Port of Broome Channel Optimisation Project – Dredging Environmental Impact Assessment

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Port of Broome Channel Optimisation Project – Dredging

Environmental Impact Assessment

Prepared for

Kimberly Ports Authority

Prepared by

BMT Pty Ltd

February 2018

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Date: 09/02/18

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Acronyms

BC Act	*Biodiversity Conservation Act 2016*
BPPH	Benthic primary producer habitat
BTAP	Broome Tropical Aquaculture Park
CALM Act	Conservation and Land Management Act 1984
CD	Chart datum
CSD	Cutter suction dredge
Cwlth	Commonwealth
DBCA	Department of Biodiversity, Conservation and Attractions
DEIA	Dredging Environmental Impact Assessment
DEMP	Dredging Environmental Management Plan
DPIRD	Department of Primary Industries and Regional Development
DPLH	Department of Planning, Lands and Heritage
DWER	Department of Water and Environmental Regulation
EIA	Environmental Impact Assessment
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
EPSD Act	*Environment Protection (Sea Dumping) Act 1981* (Commonwealth)
HAT	Highest astronomical tide
IMS	Introduced marine species
JMB	Joint Management Bodies
KPA	Kimberley Ports Authority
LAC	Light attenuation coefficient
LAT	Lowest astronomical tide
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MNES	Matters of national environmental significance
MSL	Mean Sea Level
NAGD	National Assessment Guidelines for Dredging
NTU	Nephelometric Turbidity Units
OCP	organophosphate pesticides
PAH	Polycyclic aromatic hydrocarbons
SWASP	State-Wide Array Surveillance Program
TSS	Total suspended solids
TPH	Total petroleum hydrocarbons
WA	Western Australia
LoR	Limit of Reporting

Executive Summary

The Port of Broome (hereafter the Port) is situated in West Roebuck Bay, ~5 km south west of the township of Broome, Western Australia. The Port does not have a marked entrance channel, as the natural water depths have been sufficient for passage of vessels. However, some of the larger vessels have limited access windows due to large tidal range (10 m) and presence of high spots in the access channel. In recognition of the access constraints and the growing tourism industry in Broome, the Department of Primary Industries and Regional Development, Tourism Western Australia and Kimberley Port Authority (KPA) have contributed funds to optimise the channel to allow passage of larger vessels, particularly cruise ships. Therefore, KPA propose channel optimisation works (hereafter the Project) requiring: capital dredging of several high spots, a new marked entrance channel and improved access to existing berths.

A dredging environmental impact assessment (DEIA) has been prepared in support of the referral/application requirements for formal environmental assessment and approval under the following State and Federal legislation: *Environmental Protection Act 1986*, *Environment Protection and Biodiversity Conservation Act 1999* and *Environment Protection (Sea Dumping) Act 1981* (EPSD Act) (this document). The DEIA evaluates potential impacts of the Project on environmental receptors with reference to the specific dredging and disposal methods, as well as relevant environmental legislation and guidelines. The following potential effects of the proposed Project on different environmental receptors have been assessed:

- Benthic communities and habitat:
  - indirect loss of benthic primary producer habitat.
- Marine environmental quality:
  - release of contaminants during dredging and disposal
  - hydrocarbon spills and waste generation.
- Marine fauna:
  - avifauna disturbance
  - marine fauna disturbance (collisions/noise)
  - artificial lighting
  - introduced marine species.
- Social surroundings and human health:
  - indigenous and non-indigenous heritage
  - fisheries-commercial and recreational
  - maritime safety.

To support this DEIA, two technical studies were undertaken: an assessment of the material to be dredged and hydrodynamic and plume modelling (provided as appendices to this document). The technical studies indicated that: material to be dredged were considered suitable for ocean disposal in-line with the EPSD Act as there were there were no contaminants of concern; and plume modelling indicated that dredge and disposal activities will generate a turbid plume that is restricted in both space and time. Based on the results of these technical studies and this DEIA, KPA propose to implement a number of monitoring and mitigation measures to manage the potential environmental impacts associated with the Project, including:

- turbidity monitoring
- waste and hydrocarbon management
- marine fauna monitoring and management
- introduced marine species risk assessment and identification procedures
- noise reduction measures
- completion of an archaeological assessment of the Project region prior to Project commencement
- continued stakeholder engagement of public consultation.

Stakeholders will be consulted prior to the commencement of dredging and throughout the campaign. If any environmental issues arise, contingency plans (with specific indicators, action criteria and management responses) will be implemented. The required consultation will be outlined in a Dredging Environmental Management Plan.

1. Introduction

1.1 Background

The Port of Broome (hereafter the Port) is situated in West Roebuck Bay, ~5 km south west of the township of Broome, Western Australia (WA) (Figure 1.1). Kimberley Ports Authority (KPA) is responsible for the operations of the Port, which is the largest deep-water access servicing the Kimberley region. The Port consists of a 331 m long deep water jetty extending 640 m from the shoreline, and supports livestock export, offshore oil and gas operations, pearling, fishing charter boats, cruise liners and it provides the main fuel and container receiver point for the region (KPA 2015).

The Port does not have a marked entrance channel but a 'virtual' entrance channel, as the natural water depths are sufficient for passage of vessels. The virtual entrance channel consists of nominated routes and waypoints issued to each vessel intending to use the Port. KPA has recognised the need to improve accessibility to the Port, given some larger vessels have limited access windows due to the large tidal range (10 m), presence of channel rock and high spots (shoals) in the access channel. In recognition of these access constraints and the growing tourism industry in Broome, the Department of Primary Industries and Regional Development (DPIRD), Tourism Western Australia and KPA have contributed funds to optimise the channel to allow passage of larger vessels, particularly cruise ships. Therefore, KPA propose channel optimisation works (hereafter the Project) requiring: capital dredging of several high spots, a new marked entrance channel and improved access to existing berths.

1.2 Purpose of this report

This document presents a Dredging Environmental Impact Assessment (DEIA) to evaluate the potential environmental risks posed by dredging and disposal activities. Potential effects of dredging and disposal on different environmental receptors were assessed, based on the specific nature of the works and results of sediment sampling and analysis of the material to be dredged. This DEIA supports the referral/application requirements for formal environmental assessment and approval under the following State and Federal legislation: *Environmental Protection Act 1986* (EP Act), *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Environment Protection (Sea Dumping) Act 1981* (EPSD Act). The DEIA includes proposed environmental monitoring and management measures to control the impact of the dredging, with more details to be provided in a final Dredging Environmental Management Plan (DEMP).

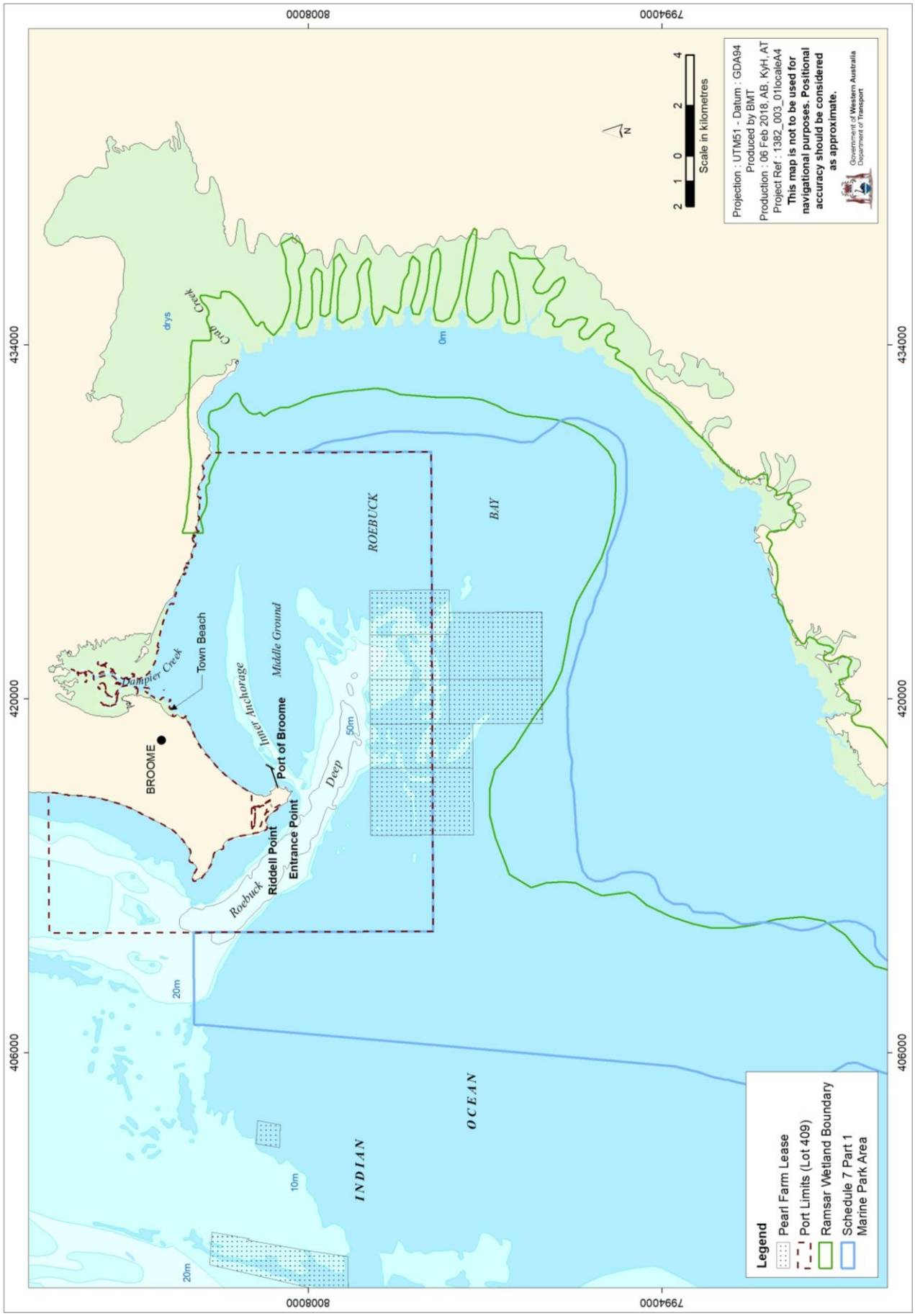


Figure 1.1 Port of Broome, conservation areas and aquaculture lease boundaries

2. Proposed Project Description

2.1 Proposed channel optimisation works

The proposed channel is based on a 'design ship' that encompasses trends in cruise ship designs and accounts for future growth in the market; a ship with an 8.5 m draft, 50 m beam and 330 m in length. Channel optimisation requires capital dredging of 102 500 m^3 (inclusive of the over-dredge volume) of marine sediments from five discrete areas (Figure 2.1). The proposed channel design includes widening the entrance channel to 260 m; with a 190 m wide channel to -10 m lowest astronomical tide (LAT) and a nominally 70 m wide channel with sloping design from -10 m LAT to -7.7 m LAT (Figure 2.1). Deepening of the turning basin will create a sloping channel depth to -10 m LAT, to suit local current and tidal level conditions, and minimise the dredging volume while maintaining full tidal access for the design ship.

In addition to channel improvements, KPA propose to deepen and widen Berths 11 and 12 to -9.5 m LAT and up to 30 m, respectively; requiring capital dredging of 11 000 m^3 (Figure 2.1). The shoal area to the north of the wharf will also be deepened to -6.5 m LAT by dredging 4500 m^3 of material; allowing safer navigation to the northern berth pockets (Figure 2.1). Therefore, the entire capital dredging project will require removal of ~120 000 m^3 of material; which equates to 150 000 m^3 of material for the purpose of the sea dumping permit application for ocean disposal of dredged material (EPSD Act; Section 3.2.3), to adequately account for over-dredge.

It is anticipated that dredging will be completed by a medium or large cutter suction dredge (CSD), to effectively remove both soft (silty) surface sediments and underlying sandstone of various strength (Section 4.1.3). The CSD will use a rotating cutter head lowered to the seabed to loosen the material that is then lifted through a suction pipe. The CSD is fixed in position by a spud at the stern and the cutter-suction arm is swept back and forth on an arc, controlled by anchors and winches. The use of a CSD should limit turbid plumes and sedimentation in the dredging area, relative to a trailing suction hopper dredger, though this depends on sediment characteristics and local hydrodynamics (Ports Australia 2014).

It is proposed to use a spreader pontoon to control placement of dredged material into the naturally deep channel adjacent to Channel Rock (-40 m LAT channel, adjacent to the hazard marker; Figure 2.1), entirely within Port waters. Offshore placement was prioritised to the onshore placement alternatives, due to the shorter pumping distance requirements but also to minimise interactions with matters of national environmental significance (MNES), Aboriginal heritage sites, the Ramsar wetland and Yawuru Nagulagun / Roebuck Bay Marine Park.

The Project is expected to take place over a 2-4 week period, including mobilisation and demobilisation of the dredge plant; subject to potential delays due to inclement weather and/or unfavourable sea state. Operations will be 24 hours a day, 7 days a week (24/7; in-line with Port activities). However, turbidity generating activities (i.e. dredging and disposal) will not be 24/7 due to operational and maintenance reasons such as: dredge positioning (moving anchors and spuds), maintenance and repairs and refuelling.

2.2 Ongoing maintenance requirements

The Port undertakes regular bathymetric surveys to monitor the water depth as part of standard Port operations. The seabed material surrounding the Port is unconsolidated sediment over consolidated (rocky) material and sand wave is observed to be transient in the area; largely north of the jetty and not within the entrance channel. It is therefore anticipated that high spots may form from time to time. Any high spots will be monitored and should operations require the removal of this material the Port will complete any maintenance works in-line with any respective environmental approvals.

2.3 Previous dredging at the Port

In 1889 the original Port operated out of Town Beach and had no infrastructure so vessels would arrive on high tides, and wait until low tide to sit on the intertidal mudflats and offload cargo. The first wharf structure at Town Beach was completed in 1897 and replaced by the existing deep water wharf at Entrance Point, which opened in 1966 but has since been extended and modified. Given the naturally deep entrance channel to the Port, there has been no dredging at this site to date.

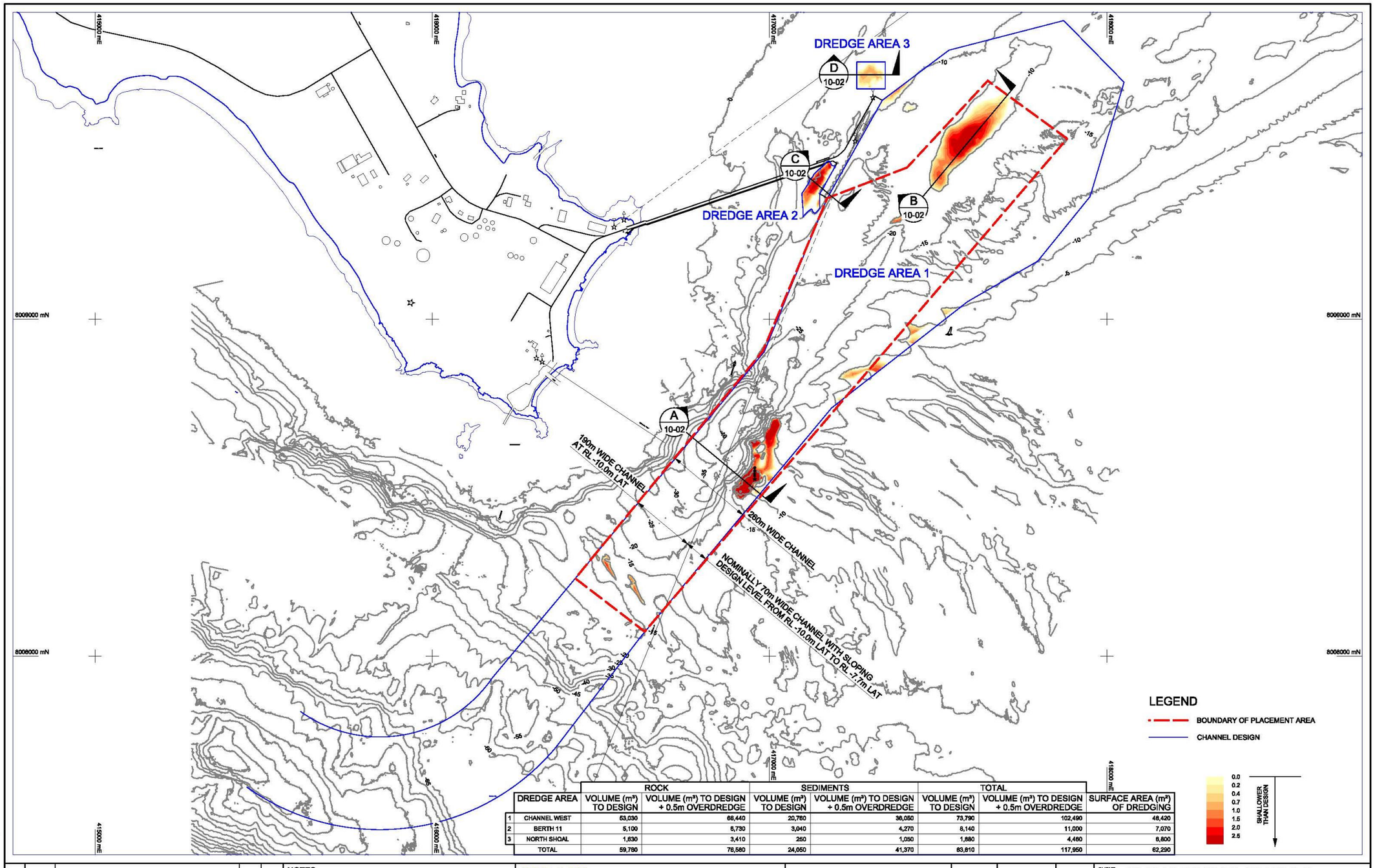
Department of Transport (DoT) had plans for a recreational boating facility that would have required dredging of material from the intertidal and subtidal zone, north of the existing Port jetty. However, the proposed boating facility was cancelled in 2013 in an attempt to reduce government spending (ABC 2013). It is understood that the DoT has recommenced the planning for a boat harbour at Riddell Point.

2.4 State dredging projects

The proposed Project is small in the context of other WA capital and maintenance dredging projects. Estimated volumes and durations for recent capital and maintenance dredging projects in WA are presented in Table 2.1 to add context to KPA's proposed Project. KPA are aware of the cultural and environmental significance of the region in which the Port operates and are working with key stakeholders and the community to ensure that the Project is carried out in-line with environmental legislative requirements (Section 3).

Table 2.1 State dredging projects

Project name and type	Year	Volume estimate (m^3)	Duration
Wheatstone LNG Capital Dredging	2015	25 000 000	2 years
Rio Tinto Dampier Port Maintenance Dredging	2016	480 000	3 months
Onslow Salt Maintenance Dredging	2016	168 000	1 month
Beadon Creek, Onslow, Capital Dredging Stage 1	2015	65 000	8 months
Beadon Creek, Onslow, Capital Dredging Stage 2	Proposed	950 000	8 months



DREDGE AREA		ROCK		SEDIMENTS		TOTAL		
		VOLUME (m³) TO DESIGN	VOLUME (m³) TO DESIGN + 0.5m OVERDREDGE	VOLUME (m³) TO DESIGN	VOLUME (m³) TO DESIGN + 0.5m OVERDREDGE	VOLUME (m³) TO DESIGN	VOLUME (m³) TO DESIGN + 0.5m OVERDREDGE	SURFACE AREA (m²) OF DREDGING
1	CHANNEL WEST	53,030	68,440	20,760	36,050	73,790	102,490	48,420
2	BERTH 11	5,100	5,730	3,040	4,270	8,140	11,000	7,070
3	NORTH SHOAL	1,630	3,410	250	1,050	1,880	4,460	5,800
	TOTAL	59,760	78,580	24,050	41,370	83,810	117,950	62,290

REV	DATE	AMENDMENT	DRN	APP
C	20/12/17	UPDATED VOLUMES WITH GEOPHYSICAL SURVEY DATA	SM	
B	16/11/17	UPDATED WITH NEW SURVEY DATA	SM	
A	03/11/17	INITIAL ISSUE	SM	

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NOTES
1. CONTOURS FROM AUGUST 2016 AND SEPTEMBER 2017 DoT SURVEYS. DATA FROM FILES BR20160819_Mean.pro RECEIVED ON 19 APRIL 2017 AND br20170919_mean.pro RECEIVED ON 9 NOVEMBER 2017
2. FOR GEOPHYSICAL SURVEY DATA INFORMATION REFER SURRICH REPORT SH20170922_November_2017_BMT_JFA_Broome_Channel_Geophysics_Report_draft0.pdf

SCALE 1 : 5000
100 0 200
METRES

DATUM
VERTICAL: BROOME, LOWEST ASTRONOMICAL TIDE 2009 13.397m BELOW BENCHMARK PWD WA "TIDAL BM" 5.32m BELOW AHD (2013)
HORIZONTAL: MAP GRID OF AUSTRALIA BASED ON GDA 94, ZONE 51

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ENGINEER	H.SUNARKO	03/11/2017
DRAWN	S.MOUCHEMORE	03/11/2017
DRAFTING CHECK	C.LIVINGSTONE	03/11/2017
ENGINEERING CHECK		
APPROVED PROJECT MGR		

CLIENT: KIMBERLEY PORTS AUTHORITY
PROJECT: BROOME CHANNEL OPTIMISATION
TITLE: SCOPE OF DREDGING GENERAL ARRANGEMENT AND VOLUME BREAKDOWN
DRAWING NUMBER: J 17005.00 - 10 - 01
REV: C

Figure 2.1 Port of Broome capital dredging footprint and disposal area

3. Relevant Environmental Legislation and Approvals

3.1 Decision-making Authorities

The following key State and Commonwealth (Cwlth) decision-making authorities have been identified for the Project:

- Environmental Protection Authority (EPA)
- Department of Water and Environmental Regulation (DWER)
- Department of Environment and Energy (DoEE) (Cwlth)
- Department of Biodiversity, Conservation and Attractions (DBCA) and Yawuru Nagulagun / Roebuck Bay Marine Park Joint Management Bodies (JMBs), specifically the Yawuru people
- Department of Jobs, Tourism, Science and Innovation
- Department of Primary Industries and Regional Development (DPIRD)
- Department of Planning, Lands and Heritage (DPLH)
- Department of Agriculture and Water Resources (Cwlth).

3.2 Relevant legislation and guidance material

3.2.1 Environmental Protection Act 1986

The EP Act is the major piece of legislation relating to the environment in WA. For projects proposed within WA State Waters, the EP Act defines the primary approvals process for undertaking environmental impact assessment (EIA). The EP Act (mainly Part IV) together with its Administration Procedures (2016) specify the objectives and requisite procedures for EIA of proposals, which must be complied with by all stakeholders, including: the proponent, the EPA, DWER EPA Services and any other relevant party.

The proposed Project will be referred to the EPA under Section 38(1) of the EP Act (Part IV) to determine the level of assessment. The EPA applies a Significance Framework to make decisions through the environmental impact assessment process, based on the concept of significance established under the EP Act. The EPA will determine if the proposal is likely to impact on any key environmental factors (e.g. Benthic Communities and Habitat, Marine Environmental Quality, Marine Fauna; see Section 5.1.1) by determining the likely significance of the expected impacts in relation to meeting the EPA's objectives for each key factor using the proponents Environmental Referral Document (EPA 2016a).

3.2.2 Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)

The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) is the Australian Government's key piece of environmental legislation. EIA is required under the EPBC Act for projects that are likely to have a significant impact on MNES defined under the EPBC Act, or in Commonwealth Waters.

Potentially relevant MNES for the Project in State Waters include (see Appendix A):

- Listed threatened and/or migratory species– including protected marine fauna.
- Wetlands of international importance (Roebuck Bay Ramsar wetland within 10 km of Project), particularly as a habitat for birds.
- West Kimberley National Heritage Place and associated values.

Where there is the potential (or uncertainty) that a proposal may significantly impact upon any of these matters, a referral to DoEE is required; for a determination on whether the proposal constitutes a 'controlled action' necessitating assessment and approval under the EPBC Act.

The EPBC Act also provides Australia's key heritage law administered at a national level by DoEE, including the registration, maintenance and protection of sites on the Australian Heritage Database (DoEE 2017a). The DoEE also administers the following Commonwealth heritage legislation:

- *Historic Shipwrecks Act 1976*
- *Aboriginal Torres Strait Islander Heritage Protection Act 1984*
- *Australian Heritage Council Act 2003.*

3.2.3 Environment Protection (Sea Dumping) Act 1981 (Cwlth)

Applications for a sea dumping permit for ocean disposal of dredged material are assessed under the Commonwealth EPSD Act by DoEE. Through the EPSD Act, the Australian Government assesses proposals to load and dump wastes and other materials at sea, permits acceptable activities and sets conditions of approval to mitigate and manage environmental impacts.

3.2.4 Biodiversity Conservation Act 2016

The *Biodiversity Conservation Act 2016* (BC Act) provides for the conservation and protection of wildlife within WA. The underlying principals of the BC Act are to conserve and protect biodiversity, biodiversity components, and to promote the ecologically sustainable use of biodiversity components, throughout WA, with regard to the principles of ecologically sustainable development. The BC Act is relatively new, so regulations replacing provisions under the *Wildlife Act 1950* are still in preparation. It is likely that threatened species and ecological communities will be adequately assessed under Part IV of the EP Act and the EPBC Act; however, DBCA will be consulted as a stakeholder during referral under the EP Act, to ensure all matters of biodiversity protection are adequately addressed.

3.2.5 Aboriginal Heritage Act 1972

Early consultation with Nyamba Buru Yawuru management team and DPLH has confirmed that there are no registered sites or heritage related issues within the Project area that are protected under the *Aboriginal Heritage Act 1972*. However, the Yawuru traditional owners will continue to be consulted as the Project progresses.

3.2.6 Historic Shipwrecks Act 1976 (Cwlth) and Maritime Archaeology Act 1973

The WA Museum is responsible for protection of pre-1900 maritime archaeological sites, under the *Maritime Archaeology Act 1973*, while the *Historic Shipwrecks Act 1976* (Cwlth) protects shipwrecks older than 75 years that rest in federal waters. Some sites may also be protected under the *Heritage of Western Australian Act 1990* due to their cultural heritage significance. KPA will liaise with the WA Museum to determine any potential impacts the Project may have on known or unknown heritage artefacts.

3.2.7 Biosecurity Act 2016 (Cwlth)

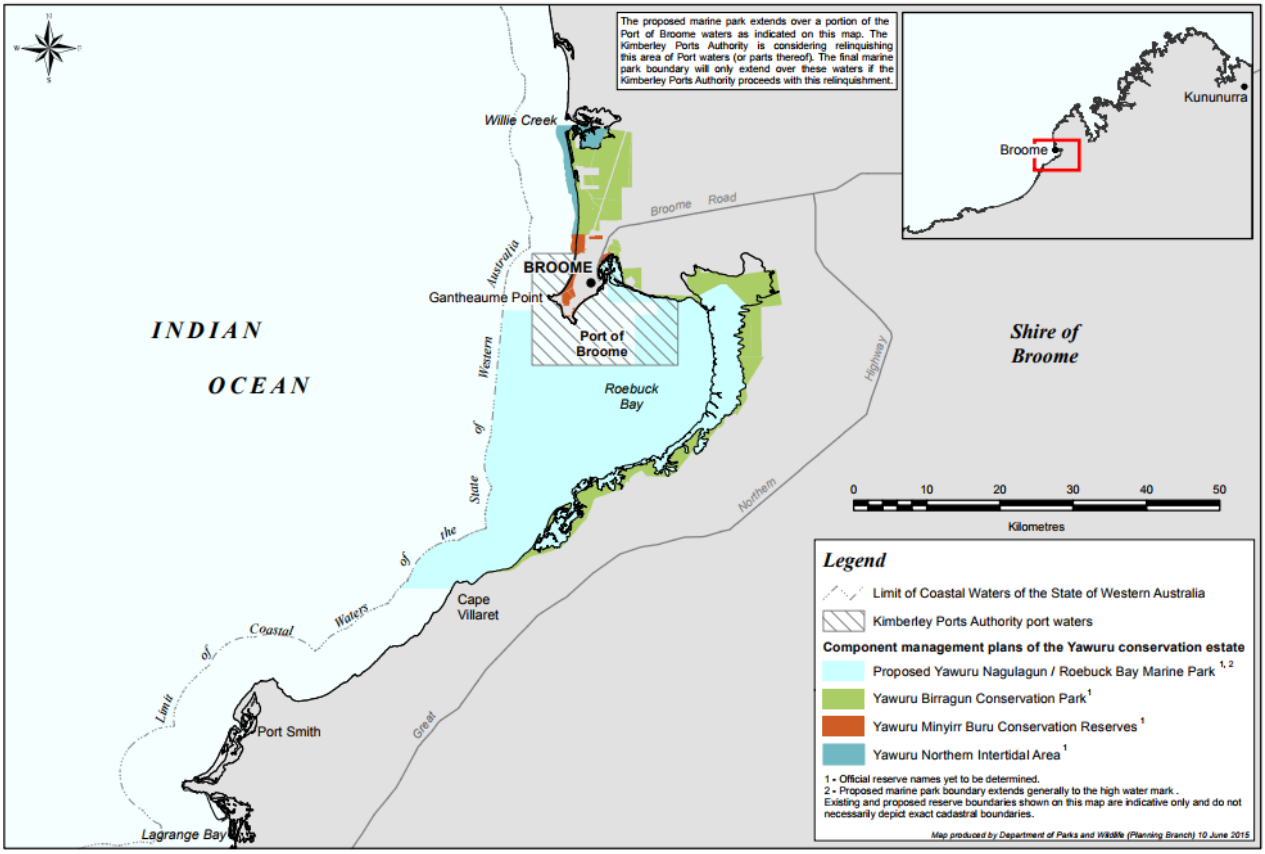
The Commonwealth *Biosecurity Act 2016* provides a regulatory framework for management of biosecurity risks, including: non-indigenous species, pests, disease and contaminants. This is managed under the Australian Government Department of Agriculture and Water Resources. The *Biosecurity Act 2016* includes regulations for ballast water, biofouling and biosecurity risks associated with marine pests and will be considered by KPA for management of these risks.

4. Description of the Environment

4.1 Physical environment

4.1.1 Location

The Port is situated in West Roebuck Bay, ~5 km south west of the township of Broome (Figure 1.1). The Port is situated within Roebuck Bay, within the Northwest bioregion and the Timor Sea Australian Drainage Division (RBWG 2009). The Yawara Nagulagun / Roebuck Bay Marine Park and the Roebuck Bay Ramsar site (declared in 1990) are adjacent to – but do not overlap with – Port waters (RBWG 2009, DPaW 2016).



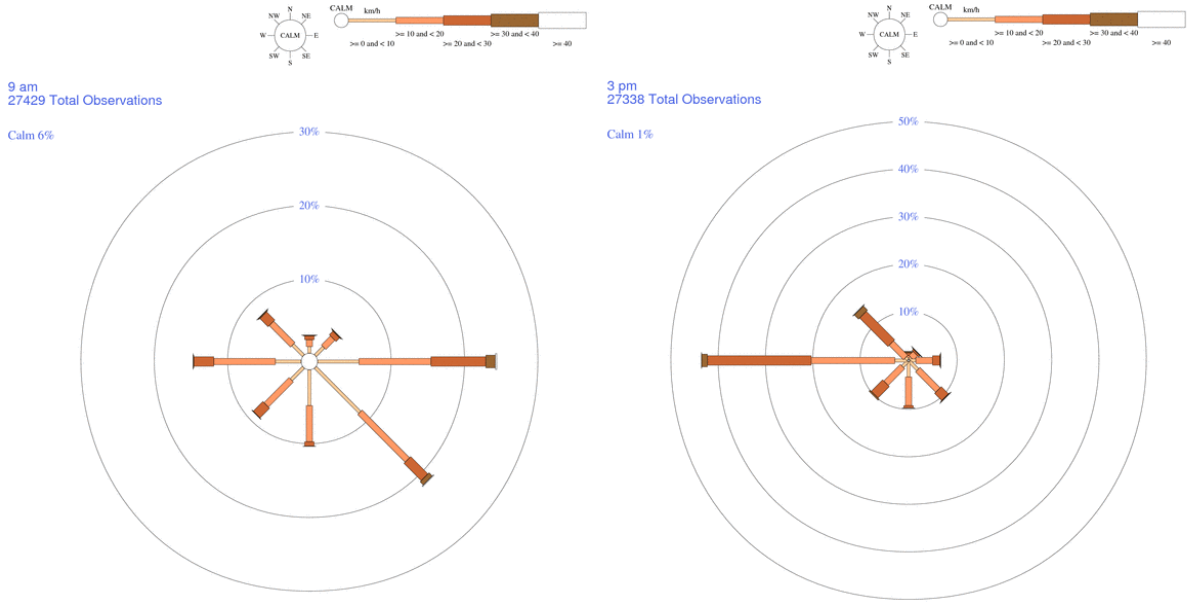
Source: DPaW (2016)

Figure 4.1 Extent of the Yawuru Nagulagun / Roebuck Bay Marine Park, Roebuck Bay

4.1.2 Climate

Broome has a tropical climate; with a winter dry season (April to October) and a summer wet season (late-November to March). During the wet season mean daily temperature ranges between ~13 and 34°C and in the wet season between ~25 and 34°C (BoM 2017a). During the wet season monthly mean rainfall ranges from ~9 to 182 mm whereas during the dry season the range is ~1 to 26 mm (BoM 2017a). The heaviest rainfall is generally associated with the passage of tropical cyclones, which typically occur between November and April, peaking in February and March, and can cause extensive flooding. Cyclones cross the coast at Broome close enough to do damage every 4 years on average, although the frequency has decreased in recent years (BoM 2017b).

Wind data recorded between 1939 and 2017 indicates that winds are predominantly from the south-east in the morning (0900) and from the west and north-west in the afternoon (1500) (Figure 4.2). Mean annual wind speed was 13.6 and 18.2 km/h at 0900 and 1500 respectively, rarely exceeding 40 km/h (BoM 2017a; Figure 4.2).



Source: BoM (2017a)

Note:

1. Wind speed recorded at Broome airport between 1939 and 2017 at 0900 (left) and 1500 (right)

Figure 4.2 Broome airport wind speed and direction

4.1.3 Geology and geomorphology

Roebuck Bay is situated in an area geologically termed the Northern Canning Basin (Watkins 1993) and is bound to the north-west and far south-east by low sand ridges and to the east and north by coastal flats of Holocene marine sediments. Roebuck Bay is a curved embayment in the Canning Basin, comprised of a wide intertidal terrace of mainly fine to medium sands, constrained by underlying sandstone and coastal limestone geology. The intertidal terrace is fringed by mangal habitat, rock outcrops and dunes (to the east and northeast) perched on a base of pindan sediments (Oceanica 2010).

The naturally deep approaches to West Roebuck Bay are illustrated in Figure 1.1 and Figure 2.1; with two channels of Roebuck Deep along the south-west of the peninsula joining Inner Anchorage to the south-west of the peninsula. Roebuck Deep likely plays a significant role in coastal mixing and circulation patterns (DPaW 2016). Inner Anchorage is partially separated from Roebuck Deep by a bank of sediments called Middle Ground. The Port jetty extends into Inner Anchorage, near the junction with Roebuck Deep. Landward of Inner Anchorage the waters are generally shallow (0 to +4 m Chart Datum; CD), periodically drying during the tidal cycle (Hydrographic Chart Aus 50). The proposed channel entrance is largely situated around Roebuck Deep, varying from -60 to -20 m LAT (Figure 1.1).

A historical geotechnical survey indicated presence of medium to high strength sandstone from 2.6-3.8 m below the surface, west of the Port jetty (Figure 1.1). Similarly, probe refusal south-east and west of the Port jetty was between <0.2 m and 0.5 m (Figure 1.1). The probing south-east of the danger marker was deeper, >1.5 m; however, given this high spot is called 'Channel Rock', this area is likely a sandstone shoal (Figure 1.1).

4.1.4 Water quality

Since 2005, potentially toxic cyanobacteria *Lyngbya majuscula* has been recorded in waters adjacent to the Broome township, within Roebuck Bay (Bennelongia 2009, Oceanica 2012, Estrella 2013, DPaW 2016). Research suggests that these algal blooms are resultant of elevated nutrients and/or bioavailable iron concentrations (Oceanica 2012, DPaW 2016). Potential sources of nutrient inputs in the region include: run-off from urban areas, seepage from the Broome South Waste Water Treatment Plant and the use of treated wastewater on – and subsequent run-off from – the Broome golf course (DPaW 2016).

Water parameters (nutrients, chlorophyll-a, total and dissolved iron, turbidity [Nephelometric Turbidity Units; NTU], total suspended sediments [TSS] and light attenuation coefficient [LAC]) were monitored adjacent to the Port jetty structures in 2011, during neap and spring tides over a wet and dry season in 2011 (Oceanica 2012). Similar to two earlier water monitoring events (1986–1989 and 2005–2008; Bennologia 2009), concentration of nutrients (total nitrogen, total phosphorus, ammonia, nitrate + nitrite and othrophosphate) and chlorophyll-a monitoring in 2011 were above default ANZECC and ARMCANZ (2000) guideline values for tropical marine inshore waters on a number of occasions, though more consistently during wet season sampling (Oceanica 2012).

Turbidity monitored at four sites adjacent to the Port was generally high, with average concentrations of TSS ranging from 15.7–24.8 mg/L during the wet season and 8.8–15.2 mg/L during the dry season, over the four tidal cycles (Oceanica 2012). Water clarity varied spatially and temporally, and the correlation between different measures of water clarity (TSS, LAC and NTU) was generally poor, though stronger during the wet season and spring tide sampling (Oceanica 2012). Eco Logical (2017) found very low (<1.5 NTU) turbidity at sites adjacent to the Port. However, data were collected in situ, during the dry season and during mild sea conditions and is not necessarily indicative of the temporal variability of turbidity in the region.

4.1.5 Sediment quality

Port activities associated with operation of a slipway, shipping of livestock, chemicals (petroleum, bitumen, barite, oil and gas) and oil and gas supplies are anticipated to result in contamination of the sediments (and soils) within and adjacent to the Port. The Department of Environment Regulation (now DWER) has classified the Port slipway as 'possibly contaminated, investigation required' (KPA 2016b). This classification was due to elevated concentrations of hydrocarbons, metals, organochlorine pesticides and asbestos containing materials in soil (terrestrial) (KPA 2016b); noting that the slipway is some distance from the Project area.

Sediment collected at one site adjacent to the Port (exact location unknown) in 2007 returned concentrations of nickel and mercury above National Assessment Guidelines for Dredging (NAGD) Screening Levels (CA 2009a), and all metal concentrations were greater than pre-industrialised Roebuck background concentrations, derived in Oldmeadow (2007; cited in Oceanica 2010) (Table 4.1).

More recent investigations of surficial sediments adjacent to the Port found concentrations of the following contaminants either below relevant limits of reporting or NAGD Screening Levels and are considered suitable for unconfined ocean disposal under the EPSD Act (BMT Oceanica 2017 [Appendix B], Eco Logical 2017; Table 4.1):

- organotins
- metals (aluminium, antimony, arsenic, cadmium, chromium, copper, cobalt, iron, lead, manganese, mercury, nickel, selenium, silver, vanadium, zinc; Table 4.1)
- organochlorine and organophosphate pesticides (OCPs)
- polychlorinated biphenyls
- polycyclic aromatic hydrocarbons (PAHs)
- total petroleum hydrocarbons (TPHs).

Similarly, concentrations of organotins, OCPs, benzene/toluene/ethylbenzene/xylene, PAHs and TPHs were below relevant NAGD Screening Levels in sediments collected from the intertidal and subtidal areas north of the Port (closer to the slipway) in 2013 (WorleyParsons 2013; as cited in Eco Logical 2017).

It is noted that concentrations of some metals in sediment sampled in 2016 and 2017 are still above the pre-industrialised Roebuck background concentrations (Table 4.1), but to a lesser extent, particularly at sites further offshore (2017 sampling sites; BMT Oceanica 2017); likely due to improved Port practices and tidal movement of sediment over time.

Aluminium and iron concentrations were in relatively high concentrations in the sample collected adjacent to the Port in 2007, 2016 and 2017 (Table 4.1). These analytes are not considered toxic in marine sediments and are likely attributed to naturally occurring iron oxides and kaolonite clays within the adjacent pindan sediments (Bennelongia et al. 2009, Oldmeadow 2007; cited in Oceanica 2010).

The sediments sampled in 2017 within the high spots and the proposed deep water disposal area within the channel were predominantly medium to coarse grained, grey-brown marine sands. The sediment settling times were minimal, with 50% of particles settling in <1 min through 1 m of water, and 90% of particles settling in <25 mins through 1 m of water (Appendix B).

For more detail on the analytes, data analysis and results of the 2017 sediment analyses, refer to the Sampling and Analysis Plan Implementation Report Data Report (BMT Oceanica 2017; Appendix B).

Table 4.1 Metal concentrations in sediment collected adjacent to Broome Port in 2007, 2016 and 2017

Parameter (mg/kg)	NAGD Screening Level[1]	Pre-industrial background concentration[2]	Site E02-1 (2007)[3]	Mean of 2016 sediment results[4]	Mean of 2017 sediment results[5]
Aluminium	–	378	28,940	1310	294
Antimony	–	0.05	0.1	<LoR	<LoR
Arsenic	20	0.18	0.6	2.5	1.8
Bismuth	–	0.11	0.7	n.d.	n.d.
Cadmium	1.5	0.12	n.d.	<LoR	<LoR
Chromium	80	16.98	42.4	8.5	3.9
Cobolt	–	1.34	3.1	<LoR	n.d.
Copper	65	4.14	9.0	1.1	0.6
Iron	–	795	17,318	3268	1440
Lead	50	4.6	7.3	1.5	0.9
Manganese	–	42.3	59.6	15.1	9.3
Mercury	0.15	0.2	**0.9**	<LoR	<LoR
Molybdenum	–	0.2	3.0	n.d	n.d
Nickel	21	5.3	**25.4**	1.1	0.9
Selenium	–	0.8	n.d	0.2	0.1
Thorium	–	3.1	6.9	n.d	n.d
Tin	–	0.3	1.2	n.d	n.d
Uranium	–	2.0	2.8	n.d	n.d
Vanadium	–	0.7	30.3	7.0	n.d
Zinc	200	7.7	60.2	3.9	1.8

Data sources: Oldmeadow (2007; cited in Oceanica 2010), Eco Logical (2017), BMT Oceanica 2017

Notes:

1. Values in bold are above the National Assessment Guidelines for Dredging (NAGD) Screening Levels (CA 2009a).
2. Pre-industrialised Roebuck Background values derived in Oldmeadow (2007; cited in Oceanica 2010).
3. Exact location of site E02-1 unknown, derived from imagery (Oldmeadow 2007; cited in Oceanica 2010).
4. Mean concentrations of metals from 12 sites adjacent to the Port (Eco Logical 2017).
5. Mean concentration of metals from 10 sites within high spots adjacent to the Port (BMT Oceanica 2017). Values below LoR were halved to calculate the mean.
6. – = no NAGD Screening Level for this contaminant, n.d. = no data, not analysed, <LoR = mean value was not calculated as all individual concentrations were below the relevant laboratory limit of reporting (LoR).

4.1.6 Hydrodynamics

The tides at Broome are semi-diurnal with a mean range of 8.27 m at spring tide (MHWS - MLWS) and 2.11 m at neap tide (MHWN - MLWN), with a lowest to highest astronomical range of 10.5 m (LAT - HAT) (Table 4.2). The tidal datums in Table 4.2 have been derived by the DoT from a tidal gauge deployed at the Port jetty between 1987 and 2009. Tidal currents mobilise bed sediments, resulting in high suspended sediments on the seafloor in Roebuck Bay, reducing only on neap tides (BPA 2009).

Tidal currents in the main channels (of Inner Anchorage and Roebuck Deep; Figure 1.1) flow parallel to the coast, with eddies and meanders occurring in less regular flow patterns in intertidal areas (Hesp & Curry 1984; cited in Oceanica 2010). Drogue measurements of currents speeds and directions in the main channels adjacent to the Port found disparity between flood and ebb tides, during both spring and neap tides, with stronger ebb flows than flood flows (Oceanica 2010). Ebb speeds during neap tides are approximately half the spring tide speeds (DAL et al. 1998; cited in Oceanica 2010). Current speeds exceeded 0.15 m/s at the Port

throughout the spring tidal cycle (maximum of 0.85 m/s), and exceeded 0.4 m/s for most of the ebb of the neap tidal cycle. Slower and more meandering flows were measured over shallow areas such as Middle Ground (Figure 1.1; Oceanica 2010). Slack water periods last for ~2.5 hrs each within a tidal cycle (DPI 2008; cited in Oceanica 2010).

The local wave climate is influenced by the effects of tide and seasonal winds acting on a predominantly westerly swell regime that ranges from ~0.5 to 1.3 m (Hesp & Curry 1984, BPA 2009). West Roebuck Bay is relatively protected from the dominant westerly swell waves. Storm surges may range up to 2 m, however, it is rare that the water level surpasses the highest astronomical tide (HAT; 10.56 CD; Table 4.2) (Hesp & Curry 1984).

Table 4.2 Tidal planes of Broome

Tidal plane	Elevation (m Chart Datum)
HAT: Highest Astronomic Tide	10.56
MHWS: Mean High Water Springs	9.28
MHWN: Mean High Water Neaps	6.32
MSL: Mean Sea Level	5.41
MLWN: Mean High Water Neaps	4.51
MLWS: Mean Low Water Springs	1.54
LAT: Lowest Astronomic Tide	0.06

Source: Oceanica (2010)

Note:

1. Elevation values based on a Western Australia Department of Transport (DoT) submergence curve for Broome (10 June 2010)

4.1.7 Sediment transport

Hydrodynamic and plume modelling was carried out to estimate the extent of the dredge plume for the proposed dredging and disposal area (Appendix C). The 3D model considered tide (neap and spring), wind and wave interactions and depth to predict the plume extent and total suspended solid (TSS) concentrations above ambient conditions. The model simulated 'high' and 'low' dredge production rates for dredging to account for unknown substrate strength and equipment capabilities; the low rate equivalent to ~2 weeks of turbidity generating activities and the high rate equivalent to ~1 week of turbidity generating activities.

Results of modelling indicate that the dredge and disposal activities will generate a turbid plume that is restricted in both space and time (Appendix C). Modelled elevated concentrations of TSS are expected to be higher in the top 25% of the water column and TSS concentrations >10 mg/L above ambient are generally restricted to Roebuck Deep for an equivalent period of 2–3 days – dependant on production rate – over the duration of dredging and disposal activities (Appendix C). Following cessation of turbidity generating activities (completion of dredging and disposal), it will take 2–3 days for TSS concentrations to return to near ambient conditions (<1 mg/L above ambient) for high production rate dredging and disposal during a neap and spring tide; <1 day for a low production rate (Table 4.3). Regardless of the dredging scenario or tidal state, TSS concentrations will be <5 mg/L above ambient within a day of cessation of turbidity generating activities. Therefore, TSS concentrations will be above ambient conditions for no more than 2-3 weeks for the entire Project, regardless of the production rate or tidal state.

Table 4.3 Depth averaged total suspended solid concentrations following cessation of dredging and disposal activities

Dredging scenario	TSS concentration after time (hours)		
	<10 mg/L	<5 mg/L	<1 mg/L
Neap – low production rate	<1	2	9
Neap – high production rate	5	11	64
Spring – low production rate	<1	2	16
Spring – high production rate	2	4	40

Notes:

1. Low production rate equivalent to ~2 weeks of turbidity generating activities; high production rate equivalent to ~1 week of turbidity generating activities
2. TSS = total suspended solids

4.2 Biological environment

4.2.1 Invertebrates

The soft sediments associated with the intertidal region of Roebuck Bay supports one of the highest biomasses of benthic invertebrates in the world (Bennelongia et al. 2009); which provides an important regional feeding ground for shorebirds and waterbirds (Section 4.2.4). Sites further offshore and adjacent to the Project (south of the Port) were characterised by a significantly lower fauna composition and lower diversity, richness and feeding guild abundance (Eco Logical 2017).

4.2.2 Significant marine fauna

The marine waters adjacent to the Port support a variety of fauna, several of which are significant and protected under the EPBC Act. A search of the online EPBC Act Protected Matters Reporting Tool identified 28 listed threatened species and 65 listed migratory species that may occur in the project area. The listed marine[1] species include: seven marine reptiles (five turtles, freshwater and saltwater crocodiles); eight elasmobranch fish (four sawfish, two sharks and two manta rays); and eight marine mammals (Table 4.4). Additional marine fauna species listed as possibly occurring within the project area included pipefishes (22) and seahorses (5) and seasnakes (16) (Appendix A). The DBCA NatureMaps tool also identified snubfin dolphin as a priority 4 species that occurs in the area (Table 4.4; Appendix A).

The marine mammals identified for the project area include dugongs, whales and dolphins (Table 4.4). The EPBC Act provides special protection for migratory species of national environmental significance. Humpback and blue whales are known to move through the region during their annual migration, north from April–August for calving in tropical waters and south from August–October for feeding, and are generally found in deeper waters offshore from Entrance Point around July–September (Figure 4.3). Cow and calf pods can use inshore waters for resting, and humpback whales breed and calf in an area from Broome to Camden Sound (IFWA 2011). Migrating killer and bryde's whales are most often seen in relatively deeper waters and in Australia are most commonly seen along the continental slope and shelf areas (IFWA 2011, Chevron Australia 2013).

The dolphins identified in the area are migratory, with the Indo-Pacific humpback dolphins, bottlenose dolphin and Australian snubfin dolphin known to congregate in Roebuck Bay, due to their preference for nearshore waters and the importance of this habitat for breeding, feeding and/or calving (IFWA 2011, Brown et al. 2014a). The Australian snubfin dolphin is an endemic species to Australia and Brown et al. (2014a) suggests that Roebuck Bay supports the highest density and largest population of snubfin dolphins recorded in the published literature to date.

[1] *Terrestrial species were excluded as they are unlikely to be impacted by the Project. Refer to Appendix A for the full output.*

Incidental sightings of snubfin dolphins have been recorded further south (i.e. Port Hedland, Montebello Islands and the Exmouth Gulf) but Roebuck Bay is considered critical habitat for this species (IFWA 2011, Allen et al. 2012); and the local community is likely a discrete population, separate to snubfin dolphins found in other regions of north-west WA (Brown et al. 2014b). Snubfin dolphins were observed frequently in the Inner Anchorage and the shallow subtidal mud flats in the eastern region of Roebuck Bay in 2013 (Figure 4.3). There is concern that snubfin dolphins are susceptible to disturbance by recreational vessels, fishing nets and increased shipping with loss of habitat one of the largest threats to the species (IFWA 2011, Allen et al. 2012).

Dugongs are known to be present within Roebuck Bay (Bennelongia et al. 2009, Brown et al. 2014a). The aerial survey completed by RPS (2009; as cited in McKenzie et al. 2017) estimated the dugong population of Roebuck Bay to be between 500 and 700 animals, dependant on the season. More recently, Brown et al. (2014a) opportunistically sighted 44 dugongs between 4 October and 05 November 2013, though some of these sightings may be re-sights (Figure 4.5). The population in Roebuck Bay was recorded feeding on seagrass beds in the northern areas of Roebuck Bay, often within the intertidal zone close to the township of Broome (Bennelongia et al. 2009, McKenzie & Yoshida 2009, McKenzie et al. 2017) but are a highly mobile species that move in and out of the bay dependant on resource availability (DPaW 2016). Information on dugongs in the Kimberley region is limited and the Western Australian Marine Science Institute is currently completing a program that will integrate indigenous knowledge, aerial surveys and tagging to develop a baseline dugong management plan for the region.

Five species of turtle frequent the Roebuck Bay area as a seasonal feeding ground and as a transit area during migration, including the loggerhead, green, olive ridley, hawksbill and flatback turtles (Bennelongia et al. 2009). Similar to dugongs, the seagrass meadows north of the Port are an important food source for these species (Bennelogia et al. 2009). Cable Beach to the north and Cape Villaret and Jacks Creek in the south of Roebuck Bay (~20 km from the Port) are known nesting areas for flatback turtles during summer (October–February) (RIS 2009, DPaW 2016), but not the beaches directly adjacent to the Project.

Four of the elasmobranch fish with habitat or breeding known to occur in the area were species of sawfish (Table 4.4). Sawfish tracking surveys by Stevens et al. (2005) indicated that sawfish prefer very shallow water over mudflats and sandbanks, where they can rest during slack tide, when water movement is low. The tidal creeks, mangroves and adjacent mudflats within Roebuck Bay, including those within the Ramsar boundary, north and east of the Project footprint, are nursery areas and refuge for the dwarf sawfish (*Pristis clavata*) (RIS 2009). It is thought that areas in north-west Australia may be contain some of the last significant populations of sawfish, with protected areas like Roebuck Bay representing important foraging, pupping (January–May) and nursing for some species (DSEWPC 2008). Net and gillnet fishing were identified as the main threat for both the freshwater and green sawfish—as the saw is entangled in the nets—and was banned in 2013 (ABC Kimberley 2013; Section 4.3.3). Manta rays range from Geraldton through to the tropics and are commonly sighted along productive coastlines where regular upwelling occurs, around shallow reefs and in sandy bottom areas so are likely to be present within the Project area. Roebuck Bay may also be considered regionally significant for devil rays and eagle rays (DPaW 2016). It is unlikely that whale sharks would access the shallower waters of Roebuck Bay and are unlikely to be affected by the Project.

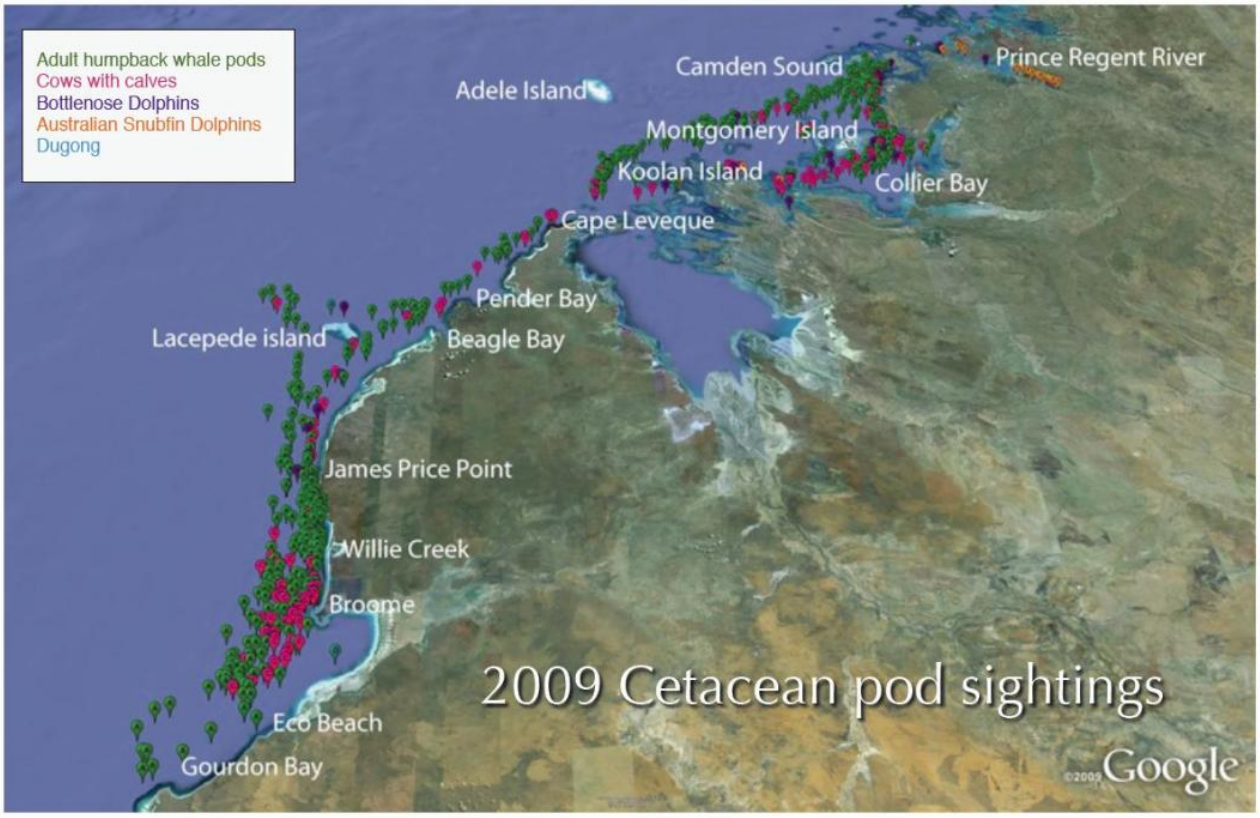
Table 4.4 Endangered and threatened marine fauna

Species	Category and/or status	Type of presence	Period of habitat use[1]
Marine mammals			
Blue whale (*Balaenoptera musculus*)	Threatened species: endangered Migratory	Species or species habitat may occur within area	July–September (migration)
Humpback whale (*Megaptera novaeangliae*)	Threatened species: vulnerable Migratory	Species or species habitat known to occur within area	July–September (migration)
Bryde's whale (*Balaenoptera edeni*)	Migratory	Species or species habitat may occur within area	–
Dugong (*Dugong dugon*)	Migratory	Foraging, feeding or related behaviour known to occur within area	–
Irrawaddy dolphin (*Orcaella brevirostris*)	Migratory	Species or species habitat known to occur within area	–
Killer whale (*Orcinus orca*)	Migratory	Species or species habitat may occur within area	–
Spotted bottlenose dolphin (*Tursiops aduncus*)	Migratory	Species or species habitat known to occur within area	–
Indo-pacific humpback dolphin (*Sousa chinensis*)	Migratory	Breeding known to occur within area	–
Snubfin dolphin (*Orcaella heinsohni*)	Priority 4 species	Known to occur in the area	–
Reptiles			
Loggerhead turtle (*Caretta caretta*)	Threatened species: endangered Migratory	Foraging, feeding or related behaviour known to occur within area	–
Green turtle (*Chelonia mydas*)	Threatened species: vulnerable Migratory	Breeding known to occur within area	October–February (nesting)
Leatherback turtle (*Dermochelys coriacea*)	Threatened species: endangered Migratory	Breeding likely to occur within area	–
Hawksbill turtle (*Eretmochelys imbricata*)	Threatened species: vulnerable Migratory	Breeding likely to occur within area	–
Flatback turtle (*Natator depressus*)	Threatened species: vulnerable Migratory	Breeding likely to occur within area	October–February (nesting)
Elasmobranch fish (sharks)			
White shark (*Carcharodon carcharias*)	Threatened species: vulnerable Migratory	Species or species habitat may occur within area	–
Dwarf sawfish (*Pristis clavata*)	Threatened species: vulnerable Migratory	Species or species habitat known to occur within area	January–May (pupping) Throughout the year (foraging and refuge)
Freshwater sawfish (*Pristis pristis*)	Threatened species: vulnerable Migratory	Species or species habitat known to occur within area	January–May (pupping) Throughout the year (foraging and refuge)

Species	Category and/or status	Type of presence	Period of habitat use[1]
Green sawfish (Pristis zijsron)	Threatened species: vulnerable Migratory	Breeding known to occur within area	January–May (pupping) Throughout the year (foraging and refuge)
Whale shark (Pristis zijsron)	Threatened species: vulnerable Migratory	Species or species habitat may occur within area	–
Narrow sawfish (*Anoxypristis cuspidata*)	Migratory	Species or species habitat may occur within area	January–May (pupping) Throughout the year (foraging and refuge)
Reef manta ray (*Manta alfredi*)	Migratory	Species or species habitat may occur within area	–
Giant manta ray (*Manta birostris*)	Migratory	Species or species habitat may occur within area	–

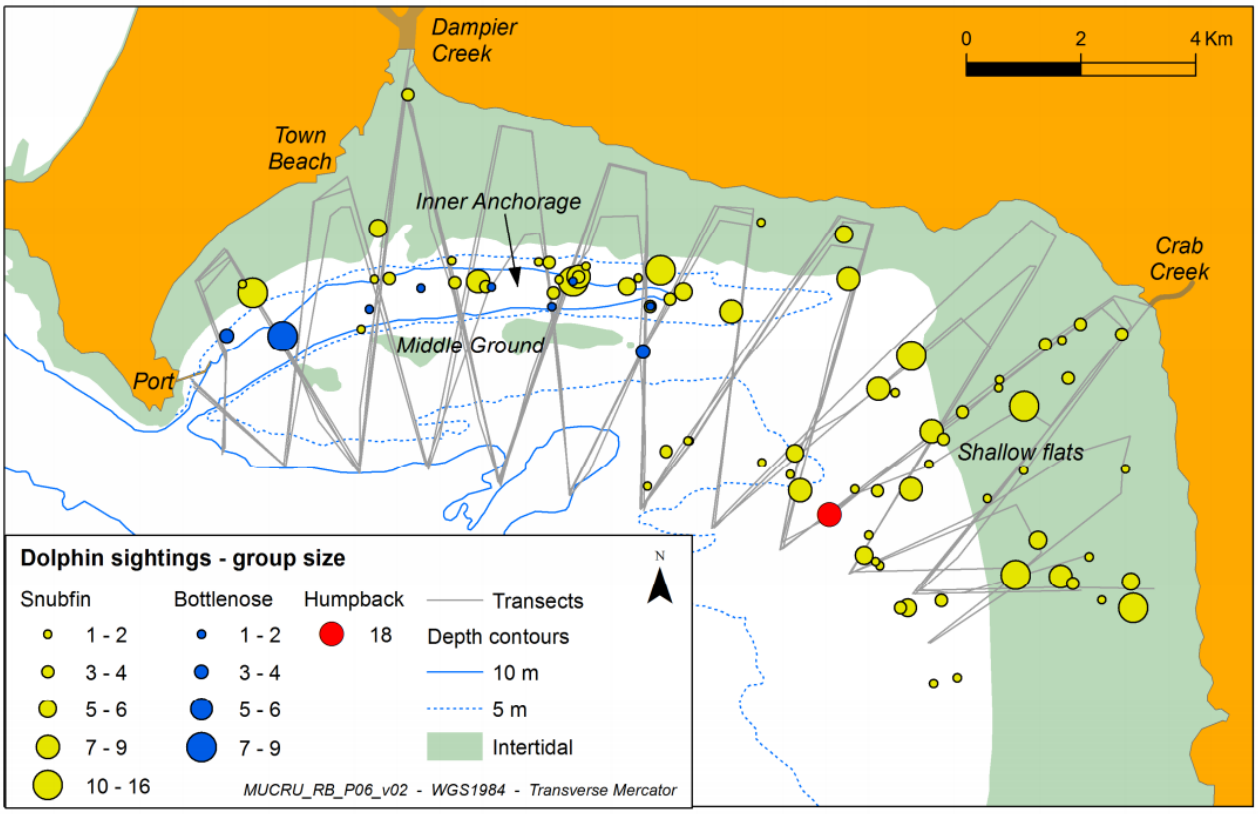
Note:

1. Period of habitat use as referenced in text, '–' = indicates there is no available data related to the species distribution or habitat association in Roebuck Bay or species occurs in the area but Roebuck Bay is not considered significant habitat for that species.



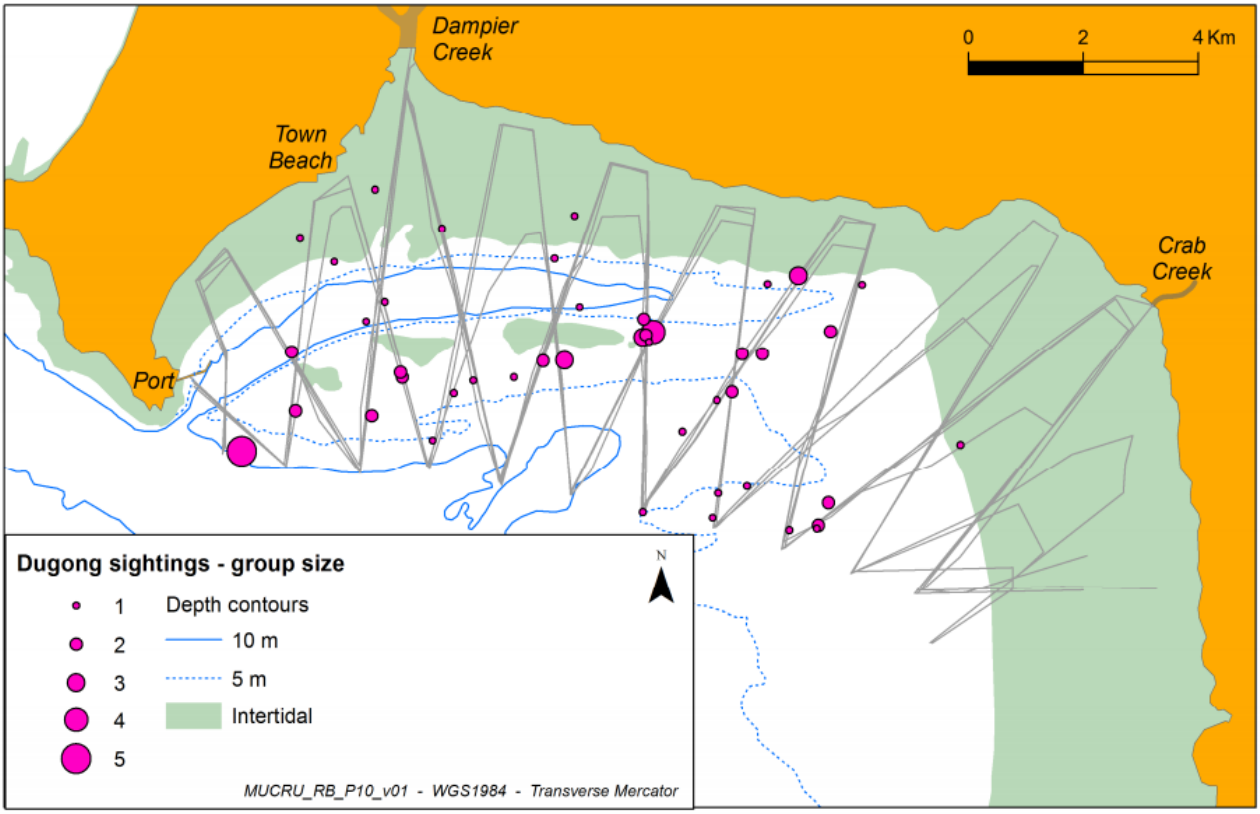
Source: Costin and Sandes (2009; cited in Oceanica 2010)

Figure 4.3 Cetacean sightings north of Gourdon Bay in 2009



Source: Brown et al. (2014a)

Figure 4.4 Dolphin sightings by group size along transects (grey lines) between 4 October and 05 November 2013



Source: Brown et al. (2014a)

Figure 4.5 Opportunistic dugong sightings by group size along transects (grey lines) between 4 October and 05 November 2013

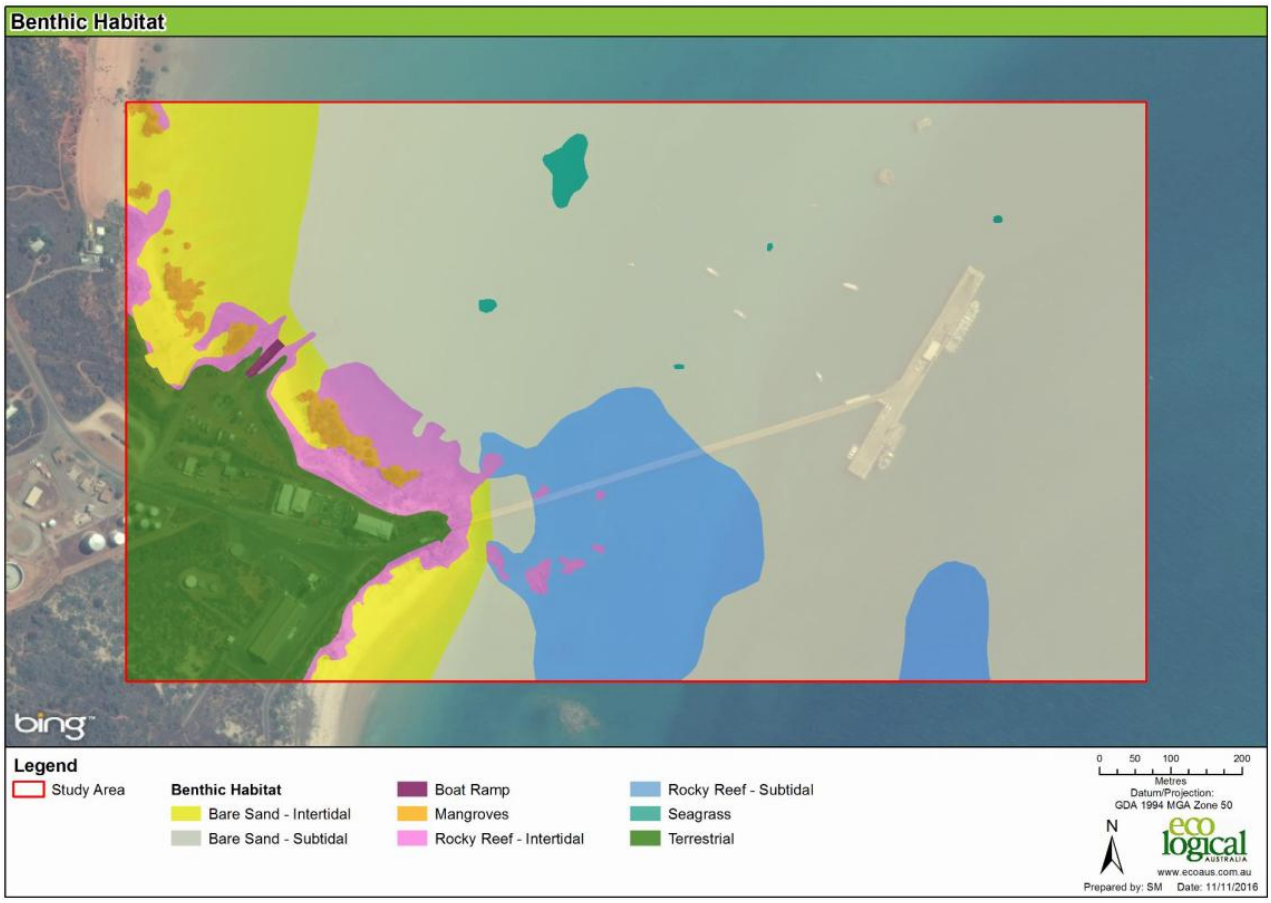
4.2.3 Benthic primary producer habitat

The benthic habitats surrounding the Port jetty are characterised by mainly bare sand with patches of moderate cover (~50%) ephemeral seagrasses (*Halodule uninervis* and *Halophila ovalis*) and subtidal reefs with low cover of algae/coral (Eco Logical 2017; Figure 4.6). Studies of seagrass health in the broader Roebuck Bay area identified the presence of the same species; with seagrass stands dominated by *Halodule univnervis*, areas of *Halophila ovalis* and smaller amounts of *Halophila minor* and *Holodule pinifolia* (McKenzie & Yoshida 2009 and McKenzie et al. 2017). The densest stands of seagrass occur in the northern intertidal regions of Roebuck Bay that are exposed for <2 hours on low tides (McKenzie & Yoshida 2009), and generally further away from the Port jetty and the Roebuck Deep and Inner Anchorage channels (BPA 2009, Eco Logical 2017; Figure 1.1). Long-term seagrass monitoring indicated that percent cover of seagrass varied spatially, seasonally and inter-annually (McKenzie et al. 2017

Previous studies by DPI (2008; cited in Oceanica 2010) have identified corals at Riddell and Entrance Points, and Roebuck Bay Jetty on the Broome Peninsula as part of a seabed stability study. Coral communities fringing Entrance Point, which are closest to the Port, experience high turbidity and consequently are less well-developed than coral communities in clearer offshore waters (BPA 2009).

Subtidal reefs are common around Entrance Point Boat Ramp, with 40–50 species of macroalgae reported in this area (BPA 2009). Further away from the Port, patches of the green alga *Caulerpa* spp. occur on the fine muddy sands of the tidal flats (BPA 2009). Overall, however, macroalgal diversity and abundance in the Kimberley region are low, which may be attributable to naturally high turbidity and tidal exposure times (Mustoe & Edmunds 2008).

Drop camera video was opportunistically taken during the 2017 sediment sampling (Section 4.1.5). The video indicated that, in the small area surveyed, the dominant substrate was bare sand and reef (Appendix D), corresponding with Eco Logical (2017) findings (Figure 4.6).



Source: EcoLogical (2017)

Figure 4.6 Benthic habitat surrounding the Port of Broome

4.2.4 Avifauna

The Port area is ~10 km to the west of the Roebuck Bay Wetland of International Importance (under the Ramsar Convention), which is one of the most important stopover areas for non-breeding migratory shorebirds within Australia and globally (Bennelogia et al. 2009). A search of the online EPBC Act Protected Matters Reporting Tool revealed three critically endangered, four endangered, one vulnerable and 53 migratory species of birds—most of which are listed in all or one of the following international treaties for migratory birds: the Japan-Australia Migratory Bird Agreement, the China-Australia Migratory Bird Agreement and Republic of Korea-Australia Migratory Bird Agreement (Appendix A).

Shorebirds and waterbirds inhabit the tidal mudflats and roost during periods of higher tides when the mudflats are inundated (Bennelogia et al. 2009). Roebuck Bay is a rich wader feeding ground; supporting a high macro-invertebrate community and a significant nursery for marine fishes and crustaceans. The surrounding vegetation formations are also important for roosting and protection, including: low closed-forest to open-scrub (mangrove) east and south of Roebuck Bay; low samphire shrubland inland of the mangroves, inland low open-woodland over grassland (RIS 2009).

Some of the birds in Appendix A that are known to roost in the nearby area have also been recorded in the Port area (grey plover [*Pluvialis squatarola*], grey-tailed tattler [*Tringa brevipes*], terek sandpiper [*Xenus cinereus*] and pacific fulva [*Pluvialis fulva*]; Chris Hassell, 2010, pers comm.; cited in Oceanica 2010). Most of the birds listed are largely associated with the intertidal mudflats and adjacent nearshore and onshore vegetation, and it is unlikely that dredging and disposal of material adjacent to the Port will impact birds, particularly given the short (2–4 weeks) duration of the works. Further, the presence and/or operation of a CSD for the duration of the Project is not outside of current Port operations/activities that would cause any additional risks to avifauna. Turbidity generated by the Project is also not anticipated to impact marine invertebrates prevalent in the intertidal areas of Roebuck Bay that are an important food source for avifauna.

4.2.5 Invasive marine species

There is a risk of invasive marine species (IMS) being introduced into the region from ballast water and biofouling due to the number and type of vessels visiting the Port. KPA is part of a State-Wide Array Surveillance Program (SWASP), in partnership with Department of Fisheries (now DPIRD). The SWASP aims to provide an early warning for the presence of IMS by deploying settlement arrays and completing shoreline searches (KPA 2016a); a method determined as effective for early detection of IMS (Eco Logical 2017). During the deployment of settlement arrays between October 2014 and May 2015, the colonial ascidian *Didemnum perlucidum* was detected on arrays deployed at Berths 2/3 (Eco Logical 2017). KPA were advised that this species is widespread and no specific actions were required at this time. However, KPA will continue the SWASP and may complete some additional monitoring as part of ongoing marine baseline studies.

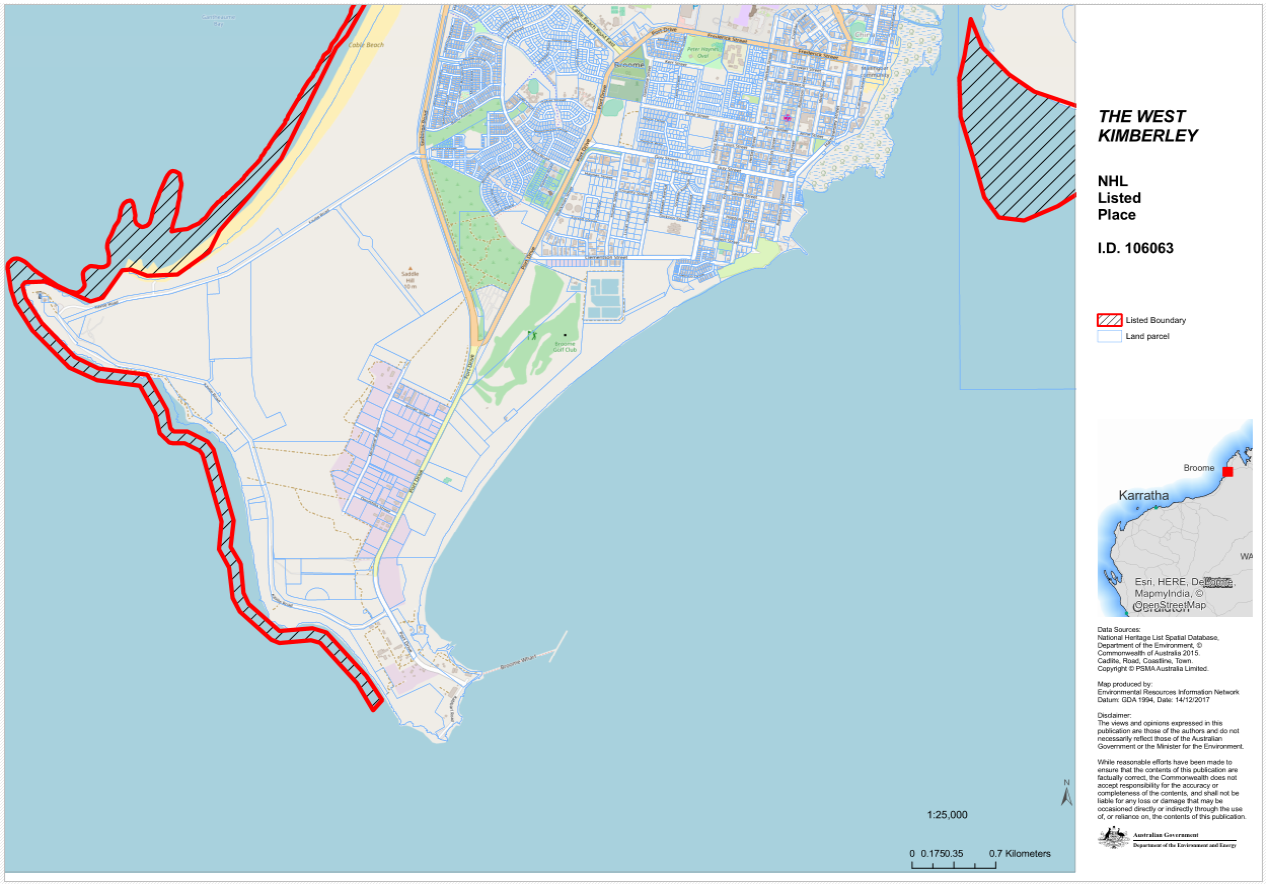
4.3 Social environment

4.3.1 Conservation

Due to the importance of the intertidal mudflats and tidal creeks of Roebuck Bay as a staging site for migratory birds (Figure 1.1 and Section 4.2.4), the area was declared as a Ramsar wetland of significance in 1990. In 2011, the west Kimberley region was added to the DoEE National Heritage Places register for places of natural, historic and indigenous significance; inclusive of Roebuck Bay. However, the Port and Project areas are not within the boundaries of the West Kimberley National Heritage Plan (Figure 4.7; M Klug, DoEE, pers. comm., 14 December 2017).

In further recognition of Roebuck Bay's ecological significance, the Yawuru Nagulagun / Roebuck Bay Marine Park was gazetted as a Class A reserve (excluding KPA waters) under the *Conservation and Land Management Act 1984* (CALM Act) in 2015. The Yawuru Nagulagun / Roebuck Bay Marine Park is jointly managed by the Yawuru Registered Native Title Body Corporate and Department of Parks and Wildlife (now DBCA). The Yawuru Nagulagun / Roebuck Bay Marine Park Joint Management Plan (DPaW 2016) details the management commitments for the marine park in-line with the Yawuru Indigenous Land Use Agreements, legislative requirements under the CALM Act and in fulfilment with the Kimberley Science and Conservation Strategy (GoWA 2011). KPA holds a Memorandum of Agreement with DBCA and Yawuru and meet quarterly to discuss any potential transboundary issues between Port operations and the Yawuru Nagulagun / Roebuck Bay Marine Park.

The potential for the Project to impact the adjacent Ramsar wetland, national heritage place and Class A reserve are considerations of this DEIA.



Source: M Klug, DoEE, pers. comm., 14 December 2017

Figure 4.7 Boundary of the West Kimberley National Heritage Place adjacent to the Port of Broome

4.3.2 Heritage and ethnography

Roebuck Bay is of cultural significance to the Yawuru traditional owners; their connection to the land is important for spiritual and cultural practices and also for access to food and ceremonial fauna species (i.e. turtles and dugongs). A search of the Department of Aboriginal Affairs Aboriginal Heritage inquiry system (http://maps.dia.wa.gov.au/AHIS2/) generated one registered aboriginal site that overlaps the project area (Entrance Pont/Yinara 12873; Figure 4.8), attributed to: artefacts; shell middens; mythological; camp. Early consultation with Nyamba Buru Yawuru management team and DPLH has confirmed that there are no registered sites or heritage related issues within the Project area; however, these stakeholders will continue to be consulted as the Project progresses (Section 7).

A search of the Heritage Council database (http://inherit.stateheritage.wa.gov.au/public) indicates the Port jetty is heritage listed, due to its significant association with shipping, imports and exports and more frequently tourism. This heritage value is not going to be disturbed as a result of the proposed works. More recently, a number of sandstone dinosaur footprints have been discovered between Entrance Point and Riddell Point, within the West Kimberley National Heritage boundaries (Figure 4.9 and Figure 4.7). The Project is unlikely to affect National Heritage protected dinosaur tracks/ichnofossils and the Port and Project areas are not within the boundary of the West Kimberley National Heritage Plan (M Klug, DoEE, pers. comm., 14 December 2017).

There are 159 known shipwreck sites in the Broome region protected under the Commonwealth *Historic Shipwrecks Act 1976* but the exact location of many of these wrecks is unknown (Figure 4.10). During World War II a surprise Japanese aerial attack destroyed a number of flying boats moored in Roebuck Bay and many of these vessels and any associated artefacts (i.e. aircrafts, aircraft parts and unexploded ordnances) have not been located (Dr R Anderson, Maritime Archaeology, Western Australian Museum, pers. comm., 19 January 2018). The World War II wrecks are protected under the *Heritage of Western Australian Act 1990* and sovereignty law as these artefacts remain the property of different nations' military forces. KPA will continue consultation with the Western Australian Museum and undertake any requisite desktop assessment and magnetometer/sonar surveys to determine potential impacts the Project may have on known or unknown heritage artefacts.

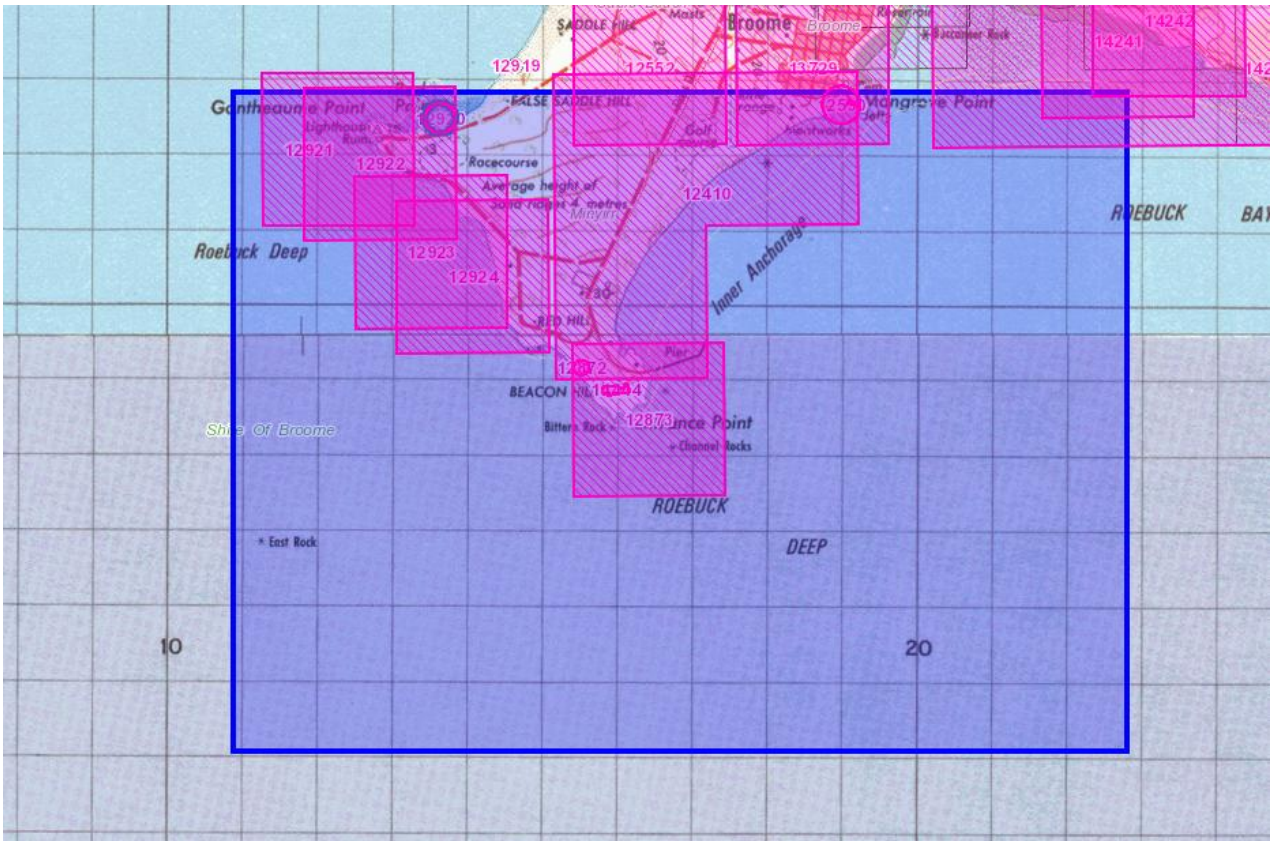


Figure 4.8 Registered Aboriginal heritage sites near the Port of Broome

Source: GHD (2017)

Figure 4.9 Heritage listed dinosaur footprint sites near the Port of Broome

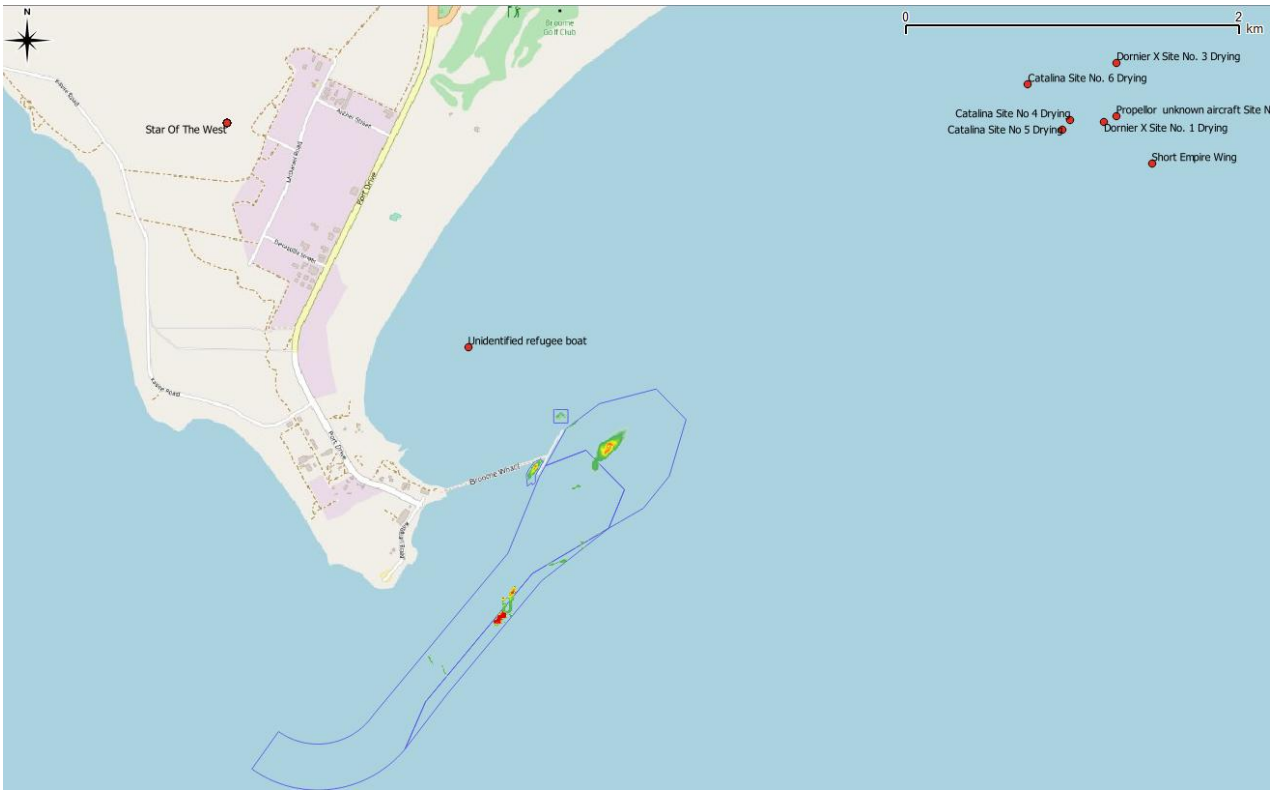


Figure 4.10 Maritime heritage sites near the Port of Broome

4.3.3 Commercial and recreation

Tourism and recreation

Broome is a popular holiday destination for travellers, mainly during the dry season (April-October). The area adjacent to the Port is popular for recreational fishing and tourism including: sight-seeing from the Jetty, bird-watching and sight-seeing tours by hovercraft (BPA 2009). Tourism is generally concentrated along the white sandy beaches (Cable Beach) or beaches just north of the Port (Simpsons and Town Beach) as much of the eastern side of Roebuck Bay can only be accessed by boat at high tide (Bennelongia et al. 2009). Boating and marine activities are popular in the area and, as of November 2016, there were 1747 recreational boats and 132 registered vessels (commercial and charter operations) in the Port catchment area (PB Advisors 2017).

The cruise shipping and tourism industry contributes ~$387M to WA's economy each year (Tourism WA 2017). A 2011–2012 survey indicated that an itinerary including a port call in Broome influenced consumer's choice and strategic state planning recommended WA offer two Tier 1 or turnaround ports by 2020; Fremantle and Broome (Our Community 2012). Broome represents the most northern cruise destination of the 10 key WA ports. Eleven cruise ships called into the Port in 2015/16; representing 20 000 passenger days[2] (Acil Allen 2016), or ~2500 passengers in Port for ~11 days of the year. The Project will allow 24 hour access for cruise vessels and, as a result, the number of cruises a year will increase to ~35 by the 2021/2022 season; representing 87 000 passenger days in Port for ~35 days a year. The maximum number of vessels that can visit the Port at any one time is restricted by the capacity of the wharf (one cruise ship at a time) and seasonal preferences (dry season; April–October).

Fishing and aquaculture

Fishing, pearling and aquaculture contribute significantly to the Broome economy (DPaW 2016, URBIS 2016). The pearling industry is the major industry in Broome (based on employment of over 1,000 people) and is based on the silver-lipped pearl oyster (*Pinctada maxim*) (Bennelongia et al. 2009). An environmental priority for the pearling industry is to maintain a high water quality in Roebuck Bay, where some pearling occurs, as pollutants can cause mortalities, reduced shell size and quality (PPA 2008; Figure 1.1). However, the Roebuck Bay area contributes only a small percentage of the total production across the region (Bennelongia et al. 2009; Figure 1.1).

In addition to pearling, Roebuck Bay supports a diverse range of for many finfish, shark and ray species, though there are limited specific studies detailing their assemblages. The shallow nearshore waters of Roebuck Bay are an important nursery area for many finfish, including the blue threadfin (*Eleutheronema tetradactylum*) (DPaW 2016). The main commercial finfish species found in this region include barramundi (*Lates calcarifer*), giant threadfin salmon (*Polydactylis macrochir*), blue threadfin salmon (*Eleutheronema tetradactylum*) (DPaW 2016). In 2013 the DPIRD (previously the Department of Fisheries) bought back Kimberley Gillnet and Barramundi Managed Fishery fisheries licences operating between the northern end of the Eighty Mile Beach and Roebuck Bay (ABC 2013, DPaW 2016). Other commercial fishing effort within the Marine Park is not significant compared to the large size of commercial fishing licence areas in the region, beyond the Marine Park. Target recreational fish species are similar to commercial but also include tripletail perch, mulloway (*Argyrosomus japonicus*), mudcrabs (*Scylla* sp.) and molluscs (Bennelongia et al. 2009).

[2] *Double occupancy per cabin multiplied by the number of days in port multiplied by the number of cruise days.*

Aquaculture is an important industry in the Kimberley. As a result, the Broome Tropical Aquaculture Park (BTAP) was developed to support production of marine finfish, pearl cultures and investigations and development of other aquaculture species (i.e. trochus, barramundi, tiger prawns, mud crab and cherabin) (Department of Fisheries; DoF 2012). There are currently four occupants within the BTAP: Kimberley Training Institute, Aqua Broome, DPIRD and the Pearling Consortium. The BTAP is managed by DPIRD (previously the Department of Fisheries) and is located adjacent to onshore Port infrastructure. BTAP can obtain seawater from an intake on the Port jetty, adjacent to the Deep Water Channel (Figure 1.1); however, this intake is not currently in use. The DPIRD and respective leaseholders will be consulted as the Project progresses.

5. Environmental Impact Assessment

5.1 Relevant environmental factors and impact assessment

5.1.1 Environmental factors, values and objectives

The EPA's (2016b) environmental factors are those parts of the environment that may be impacted by an aspect of a proposal. They provide a systematic approach to interpreting environmental information for the purpose of environmental impact assessment and a structure for the assessment report. The EPA has 14 environmental factors, organised into five themes: Sea, Land, Water, Air and People (Table 5.1). Environmental factors that are relevant to, and considered by, this DEIA include:

- benthic communities and habitats
- marine environmental quality
- marine fauna
- social surroundings
- human health.

The EPA has identified an environmental objective for each environmental factor (Table 5.1). The EPA makes judgements against these objectives on whether the environmental impact of a proposal may be significant. The environmental objectives are aimed towards ensuring the objects and principles of the EP Act are achieved. The EPA has also published guidelines on every environmental factor and associated objective and technical guidance for several of the environmental factors.

Table 5.1 Environmental factors and objectives (EPA 2016b)

Theme	Factor	Objective
Sea	Benthic Communities and Habitats	To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained.
	Coastal Processes	To maintain the geophysical processes that shape coastal morphology so that the environmental values of the coast are protected.
	Marine Environmental Quality	To maintain the quality of water, sediment and biota so that environmental values are protected.
	Marine Fauna	To protect marine fauna so that biological diversity and ecological integrity are maintained.
Land	Flora and Vegetation	To protect flora and vegetation so that biological diversity and ecological integrity are maintained.
	Landforms	To maintain the variety and integrity of distinctive physical landforms so that environmental values are protected.
	Subterranean Fauna	To protect subterranean fauna so that biological diversity and ecological integrity are maintained.
	Terrestrial Environmental Quality	To maintain the quality of land and soils so that environmental values are protected.
	Terrestrial Fauna	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.
Water	Hydrological Processes	To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.
	Inland Waters Environmental Quality	To maintain the quality of groundwater and surface water so that environmental values are protected.
Air	Air Quality	To maintain air quality and minimise emissions so that environmental values are protected.
People	Social Surroundings	To protect social surroundings from significant harm.
	Human Health	To protect human health from significant harm.

Source: EPA (2016b)

5.1.2 Alignment with values and objectives of the Yawuru Nagulagun / Roebuck Bay Marine Park Management Plan

The Yawuru Nagulagun / Roebuck Bay Marine Park Management Plan (DPaW 2016) sets out ecological and social values for protection and establishes specific objectives and associated long-term targets for each of those values. These values are listed below, as described in DPaW (2016).

Summary of Yawuru cultural values

The Yawuru cultural values outline specific objectives for the connection between the Yawuru people and Yawuru country. The objective of these values is to maintain the connection to their traditional coastal and sea country through identity and place, family networks, spiritual practice and resource gathering. The Yawuru cultural values and objectives are (DPaW 2016):

- **Living cultural landscapes:** raising awareness and respect for the marine park as part of the living cultural landscape of Yawuru country.
- **Traditional ecological knowledge:** gaining better understanding of Yawuru traditional ecological knowledge applicable to the marine park, and investigating opportunities for integration with conservation science and management.
- **Enjoyment of country and customary practices:** providing for, recognising and maintaining the rights of Yawuru people to enjoy country and undertake customary practices.
- **Responsibility for country:** promotion and recognition of the responsibilities of protecting sacred and significant areas within the marine park.

Summary of ecological values

Ecological values are a combination of the physical, chemical and biological characteristics of the marine park that play a significant role in maintaining the rich biodiversity within the marine park. These ecological values are tightly linked to the Yawuru cultural values (above). The ecological values and objectives are (DPaW 2016):

- **Geomorphology:** increase awareness and importance of the importance of the marine park's geomorphology; a tidal dominated tropical coastal embayment with a range of geomorphic features (intertidal mudflats, creeks, dinosaur footprints, carbonate shoals and the Roebuck Deep).
- **Water and sediment quality:** maintenance of high water and sediment quality as required for a healthy marine ecosystem.
- **Segrass and algae communities:** maintenance of marine plants within the marine park that provide important habitat and refuge areas for fish and invertebrates.
- ***Gundurung* (mangrove communities):** maintenance of *Gundurung* within and adjacent to the marine park as critical habitat for many marine and terrestrial wildlife species.
- ***Bundu* (saltmarsh and saline grassland communities:** maintenance of *Bundu* that play an important role in binding soil and providing habitat for shorebirds.
- **Filter feeder communities:** protect the diverse range of filter feeding communities within the marine park.
- **Intertidal sand and mudflat communities:** protect intertidal sand and mudflats that support invertebrate communities essential to shorebird populations.
- **Waterbirds including migratory *gamirda-gamirda* (shorebirds):** protection of waterbirds within the marine park, including a number of nationally and internationally significant populations of migratory species.
- **Invertebrates:** improve understanding and of the highly diverse marine invertebrate populations within the marine park as a food source for a variety of animals, including birds, fish and turtles.
- **Finfish:** a diversity of finfish species provides recreational and customary fishing opportunities.
- **Marine mammals:** dugongs, whale and several dolphin species inhabit or migrate through the marine park.
- ***Gurlibil* (marine turtles):** five species of turtles frequent the waters of Roebuck Bay and flatback turtles nest in and adjacent to the marine park.

Summary of social values

The marine park serves to protect important natural environments that provide important public access and protection of outdoor recreation areas, nature-based tourism and historical and culturally valuable sites. The social values and objectives are (DPaW 2016):

- **Maritime heritage:** unique maritime heritage of Roebuck Bay as a result of its marine resources, safe anchorage and establishment of the pearling industry in the 1870s.
- **Seascapes:** protection of natural vistas of turquoise waters, shoals and reefs, rocky shores, intertidal flats, mangroves and beaches with abundant wildlife.
- **Nature based and cultural tourism:** undisturbed natural environment offering a variety of naturebased and cultural attractions and opportunities.
- **Pearling and commercial fishing:** warm tropical waters and large tidal range provide optimal conditions for production of high quality pearl oysters and limited commercial fisheries.
- **Recreational and customary fishing:** diverse range of quality recreational and customary fishing opportunities.
- **Resources and infrastructure:** work collaboratively with the Port, a major Port servicing the Kimberly on the doorstep of the marine park.
- **Research opportunities:** relatively undisturbed natural environment of Roebuck Bay provide unique opportunities for cultural, ecological and social research.

The values, management objectives and long-term targets described in the Yawuru Nagulagun / Roebuck Bay Marine Park Management Plan (DPaW 2016) can be readily aligned with the EPA's (2016b) environmental factors and primary management objectives (EPA 2016a), as shown in Table 5.2.

This DEIA considers potential impacts on both the EPA's (2016) environmental factors and the values of the Yawuru Nagulagun / Roebuck Bay Marine Park Management Plan (DPaW 2016) that are relevant to, and considered by, this DEIA. An environmental risk assessment (Appendix A) was undertaken for the Project, incorporating a stakeholder consultation process (Section 7). All risk assessments were based on the combined likelihood and consequence of each potential residual risk occurring; that is, the potential likelihood and consequence of the potential impact or risk occurring following management and/or mitigation actions being implemented. As a result of the risk assessment process, four environmental factors were defined as being potentially impacted by the project (Table 5.2) (on either a low or medium level; Appendix E). These potential environmental impacts are discussed further in Section 5.2.

Table 5.2 Alignment of environmental factors (EPA 2016) with values and objectives of the Yawuru Nagulagun / Roebuck Bay Marine Park Management Plan (DPaW 2016)

Environmental Factor (EPA 2016a)	Yawuru Nagulagun / Roebuck Bay Marine Park Management Plan (DPaW 2016)
Benthic communities and habitats	• Seagrass and algae communities • Filter feeding communities
Marine environmental quality	• Geomorphology • Water and sediment quality
Marine fauna	• Waterbirds including migratory *gamirda-gamirda* (shorebirds) • Invertebrates • Finfish • Marine mammals • *Gurlibil* (marine turtles)
Social surroundings and human health	• Enjoyment of country and customary practices • Responsibility for country • Maritime heritage • Seascapes • Nature based and cultural tourism • Pearling and commercial fishing • Recreational and customary fishing • Resources and infrastructure

5.1.3 Potential for cumulative impacts

Although there is a risk an individual project may have potential impacts to the environment, impacts from other projects in the region can lead to increased deleterious effects on environmental and social values. However, dredging activities and development of coastal infrastructure in Roebuck Bay are negligible and therefore cumulative impacts can be discounted.

5.2 Potential impacts on environmental factors

5.2.1 Benthic communities and habitats

There is no significant benthic primary producer habitat (BPPH) within the dredge or disposal area (Section 4.2.3) so there will be no direct disturbance or removal of BPPH. However, turbidity generated by dredging and disposal of material reduces light available for photosynthesis and can have an adverse effect on BPPH should turbidity persist in space and time, depending on the physiological characteristics of the seagrass species present. Colonising seagrasses like *Halodule* spp. and *Halophila spp.* can recover quickly from a period of stress or disturbance due to fast reiteration of ramets and a viable seed bank but are vulnerable to changes in light availability due to low carbohydrate stores (Longstaff & Dennison 1999, Unsworth et al. 2015, Fraser et al. 2017).

Modelling indicates that the turbid plume generated by the Project is unlikely to shade any existing stands of seagrass and is generally restricted to Roebuck Deep (Appendix C). Further, plume modelling indicates that TSS concentrations will only be elevated above background for a period of 2-3 weeks; depending on the production rate and tidal state (Section 4.1.7; Appendix C). Given that background TSS concentrations adjacent to the Port range from 15.7–24.8 mg/L during the wet season and 8.8-15.2 mg/L during the dry season it is likely that seagrass, if present within the limited extent of the plume, would be able to tolerate an increase in TSS concentration of 10–20 mg/L above background for the short duration of the Project (Appendix C). Nonetheless, standard turbidity monitoring and management will be implemented for the duration of the Project (Section 6).

There is unlikely to be increased turbidity generated by large vessels entering the Port on low tides during operation of the deepened channel given vessels are already entering the Port with minimum under keel clearance. Incidence of turbidity generated by low under keel clearance should decrease following the proposed Project.

5.2.2 Marine environmental quality

Release of contaminants during dredging and disposal

Concentrations of metals, organotins, and hydrocarbons were generally below the LoR and in all cases below the NAGD screening levels (Section 4.1.5; Appendix B). Based on these results, the material is considered suitable for ocean disposal under the EPSD Act.

Hydrocarbon spills and waste generation

Various hydrocarbons will be used during the Project and operation of the depended channel, including: fuel, oil and lubricants for machinery. There is a risk of hydrocarbon spills, negatively impacting marine flora and fauna as well as beach users. Rubbish and hazardous waste may also be generated, which can pollute the environment if not contained and removed from site. Therefore, hydrocarbon use and waste will be actively managed (Section 6).

5.2.3 Marine fauna

Avifauna disturbance

The Port area is ~10 km to the west of the Roebuck Bay Wetland of International Importance. Therefore, referral to the DoEE under the EPBC Act is required 'for an action occurring within or outside a declared Ramsar wetland if the action has, will have, or is likely to have a significant impact on the ecological character of the Ramsar wetland'.

Consideration of the 'significant impact criteria' (Table 5.3) defined under the EPBC Policy Statement 1.1 indicates that the Project presents negligible risk of significant impact on the ecological character of the Roebuck Bay Wetland, and will not require formal assessment.

Table 5.3 Assessment of EPBC Act significant impact criteria

Significant impact criteria	Risk	Notes
Does the action result in areas of the wetland being destroyed or substantially modified?	None	• Small scale works wholly within Port waters, away from the intertidal sand and mud flats
Does the action result in a substantial and measurable change in the hydrological regime of the wetland?	None	• No change in volume, timing, duration or frequency of ground/surface water flows
Does the action result in the habitat or lifecycle of native species, including invertebrate fauna and fish species, dependent on the wetland being seriously affected?	None	• Small scale works wholly within Port waters, away from the intertidal sand and mud flats
Does the action result in a substantial and measurable change in the water quality of the wetland?	None	• Slight, localised water quality change within Port waters (Section 4.1.7)
Does the action result in an invasive species that is harmful to the ecological character of the wetland being established (or an existing invasive species being spread) in the wetland?	Low	• Risk of introduced marine species will be managed • No Project plant or vessel is required to enter the wetland, and will remain in Port waters

Marine fauna disturbance (collision/noise)

The Marine fauna known to occur in the Project area (Section 4.2.2) may be impacted by collisions with vessels during the Project and ongoing Port operations, with the potential impact resulting in injury or fatality. The mobility of snubfin dolphins and other dolphins leads to minimal risk of these species being injured or entrained by the slow moving and audible CSD. Dugongs, whales and turtles would also be able to hear the CSD and have plenty of time to respond. It is proposed to complete the Project in Quarter 4 October 2018, which is early in the flatback turtle breeding season, limiting the number of turtles in the region during dredging. Further, important foraging habitats for dugongs and turtles are not found within the Project footprint and, therefore, it less likely these species will be in the direct path of the CSD. Placement of material will occur adjacent to the dredging footprint, reducing transit requirements for work vessels and collision incidents as a result of the Project. Proposed mitigation measures for prevention of collision and entrainment are detailed in Section 6.

Noise generated by dredging activities has the potential to disturb marine fauna, causing temporary or even long-term avoidance of an area that may be important for feeding, reproduction or sheltering. Underwater noise may interfere with communication systems of fish and marine mammals, masking important biological cues or causing behavioural disturbance (Richardson et al. 1995, National Research Council 2005, Southall et al. 2007). Intense underwater noise in close proximity to marine fauna may cause temporary or permanent hearing damage or death (Southall et al. 2007). These impacts may affect critical behaviours and functions, such as feeding, migration, breeding and response to predators, all of which may ultimately affect an individual animal's survival (National Research Council 2005). In general, noise generated by (and the auditory bandwidth of) large marine mammals are low frequency to allow communication over long distances underwater (Table 5.4).

The proposed machinery used during the Project (CSD, spreader pontoon and transfer vessel/s) generates noise that can disturb wildlife located within hearing range. However, sounds generated by dredging at the source of the CSD (i.e. cutting, pumping, inboard engine etc.) are at the lower end of noise emission pressures in the aquatic environment (CEDA 2011; Figure 5.1) and outside of the auditable bandwidth of the marine mammals likely to occur in the region (Table 5.4). Further, the Project is within an active Port, where large vessels are commonplace and can be the source of similar, if not a higher, underwater noise compared to a CSD (CEDA 2011; Figure 5.1). Noting that noise generated by the CSD is dependent on a number of variables i.e. sediment characteristics, vessel size, water quality and depth. The CSD is largely immobile throughout dredging (anchored with a spud) and placement of material will occur adjacent to the dredge site, minimising sound generated by vessels transiting throughout the Port. Therefore, due to the small scale and short duration of the dredging campaign, it is unlikely that fauna will be significantly impacted by the noise generated by the Project.

Due to a projected increase of cruise vessels from 11 to ~35 per year the potential for vessel collisions and noise pollution affecting marine fauna may also increase. Wharf and jetty restrictions only allow for one cruise vessel to access the Port at any one time (assisted by two tug vessels). Therefore, the increased number of cruise, or other, vessels is not anticipated to affect marine fauna species.

Table 5.4 Auditory bandwidth of marine mammals likely to occur adjacent to the Port

Species	Estimated auditory bandwidth
Blue whale (*Balaenoptera musculus*) Humpback whale (*Megaptera novaeangliae*) Bryde's whale (*Balaenoptera edeni*)	7 Hz−22 kHz
Irrawaddy dolphin (*Orcaella brevirostris*) Killer whale (*Orcinus orca*) Spotted bottlenose dolphin (*Tursiops aduncus*) Indo-pacific humpback dolphin (*Sousa chinensis*) Snubfin dolphin (*Orcaella heinsohni*)	150 Hz−160 kHz

Source: Southall et al (2007)

Sound source	Source level at 1m	Bandwidth	Main energy	Duration	Directionality	Source
Explosives	272dB-287dB re 1µPa zero-to-peak	2Hz-~1kHz>	6Hz-21Hz	~1ms	Omni-directional	1)
Seismic air gun arrays	220dB-262dB re 1µPa peak- to-peak	5Hz-100kHz	10Hz-120Hz	10ms-100ms	Downwards	2)
Pile driving	220dB-257dB re 1µPa peak-to-peak	10Hz >-20kHz	100Hz-200Hz	5ms-100ms	Omni-directional	1), 2)
Echosounders	230dB-245dB re 1µPa (rms)	11.5kHz-100kHz	Various	0.01ms-2ms	Downwards	2)
Low-frequency military sonar	240dB re 1µPa peak	0.1kHz-0.5kHz	-	6s-100s	Horizontally focussed	3)
Sperm whale click	236dB re 1µPa rms	5kHz-40kHz	15kHz	100µs	Directional	4)
Mid-frequency military sonar	223dB-235dB re 1µPa peak	2.8kHz-8.2kHz		0.5s-2s	Horizontally focussed	1)
Sparkers, boomers, chirp sonars	204-230 dB re 1µPa (rms)	0.5-12kHz	Various	0.2ms	Downwards	2)
Harbour porpoise click	205dB re 1µPa peak-to-peak	110kHz-160kHz	130kHz-140kHz	100µs	Directional	5)
Shipping (large vessels)	180dB-190dB re 1µPa (rms)	6Hz >-30kHz	<200Hz	Continuous	Omni-directional	1)
TSHD	186dB-188dB re 1µPa rms	30Hz>-20kHz	100Hz-500Hz	Continuous	Omni-directional	6), 7)
Snapping shrimp	183dB-189dB re 1µPa peak-to-peak	<2kHz-200kHz	2kHz-5kHz	Milliseconds	Omni-directional	8)
CSD	172dB-185dB re 1µPa rms	30Hz>-20kHz	100Hz-500Hz	Continuous	Omni-directional	6), 7)
Construction and maintenance ships	150dB-180dB 1µPa rms	20Hz-20kHz	<1kHz	Continuous	Omni-directional	1)
Drilling	115dB-117dB re 1µPa (at 405m and 125m)	10Hz-~1kHz	<30Hz-60Hz	Continuous	Omni-directional	1)

Source: CEDA (2011)

Figure 5.1 Biological and manmade sound sources listed in decreasing order of source levels at 1 m

Artificial lighting

If artificial lighting is used during the Project works, it has the potential to disrupt the behaviour of light sensitive marine fauna, specifically marine turtle hatchlings (DoEE 2017b). Artificial lighting is not expected to be a key environmental impact during or following Project completion, given the: Project works will be temporary and localised in nature; there is no turtle nesting adjacent to the Port; and turtle nesting season (October-February) is largely outside of the popular tourism period (April-October).

Introduced marine species

Dredging plant and operational vessels may result in the introduction of non-indigenous marine species to the area (introduced marine species; IMS). IMS can have significant impacts on marine ecosystems and marine industries; however, only a small fraction of IMS are able to thrive and successfully colonise new habitats (Mack et al. 2000). IMS have the potential to displace native species, change community structure and food webs, and alter ecosystem processes such as nutrient cycling and sedimentation or damage marine industries through diminishing fisheries, fouling ship's hulls and clogging intake pipes (Molnar et al. 2008). The primary means by which non indigenous marine species may be introduced is via biofouling (the attachment of organisms) to vessel hulls and/or ballast water (water that a vessel takes on board to provide stability).

In Australia, around 250 introduced marine pests have been identified, of which over 75% are believed to have been introduced through biofouling rather than in ballast water (Bax et al. 2003). Indeed, biofouling may pose a higher potential risk of introducing marine species. Mitigation measures can be employed for both biofouling and ballast water to minimise the risk of introduced marine species. Before mobilising vessels contracted to the Project, KPA will verify that the vessels are in compliance with DPIRD biosecurity requirements. This process may involve contracted vessels completing the DPIRD risk assessment (likely including liaison with the DPIRD; see https://vesselcheck.fish.wa.gov.au/) for any vessel entering the Port from international or interstate waters.

All vessels entering the Port (from intrastate, interstate and international water) comply with vessel management procedures in-line with the Australian Government Department of Agriculture, Fisheries and Forestry marine pest management guidelines (CA 2009b) and adhere to the requirements of the *Biosecurity Act 2016*, with the following information to be provided to the relevant government authorities:

- Evidence that sediment and ballast water has, or will be, managed to prevent IMS entering and moving within WA. Alternatively, a maintained ballast water management plan and record book should be provided on request.
- Vessel's log entries showing operational history since last antifouling coating application or IMS inspection, or a maintained biofouling management plan and record book.
- The most recent in-water cleaning or dry dock/slip report and IMS inspection report.
- Evidence of either an active marine growth prevention system or a suitable manual treatment regime for internal seawater pipe-works.
- The most recent antifouling coating application certificate or original receipts or invoices stating the coating type, volume purchased, vessel name (if possible) and date of application.
- Type of vessel.

5.2.4 Social surroundings and human health

Indigenous and non-indigenous heritage areas

The Nyamba Buru Yawuru management team have been consulted as key stakeholders regarding the proposed Project, to ensure heritage sites, seascapes, the enjoyment of country and customary practices are identified and preserved.

KPA will continue consultation with the Western Australian Museum and undertake any requisite desktop assessment and magnetometer/sonar surveys to determine potential impacts the Project may have on known or unknown heritage artefacts.

Fisheries–commercial and recreational

Based on hydrodynamic and plume modelling (Sections 4.1.7; Appendix C) it is not anticipated that the plume generated by the Project will elevate turbidity at the offshore aquaculture leases beyond 1–2 mg/L above ambient. Modelling indicates that turbidity in the work areas will be elevated above background for a period of 2–3 weeks, though elevated turbidity adjacent to the aquaculture leases will occur much more sporadically and for shorter periods of time (Appendix C).

Noise generated by dredging is within the range of sound generated by large shipping vessels, which are commonplace in Port waters (Section 5.2.3) and is not expected to impact adjacent aquaculture (pearling) leases.

Given the Project will take place within Port waters for a short (2–4 weeks) period of time it is unlikely that recreational fishing will be significantly impacted.

Maritime safety

The potential maritime safety risks associated with increased vessel traffic during dredging and disposal works are negligible, particularly given the works will take place within Port managed water and any recreational vessels can easily avoid the area and/or the slow moving CSD. However, a temporary notice to mariners will be issued by the Harbour Master to inform the general public on the project activities.

6. Proposed Monitoring and Management

A preliminary register of measurable and/or auditable environmental commitments to manage the potential environmental impacts associated with the Project (Section 5.2) are provided in Table 6.1. Environmental monitoring and management will be outlined in further detail in a DEMP to be prepared prior to commencement of the Project. The DEMP will include:

- detailed monitoring and management requirements (in-line with Table 6.1)
- timing/frequency of monitoring and management commitments
- responsibilities for monitoring and management commitments
- contingency planning/measures in the event of an environmental or safety issue
- stakeholder consultation
- reporting requirements to government and environmental regulators.

An archaeological assessment of the Project region will also be completed prior to Project commencement.

Table 6.1 Relevant environmental factors, objectives[1], performance indicators and proposed measurement criteria

Environmental factor		Equivalent marine park cultural, ecological and social values[2]	Objective	Performance criteria[3]	Standards[4]	Performance indicators[5]
1	Benthic communities and habitat	• Seagrass and algae communities • Filter feeding communities	To protect benthic communities and habitat so that biological diversity and ecological integrity are maintained	Ensure that benthic communities and habitat outside of the Project footprint are not impacted as a result of the Project	**Construction** Dredging Environmental Management Plan (DEMP) detailing management of turbidity, including: • remain within approved dredge and disposal areas • monitoring and control of turbidity/production at the dredge itself • plume sketches • site photographs • remote imagery; and/or • aerial imagery **Operation** No specific ongoing management requirements, though KPA are actively involved in the Roebuck Bay Long-term seagrass monitoring	**Construction** • System in place to review plume sketches and photography to determine plume extent is within modelled expectations • Tracking device on the CSD to confirm dredge positioning • Post-dredge bathymetric survey • Third-party audit of DEMP outcomes **Operation** n/a
2	Marine environmental quality	• Geomorphology • Water and sediment quality	To maintain the quality of water, sediment and biota so that environmental values are protected	No impacts to marine environmental quality as a result of the Project	**Construction** DEMP detailing procedures for: • Waste management and disposal in-line with existing Port requirements (KPA 2016a) • Hydrocarbon spill management • Remain compliant with the International Maritime Organisation International Convention for the Prevention of Pollution from Ships (MARPOL Compliant) as a contractual requirement	**Construction** • System in place to ensure waste management and spill prevention procedures • Inspect plant daily • Adherence to refuelling procedures • Audit spill response and clean-up procedures • Third-party audit of DEMP outcomes

Environmental factor		Equivalent marine park cultural, ecological and social values[2]	Objective	Performance criteria[3]	Standards[4]	Performance indicators[5]

					Operation
					• Update the following plans and procedures, where relevant, to reflect any change in operation as a result of the Project:
					  • Port of Broome Marine Oil Pollution Contingency Plan
					  • Port of Broome Cyclone Contingency Plan
					  • Port of Broome Marine Safety Plan
					  • Port of Broome Emergency Response Plan
						Operation
						• Complete internal audit in-line with EMS requirements

3	Marine fauna	• Waterbirds including migratory *gamirda-gamirda* (shorebirds) • Invertebrates • Finfish • Marine mammals • *Gurlibil* (marine turtles)	To protect marine fauna so that biological diversity and ecological integrity are maintained	Ensure the risk of harm to susceptible marine fauna from all aspects of the Project (including noise, collision, entrainment, introduced marine species) is acceptably low	**Construction** DEMP detailing procedures for the management of works, including: • KPA will implement EPBC Regulations 2000 – Part 8 Division 8.1: Interacting with cetaceans, throughout the all phases of the Project • Presence of a dedicated Marine Fauna Observer during dredging and disposal activities • Pre-start (15 minute) visual survey to ensure no marine fauna are present at the time of dredge start-up • Definition and maintenance of marine fauna exclusion zone and/or stand down for vessels underway • Notification of introduced marine species and document any disturbance or impacts to marine mammals; including date, number of individuals, corrective actions undertaken	**Construction** • Systems in place to record presence and location of protected marine fauna • Reporting process for detection of dead or injured marine fauna • Third-party audit of DEMP outcomes • Retain vessel check paperwork for audit purposes

Environmental factor		Equivalent marine park cultural, ecological and social values[2]	Objective	Performance criteria[3]	Standards[4]	Performance indicators[5]
					• Subcontractors complete the vessel risk assessment for the dredge and support vessels in consultation with the Department of Primary Industries and Regional Development • Machinery in good working order to reduce any unnecessary noise • Where possible leave engines, thrusters or other noise generating equipment in standby or switched off if not in use • Turn suction pumps off when not in close proximity to the sea floor **Operation** • Notification of introduced marine species • Continue the State Wide Array Surveillance Program (SWASP) in-line with KPA (2016a) and DPIRD requirements • Update the EMP (KPA 2016a), where relevant	**Operation** • Complete internal audit in-line with EMS requirements
4	Social surroundings	• Enjoyment of country and customary practices • Responsibility for country • Maritime heritage • Seascapes • Nature based and cultural tourism	To protect social surroundings from significant harm	No impact to known heritage sites	**Construction** • Complete requisite archaeological assessment of the Project region prior to Project approvals • DEMP to outline procedures to be followed in the event a shipwreck, relic, indigenous or otherwise, is identified • Project carried out within the approved timeframe, accepting uncontrolled delays • Public education, including public notices and community liaison • Department of Transport temporary notice to mariners	**Construction** • Retain vessel check/temporary notice to mariners paperwork for audit purposes • Third-party audit of DEMP outcomes

Environmental factor		Equivalent marine park cultural, ecological and social values[2]	Objective	Performance criteria[3]	Standards[4]	Performance indicators[5]
		• Pearling and commercial fishing • Recreational and customary fishing • Resources and infrastructure			• Public comments and concerns will be received by KPA via email info@kimberleyports.wa.gov.au (available on their website: http://www.kimberleyports.wa.gov.au) **Operation** • Update the EMP (KPA 2016 a), where relevant	**Operation** • Complete internal audit in-line with EMS requirements

Notes:

1. EPA (2016b) Statement of Environmental Principles, Factors and Objectives, as relevant to the Project
2. Cultural and ecological values as per DPaW (2016), as relevant to the Project
3. Performance criteria = the performance criteria are the proposal-specific desired state for an environmental factor/s that an organisation sets out to achieve from the implementation of outcome-based provisions
4. Standards = can include company standards, regulatory requirements, and recognised Australian and International Standards
5. Performance indicators = measureable/auditable outcomes that ensure that the company's environmental performance
6. Construction = monitoring and management during the Project
7. Operation = monitoring and management implemented during standard Port operations, following the Project
8. DEMP = Dredging Environmental Management Plan; DPIRD = Department of Primary Industries and Regional Development, KPA = Kimberley Ports Authority, n/a = not applicable

7. Stakeholder Consultation

KPA strongly values stakeholder input to ensure stakeholder views are understood and any issues raised are addressed early in the environmental assessment process or through appropriate project management. An overview of the stakeholder consultation that took place at the time of preparing this DEIA is detailed in Table 7.1. Noting additional consultation with key stakeholders also took place during Project feasibility and scoping phases. Feedback from early consultation (pre-referral) and document references to address stakeholder comments is provided in Table 7.2.

Table 7.1 Overview of stakeholder meetings/presentations and forums

Target group	Type of consultation	Date
KPA Community Consultation Committee	Meeting	9 October 2017 11 December 2017
Department of Water and Environmental Regulation – Environmental Protection Authority Services	Meetings and updates	24 October 2017 17 November 2018 12 January 2018
Department of Planning, Lands and Heritage	Meeting and updates	24 October 2017
Department of Biodiversity, Conservation and Attractions and Nyambu Buru Yawuru	Meeting	31 October 2017
Environs Kimberley	Meeting	6 November 2017
Nyambu Buru Yawuru	Meetings	10 November 2017 28 November 2017 8 December 2017
Paspaley	Phone meetings	14 November 2017 31 January 2018
Broome Chamber of Commerce	Meeting	15 November 2017
Pearl Producers Association	Meetings	17 November 2017 31 January 2018
Roebuck Bay Working Group	Meeting	30 November 2017
Department of Environment and Energy	Meeting	10 January 2018
Stakeholders – public	Project update/overview handout	Released December 2017 Released January 2018 Appendix F
Public Consultation Forum	Project presentation at Broome Civic Centre	31 January 2018
Media releases	Newspaper advertisements/online media	October 2017 January 2018

Table 7.2 Overview of stakeholder consultation comments and response

Stakeholder type	Stakeholder	Comment[1]	Response and document reference
Australian Federal Government	Department of Environment and Energy	Ongoing consultation with the DoEE prior to referral and meeting on 10 January 2017. Suggested consideration of the following items as part of the DEIA: 1. Terrestrial impacts (noise, toilet facilities, parking) 2. Operational impacts related to increased vessel activity (i.e. waste management, hydrocarbon spills, marine fauna collisions and noise impacts) 3. Increased turbidity caused by vessels entering the Port on low tides 4. Affect of dredging on hydrodynamics in Roebuck Bay.	1. Terrestrial impacts are not specifically addressed within this DEIA as they are considered insignificant in the scope of the Project. Only one cruise ship of approximately ≤3500 passengers will be able to come to Port at any one time. The main difference is the number of days cruise vessels are in port throughout the year, not the number of passengers (Section 4.3.3). Parking facilities not required as passengers are transported by approved buses, a process already in operation given the Port is a Maritime Safety Zone and operational port. 2. Impacts on marine fauna (collision/noise) addressed in Section 5.2.3. 3. Increased turbidity from vessel propeller wash at low tide is likely to decrease with increased under keel clearance (Section 5.2.1). 4. Given the small scope of the project, it is not anticipated that the hydrodynamics in Roebuck Bay will be impacted by the removal of material from high spots adjacent to the Port.
	Department of Environment and Energy – Queensland South and Sea Dumping Section | Environment Standards Division	Ongoing consultation with the DoEE Sea Dumping Permit Section prior to application for sea dumping permit	See comments above from DoEE
State Government	Department of Water and Environmental Regulation – Environmental Protection Authority Services	Ongoing consultation with the EPA prior to referral of the Project	n/a

Stakeholder type	Stakeholder	Comment[1]	Response and document reference
	Department of Biodiversity, Conservation and Attractions	Ongoing consultation required, no specific comment to date	n/a
	Department of Planning, Lands and Heritage	DPLH have confirmed that there are no registered sites in the project area	n/a
Native title groups, industry, business, community and special interest groups	Nyamba Buru Yawuru Ltd	Specifically discussed heritage related concerns for the project. Confirmed there are no particular heritage issues to date, however, have requested information on the DEIA and plume model once these are complete. Other questions included: 1. will explosives be used? 2. will the works be undertaken during specific tides? 3. how will the dredge noise impact marine life? 4. will fish /marine life be impacted by the dredge? 5. how will the sediment be managed?	In response to queries: 1. no explosives will be used 2. dredging will not be restricted to a specific tide due to the short duration of works and minimal impact predicted, regardless of tidal state (Section 4.1.7) 3. noise generated by the small scale and short duration of the Project is unlikely to significantly impact marine fauna (Section 5.2.3) 4. impacts on marine fauna addressed in Section 5.2.3 5. spreader pontoon to control placement of dredged material (refer project description, Section 2.1)
	Shire of Broome	No feedback at the time of preparing this DEIA	n/a
	Roebuck Bay Working Group	Queries from the group included: 1. the potential impacts on seagrass, snubnose dolphins and dugongs 2. the currents in the Bay and how the dredge plume will spread 3. the type of dredge that will be used 4. impact on seagrass as a result of changes to the channel. The group requested ongoing updates throughout the project due to the community interest in the project.	1. Impacts on benthic primary producer habitat addressed in Section 5.2.1 and impacts on marine fauna addressed in Section 5.2.3 2. Dredge plume characteristics detailed in Section 4.1.7 3. Project description including dredge plant description in Section 2.1, to be further defined following detailed geotechnical survey completion 4. Given the small scope of the project, it is not anticipated that the hydrodynamics in Roebuck Bay will be impacted by the removal of material from high spots adjacent to the Port.
	KPA Community Consultation Committee	Ongoing updates to be provided to the committee. The committee generally see the value of the Project for the cruise industry and Broome Concerns about potential impacts on seagrass and snubnose dolphins were raised.	Impacts on benthic primary producer habitat addressed in Section 5.2.1 and impacts on marine fauna addressed in Section 5.2.3 DoEE has advised that the Project area is not within the boundaries of the West Kimberley National Heritage Plan (Section 4.3.1)

Stakeholder type	Stakeholder	Comment[1]	Response and document reference
		Queried whether the Project/Port area is within the West Kimberley National Heritage Plan No 106063 – Dampier Coast cretaceous Landscape (trace fossils including dinosaur tracks)	
	Environs Kimberley	Raised concern over potential impacts (including noise, sediment and equipment) from the project on seagrass and marine life including dugongs, turtles and snubnose dolphins Discussed the timings for the dredging work Queried whether there would be ongoing/annual maintenance dredging requirements as a result of the Project. Indicated they will recommend a higher level of assessment for this Project and will provide comment on referral.	No significant impacts to seagrass (Section 5.2.1) and significant marine fauna (5.2.3) anticipated as a result of the project. Maintenance requirements addressed in Section 2.2 but unlikely to be frequent or wide-spread.
	Paspaley Pearl Producers Association	Paspaley and Pearl Producers Association were consulted separately but raised very similar queries: 1. Will there be any blasting or other significant noise impacts? 2. Provide detail on plume modelling and model accuracy 3. Provide detail on the composition of material to be dredged. 4. Potential for contamination and acid sulfate soils as a result of dredging. 5. Can the material be pumped further below the surface of the water and would this result in a smaller turbid plume footprint? 6. General comment regarding a new aquaculture/pearling lease that was gazetted mid-2017 and is adjacent to the Port. 7. Paspaley and the Pearl Producers Association indicated that late-September and October were a critical time for oyster harvesting/seeding activities. This timing aligns with Q4, in which the COP is proposed to take place.	1. The Channel Optimisation Project (COP) will not require any blasting or pile driving activities (Section 2.1). Given the sound generated by a CSD is within the lower sound pressure levels, and within the range of sound generated by other large shipping vessels in the Port, it is unlikely that the operation of the CSD for the short 2−4 week period will impact oysters, or the outcomes of the research (Section 5.2.3 and 5.2.4). 2. Some of the ways the modelling approach identifies and accounts for the variability in the input data and site conditions by: • Accounting for variability in the spill/production rates. • Use of a tidal window scenario approach; looking at spring (high tidal current and flushing) and neap (lower tidal current and flushing) conditions. • Running both 2D and 3D plume modelling. The 3D plume model sediment settling and dispersion behaviour at different layers in the water column and further refines the area of impact. Refer to Appendix C for the full plume model report. 3. Sediments within the capital dredging footprint were generally characterised by medium (250–500 µm) to fine (125–250 µm) grained sands, with large portions of gravel (>2000 µm) (Appendix B).

Stakeholder type	Stakeholder	Comment[1]	Response and document reference
			4. It is considered highly unlikely that the proposed Project will result in disturbance of acid sulfate soils resulting in oxidation of sulfidic materials and the acidification, deoxygenation and contamination of the marine water, for the following reasons: • The total organic carbon concentrations were low (<0.15%) and there was no sulphuric odour or black gel-type material in the sediments sampled within the channel optimisation footprint (Appendix B; Table 3.1). These physical properties are not indicative of sediments greatly enriched in monosulfides, acid sulfate and/or potential acid sulfate soils. • The material will have very limited (if any) exposure to atmospheric oxygen, limiting oxidation of potential sulfides, as a result of the proposed dredging and disposal methods (Section 2.1). • The proposed dredging and disposal areas are exposed to a high rate of frequent flushing, largely as a result of tidal ocean water exchange (i.e. not located in enclosed inland waters) so widespread deoxygenation is unlikely. • The seawater adjacent to the Port has pH that ranges between 8.2 and 8.4 (Eco Logical 2017), indicating sufficient pH buffering capacity. • Concentrations of metals in material to be dredged are below relevant National Assessment Guidelines for Dredging (CA 2009a; Appendix B) so there is a low risk of mobilisation of metals and potential impacts to marine environmental quality. 5. Regulatory approval is required prior to procurement of the CSD and associated equipment. As such, KPA is unable to confirm the specification of the equipment to be used. However, modelling indicates that turbidity near aquaculture leases will be 1–2 mg/L above ambient conditions for less than ~10 hours over a 7 day period of turbidity generating activities, based conservatively on a neap tide, high production rate of dredging (Appendix C). 6. Most recent lease boundary information provided by DPIRD on 6 February 2018 and included in Figure 1.1. The inclusion of additional lease areas north of the Port did not change the results of this DEIA– outside of the area of influence for the Project and Project related activities.

Stakeholder type	Stakeholder	Comment[1]	Response and document reference
			7. KPA note timing of oyster harvesting/seeding activities and will continue consultation with Paspaley and the Pearl Producers Association. However, the DEIA indicates low risk to adjacent aquaculture leases as a result of Project activities. KPA also noted that provision of any baseline/ambient physical water quality data (specifically, total suspended solid concentrations) collected within/adjacent to the lease areas would assist with the risk assessment.
	Broome wider community	Queries raised during the public consultation forum included: 1. Is there a requirement for ongoing maintenance dredging? 2. What does 2 mg/L total suspended solid concentration look like? Will the community be able to see a 2 mg/L increase above ambient conditions? 3. Will there be monitoring of the dredging as it happens to ensure that the plume matches what the modelling has indicated?	1. The Port has not required maintenance dredging to date so it is not anticipated that the Project would require any ongoing maintenance dredging. Regardless, the Port will continue to undertake annual bathymetric surveys to monitor the water depth as part of standard Port operations (Section 2.2). 2. In general, total suspended solids concentrations below 20 mg/L appear clear, while levels over 40 mg/L may begin to appear cloudy. Ambient total suspended solid concentrations adjacent to the Port are naturally variable (Section 4.1.4) so the community may not notice the short periods that turbidity is elevated as a result of channel optimisation works. 3. Standard turbidity monitoring and management will be implemented for the duration of the Project (Section 6).
	Western Australian Museum	Indicated there were 158 shipwreck sites in the Roebuck Bay/Broome region, though information on the location of these relics is limited. The WA Museum provided approximate locations for the shipwrecks, which were mapped and provided in Section 4.3.2. WA Museum recommended a thorough desktop assessment and magnetometer survey of the channel deepening area.	KPA will continue consultation with the Western Australian Museum and undertake any requisite desktop assessment and magnetometer/sonar surveys to determine any potential impacts the Project may have on known or unknown heritage artefacts.
	Port Logistics Consultative Committee Working Group	No feedback at the time of preparing this DEIA	n/a

Notes:

1. DEIA = Dredging Environmental Impact Assessment, KPA = Kimberley Port Authority, DoEE = Department of Environment and Energy, n/a = not applicable.

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Appendix A

Protected Matters Reporting Tool and NatureMap Outputs

Appendix B

Port of Broome Capital Dredging – Sediment Sampling Analysis Plan Implementation Report

Appendix C

BMT Dredge Plume Modelling Report

Appendix D

Towed Video Map and Photos

Appendix E

Environmental Risk Assessment

Appendix F

Project Updates

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