brevipes		
Grey-tailed Tattler [851]		Species or species habitat known to occur within area
Tringa nebularia		
Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis		
Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -
Commonwealth Land - Australian Postal Commission
Commonwealth Land - Australian Telecommunications Commission
Commonwealth Land - Commonwealth Trading Bank of Australia
Commonwealth Land - Defence Service Homes Corporation
Commonwealth Land - Director of War Service Homes
Commonwealth Land - Telstra Corporation Limited

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus		
Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis		
Cattle Egret [59542]		Breeding likely to occur within area
Arenaria interpres		
Ruddy Turnstone [872]		Species or species habitat known to occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species

Name	Threatened	Type of Presence
		habitat known to occur within area
[Calidris ferruginea](#) Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
[Calidris melanotos](#) Pectoral Sandpiper [858]		Species or species habitat likely to occur within area
[Calidris ruficollis](#) Red-necked Stint [860]		Species or species habitat known to occur within area
[Calonectris leucomelas](#) Streaked Shearwater [1077]		Species or species habitat known to occur within area
[Catharacta skua](#) Great Skua [59472]		Species or species habitat may occur within area
[Charadrius bicinctus](#) Double-banded Plover [895]		Species or species habitat known to occur within area
[Charadrius leschenaultii](#) Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
[Charadrius mongolus](#) Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat known to occur within area
[Charadrius ruficapillus](#) Red-capped Plover [881]		Species or species habitat known to occur within area
[Diomedea antipodensis](#) Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
[Diomedea epomophora](#) Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
[Diomedea exulans](#) Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
[Diomedea gibsoni](#) Gibson's Albatross [64466]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
[Diomedea sanfordi](#) Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
[Eudyptula minor](#) Little Penguin [1085]		Breeding known to occur within area
[Fregata ariel](#) Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
[Fregata minor](#) Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat likely to occur within area
[Gallinago hardwickii](#) Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Species or species habitat known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Larus dominicanus Kelp Gull [809]		Breeding known to occur within area
Larus novaehollandiae Silver Gull [810]		Breeding known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat likely to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius phaeopus Whimbrel [849]		Species or species habitat known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur

Name	Threatened	Type of Presence within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Species or species habitat known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat likely to occur within area
Puffinus griseus Sooty Shearwater [1024]		Species or species habitat likely to occur within area
Puffinus pacificus Wedge-tailed Shearwater [1027]		Breeding known to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Sterna albifrons Little Tern [813]		Breeding likely to occur within area
Sterna bergii Crested Tern [816]		Breeding known to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta Shy Albatross [89224]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche sp. nov. Pacific Albatross [66511]	Vulnerable*	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely

Name	Threatened	Type of Presence
		to occur within area
Thinornis rubricollis rubricollis Hooded Plover (eastern) [66726]	Vulnerable	Species or species habitat likely to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area
Fish		
Acentronura tentaculata Shortpouch Pygmy Pipehorse [66187]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Heraldia nocturna Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish [66227]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus abdominalis Big-belly Seahorse, Eastern Potbelly Seahorse, New Zealand Potbelly Seahorse [66233]		Species or species habitat may occur within area
Hippocampus whitei White's Seahorse, Crowned Seahorse, Sydney Seahorse [66240]		Species or species habitat likely to occur within area
Histiogamphelus briggsii Crested Pipefish, Briggs' Crested Pipefish, Briggs' Pipefish [66242]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Notiocampus ruber Red Pipefish [66265]		Species or species habitat may occur within area
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse [66275]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Solenostomus paradoxus Ornate Ghostpipefish, Harlequin Ghost Pipefish, Ornate Ghost Pipefish [66184]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Mammals		
Arctocephalus forsteri Long-nosed Fur-seal, New Zealand Fur-seal [20]		Species or species habitat may occur within area
Arctocephalus pusillus Australian Fur-seal, Australo-African Fur-seal [21]		Species or species habitat may occur within area
Dugong dugon Dugong [28]		Species or species habitat may occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans		[Resource Information]
Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area

Name	Status	Type of Presence
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves	[Resource Information]
Name	State
Awabakal	NSW
Glenrock	NSW
Lake Macquarie	NSW
Moon Island	NSW
Munmorah	NSW
Tingira Heights	NSW
Wallarah	NSW

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
North East NSW RFA	New South Wales

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Alauda arvensis Skylark [656]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Lonchura punctulata Nutmeg Mannikin [399]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Pycnonotus jocosus Red-whiskered Bulbul [631]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides Alligator Weed [11620]		Species or species habitat likely to occur within area
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		Species or species habitat likely to occur within area
Asparagus scandens Asparagus Fern, Climbing Asparagus Fern [23255]		Species or species habitat likely to occur within area
Cabomba caroliniana Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Chrysanthemoides monilifera subsp. rotundata Bitou Bush [16332]		Species or species habitat likely to occur within area
Cytisus scoparius Broom, English Broom, Scotch Broom, Common Broom, Scottish Broom, Spanish Broom [5934]		Species or species habitat likely to occur within area
Eichhornia crassipes Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Senecio madagascariensis Fireweed, Madagascar Ragwort, Madagascar Groundsel [2624]		Species or species habitat likely to occur within area
Solanum elaeagnifolium Silver Nightshade, Silver-leaved Nightshade, White Horse Nettle, Silver-leaf Nightshade, Tomato Weed, White Nightshade, Bull-nettle, Prairie-berry, Satansbos, Silver-leaf Bitter-apple, Silverleaf-nettle, Trompillo [12323]		Species or species habitat likely to occur within area

Nationally Important Wetlands [Resource Information]

Name	State
Jewells Wetland	NSW
Lake Macquarie	NSW

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-33.05178 151.67784

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

Data from the BioNet BioNet Atlas website, which holds records from a number of custodians. The data are only indicative and cannot be considered a comprehensive inventory, and may contain errors and omissions. Species listed under the Sensitive Species Data Policy may have their locations denatured (^ rounded to 0.1Â°; ^^ rounded to 0.01Â°). Copyright the State of NSW through the Office of Environment and Heritage. Search criteria : Public Report of all Valid Records of Animals in selected area [North: -33.00 West: 151.63 East: 151.73 South: -33.10] returned a total of 10,361 records of 361 species.
Report generated on 20/01/2020 12:07 PM

Kingdom	Class	Family	Species Code	Scientific Name	Exotic	Common Name	NSW status	Comm. status	Records
Animalia	Reptilia	Cheloniidae	2004	*Caretta caretta*		Loggerhead Turtle	E1,P	E	2
Animalia	Reptilia	Cheloniidae	2007	*Chelonia mydas*		Green Turtle	V,P	V	5
Animalia	Reptilia	Cheloniidae	T110	*Cheloniidae sp.*		unidentified sea turtle	P		19
Animalia	Reptilia	Cheloniidae	2008	*Eretmochelys imbricata*		Hawksbill Turtle	P	V	1
Animalia	Aves	Spheniscidae	0005	*Eudyptula minor*		Little Penguin	P		21
Animalia	Mammalia	Dugongidae	1558	*Dugong dugon*		Dugong	E1,P		3
Animalia	Mammalia	Otariidae	T099	*Arctocephalus sp.*		Unidentified Fur-seal	P		3
Animalia	Mammalia	Otariidae	9040	*Seal sp.*		Unidentified Seal	P		3
Animalia	Mammalia	Balaenidae	1561	*Eubalaena australis*		Southern Right Whale	E1,P	E	1
Animalia	Mammalia	Balaenopteridae	1575	*Megaptera novaeangliae*		Humpback Whale	V,P	V	1
Animalia	Mammalia	Ziphiidae	1593	*Mesoplodon grayi*		Gray's Beaked Whale	P		1
Animalia	Mammalia	Delphinidae	1616	*Delphinus delphis*		Common Dolphin	P		1
Animalia	Mammalia	Delphinidae	1900	*Tursiops truncatus*		Bottlenose Dolphin	P		2

Appendix B
Infauna Data

Phylum	Subphylum	Class	Subclass	Order	Suborder (so) / Superfamily (sf)	Family / Other Taxa	Common Name	Total
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata	Eunicida	Cirratulidae	Spagetti worms	33
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata	Eunicida	Dorvelliidae	Dorveliid worms	133
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata	Eunicida	Lumbrineridae	Lumbrinerid worms	70
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata	Eunicida	Oenoidae	Oenoid worms	4
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata	Eunicida	Onuphidae	Onuphid worms	150
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata	Phyllodocida	Glyceridae	Glycerid worms	1
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata	Phyllodocida	Hesionidae	Hesionid worms	70
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata	Phyllodocida	Nephtyidae	Nephtyid worms	3
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata	Phyllodocida	Nereididae	Nereidid worms	18
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata	Phyllodocida	Phyllodocidae	Paddle worms	39
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata	Phyllodocida	Polynoidae	Polynoid worms	5
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata	Phyllodocida	Sigalionidae	Sigalionid worms	20
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata	Phyllodocida	Syllidae	Syllid worms	273
Annelida	undifferentiated	Polychaeta	Palpata	Canalipalpata	Sabellida	Oweniidae	Oweniid worms	1
Annelida	undifferentiated	Polychaeta	Palpata	Canalipalpata	Sabellida	Sabellidae	Feather duster worms	15
Annelida	undifferentiated	Polychaeta	Palpata	Canalipalpata	Sabellida	Serpulidae	Serpulid worms	0
Annelida	undifferentiated	Polychaeta	Palpata	Canalipalpata	Spionida	Chaetopteridae	Chaetopterid worms	29
Annelida	undifferentiated	Polychaeta	Palpata	Canalipalpata	Spionida	Megalonidae	Megalonid worms	1
Annelida	undifferentiated	Polychaeta	Palpata	Canalipalpata	Spionida	Poecilochaetidae	Poecilochaetid worms	1
Annelida	undifferentiated	Polychaeta	Palpata	Canalipalpata	Spionida	Spionidae	Spionid worms	1662
Annelida	undifferentiated	Polychaeta	Palpata	Canalipalpata	Terebellida	Pectinariidae	Trumpet worms	0
Annelida	undifferentiated	Polychaeta	Palpata	Canalipalpata	Terebellida	Terrebellidae	Terebellid worms	42
Annelida	undifferentiated	Polychaeta	Palpata	Canalipalpata	Terebellida	Trichobranchidae	Trichobranchid worms	8
Annelida	undifferentiated	Polychaeta	Scolecida	Scolecida	Scolecida	Capitellidae	Capitellid worms	15
Annelida	undifferentiated	Polychaeta	Scolecida	Scolecida	Scolecida	Maldanidae	Bamboo worms	0
Annelida	undifferentiated	Polychaeta	Scolecida	Scolecida	Scolecida	Opheliidae	Opheliid worms	9
Annelida	undifferentiated	Polychaeta	Scolecida	Scolecida	Scolecida	Orbiniidae	Rag worms	25
Annelida	undifferentiated	Polychaeta	Scolecida	Scolecida	Scolecida	Paraonidae	Paraonid worms	131
Annelida	undifferentiated	Polychaeta	undifferentiated	undifferentiated	Polycaeta insertae-sedis	Polygordiidae	Polygoriid worms	7518
Arthropoda	Chelicerata	Pycnogonida	undifferentiated	undifferentiated	undifferentiated	Pycnogonida sp.	Sea spiders	1
Arthropoda	Crustacea	Copepoda	undifferentiated	undifferentiated	undifferentiated	undifferentiated	Copepods	1
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Amphipoda	So: Amphilochidea	Dexaminidae	Amphipods	22
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Amphipoda	So: Amphilochidea	Lysianassidae	Lysianassid amphipods	69
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Amphipoda	So: Amphilochidea	Phoxocephalidae	Amphipods	208
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Amphipoda	So: Amphilochidea	Platyischnopidae	Amphipods	183
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Amphipoda	So: Amphilochidea	Urothoidae	Amphipods	58
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Amphipoda	So: Gammaridea	Amphipoda spp	Amphipods	36
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Amphipoda	So: Senticaudata	Caprellidae	Capreliid amphipod	179
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Amphipoda	So: Senticaudata	cf Aoridae	Amphipods	112
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Amphipoda	So: Senticaudata	Corophiidae	Corophid amphipods	4
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Cumacea	undifferentiated	Bodotriidae	Bodotriid cumaceans	417
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Cumacea	undifferentiated	Cumacea spp (Other)	Cumaceans squat	38
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Decapoda	So. Eucarida	Porcellanidae	Porcelline crabs	3
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Isopoda	So. Anthuridea	Anthuridae	Anthurid isopods	260
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Isopoda	So. Cymothoida	Gnathiidae	Gnathid isopods	0
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Isopoda	So.Sphaeromatidea	Serolidae	Serolid isopods	0
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Isopoda	So.Sphaeromatoidea	Serolidae	Serolid isopods	1
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Isopoda	So.Sphaeromatoidea	Sphaeromatidae	Sphaeromatid isopods	3
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Isopoda	So: Cymothoida	Cirolanidae	Cirolanid isopods	14
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Isopoda	So: Vlavifera	Arcturidae	Arcturid isopods	27
Arthropoda	Crustacea	Malocostraca	Peracarida	Tanaidacea	So: Tanaidomorpha	Leptochelliidae	Leptochellid tanaids	3
Arthropoda	Crustacea	Malocostraca	Peracarida	Tanaidacea	undifferentiated	Apseudidae	Apseudid tanaids	28
Arthropoda	Crustacea	Malocostraca	undifferentiated	Decapoda	So: Brachyura	Brachyura	Crab megalopa	1
Arthropoda	Crustacea	Malocostraca	undifferentiated	Decapoda	So: Brachyura	Leucosidae	Pebble crabs	2
Arthropoda	Crustacea	Malocostraca	undifferentiated	Decapoda	So: Pleocyemata	Majidae	Spider crabs	2
Arthropoda	Crustacea	Malocostraca	undifferentiated	Decapoda	undifferentiated	Alpheidae	Snapping shrimp	0
Arthropoda	Crustacea	Malocostraca	undifferentiated	Decapoda	undifferentiated	Callianassidae	Ghost shrimps	0
Arthropoda	Crustacea	Malocostraca	undifferentiated	Decapoda	undifferentiated	Decapod (larvae)	Decapod larvae	2
Arthropoda	Crustacea	Malocostraca	undifferentiated	Decapoda	undifferentiated	Decapoda spp.	shrimp	1
Arthropoda	Crustacea	Malocostraca	undifferentiated	Decapoda	undifferentiated	Diogenidae	Hermit crabs	0
Arthropoda	Crustacea	Malocostraca	undifferentiated	Decapoda	undifferentiated	Hexapodiidae	Hexapod crabs	1
Arthropoda	Crustacea	Malocostraca	undifferentiated	Decapoda	undifferentiated	Mysidae	Opossum shrimps	5
Arthropoda	Crustacea	Malocostraca	undifferentiated	Decapoda	undifferentiated	Processidae	Processid shrimps	2
Arthropoda	Crustacea	Ostracoda	undifferentiated	undifferentiated	undifferentiated	Ostracod sp A	Seed shrimps/oval	28
Chaetognatha	undifferentiated	undifferentiated	undifferentiated	undifferentiated	undifferentiated	Chaetognatha	Arrow worms	1
Chordata	Cephalochordata	Leptocardii	undifferentiated	Amphioxiformes	undifferentiated	Branchiostomidae	Lancelets	1
Chordata	Tunicata	Appendicularia	undifferentiated	Copelata	undifferentiated	Oikopleuridae	Sea-squirt larvae	1
Chordata	Tunicata	undifferentiated	undifferentiated	undifferentiated	undifferentiated	Tunicata sp.	Sea squirts with sand	10
Chordata	Vertebrata	Osteichthyes	undifferentiated	undifferentiated	undifferentiated	Osteichthyes	Fish larvae	0
Cnidaria	undifferentiated	Anthozoa	Octocorillia	Pennatulacea	undifferentiated	Pennatulacea	Sea pens	1
Cnidiria	undifferentiated	Anthozoa	Hexacorallia	Actiniaria	undifferentiated	Anthnemonae	Anemone	3
Echinodermata	Asterozoa	Stelleroidea	Ophiuroidea	Ophiurida	undifferentiated	Ophionereididae	Ophionereid brittle stars	21
Echinodermata	Asterozoa	Stelleroidea	Ophiuroidea	Ophiurida	undifferentiated	Ophiurida spp	Brittle stars (juveniles)	11
Echinodermata	Asterozoa	Stelleroidea	Ophiuroidea	Ophiurida	undifferentiated	Ophiurida (other)	Brittle stars	1
Echinodermata	Crinozoa	Crinoidea	undifferentiated	undifferentiated	undifferentiated	Crinoidea	Crinoid	0
Echinodermata	Echinozoa	Echinoidea	Euechinoidea	Spatangoida	So: Brissidina	Loveniidae	Loveniid sea urchins	14
Echinodermata	Echinozoa	Echinoidea	Euechinoidea	undifferentiated	undifferentiated	Euechinoidea sp.	Urchin	0
Mollusca	Diasoma	Bivalvia	Heterodonta	Arcoida	undifferentiated	Glycymerididae	Glycmerid clams	4
Mollusca	Diasoma	Bivalvia	Heterodonta	Cardiida	Sf. Tellinoidea	Donacidae	Surf clams	3
Mollusca	Diasoma	Bivalvia	Heterodonta	Cardiida	Sf. Tellinoidea	Tellinidae	Tellins	9
Mollusca	Diasoma	Bivalvia	Heterodonta	undifferentiated	Sf. Mactroidea	Mactridae	Mactrid clams	96
Mollusca	Diasoma	Bivalvia	Heterodonta	undifferentiated	undifferentiated	Heterodonta	Heterodont clams (juveniles)	93
Mollusca	Diasoma	Bivalvia	Heterodonta	Venerida	Sf. Mactroidea	Mesodesmatidae	Mesodesmatid clams	17
Mollusca	Diasoma	Bivalvia	Pteriomorphia	Mytiloida	Sf. Mytiloidea	Mytilidae	Marine Mussells	2
Mollusca	Diasoma	Gastrapoda	Caenogastropoda	Littorinimorpha	Sf. Calyptraeoidea	Calyptraeidae	Slipper limpets	27
Mollusca	Diasoma	Gastrapoda	Caenogastropoda	Littorinimorpha	Sf. Rissooidea	Rissoidae	Rissoid snails	4
Mollusca	Diasoma	Gastrapoda	Caenogastropoda	Littorinimorpha	Sf. Tuncatelloidea	Anabathridae	Anabathrid snails	2
Mollusca	Diasoma	Gastrapoda	Caenogastropoda	Neogastrapoda	Sf. Buccinoidea	Buccinidae	Buccinid snails	3
Mollusca	Diasoma	Gastrapoda	Caenogastropoda	Neogastrapoda	Sf. Buccinoidea	Columbellidae	Columbellid snails	8
Mollusca	Diasoma	Gastrapoda	Caenogastropoda	Neogastrapoda	Sf. Buccinoidea	Nassariidae	Dog whelk	2
Mollusca	Diasoma	Gastrapoda	Caenogastropoda	Neogastrapoda	undifferentiated	Marginellidae	Margin Shells	1
Mollusca	Diasoma	Gastrapoda	Heterobranchia	Cephalaspidea	Sf. Cylichnoidea	cf. Cylichnidae	Cylichnid snail	1
Mollusca	Diasoma	Gastrapoda	Heterobranchia	Cephalaspidea	Sf. Philinoidea	Philinidae	Philinid snails	0
Mollusca	Diasoma	Gastrapoda	Heterobranchia	Pleurobranchida	Sf. Pleurobranchoidea	Pleurobranchidae	Side-gilled slug	1
Mollusca	Diasoma	Gastrapoda	Heterobranchia	undifferentiated	Sf. Acteonoidea	Acteonidae	Acteonid snails	1
Mollusca	Diasoma	Gastrapoda	Heterobranchia	undifferentiated	Sf. Pyramidelloidea	Pyramidellidae	Pyramid snails	8
Mollusca	Diasoma	Gastrapoda	Heterobranchia	undifferentiated	undifferentiated	Haminoeidae	Marine slugs	1
Mollusca	Diasoma	Gastrapoda	Heterobranchia	undifferentiated	undifferentiated	Heterobranchia sp	Marine slugs (juveniles)	4
Mollusca	Diasoma	Gastrapoda	undifferentiated	undifferentiated	Sf. Mitroidea	Mitiridae	Mitres	1
Mollusca	Diasoma	Gastrapoda	undifferentiated	undifferentiated	Sf. Naticoidea	Naticidae	Moon snails	4
Mollusca	Diasoma	Gastrapoda	undifferentiated	undifferentiated	undifferentiated	Gastrapoda spp	Gastrapods	4
Mollusca	Diasoma	Gastrapoda	Vetigastropoda	undifferentiated	Sf. Trochoidea	Trochidae	Trochids (juvenile)	22
Mollusca		Gastrapoda	Heterobranchia	Nudibranchia	Sf. Aeolidioidea	Facelinidae	Aeolid nudibranchs	2
Nematoda	undifferentiated	undifferentiated	undifferentiated	undifferentiated	undifferentiated	Nematoda spp	Nematodes	2014
Nemertea	undifferentiated	undifferentiated	undifferentiated	undifferentiated	undifferentiated	Nemertea	Velvet worms	1
Nemertia	Nemertia	Enopla	undifferentiated	Hoplonemertea	undifferentiated	Hoplonemertea spp	Ribbon worms	72
Phoronida	undifferentiated	undifferentiated	undifferentiated	undifferentiated	undifferentiated	Phoronidae	Horseshoe worms	2149
Platyhelminthes	undifferentiated	Turbellaria	undifferentiated	Polycladida	undifferentiated	Polycladida	Polyclad flatworms	20
Porifera	undifferentiated	Demospongiae	Keratosa	Dictyoceratida	undifferentiated	Spongiidae	Sponges	0
Porifera	undifferentiated	Hexactinellida	undifferentiated	undifferentiated	undifferentiated	Hexactinellida	Glass sponges	0
Sipuncula	undifferentiated	Sipunculidea	undifferentiated	Sipunculiformes	undifferentiated	Sipunculiformes spp	Peanut worms	212
							Total Abundance	16839
							Taxa Richness	111

Family / Other Taxa	Common Name	5N-A	5N-B	5N-C	5N-D	5N-E	5S-A	5S-B	5S-C	5S-D	5S-E	20N-A	20N-B	20N-C	20N-D	20N-E	20S-A	20S-B	20S-C	20S-D	20S-E
Cirratulidae	Spagetti worms	1		2	1		4	1			2		1		2		2	1		1	
Dorvelliidae	Dorvellid worms	1	10	3	1	3	2	6	4	3	2	6	1	1	1	5	18	14	8	7	6
Lumbrineridae	Lumbrinerid worms	1		1		4	3	1	1	2	2	2		1		1		3	3	2	2
Oenoidae	Oenoid worms																				
Onuphidae	Onuphid worms	1	1	2	4		1				7	1		1	9	1	2				
Glyceridae	Glycerid worms		1																		
Hesionidae	Hesionid worms			1	2		2	2			2	1			1		23	4	6	15	8
Nephtyidae	Nephtyid worms																				
Nereididae	Nereidid worms				3				1												
Phyllodocidae	Paddle worms	1				4	2	4	3			1		1	1	2	2	3	3		7
Polynoidae	Polynoid worms								1												
Sigalionidae	Sigalionid worms	1	1	1		1	1	1				2		1					1		1
Syllidae	Syllid worms	2	5	5	9	9	7	9	1	1	8	8	1	2	4	16	14	11	11	11	25
Oweniidae	Oweniid worms																				
Sabellidae	Feather duster worms		1		1	1	1	3												2	
Serpulidae	Serpulid worms																				
Chaetopteridae	Chaetopterid worms		2	1		2		2			1		1			1				2	
Megalonidae	Megalonid worms											1									
Poecilochaetidae	Poecilochaetid worms																				
Spionidae	Spionid worms	15	17	9	34	16	17	46	6	5	29	19	5	7	8	19	11	38	7	14	17
Pectinariidae	Trumpet worms																				
Terrebellidae	Terebellid worms		2		1	1	6	1			3						1	4		6	6
Trichobranchidae	Trichobranchid worms																				
Capitellidae	Capitellid worms		1	1		1		1								1		1			
Maldanidae	Bamboo worms																				
Opheliidae	Opheliid worms																				
Orbiniidae	Rag worms	1	1				1	1							1	1			1		
Paraonidae	Paraonid worms	2	6	1	8	11	1	1	1	8	8	5		6	4	12	4	17	1	4	4
Polygordiidae	Polygordiid worms	210	162	176	504	310	63	388	72	8	192	220	18	30	10	814	544	804	204	1421	329
Pycnogonida sp.	Sea spiders																				
undifferentiated	Copepods																				
Dexaminidae	Amphipods	1				1						1								4	
Lysianassidae	Lysianassid amphipods	3	1	2	2	3			1		2	4			1	1	1	1	3	2	
Phoxocephalidae	Amphipods	12	9	6	5	10	2	3	1		2	4	2	3	1	2			2		3
Platyischnopidae	Amphipods	11	4	10	1	10	3		2	2		1	3	1		2	2	5	2	3	6
Urothoidae	Amphipods	2		3	1	1							1	1				2		1	
Amphipoda spp	Amphipods				1	4					1								4	4	
Caprellidae	Caprellid amphipod		4	2	2	1	1	5	4	2	7	8	2		11	4	3		13	22	4
cf Aoridae	Amphipods		1	2				5	1	1	1	4	2		5	2	1		1	18	1
Corophiidae	Corophid amphipods																				
Bodotriidae	Bodotriid cumaceans	16	47	48	7	16	5	28	5	2	5	13	1	8	6	2		2	4	3	11
Cumacea spp (Other)	Cumaceans squat			2	1			1				1		1	1					2	2
Porcellanidae	Porcelline crabs																				
Anthuridae	Anthurid isopods	20	9	11	19	10	8	8	4	4	8	9	2	2	6	5	12	11	8	13	6
Gnathiidae	Gnathid isopods																				
Serolidae	Serolid isopods																				
Serolidae	Serolid isopods																				
Sphaeromatidae	Sphaeromatid isopods																				
Cirolanidae	Cirolanid isopods		1	1		1										1					
Arcturidae	Arcturid isopods			1				1							2	1				1	
Leptochelliidae	Leptochelliid tanaids					2															
Apseudidae	Apseudid tanaids				1		3	2		2		1								2	1
Brachyura	Crab megalopa																				
Leucosidae	Pebble crabs																				
Majidae	Spider crabs																				
Alpheidae	Snapping shrimp																				
Callianassidae	Ghost shrimps																				
Decapod (larvae)	Decapod larvae	1																			
Decapoda spp.	shrimp																				
Diogenidae	Hermit crabs																				
Hexapodiidae	Hexapod crabs																				
Mysidae	Opossum shrimps	1																			
Processidae	Processid shrimps					1															
Ostracod sp A	Seed shrimps/oval	1		1	1										1	1		1	2	4	
Chaetognatha	Arrow worms																				
Branchiostomidae	Lancelets																		1		
Oikopleuridae	Sea-squirt larvae																				
Tunicata sp.	Sea squirts with sand																				
Osteichthyes	Fish larvae																				
Pennatulacea	Sea pens																				
Anthnemonae	Anemone																		1		
Ophionereididae	Ophionereid brittle stars	1		1		1			1			1									
Ophiurida spp	Brittle stars (juveniles)		1															1			
Ophiurida (other)	Brittle stars																				
Crinoidea	Crinoid																				
Loveniidae	Loveniid sea urchins	1															1				
Euechinoidea sp.	Urchin																				
Glycymeridae	Glycmerid clams																				
Donacidae	Surf clams																	1			
Tellinidae	Tellins							1										1			
Mactridae	Mactrid clams		7			2	1	2			1						2	1		1	
Heterodonta	Heterodont clams (juveniles)	3		5			1	1		1	2	2	2	1	3		1	2	2	3	
Mesodesmatidae	Mesodesmatid clams																				
Mytilidae	Marine Mussells																				
Calyptraeidae	Slipper limpets		1		2		1					3		2	1			2	1		
Rissoidae	Rissoid snails																				
Anabathridae	Anabathrid snails																	1			
Buccinidae	Buccinid snails																				
Columbellidae	Columbellid snails																	1			
Nassariidae	Dog whelk																				
Marginellidae	Margin Shells																				
cf. Cylichnidae	Cylichnid snail																				
Philinidae	Philinid snails																				
Pleurobranchidae	Side-gilled slug																				
Acteonidae	Acteonid snails																				
Pyramidellidae	Pyramid snails													1	1	1					
Haminoeidae	Marine slugs																				
Heterobranchia sp	Marine slugs (juveniles)																				
Mitiridae	Mitres								1												
Naticidae	Moon snails																				
Gastrapoda spp	Gastrapods																		1	1	
Trochidae	Trochids (juvenile)																				
Facelinidae	Aeolid nudibranchs																				
Nematoda spp	Nematodes	10	9	24	8	51	15	5	6	3	10	12	2	7		6	263	1253	74	81	29
Nemertea	Velvet worms																				
Hoplonemertea spp	Ribbon worms	1	2		2	4	4	2		1	4	2	1	1	2		1	2	6	2	6
Phoronidae	Horseshoe worms	186	125	118	197	106	32	20	8	11	27	14	7	10	23	12	2	11	6	35	65
Polycladida	Polyclad flatworms								1	1			9					2	1	1	1
Spongiidae	Sponges																				
Hexactinellida	Glass sponges																				
Sipunculiformes spp	Peanut worms	2	5	4	3	1	4	4	2	4	2	2	2	2	3	4			2	2	1
	Total Abundance	**508**	**436**	**444**	**821**	**588**	**191**	**555**	**127**	**61**	**328**	**348**	**63**	**90**	**108**	**917**	**910**	**2200**	**379**	**1690**	**541**
	Taxa Richness	**28**	**28**	**29**	**27**	**30**	**27**	**30**	**22**	**18**	**24**	**28**	**19**	**22**	**25**	**25**	**21**	**29**	**29**	**32**	**23**

Family / Other Taxa	Common Name	100N-A	100N-B	100N-C	100N-D	100N-E	100S-A	100S-B	100S-C	100S-D	100S-E	200N-A	200N-B	200N-C	200N-D	200N-E	200S-A	200S-B	200S-C	200S-D	200S-E
Cirratulidae	Spagetti worms			2	3	3	3								2						
Dorvelliidae	Dorvellid worms	1	2	1	2						1	1		3	3	1					
Lumbrineridae	Lumbrinerid worms	3	3		2					1	1	1		1	2		4	2		2	
Oenoidae	Oenoid worms		1												2						
Onuphidae	Onuphid worms		4	3	8	2	2	2	3	3	4		21	12	3	4	1	3	1	5	3
Glyceridae	Glycerid worms																				
Hesionidae	Hesionid worms											1			1						
Nephtyidae	Nephtyid worms																				
Nereididae	Nereidid worms	1		11							1										
Phyllodocidae	Paddle worms																			1	
Polynoidae	Polynoid worms														1					1	
Sigalionidae	Sigalionid worms		1	2		2					1	1				1				1	
Syllidae	Syllid worms		2	2	3		2		1	11		3		1	1	1	3	1		4	12
Oweniidae	Oweniid worms								1												
Sabellidae	Feather duster worms		1	1	2								1								
Serpulidae	Serpulid worms																				
Chaetopteridae	Chaetopterid worms				1		6				5			1	1						1
Megalonidae	Megalonid worms																				
Poecilochaetidae	Poecilochaetid worms			1																	
Spionidae	Spionid worms	2	9	8	8	2	141	70	83	125	140	10	11	10	24	9	19	5	5	32	67
Pectinariidae	Trumpet worms																				
Terrebellidae	Terebellid worms	1							1				2		1	2				1	1
Trichobranchidae	Trichobranchid worms											1		2	1						
Capitellidae	Capitellid worms					1		1			1			1	2	1		1			1
Maldanidae	Bamboo worms																				
Opheliidae	Opheliid worms						2	1					1		1						
Orbiniidae	Rag worms		1			1	4	1	1	1	1						1	1		1	1
Paraonidae	Paraonid worms						2			3			1	1				2		1	
Polygordiidae	Polygordiid worms	46	79	395	52	9	1	2	2	6	1		4	6			1	4	2	16	7
Pycnogonida sp.	Sea spiders																				
undifferentiated	Copepods																				
Dexaminidae	Amphipods				2	1	1			4	2			1			1		1	2	
Lysianassidae	Lysianassid amphipods	1	3	3	21	2	1	2		1		3				1				1	
Phoxocephalidae	Amphipods	4	12	8	12	6	7	3		2	14	4	8	1	7		1		1	2	1
Platyischnopidae	Amphipods	8	18	13	11	8						2	2	6	3		1		1	5	3
Urothoidae	Amphipods	7	4	3	4	4	2	1	1		1	2		1	2	1		1		1	2
Amphipoda spp	Amphipods		1	1		1		1					3	2	3				1	3	
Caprellidae	Caprellid amphipod	1	3	13	6	4	2	1	1	3	1	1	10	8	27						
cf Aoridae	Amphipods	1	3	9	13	3			3	3	1	2	10	7	7			1			
Corophiidae	Corophid amphipods											2		1							
Bodotriidae	Bodotriid cumaceans	16	20	26	20	7	7	1	3	2	1	16	13	3	19	3	2	2		2	2
Cumacea spp (Other)	Cumaceans squat		3	2	1							3	2	4	1		2			1	
Porcellanidae	Porcelline crabs							2													
Anthuridae	Anthurid isopods	13	12	14	5	5		1	1	1	4	1	2	2	7	2					
Gnathiidae	Gnathid isopods																				
Serolidae	Serolid isopods																				
Serolidae	Serolid isopods						1														
Sphaeromatidae	Sphaeromatid isopods		1		1															1	
Cirolanidae	Cirolanid isopods							2	1	1	2									1	1
Arcturidae	Arcturid isopods	1	3	1	3							2	4	4	1	1					
Leptochelliidae	Leptochelliid tanaids			1																	
Apseudidae	Apseudid tanaids		6	3	1		1	1			1						1		1		1
Brachyura	Crab megalopa																				
Leucosidae	Pebble crabs										1										
Majidae	Spider crabs									1											
Alpheidae	Snapping shrimp																				
Callianassidae	Ghost shrimps																				
Decapod (larvae)	Decapod larvae									1											
Decapoda spp.	shrimp			1																	
Diogenidae	Hermit crabs																				
Hexapodiidae	Hexapod crabs																			1	
Mysidae	Opossum shrimps			1			1													1	1
Processidae	Processid shrimps																				
Ostracod sp A	Seed shrimps/oval		1		3		1				1										1
Chaetognatha	Arrow worms																				
Branchiostomidae	Lancelets																				
Oikopleuridae	Sea-squirt larvae						1														
Tunicata sp.	Sea squirts with sand	1	1	1	2			1						1							
Osteichthyes	Fish larvae																				
Pennatulacea	Sea pens					1															
Anthnemonae	Anemone			1																	
Ophionereididae	Ophionereid brittle stars	1	1	1			1	1				1	1		1		1	2	1	1	
Ophiurida spp	Brittle stars (juveniles)						1		1	1				1						1	
Ophiurida (other)	Brittle stars																				
Crinoidea	Crinoid																				
Loveniidae	Loveniid sea urchins			1							1								1		
Euechinoidea sp.	Urchin																				
Glycymeridae	Glycmerid clams		1	1																	
Donacidae	Surf clams																1				
Tellinidae	Tellins			1												1				1	1
Mactridae	Mactrid clams	2	3	12	11	4				2		1	2	2	6		2		1	1	1
Heterodonta	Heterodont clams (juveniles)		2	12		2	3	3	4	3			2	2	4	2				3	3
Mesodesmatidae	Mesodesmatid clams									1											3
Mytilidae	Marine Mussells							1					1								
Calyptraeidae	Slipper limpets	3			4	2													2	1	
Rissoidae	Rissoid snails	1																			
Anabathridae	Anabathrid snails																				
Buccinidae	Buccinid snails				1						1				1						
Columbellidae	Columbellid snails																		1		
Nassariidae	Dog whelk																				
Marginellidae	Margin Shells							1													
cf. Cylichnidae	Cylichnid snail																				
Philinidae	Philinid snails																				
Pleurobranchidae	Side-gilled slug																				
Acteonidae	Acteonid snails																				
Pyramidellidae	Pyramid snails					1		1				1	1	1							
Haminoeidae	Marine slugs																				
Heterobranchia sp	Marine slugs (juveniles)										1							1			
Mitiridae	Mitres																				
Naticidae	Moon snails																				
Gastrapoda spp	Gastrapods		2																		
Trochidae	Trochids (juvenile)						2					1			2			3	2	4	2
Facelinidae	Aeolid nudibranchs																				2
Nematoda spp	Nematodes	12	8	24	3	5	1			1	1	2	3	1	2			2	1	3	5
Nemertea	Velvet worms																				
Hoplonemertea spp	Ribbon worms	1	2	3		1	3				3	1		1	1	1	1				2
Phoronidae	Horseshoe worms	122	495	353	36	90						3	5	5	5	1					
Polycladida	Polyclad flatworms												1								
Spongiidae	Sponges																				
Hexactinellida	Glass sponges																				
Sipunculiformes spp	Peanut worms	3	11	27	18	14	8		1	9	6	8	10	4	7	4	1		3	1	9
	Total Abundance	**252**	**719**	**962**	**259**	**181**	**207**	**100**	**108**	**186**	**198**	**74**	**121**	**96**	**151**	**36**	**43**	**31**	**25**	**102**	**133**
	Taxa Richness	**24**	**34**	**37**	**30**	**26**	**27**	**22**	**16**	**23**	**27**	**26**	**25**	**31**	**33**	**17**	**17**	**15**	**16**	**32**	**25**

Family / Other Taxa	Common Name	500N-A	500N-B	500N-C	500N-D	500N-E	500S-A	500S-B	500S-C	500S-D	500S-E
Cirratulidae	Spagetti worms										
Dorvelliidae	Dorvellid worms	1	1	1				2			
Lumbrineridae	Lumbrinerid worms	1	1	3	1					2	2
Oenoidae	Oenoid worms	1									
Onuphidae	Onuphid worms	3		2	1		3	1	7	6	6
Glyceridae	Glycerid worms										
Hesionidae	Hesionid worms										
Nephtyidae	Nephtyid worms									3	
Nereididae	Nereidid worms				1						
Phyllodocidae	Paddle worms							1		2	1
Polynoidae	Polynoid worms				1				1		
Sigalionidae	Sigalionid worms										
Syllidae	Syllid worms	1	1		2		3	1		5	1
Oweniidae	Oweniid worms										
Sabellidae	Feather duster worms									1	
Serpulidae	Serpulid worms										
Chaetopteridae	Chaetopterid worms									1	
Megalonidae	Megalonid worms										
Poecilochaetidae	Poecilochaetid worms										
Spionidae	Spionid worms	70	130	51	45	41	16	27	15	61	9
Pectinariidae	Trumpet worms										
Terrebellidae	Terebellid worms										
Trichobranchidae	Trichobranchid worms							2	2		
Capitellidae	Capitellid worms										
Maldanidae	Bamboo worms										
Opheliidae	Opheliid worms	1						1		2	
Orbiniidae	Rag worms				1	1	1	1			
Paraonidae	Paraonid worms		3				1				
Polygordiidae	Polygordiid worms		1	8	1	5	1	4	1	14	
Pycnogonida sp.	Sea spiders										
undifferentiated	Copepods						1				
Dexaminidae	Amphipods										
Lysianassidae	Lysianassid amphipods				1						
Phoxocephalidae	Amphipods	11	4	2	5	3	4	7	1	2	
Platyischnopidae	Amphipods	4		2	1			9	2	8	
Urothoidae	Amphipods		3	1	1		3	1			
Amphipoda spp	Amphipods		2							3	1
Caprellidae	Caprellid amphipod									2	
cf Aoridae	Amphipods	1	1								
Corophiidae	Corophid amphipods										
Bodotriidae	Bodotriid cumaceans	1		2	1			1	1	2	
Cumacea spp (Other)	Cumaceans squat	1		2	2	1		2			
Porcellanidae	Porcelline crabs	1									
Anthuridae	Anthurid isopods							3			
Gnathiidae	Gnathid isopods										
Serolidae	Serolid isopods										
Serolidae	Serolid isopods										
Sphaeromatidae	Sphaeromatid isopods										
Cirolanidae	Cirolanid isopods									1	
Arcturidae	Arcturid isopods					1					
Leptochelliidae	Leptochellid tanaids										
Apseudidae	Apseudid tanaids										
Brachyura	Crab megalopa										1
Leucosidae	Pebble crabs			1							
Majidae	Spider crabs									1	
Alpheidae	Snapping shrimp										
Callianassidae	Ghost shrimps										
Decapod (larvae)	Decapod larvae										
Decapoda spp.	shrimp										
Diogenidae	Hermit crabs										
Hexapodiidae	Hexapod crabs										
Mysidae	Opossum shrimps										
Processidae	Processid shrimps										
Ostracod sp A	Seed shrimps/oval	1		1				1		3	2
Chaetognatha	Arrow worms										
Branchiostomidae	Lancelets										
Oikopleuridae	Sea-squirt larvae										
Tunicata sp.	Sea squirts with sand	1					1				
Osteichthyes	Fish larvae										
Pennatulacea	Sea pens										
Anthnemonae	Anemone										
Ophionereididae	Ophionereid brittle stars					1			1		
Ophiurida spp	Brittle stars (juveniles)	1		1						1	1
Ophiurida (other)	Brittle stars	1									
Crinoidea	Crinoid										
Loveniidae	Loveniid sea urchins	2	1	1	1	1		1		1	1
Euechinoidea sp.	Urchin										
Glycymerididae	Glycmerid clams							1			
Donacidae	Surf clams		1								
Tellinidae	Tellins	1							1		
Mactridae	Mactrid clams	2	8	8	5	5					
Heterodonta	Heterodont clams (juveniles)			3		1			2	7	1
Mesodesmatidae	Mesodesmatid clams							2	2	8	1
Mytilidae	Marine Mussells										
Calyptraeidae	Slipper limpets			1							
Rissoidae	Rissoid snails										
Anabathridae	Anabathrid snails									1	
Buccinidae	Buccinid snails										
Columbellidae	Columbellid snails	2							1	3	
Nassariidae	Dog whelk	1			1						
Marginellidae	Margin Shells										
cf. Cylichnidae	Cylichnid snail										1
Philinidae	Philinid snails										
Pleurobranchidae	Side-gilled slug						1				
Acteonidae	Acteonid snails							1			
Pyramidellidae	Pyramid snails										
Haminoeidae	Marine slugs							1			
Heterobranchia sp	Marine slugs (juveniles)			1				1			
Mitriidae	Mitres										
Naticidae	Moon snails	1	1							2	
Gastrapoda spp	Gastrapods										
Trochidae	Trochids (juvenile)	1	1	1	1			1		1	
Facelinidae	Aeolid nudibranchs										
Nematoda spp	Nematodes	2	1	2	1			1		1	1
Nemertea	Velvet worms				1						
Hoplonemertea spp	Ribbon worms					2	2	1			
Phoronidae	Horseshoe worms			1	1			1	1	1	
Polycladida	Polyclad flatworms						1				
Spongiidae	Sponges										
Hexactinellida	Glass sponges										
Sipunculiformes spp	Peanut worms				1		3	4	1	4	1
	Total Abundance	**113**	**160**	**95**	**76**	**62**	**41**	**79**	**39**	**149**	**30**
	Taxa Richness	**25**	**16**	**21**	**22**	**11**	**14**	**27**	**15**	**29**	**15**

Family / Other Taxa	Common Name	Swansea-A	Swansea-B	Swansea-C	Swansea-D	Swansea-E	North Ref-A	North Ref-B	North Ref-C	North Ref-D	North Ref-E
Cirratulidae	Spagetti worms					2	1	2			
Dorvelliidae	Dorvelliid worms	9	2				1		1		
Lumbrineridae	Lumbrinerid worms	2	2	2	2	1					
Oenoidae	Oenoid worms									1	
Onuphidae	Onuphid worms	1	2	1		3	15	8	2	3	8
Glyceridae	Glycerid worms										
Hesionidae	Hesionid worms	1									
Nephtyidae	Nephtyid worms						1				
Nereididae	Nereidid worms						2				1
Phyllodocidae	Paddle worms										
Polynoidae	Polynoid worms										
Sigalionidae	Sigalionid worms						1			1	
Syllidae	Syllid worms	18	12	15	4	4	6	20	2	1	3
Oweniidae	Oweniid worms						1				
Sabellidae	Feather duster worms							1			
Serpulidae	Serpulid worms									1	
Chaetopteridae	Chaetopterid worms					1	6		1		2
Megalonidae	Megalonid worms										
Poecilochaetidae	Poecilochaetid worms										
Spionidae	Spionid worms	9	40	16	4	9	45	106	22	29	33
Pectinariidae	Trumpet worms						1				
Terrebellidae	Terebellid worms		1	1			1	2			
Trichobranchidae	Trichobranchid worms								1		1
Capitellidae	Capitellid worms										
Maldanidae	Bamboo worms							1			
Opheliidae	Opheliid worms										1
Orbiniidae	Rag worms										1
Paraonidae	Paraonid worms	12		1							
Polygordiidae	Polygordiid worms	50	133	118	9	61	4	1		2	1
Pycnogonida sp.	Sea spiders		1					1	2		2
undifferentiated	Copepods										
Dexaminidae	Amphipods						1	2		1	1
Lysianassidae	Lysianassid amphipods				1	1	1	13		1	1
Phoxocephalidae	Amphipods		3	2	1	3	7	17	13	4	10
Platyischnopidae	Amphipods	1	3	2	1	1		5	1	2	2
Urothoidae	Amphipods						1	2			2
Amphipoda spp	Amphipods						37	19	11	3	11
Caprellidae	Caprellid amphipod		1					31	2	1	
cf Aoridae	Amphipods					2	3	48	12	1	10
Corophiidae	Corophid amphipods		1								2
Bodotriidae	Bodotriid cumaceans	3	4	3	3	2	3	6	2		2
Cumacea spp (Other)	Cumaceans squat						3	19			4
Porcellanidae	Porcelline crabs							1	1		
Anthuridae	Anthurid isopods	5	4	1	2		2	4	2	1	3
Gnathiidae	Gnathid isopods							1			1
Serolidae	Serolid isopods						1	1	3		
Serolidae	Serolid isopods										
Sphaeromatidae	Sphaeromatid isopods										
Cirolanidae	Cirolanid isopods			1				1			
Arcturidae	Arcturid isopods						1	13			4
Leptochelliidae	Leptochelliid tanaids								1		1
Apseudidae	Apseudid tanaids										
Brachyura	Crab megalopa										
Leucosidae	Pebble crabs								1		
Majidae	Spider crabs								1		
Alpheidae	Snapping shrimp							1			
Callianassidae	Ghost shrimps						1				
Decapod (larvae)	Decapod larvae										
Decapoda spp.	shrimp										
Diogenidae	Hermit crabs							1			
Hexapodiidae	Hexapod crabs										
Mysidae	Opossum shrimps										
Processidae	Processid shrimps				1				2		
Ostracod sp A	Seed shrimps/oval		1				3	3			3
Chaetognatha	Arrow worms					1					
Branchiostomidae	Lancelets										
Oikopleuridae	Sea-squirt larvae										
Tunicata sp.	Sea squirts with sand	1									1
Osteichthyes	Fish larvae								1		
Pennatulacea	Sea pens								1		
Anthnemonae	Anemone			1					8		1
Ophionereididae	Ophionereid brittle stars					1					1
Ophiurida spp	Brittle stars (juveniles)						1		5		1
Ophiurida (other)	Brittle stars										
Crinoidea	Crinoid							1			
Loveniidae	Loveniid sea urchins							1	1		1
Euechinoidea sp.	Urchin								1		
Glycymerididae	Glycmerid clams			1							
Donacidae	Surf clams										
Tellinidae	Tellins					1					
Mactridae	Mactrid clams	1						2			
Heterodonta	Heterodont clams (juveniles)		4		1				3		
Mesodesmatidae	Mesodesmatid clams										
Mytilidae	Marine Mussells						1				2
Calyptraeidae	Slipper limpets				1						
Rissoidae	Rissoid snails		3								2
Anabathridae	Anabathrid snails										
Buccinidae	Buccinid snails										
Columbellidae	Columbellid snails										1
Nassariidae	Dog whelk										
Marginellidae	Margin Shells										
cf. Cylichnidae	Cylichnid snail										
Philinidae	Philinid snails										1
Pleurobranchidae	Side-gilled slug										
Acteonidae	Acteonid snails										
Pyramidellidae	Pyramid snails										
Haminoeidae	Marine slugs									1	
Heterobranchia sp	Marine slugs (juveniles)							10		1	9
Mitiridae	Mitres										
Naticidae	Moon snails										
Gastrapoda spp	Gastrapods								3		1
Trochidae	Trochids (juvenile)										
Facelinidae	Aeolid nudibranchs										
Nematoda spp	Nematodes	23	14	10	14	2	1	4	1	1	4
Nemertea	Velvet worms										
Hoplonemertea spp	Ribbon worms	1	2			1	1	2			1
Phoronidae	Horseshoe worms	2	6	2	4		4	7		1	2
Polycladida	Polyclad flatworms				2			1			1
Spongiidae	Sponges								1		
Hexactinellida	Glass sponges								3		
Sipunculiformes spp	Peanut worms		4	1			9	6	4	4	5
	Total Abundance	**139**	**243**	**178**	**50**	**96**	**166**	**364**	**115**	**60**	**144**
	Taxa Richness	**16**	**21**	**17**	**15**	**17**	**32**	**37**	**32**	**20**	**41**

Appendix B – PMST Output

Australian Government
Department of the Environment and Energy

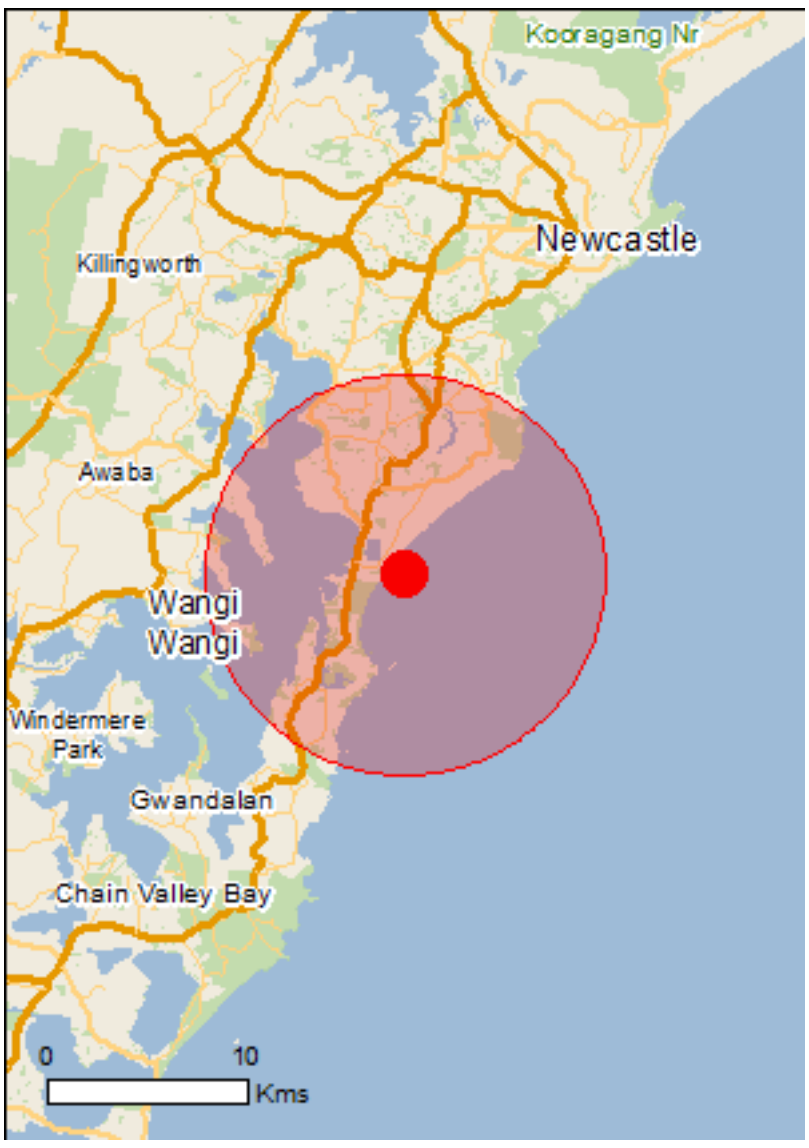
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

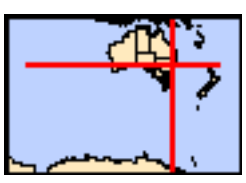
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 21/11/19 12:03:07



Coordinates
Buffer: 10.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	5
Listed Threatened Species:	79
Listed Migratory Species:	72

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	7
Commonwealth Heritage Places:	None
Listed Marine Species:	98
Whales and Other Cetaceans:	16
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	8
Regional Forest Agreements:	1
Invasive Species:	47
Nationally Important Wetlands:	2
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Hunter estuary wetlands	Within 10km of Ramsar

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
Temperate East

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Central Hunter Valley eucalypt forest and woodland	Critically Endangered	Community may occur within area
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	Endangered	Community likely to occur within area
Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	Critically Endangered	Community likely to occur within area
Posidonia australis seagrass meadows of the Manning-Hawkesbury ecoregion	Endangered	Community likely to occur within area
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Species or species habitat known to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat known to occur within area
Dasyornis brachypterus Eastern Bristlebird [533]	Endangered	Species or species habitat likely to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea antipodensis gibsoni Gibson's Albatross [82270]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Fregetta grallaria grallaria White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian) [64438]	Vulnerable	Species or species habitat likely to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat known to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Pterodroma leucoptera leucoptera Gould's Petrel, Australian Gould's Petrel [26033]	Endangered	Species or species habitat may occur within area
Pterodroma neglecta neglecta Kermadec Petrel (western) [64450]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Species or species habitat may occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche bulleri platei Northern Buller's Albatross, Pacific Albatross [82273]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta cauta Shy Albatross [82345]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta steadi White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thinornis rubricollis rubricollis Hooded Plover (eastern) [66726]	Vulnerable	Species or species habitat likely to occur within area
Fish		
Epinephelus daemelii Black Rockcod, Black Cod, Saddled Rockcod [68449]	Vulnerable	Species or species habitat likely to occur within area
Frogs		
Heleioporus australiacus Giant Burrowing Frog [1973]	Vulnerable	Species or species habitat may occur within area
Litoria aurea Green and Golden Bell Frog [1870]	Vulnerable	Species or species habitat known to occur

Name	Status	Type of Presence
		within area
Litoria littlejohni Littlejohn's Tree Frog, Heath Frog [64733]	Vulnerable	Species or species habitat may occur within area
Mammals		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat likely to occur within area
Dasyurus maculatus maculatus (SE mainland population) Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat known to occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat known to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Potorous tridactylus tridactylus Long-nosed Potoroo (SE Mainland) [66645]	Vulnerable	Species or species habitat likely to occur within area
Pseudomys novaehollandiae New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat known to occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Plants		
Acacia bynoeana Bynoe's Wattle, Tiny Wattle [8575]	Vulnerable	Species or species habitat likely to occur within area
Angophora inopina Charmhaven Apple [64832]	Vulnerable	Species or species habitat likely to occur within area
Caladenia tessellata Thick-lipped Spider-orchid, Daddy Long-legs [2119]	Vulnerable	Species or species habitat likely to occur within area
Corunastylis insignis Wyong Midge Orchid 1, Variable Midge Orchid 1 [84692]	Critically Endangered	Species or species habitat known to occur within area
Cryptostylis hunteriana Leafless Tongue-orchid [19533]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat known to occur within area
Cynanchum elegans White-flowered Wax Plant [12533]	Endangered	Species or species habitat known to occur within area
Diuris praecox Newcastle Doubletail [55086]	Vulnerable	Species or species habitat known to occur within area
Eucalyptus camfieldii Camfield's Stringybark [15460]	Vulnerable	Species or species habitat likely to occur within area
Eucalyptus parramattensis subsp. decadens Earp's Gum, Earp's Dirty Gum [56148]	Vulnerable	Species or species habitat likely to occur within area
Grevillea parviflora subsp. parviflora Small-flower Grevillea [64910]	Vulnerable	Species or species habitat known to occur within area
Grevillea shiressii [19186]	Vulnerable	Species or species habitat likely to occur within area
Melaleuca biconvexa Biconvex Paperbark [5583]	Vulnerable	Species or species habitat may occur within area
Persicaria elatior Knotweed, Tall Knotweed [5831]	Vulnerable	Species or species habitat likely to occur within area
Pterostylis gibbosa Illawarra Greenhood, Rufa Greenhood, Pouched Greenhood [4562]	Endangered	Species or species habitat may occur within area
Rutidosis heterogama Heath Wrinklewort [13132]	Vulnerable	Species or species habitat likely to occur within area
Syzygium paniculatum Magenta Lilly Pilly, Magenta Cherry, Daguba, Scrub Cherry, Creek Lilly Pilly, Brush Cherry [20307]	Vulnerable	Species or species habitat known to occur within area
Tetratheca juncea Black-eyed Susan [21407]	Vulnerable	Species or species habitat known to occur within area
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or

Name	Status	Type of Presence
		related behaviour known to occur within area
Sharks		
Carcharias taurus (east coast population)		
Grey Nurse Shark (east coast population) [68751]	Critically Endangered	Species or species habitat likely to occur within area
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus		
Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes		
Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area
Ardenna grisea		
Sooty Shearwater [82651]		Species or species habitat likely to occur within area
Ardenna pacifica		
Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Calonectris leucomelas		
Streaked Shearwater [1077]		Species or species habitat known to occur within area
Diomedea antipodensis		
Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora		
Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans		
Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi		
Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Fregata ariel		
Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor		
Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat likely to occur within area
Macronectes giganteus		
Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Sternula albifrons Little Tern [82849]		Breeding likely to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta Shy Albatross [89224]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area

Name	Threatened	Type of Presence
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Dugong dugon Dugong [28]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat may occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat likely to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat may occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat likely to occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius phaeopus Whimbrel [849]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Pluvialis fulva		
Pacific Golden Plover [25545]		Species or species habitat known to occur within area
Thalasseus bergii		
Crested Tern [83000]		Breeding known to occur within area
Tringa brevipes		
Grey-tailed Tattler [851]		Species or species habitat known to occur within area
Tringa nebularia		
Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis		
Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -
Commonwealth Land - Australian Postal Commission
Commonwealth Land - Australian Telecommunications Commission
Commonwealth Land - Commonwealth Trading Bank of Australia
Commonwealth Land - Defence Service Homes Corporation
Commonwealth Land - Director of War Service Homes
Commonwealth Land - Telstra Corporation Limited

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus		
Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis		
Cattle Egret [59542]		Breeding likely to occur within area
Arenaria interpres		
Ruddy Turnstone [872]		Species or species habitat known to occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species

Name	Threatened	Type of Presence
		habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat likely to occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Catharacta skua Great Skua [59472]		Species or species habitat may occur within area
Charadrius bicinctus Double-banded Plover [895]		Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Species or species habitat known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea gibsoni Gibson's Albatross [64466]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Eudyptula minor Little Penguin [1085]		Breeding known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat likely to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Species or species habitat known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Larus dominicanus Kelp Gull [809]		Breeding known to occur within area
Larus novaehollandiae Silver Gull [810]		Breeding known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat likely to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius phaeopus Whimbrel [849]		Species or species habitat known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur

Name	Threatened	Type of Presence within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Species or species habitat known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat likely to occur within area
Puffinus griseus Sooty Shearwater [1024]		Species or species habitat likely to occur within area
Puffinus pacificus Wedge-tailed Shearwater [1027]		Breeding known to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Sterna albifrons Little Tern [813]		Breeding likely to occur within area
Sterna bergii Crested Tern [816]		Breeding known to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta Shy Albatross [89224]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche sp. nov. Pacific Albatross [66511]	Vulnerable*	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely

Name	Threatened	Type of Presence
		to occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat likely to occur within area
Thinornis rubricollis rubricollis Hooded Plover (eastern) [66726]	Vulnerable	Species or species habitat likely to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area
Fish		
Acentronura tentaculata Shortpouch Pygmy Pipehorse [66187]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Heraldia nocturna Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish [66227]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus abdominalis Big-belly Seahorse, Eastern Potbelly Seahorse, New Zealand Potbelly Seahorse [66233]		Species or species habitat may occur within area
Hippocampus whitei White's Seahorse, Crowned Seahorse, Sydney Seahorse [66240]		Species or species habitat likely to occur within area
Histiogamphelus briggsii Crested Pipefish, Briggs' Crested Pipefish, Briggs' Pipefish [66242]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Notiocampus ruber Red Pipefish [66265]		Species or species habitat may occur within area
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse [66275]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Solenostomus paradoxus Ornate Ghostpipefish, Harlequin Ghost Pipefish, Ornate Ghost Pipefish [66184]		Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Mammals		
Arctocephalus forsteri Long-nosed Fur-seal, New Zealand Fur-seal [20]		Species or species habitat may occur within area
Arctocephalus pusillus Australian Fur-seal, Australo-African Fur-seal [21]		Species or species habitat may occur within area
Dugong dugon Dugong [28]		Species or species habitat may occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans		[Resource Information]
Name	Status	Type of Presence
Mammals		

Name	Status	Type of Presence
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Awabakal	NSW
Glenrock	NSW
Lake Macquarie	NSW
Moon Island	NSW
Munmorah	NSW
Pulbah Island	NSW
Tingira Heights	NSW
Wallarah	NSW

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
North East NSW RFA	New South Wales

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Alauda arvensis Skylark [656]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Lonchura punctulata Nutmeg Mannikin [399]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Pycnonotus jocosus Red-whiskered Bulbul [631]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides Alligator Weed [11620]		Species or species habitat likely to occur within area
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		Species or species habitat likely to occur within area
Asparagus scandens Asparagus Fern, Climbing Asparagus Fern		Species or species

Name	Status	Type of Presence
[23255]		habitat likely to occur within area
Cabomba caroliniana Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera subsp. rotundata Bitou Bush [16332]		Species or species habitat likely to occur within area
Cytisus scoparius Broom, English Broom, Scotch Broom, Common Broom, Scottish Broom, Spanish Broom [5934]		Species or species habitat likely to occur within area
Eichhornia crassipes Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Senecio madagascariensis Fireweed, Madagascar Ragwort, Madagascar Groundsel [2624]		Species or species habitat likely to occur within area
Solanum elaeagnifolium Silver Nightshade, Silver-leaved Nightshade,		Species or species

Name	Status	Type of Presence
White Horse Nettle, Silver-leaf Nightshade, Tomato Weed, White Nightshade, Bull-nettle, Prairie-berry, Satansbos, Silver-leaf Bitter-apple, Silverleaf-nettle, Trompillo [12323]		habitat likely to occur within area

Nationally Important Wetlands

[Resource Information]

Name	State
Jewells Wetland	NSW
Lake Macquarie	NSW

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-33.0535 151.67738

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

Appendix C – Likelihood of occurrence

Species	EPBC Act status	FM Act status	BC Act status	Description	Likelihood of occurrence
Threatened species					
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 intake pipe area; as the nearshore benthic environment consists primarily of sandy habitat (Advisian, 2016). The intake pipe will provide 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 intake 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.

Species	EPBC Act status	FM Act status	BC Act status	Description	Likelihood of occurrence
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 intake pipe 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. The 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.
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 inhabit coastal regions north of Sydney.	**May occur** Individuals may transit or be present within the intake pipe 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 intake pipe area.
Marine reptiles					
Loggerhead turtle *(Caretta caretta)*	E, Mig		E1, P	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, P	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.

Species	EPBC Act status	FM Act status	BC Act status	Description	Likelihood of occurrence
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 in NSW (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		P	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.
Flatback turtle (*Natator depressus*)	V, Mig			Nesting sites occur between Bundaberg in QLD 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					
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.

Species	EPBC Act status	FM Act status	BC Act status	Description	Likelihood of occurrence
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.
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.
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.

Species	EPBC Act status	FM Act status	BC Act status	Description	Likelihood of occurrence
Southern right whale (*Eubalaena australis*)	E, Mig		E1, P	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, P	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, P	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 project area is located in a 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.
Common dolphin (*Delphinus delphis)*			P	This species distribution across Australia is not well known, but they have been recorded in NSW, QLD, TAS and WA. Habitat information has only been gathered from outside of Australia. They are usually found in waters over the continental shelf. Usually occur in habitats inhabited by small epipelagic fishes including anchovies and sardines (Evans 1994; Forcada & Hammond 1998).	**May occur** This species is more commonly associated with deeper waters, however its coastal distribution is not known in Australia providing potential for it to occur within the project area.
Bottlenose dolphin (*Tursiops truncatus)*			P	Distribution in Australia is not well known, however it has been recorded off QLD, NSW, Tasmania, SA and south-west WA. Usually found in offshore waters deeper than 30 m, but have been recorded in coastal waters. When inshore they occur in bays, lagoons and estuaries as well as open coastal waters (Hale et al. 2000; Ross 2006).	**Likely to occur** Occurs in nearshore environments consistent with the project area.

Species	EPBC Act status	FM Act status	BC Act status	Description	Likelihood of occurrence
Gray's beaked whale (*Mesoplodon grayi)*			P	Known only from standings along the Australian coast in SA, VIC, Tasmania and NSW. Occurs in waters approximately 200 nm from the coast, between 30° S and 50° S in waters deeper than 200 m. Occurs in temperate to sub-Antarctic waters (Pittman 2002; Ross 2006).	**Unlikely to occur** This species occurs in deep, offshore waters, it is not a coastal occurring species.
Birds					
38 EPBC listed species 83 listed State species					**Likely to occur** Marine, 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. Terrestrial and wetland species are likely to occur on the foreshore to rest and forage.

Species	EPBC Act status	FM Act status	BC Act status	Description	Likelihood of occurrence
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). This includes White's seahorse (*Hippocampus whitei*), listed as endangered under the FM Act. This species prefers shallow-water estuarine habitats and is most commonly recorded in Port Stephens, Sydney Harbour and Port Hacking. This species is considered unlikely to occur within the project area due to its preference for sheltered estuarine habitats (DPI, 2019).	**Likely to occur** The hard substrate of the nearby 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 proposed intake pipe area.
Migratory species					
Sharks					
Porbeagle *(Lamna nasus)*	Mig			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.

Species	EPBC Act status	FM Act status	BC Act status	Description	Likelihood of occurrence
Rays					
Reef manta ray (*Manta alfredi)*	Mig			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.
Giant manta ray (*Manta birostris)*	Mig			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.
Marine mammals					
Bryde's whale *(Balaenoptera edeni)*	Mig			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)*	Mig			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)*	Mig			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 within the species most northerly distribution.

Species	EPBC Act status	FM Act status	BC Act status	Description	Likelihood of occurrence
Killer whale *(Orcinus orca)*	Mig			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.
Australian Humpback Dolphin *(Sousa sahulensis)*	Mig			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.
Birds					
43 species	Mig				**Likely to 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. These species are likely to rest along the foreshore within the project area.

Key: CE - Critically Endangered; E/E1 – Endangered; V – Vulnerable; P – Protected; Mig - Migratory

Appendix D – Assessment under the EPBC Act

The following significant impact assessments were undertake in accordance with the Significant Impact Guidelines (version 1.1.) under the EPBC Act for MNES species considered likely to occur within the project area as determined in Section 4.2.2.

The follow species groups were assessed:

- Four marine mammals
- Three marine reptiles
- One shark
- The Syngnathids group
- Shorebirds group (migratory and resident)

All species assessed were considered unlikely to be significantly impacted by the proposed works as shown in the following tables.

Significant impact criteria	Impact outcomes
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of an important population of a species	**Unlikely** Humpback whale 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 primarily occurs off the coast of Mackay, QLD. This species does not feed, rest or calve in or around the project area. However, it will pass through the area on its annual migration. Depending on the construction timing, mitigation measures will need to be implemented if construction is to occur during the migration window. As this species exhibits avoidance behaviour to artificial noise, coupled with the mitigation techniques suggested, it is considered unlikely that the proposed works will impact the lifecycle of this species.
Reduce the area of occupancy of an important population	**Unlikely** Humpback whale This species will pass through the area on its annual migration. Depending on the construction timing, mitigation measures will need to be implemented if construction is to occur during the migration window. This species exhibits avoidance behaviour to artificial noise, and will most likely migrate over deeper waters further offshore. As offshore habitat also provides suitable migratory area it is not anticipated that there will be a permanent reduction in the area of occupancy for this species.
Fragment an existing important population into two or more populations	**Unlikely** Humpback whale This species may exhibit avoidance behaviour if passing the area during construction of the intake pipe. Mitigation measures are in place to manage activities for avoidance of impact to this species. Therefore, the survey activities are not expected to fragment a population into two or more populations.

Significant impact criteria	Impact outcomes
Adversely affect habitat critical to the survival of a species	**Unlikely** Humpback whale The project area is outside the identified key feeding, calving and resting habitats for this species. Rather, this species will migrate past the project area. Depending on the construction timing, mitigation measures will need to be implemented if construction is to occur during the migration window. This species exhibits avoidance behaviour to artificial noise, and will most likely migrate over deeper waters further offshore. These waters provide suitable habitat and any displacement would be temporary (during the construction period). It is not anticipated that there will be a permanent habitat reduction, with the whales able to return to the area during migration upon completion of the works.
Disrupt the breeding cycle of an important population	**Unlikely** Humpback whale This species does not feed, rest or calve in or around the project area.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely** Humpback whale This species will pass through the area on its annual migration. Depending on the construction timing, mitigation measures will need to be implemented if construction is to occur during the migration window. This species exhibits avoidance behaviour to artificial noise, and will most likely migrate over deeper waters further offshore temporarily (during the construction period). It is not anticipated that there will be a permanent habitat reduction, with the whales returning to the area during migration upon completion of the works.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Unlikely** Humpback whale The proposed works are not expected to result in any invasive species that are harmful to the species becoming established in the species habitat. Environmental management measures implemented are in conjunction with accepted international and domestic practice with risk of introduction of invasive species to as low as reasonably practicable.
Introduce disease that may cause the species to decline	**Unlikely** Humpback whale The proposed works are not expected to result in the introduction of disease that may cause the species to decline. Environmental management measures implemented are in conjunction with accepted international and domestic practice with risk of introduction of disease to as low as reasonably practicable.
Interfere substantially with the recovery of the species	**Unlikely** Humpback whale The proposed works are not expected to interfere with the recovery of the species. Whales may temporarily (during the construction period) be displaced from the immediate area due to artificial noise avoidance behaviour. It is not anticipated that there will be a permanent habitat reduction, with the whales returning to the area during migration upon completion of the works.

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 will:	
Lead to a long-term decrease in the size of a population	**Unlikely** Southern right whale Feeding grounds of the southern right whale are in deep sub-Antarctic waters. Migrations generally 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 will affect the species lifecycle. Individuals may travel past the area during migrations however the species will be able to avoid project activities. In particular, as project activities are coastal in nature the risk of entanglement is expected to be mitigated given whales will pass the project area further offshore.
Reduce the area of occupancy of the species	**Unlikely** Southern right whale 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. This species is migratory, migrating between 60°S and 32°S. This species is likely to pass the project area during migrations further offshore. There are no known feeding or breeding areas near the project area. Therefore, activities associated with the project are not anticipated to reduce the area of occupancy of this species.
Fragment an existing population into two or more populations	**Unlikely** Southern right whale The proposed activity will not permanently fragment an existing population into two or more populations. The proposed works may temporarily displace whales to further offshore waters as they avoid the increased construction noise of the area. Whales are expected to return after cessation of works and are not anticipated to be permanently affected.
Adversely affect habitat critical to the survival of a species	**Unlikely** Southern right whale Feeding grounds of the southern right whale are in deep sub-Antarctic waters. Migratory behaviour generally occurs between 60°S and 32°S. 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 will affect the species critical habitat. Individuals may travel through the area during migrations however the species will be able to avoid project activities to avoid adverse effects from project activities.
Disrupt the breeding cycle of a population	**Unlikely** Southern right whale 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 will affect the species breeding cycle.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely** Southern right whale The habitat for the southern right whale is unlikely to be significantly modified, destroyed, isolated or decrease due to the proposed works as there are no breeding grounds within the project area. Any impact on this species is unlikely as species are expected to pass offshore of the project at distance from direct influence of the project activities. None of the proposed activities will alter that habitat suitability for whales post cessation of works.

Significant impact criteria	Impact outcome
Result in invasive species that are harmful to an endangered species becoming established in the endangered species habitat	**Unlikely** Southern right whale The proposed works are not expected to result in any invasive species that are harmful to the species becoming established in the species habitat. Environmental management measures implemented are in conjunction with accepted international and domestic practice with risk of introduction of invasive species to as low as reasonably practicable.
Introduce disease that may cause the species to decline	**Unlikely** Southern right whale The proposed works are not expected to result in the introduction of disease that may cause the species to decline. Environmental management measures implemented are in conjunction with accepted international and domestic practice with risk of introduction of disease to as low as reasonably practicable.
Interfere with the recovery of the species	**Unlikely** Southern right whale The proposed works will not interfere with the recovery of the species. Whales may temporarily be displaced from the immediate area due to artificial noise avoidance behaviour. However, this species is nomadic in the area and does not usually travel as far inshore as the proposed works. It is anticipated that should this species exhibit any temporary avoidance behaviour that will result in the species moving further offshore of the area during the proposed works.

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 will:	
Lead to a long-term decrease in the size of a population	**Unlikely** Loggerhead turtle The proposed works are unlikely to lead to a long-term decrease in the population size of the loggerhead turtle. The proposal site is not close to any known breeding grounds for this species.
Reduce the area of occupancy of the species	**Unlikely** Loggerhead turtle It is considered that the species is likely to occupy the area of the proposed works. Previous records show that individuals have been observed in the region. If present, the species is expected to transit the project area between food sources/foraging grounds. The proposed works will be short-term in nature and overall there will be no reduction in the area of occupancy of the loggerhead turtle.
Fragment an existing population into two or more populations	**Unlikely** Loggerhead turtle The proposed activity will not permanently fragment an existing population into two or more populations. The proposed works may temporarily displace turtles as they avoid the increased artificial noise of the area. Turtles are expected to return after cessation of works and are not anticipated to be permanently affected.
Adversely affect habitat critical to the survival of a species	**Unlikely** Loggerhead turtle The proposed works will not adversely affect habitat critical to the survival of the species. The proposal site is not close to any known breeding grounds for this species. However the nearby outfall pipe is covered in sponges that this species may feed on. Lake Macquarie also has rocky reefs known to be grazed by turtles, therefore this species may transit through the project area to Lake Macquarie. This species can avoid the area and still access Lake Macquarie, therefore it is not anticipated that proposed works will have an effect on the lifecycle of the species.
Disrupt the breeding cycle of a population	**Unlikely** Loggerhead turtle The proposal site is not close to any known breeding grounds for this species and therefore is not expected to disrupt the breeding cycle of the species.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely** Loggerhead turtle The habitat important for breeding and recruitment of the loggerhead turtle does not occur within the project area; as such it is unlikely to be significantly modified, destroyed, isolated or decrease due to the proposed works. Any impact on this species is unlikely and if impacts were to occur, would be short-term and localised in nature. These may include the following: • Entanglement in marine equipment during the proposed works – unlikely as turtles are expected to show avoidance of construction vessels • Behavioural avoidance of the area during the proposed works – suitable adjacent habitat exists; temporary in nature • Potential exposure to pollutants that arise as a consequence of the proposed works – unlikely as controls to mitigate risk of pollutant release will be in effect Accordingly an impact that affects species decline is unlikely to occur.

Significant impact criteria	Impact outcome
Result in invasive species that are harmful to an endangered species becoming established in the endangered species habitat	**Unlikely** Loggerhead turtle The proposed works are not expected to result in any invasive species that are harmful to the species becoming established in the species habitat. Environmental management measures implemented are in conjunction with accepted international and domestic practice with risk of introduction of invasive species to as low as reasonably practicable.
Introduce disease that may cause the species to decline	**Unlikely** Loggerhead turtle The proposed works are not expected to result in the introduction of disease that may cause the species to decline. Environmental management measures implemented are in conjunction with accepted international and domestic practice with risk of introduction of disease to as low as reasonably practicable.
Interfere with the recovery of the species	**Unlikely** Loggerhead turtle The proposed works are not expected to interfere with the recovery of the species. Turtles may temporarily be displaced from the immediate area due to artificial noise avoidance behaviour. However, this species is nomadic in the area and nearby Lake Macquarie contains habitat and resources for this species to utilise.

Significant impact criteria	Impact outcomes
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of an important population of a species	**Unlikely** Green turtle The proposed works are unlikely to lead to a long-term decrease in the population size of the green turtle. The proposal site is not close to any known breeding grounds for this species.
Reduce the area of occupancy of an important population	**Unlikely** Green turtle It is considered that the species is likely to occupy the area of the proposed works. If present, the species is expected to transit the project area between food sources/foraging grounds. Previous records show that individuals have been observed in the region. The proposed works will be short-term in nature and overall there will be no reduction in the area of occupancy of the green turtle.
Fragment an existing important population into two or more populations	**Unlikely** Green turtle The proposed activity will not permanently fragment an existing population into two or more populations. The proposed works may temporarily displace turtles as they avoid the increased artificial noise of the area. Turtles are expected to return after cessation of construction works and are not anticipated to be permanently affected.
Adversely affect habitat critical to the survival of a species	**Unlikely** Green turtle The proposed works will not adversely affect habitat critical to the survival of the species. The proposal site is not close to any known breeding grounds for this species nor any seagrass beds. Lake Macquarie contains seagrass beds known to be grazed by turtles, therefore this species may transit through the project area to Lake Macquarie. This species can avoid the area and still access Lake Macquarie, therefore it is not anticipated that proposed works will have an effect on the lifecycle of the species.
Disrupt the breeding cycle of an important population	**Unlikely** Green turtle The proposal site is not close to any known breeding grounds for this species and will not disrupt 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** Green turtle The habitat for the green turtle is unlikely to be significantly modified, destroyed, isolated or decrease due to the proposed works as there are no breeding grounds within the project area. Any impact on this species is unlikely and if impacts were to occur, would be short-term and localised in nature. Behavioural avoidance of the area during the proposed works would not unduly influence the species as suitable adjacent habitat exists adjacent the project area. Displacement would be temporary in nature. Other potential localised short-term impacts to individuals may include the following: • Entanglement in marine equipment during the proposed works • Potential exposure to pollutants that arise as an unplanned consequence of the proposed works However, these are considered highly unlikely given behavioural avoidance of the area during works would mitigate exposure to other risks.

Significant impact criteria	Impact outcomes
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Unlikely** Green turtle The proposed works are not expected to result in any invasive species that are harmful to the species becoming established in the species habitat. Environmental management measures implemented are in conjunction with accepted international and domestic practice with risk of introduction of invasive species to as low as reasonably practicable.
Introduce disease that may cause the species to decline	**Unlikely** Green turtle The proposed works are not expected to result in the introduction of disease that may cause the species to decline. Environmental management measures implemented are in conjunction with accepted international and domestic practice with risk of introduction of disease to as low as reasonably practicable.
Interfere substantially with the recovery of the species	**Unlikely** Green turtle The proposed works are not expected to interfere with the recovery of the species. Turtles may temporarily be displaced from the immediate area due to artificial noise avoidance behaviour. However, this species is nomadic in the area and nearby Lake Macquarie contains habitat and resources for this species to utilise.

Significant impact criteria	Impact outcomes
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
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. As the works are not located near a breeding area, it is anticipated that proposed works will not have an effect on the population of the species.
Reduce the area of occupancy of an important population	**Unlikely** Hawksbill turtle 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 nearby outfall pipe within the project area. Lake Macquarie is also known to contain hawksbill turtles as it provides foraging habitat. Therefore this species may transit through the intake pipe 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 will not be impacted, it is anticipated that proposed works will 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 will not fragment an existing population into two or more populations.
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 will 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 will 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 will not be impacted, it is not anticipated that proposed works will 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 will 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 will not adversely affect habitat used by the species to the extent that the species is likely to decline.

Significant impact criteria	Impact outcomes
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Unlikely** Hawksbill turtle The proposed works are not expected to result in any invasive species that are harmful to the species becoming established in the species habitat. Environmental management measures implemented are in conjunction with accepted international and domestic practice with risk of introduction of invasive species to as low as reasonably practicable.
Introduce disease that may cause the species to decline	**Unlikely** Hawksbill turtle The proposed works are not expected to result in the introduction of disease that may cause the species to decline. Environmental management measures implemented are in conjunction with accepted international and domestic practice with risk of introduction of disease to as low as reasonably practicable.
Interfere substantially with the recovery of the species	**Unlikely** Hawksbill turtle The proposed works are not expected to interfere with the recovery of the species. Turtles may temporarily be displaced from the immediate area due to artificial noise avoidance behaviour. However, this species is nomadic in the area and nearby Lake Macquarie contains habitat and resources for this species to utilise.

Significant impact criteria	Impact outcomes
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of an important population of a species	**Unlikely** Great white shark 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. 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. Therefore, activities associated with the project are not anticipated to disrupt the lifecycle of this species.
Reduce the area of occupancy of an important population	**Unlikely** Great white shark As identified above, juveniles, sub-adults and adults appear to 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. Therefore, activities associated with the project are not anticipated to disrupt the area of occupancy of an important population of this species.
Fragment an existing important population into two or more populations	**Unlikely** Great white shark As identified above, 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. Sharks may be temporarily displaced from the area due to behavioural avoidance from the artificial noise. Therefore, activities associated with the project are not anticipated to fragment a population.
Adversely affect habitat critical to the survival of a species	**Unlikely** Great white shark The project area is not considered to form habitat critical to the survival of the Great white shark. The proposed survey works are not expected to adversely affect critical habitat for this species.
Disrupt the breeding cycle of an important population	**Unlikely** Great white shark Great white sharks, if present in the project area, are expected as transient visitors only. Therefore, the proposed survey is not expected to disrupt the breeding cycle of this 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** Great white shark 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. Therefore, activities for the proposed works are not anticipated to impact habitat associated with this species.

Significant impact criteria	Impact outcomes
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Unlikely** Great white shark The proposed works are not expected to result in any invasive species that are harmful to the species becoming established in the species habitat. Environmental management measures implemented are in conjunction with accepted international and domestic practice with risk of introduction of invasive species to as low as reasonably practicable.
Introduce disease that may cause the species to decline	**Unlikely** Great white shark The proposed works are not expected to result in the introduction of disease that may cause the species to decline. Environmental management measures implemented are in conjunction with accepted international and domestic practice with risk of introduction of disease to as low as reasonably practicable.
Interfere substantially with the recovery of the species	**Unlikely** Great white shark The proposed works are not expected to interfere with the recovery of the species. Sharks may temporarily be displaced from the immediate area due to artificial noise avoidance behaviour. However, this species is nomadic in the area, with suitable, comparable habitat available nearby.

Significant impact criteria	Impact outcomes
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: Criteria for Syngnathids are not available; these have been used a proxy	
Lead to a long-term decrease in the size of an important population of a species	**Unlikely** Syngnathids The proposed works are unlikely to lead to a long-term decrease in the population size of these species. Core breeding habitat is not expected to be disrupted/affected by the proposed works.
Reduce the area of occupancy of an important population	**Unlikely** Syngnathids If present at the time of construction, these species may occupy weedy seabed habitat or other subtidal 'structure'. Previous records show that individuals have been observed in the region, however the immediate around of the intake pipe is flat sand beds with no structures to inhabit. The proposed works will be short-term in nature and overall there is not expected to be a reduction in the area of occupancy.
Fragment an existing important population into two or more populations	**Unlikely** Syngnathids The proposed activity will not permanently fragment habitat or other factors that would support these populations. Construction works will be temporary in nature, with the resulting intake pipe being placed in open, sandy sea bed that is devoid of structures that could be utilised by these species. Due to a lack of habitat, it is considered unlikely that the proposed works will fragment an existing population.
Adversely affect habitat critical to the survival of a species	**Unlikely** Syngnathids The proposed works will not adversely affect habitat critical to the survival of the species as no direct habitat impacts are expected during mapping of the seabed conditions.
Disrupt the breeding cycle of an important population	**Unlikely** Syngnathids The proposal site is not close to any known breeding grounds for this species and will not disrupt 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** Syngnathids The habitat for these species won't be directly contacted by proposed works. It is therefore not expected to be significantly modified, destroyed, isolated or decreased due to the proposed works such that these species would decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Unlikely** Syngnathids The proposed works are not expected to result in any invasive species that are harmful to the species becoming established in the species habitat. Environmental management measures implemented are in conjunction with accepted international and domestic practice with risk of introduction of invasive species to as low as reasonably practicable.
Introduce disease that may cause the species to decline	**Unlikely** Syngnathids The proposed works are not expected to result in the introduction of disease that may cause the species to decline. Environmental management measures implemented are in conjunction with accepted international and domestic practice with risk of introduction of disease to as low as reasonably practicable.

Significant impact criteria	Impact outcomes
Interfere substantially with the recovery of the species	**Unlikely** Syngnathids The proposed works are not expected to interfere with habitats important for breeding of the species; accordingly no affects to the recovery of the species are expected.

Significant impact criteria	Impact outcomes
An action is likely to have a significant impact on a species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of an important population of a species	**Unlikely** Shorebirds The proposed works are unlikely to lead to a long-term decrease in the population size of these species. Core breeding habitat of migratory shorebirds is not expected to be disrupted/affected by the proposed works as these species to not nest/breed in Australia Birds that nest on Australia beaches (e.g. oystercatchers (*Haematopus spp.*) may temporarily avoid the area to nest if construction works occur during nesting seasons. However, these species do not have specific nesting grounds and can utilise nearby and adjacent suitable nesting habitat. It is anticipated that these species will return to utilise the project area again after completion of construction works.
Reduce the area of occupancy of an important population	**Unlikely** Shorebirds Depending on the construction method chosen, the available habitat on the shore within the project area may be reduced temporarily during construction works as birds exhibit avoidance behaviour. However, as these works are temporary, species are expected to return to the site upon completion of construction. The most common birds sighted around the project are migratory and therefore can utilise nearby and adjacent areas to rest and feed during construction works as necessary.
Fragment an existing important population into two or more populations	**Unlikely** Shorebirds There are no resident populations of shorebirds within the project area. Migratory and individual/paired species occur in the area and can utilise adjacent and nearby suitable habitat during the construction works period. Works are not anticipated to fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of a species	**Unlikely** Shorebirds Depending on the construction method chosen, birds that utilise the shore environment may be temporarily displaced from the project area during construction works and will avoid the area. After the completion of works, it is anticipated that shorebirds will return to utilise the area.
Disrupt the breeding cycle of an important population	**Unlikely** Shorebirds The migratory shorebirds do not breed or nest in Australia. Birds that nest on Australia beaches (e.g. oystercatchers (*Haematopus spp.*) may temporarily avoid the area to nest if construction works occur during nesting seasons. However, these species do not have specific nesting grounds and can utilise nearby and adjacent suitable nesting habitat. It is anticipated that these species will return to utilise the project area again after completion of construction works.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely** Shorebirds Depending on the construction method chosen, birds that utilise the shore environment may be temporarily displaced from the project area during construction works and will avoid the area. After the completion of works, it is anticipated that shorebirds will return to utilise the area. As the construction works are temporary, it is not anticipated that the temporary modification of the habitat will lead to a decreased in the quality of habitat to the extent that the species are likely to decline.

Significant impact criteria	Impact outcomes
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Unlikely** Shorebirds The proposed works are not expected to result in any invasive species that are harmful to the species becoming established in the species habitat. Environmental management measures implemented are in conjunction with accepted international and domestic practice with risk of introduction of invasive species to as low as reasonably practicable.
Introduce disease that may cause the species to decline	**Unlikely** Shorebirds The proposed works are not expected to result in the introduction of disease that may cause the species to decline. Environmental management measures implemented are in conjunction with accepted international and domestic practice with risk of introduction of disease to as low as reasonably practicable.
Interfere substantially with the recovery of the species	**Unlikely** Shorebirds The migratory shorebirds do not breed or nest in Australia. Birds that nest on Australia beaches (e.g. oystercatchers (*Haematopus spp.*) may temporarily avoid the area to nest if construction works occur during nesting seasons. However, these species do not have specific nesting grounds and can utilise nearby and adjacent suitable nesting habitat. It is anticipated that these species will return to utilise the project area again after completion of construction works. Therefore, interference to substantially impact the recovery of these species is not anticipated.

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 will:	
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species	**Unlikely** Dugong The proposed works will not adversely affect habitat critical to the survival of the species. The project area is not close to any known breeding grounds for this species nor does it contain any seagrass beds. Lake Macquarie contains seagrass beds known to be grazed by dugongs, therefore this species may transit past the project area to Lake Macquarie. This species can avoid the area and still access Lake Macquarie, therefore it is not anticipated that proposed works will have an effect on the available habitat for the species.
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 result in any invasive species that are harmful to the species becoming established in the species habitat. Environmental management measures implemented are in conjunction with accepted international and domestic practice with risk of introduction of invasive species to as low as reasonably practicable.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) or an ecologically significant proportion of the population of a migratory species	**Unlikely** Dugong The proposed works are not expected to seriously disrupt the lifecycle of an ecologically significant proportion of the population of the species. Short-term temporary disruption may occur due to the construction works with individuals exhibiting avoidance behaviour however normal behaviour and use of the species habitat within the proposal site will return upon completion of the construction works.

Appendix E – Assessment under the BC Act

The following assessments were undertaken in accordance with the Threatened species test of significance under the BC Act for threatened species considered likely to occur within the project area as determined in Section 4.2.2.

The following species were assessed:

- New Zealand fur seal
- Dugong
- Shorebirds group (migratory and resident)

All species assessed were considered unlikely to be significantly impacted by the proposed works as shown in the following tables.

Significant impact criteria	Impact outcome
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	**Unlikely** New Zealand fur seal The New-Zealand fur seal occurs in Australian coastal waters and offshore islands of South and Western Australia as well as southern Tasmania. Small populations also are present along the southern NSW coast, particularly on Montague Island but also other isolated areas north of Sydney. There are no known breeding sites within or around Belmont. Therefore, activities associated with the project are note expected to 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	**Unlikely** New Zealand fur seal No endangered ecological community or critically endangered ecological community is located within the project area.

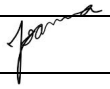
Significant impact criteria	Impact outcome
c. In relation to the habitat of a threatened species or ecological community: (i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and (ii) whether an area of habitat is likely to become fragmented 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	**Unlikely** New Zealand fur seal 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. The 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. 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 by the area whilst foraging. This species may display avoidance behaviour in response to the project activity, however this is expected to be temporary with animals returning to the area upon completion of the works. Therefore, activities associated with the project are not expected to 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)	**Unlikely** New Zealand fur seal 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.	**Unlikely** New Zealand fur seal 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.

Significant impact criteria	Impact outcome
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	**Unlikely** Dugong The proposed works are not expected to seriously disrupt the lifecycle of an ecologically significant proportion of the population of the species. Dugongs do not have specific breeding and calving grounds in NSW. There is evidence to suggest they utilise shallow waters such as tidal sand banks and estuaries to calve (Marsh et al. 2011). These sheltered areas are not present within the project area. Short-term temporary disruption may occur due to the construction works with individuals exhibiting avoidance behaviour however normal behaviour and use of the species habitat within the proposal site will return upon completion of the construction works.
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	**Unlikely** Dugong 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	**Unlikely** Dugong The proposed works will not adversely affect habitat critical to the survival of the species. The project area is not close to any known breeding grounds for this species nor does it contain any seagrass beds. Lake Macquarie contains seagrass beds known to be grazed by dugongs, therefore this species may transit past the project area to Lake Macquarie. This species can avoid the area and still access Lake Macquarie, therefore it is not anticipated that proposed works will have an adverse effect on the available habitat for 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)	**Unlikely** Dugong 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.	**Unlikely** Dugong 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.

Significant impact criteria	Impact outcome
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	**Unlikely** Shorebirds The migratory shorebirds do not breed or nest in Australia. Birds that nest on Australia beaches (e.g. oystercatchers (*Haematopus spp.*) may temporarily avoid the area to nest if construction works occur during nesting seasons. However, these species do not have specific nesting grounds and can utilise nearby and adjacent suitable nesting habitat. It is anticipated that these species will return to utilise the project area again after completion of construction works.
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	**Unlikely** Shorebirds 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	**Unlikely** Shorebirds Depending on the construction method chosen, birds that utilise the shore environment may be temporarily displaced from the project area during construction works and will avoid the area, particularly for the trenching activities. After the completion of works, it is anticipated that shorebirds will return to utilise the area. As the construction works are temporary, it is not anticipated that the temporary modification of the habitat will lead to a decreased in the quality of habitat or fragment the habitat to the extent that the species are likely to decline.
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)	**Unlikely** Shorebirds 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.	**Unlikely** Shorebirds 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.

GHD
Level 3 GHD Tower 24 Honeysuckle Drive Newcastle NSW 2300
PO BOX 5403 Hunter Region Mail Centre NSW 2310
T: 61 2 4979 9999 F: 61 2 4979 9988 E: ntlmail@ghd.com

2219573-46052/https://projects.ghd.com/oc/newcastle1/cs0865hwctemporaryde/Delivery/Documents/Marine Assessment AR.docx
Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	M. Hooper	J. El Khoury		N. Malcolm		26/06/2020
1	M. Hooper	J. El Khoury		N. Malcolm		29/07/2020

www.ghd.com