Draft Dredging and Spoil Disposal Management Plan

New Marine Facilities to Service Mandorah and Cox Peninsula

ZMD01890

Prepared for
Department of Infrastructure, Planning and Logistics

17 February 2023

Cardno®

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1 Introduction

1.1 Project Description

The Northern Territory Government (NTG) has identified the need to develop a safe, Disability Discrimination Act 1992 (Cwth: DDA) compliant and more weather-resistant ferry berthing facility at Mandorah, to improve transport connectivity between Cox Peninsula and Darwin. The project is located adjacent the existing Mandorah Jetty, which currently services the transfer of ferry passengers, but does not comply with access requirements for persons with a disability. Key components of the proposed facilities are:

A safe harbour formed by rock armoured breakwaters – large northern breakwater and smaller southern breakwater;

Capital dredging of an access channel, turning basin and berthing areas for the ferry and recreational vessels;

A new single lane boat ramp within the harbour, connecting to the existing carpark at the site;

> A new floating pontoon, gangway, jetty (TBC) and rock armoured pedestrian causeway inside the harbour, to allow passengers to access the ferry from land. These facilities will provide a DDA compliant access solution for people who need mobility assistance and may include a mechanical lift (to be confirmed in the D&C stage);

A ferry terminal building established by repurposing an existing building at the site (Lot 50) and new carpark with a short road connecting it to the existing carpark, as well as pedestrian paths and minor onshore amenities; and

Minor modification to the existing carpark to incorporate access and manoeuvring for the new boat ramp, as well as allow additional trailer parking.

1.1.1 Project Location

Mandorah is located near the eastern tip of the Cox Peninsula in the Northern Territory, approximately six kilometres west of Darwin (Figure 1-1). Access to Mandorah from Darwin is via the regular ferry service, or by driving approximately 120 km along the road network.

1.1.2 Proposed Dredging and Disposal Actions

The proposed dredging program will comprise the following actions:

- Dredging by cutter suction dredger (CSD) and offshore disposal by piping (dispersed in water column) of up to approximately 15,000-30,000 m^3 of unconsolidated marine sediments; and
- Dredging of approximately 70,000 m^3 of rock material by backhoe dredger (BHD) and / or land based equipment such as a long reach excavator. Dredged rock material will be used in the project construction (core material for breakwaters, causeway, boat ramp and general fill). Any excess dredged rock material will be utilised on other Darwin projects as fill.

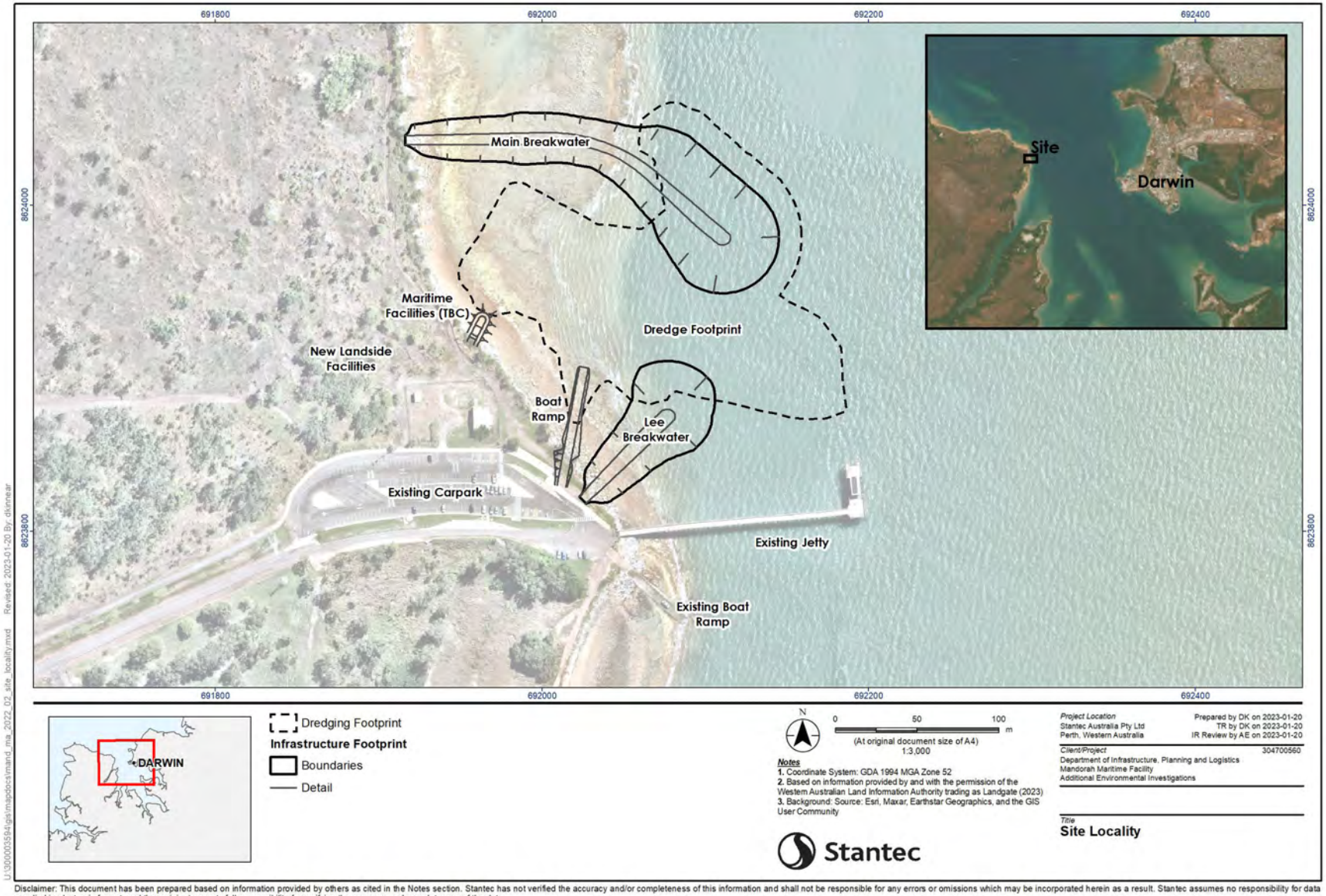

Figure 1-1. Locality Plan

1.2 Legislative Context

This *Draft Dredging and Spoil Disposal Management Plan (DSDMP)* has been prepared to demonstrate the management controls throughout the dredging and spoil disposal activities. The NT *Environment Protection Act 2019* (EP Act) aims to protect the environment through sustainable development and manage significant disturbances through an environmental approval process. Under the act, the NT EPA regulates the environmental impact assessment process to identify potential environmental impacts of development proposals. This *Draft DSDMP* outlines the monitoring and management procedures that will be implemented during the dredging phase, to protect the NT EPA's Environmental Factors and achieve the corresponding Environmental Objectives. Territory and Commonwealth legislation relevant to the project and this Draft DSDMP is summarised in Table 1-1 and Table 1-2 respectively.

Table 1-1. Relevant Territory Legislation

Document	Purpose / Objectives	Agency
Environment Protection Act 2019 (EP Act) and *Regulations 2020* (EP Regulations)	Protect the environment of the Territory; Promote ecologically sustainable development so that the wellbeing of the people of the Territory is maintained or improved without adverse impact on the environment of the Territory; Recognise the role of environmental impact assessment and environmental approval in promoting the protection and management of the environment of the Territory; Provide for broad community involvement during the process of environmental impact assessment and environmental approval; Recognise the role that Aboriginal people have as stewards of their country as conferred under their traditions and recognised in law, and the importance of participation by Aboriginal people and communities in environmental decision-making processes.	Department of Environment, Parks and Water Security
Northern Territory Environment Protection Authority Act 2012 (NT EPA Act)	Promote ecologically sustainable development; Protect the environment, having regard to the need to enable ecologically sustainable development; Promote effective waste management and waste minimisation strategies; and Enhance community and business confidence in the environmental protection regime of the Territory.	Department of Environment, Parks and Water Security
Waste Management and Pollution Control Act 1998 and *Regulations 1998*	Protect, and where practicable to restore and enhance the quality of, the Territory environment by: - Preventing pollution; - Reducing the likelihood of pollution occurring; - Effectively responding to pollution; - Avoiding and reducing the generation of waste; - Increasing the re-use and re-cycling of waste; and - Effectively managing waste disposal; Encourage ecologically sustainable development; and To facilitate the implementation of national environment protection measures made under the National Environment Protection Council (Northern Territory) Act 1994 (described below).	Department of Environment, Parks and Water Security

Document	Purpose / Objectives	Agency
Marine Pollution Act 1999 and *Regulations 2003*	The overall purpose of this Act is to protect the Territory's marine and coastal environment by minimising intentional and negligent discharges of ship-sourced pollutants into coastal waters. This purpose is to be achieved primarily by giving effect to relevant provisions of the following annexes of MARPOL: Annex I (which deals with pollution by oil); Annex II (which deals with pollution by noxious liquid substances in bulk); Annex III (which deals with pollution by harmful substances in packaged form); Annex V (which deals with pollution by garbage). The purpose is also to be achieved by: Providing an approach to protecting the Territory's marine and coastal environment from ship-sourced pollutants complementary to the approach of the Commonwealth and the States of the Commonwealth; Making provision about the discharge of sewage from ships; Enabling shipping casualties that are polluting, or threatening to pollute, coastal waters, to be dealt with; and Imposing severe penalties on persons who pollute the Territory's marine and coastal environment in contravention of this Act.	Department of Environment, Parks and Water Security
National Environment Protection Council (Northern Territory) Act 1994	The object of this Act is to ensure that, by means of the establishment and operation of the National Environment Protection Council: People enjoy the benefit of equivalent protection from air, water or soil pollution and from noise, wherever they live in Australia; and Decisions of the business community are not distorted, and markets are not fragmented, by variations between participating jurisdictions in relation to the adoption or implementation of major environment protection measures.	Department of Environment, Parks and Water Security
Territory Parks and Wildlife Conservation Act 1976 (TPWC Act) and *Regulations 2001*	Provides for the protection, conservation and sustainable utilisation of wildlife; and Provides protection of listed threatened species for which proponents must consider direct and indirect impacts on a listed threatened species or place covered under this Act.	Department of Environment, Parks and Water Security
Water Act 1992 (Water Act) and *Regulations 1992*	Provides for the investigation, allocation, use, control, protection, management and administration of water resources, including extraction of groundwater, waste water management and water pollution; and Provides for water allocation plans, drilling licences, bore construction permits, water extraction licences, waste discharge licences, fees and charges, and penalties for offences against the Act.	Department of Environment, Parks and Water Security
Ports Management Act 2015	To provide for the control, management and operation of ports, and for related purposes.	Department of Infrastructure, Planning and Logistics

Document	Purpose / Objectives	Agency
Ports Management Regulations 2015	Details regulations under the *Ports Management Regulations 2015.*	Department of Infrastructure, Planning and Logistics
Heritage Act 2011 and *Heritage Regulations 2012*	The object of this Act is to provide for the conservation of the Territory's cultural and natural heritage. The object is achieved by: Declaring places and objects of heritage significance to be heritage places and objects; Declaring classes of places and objects of heritage significance to be protected classes of heritage places and objects; Establishing the Heritage Council; Providing for heritage agreements to encourage the conservation, use and management of heritage places and objects; Regulating work on heritage places and objects; and Establishing enforcement and offence provisions.	Department of Territory Families, Housing and Communities
Northern Territory Aboriginal Sacred Sites Act 1989 and *Sacred Sites Regulations 2004*	Facilitates the protection and registration of sacred sites, through: Providing entry onto sacred sites and the conditions to which such entry is subject; Procedures for avoidance of sacred sites when developing and using land; Establishing an Authority for the purposes of the Act; and Procedures for the review of decisions of the Authority by the Minister.	Aboriginal Areas Protection Authority

Table 1-2. Relevant Commonwealth Legislation

Document	Purpose / Objectives	Agency
Environment Protection and Biodiversity Conservation Act 1999	Provides for the protection of the environment and conservation of biodiversity, particularly species and places of national significance. Invoked only if a development is likely to have environmental impacts of national significance	Australian Government Department of Agriculture, Water and the Environment
Environment Protection (Sea Dumping) Act 1981	Regulates the loading and dumping of waste at sea and the placement of artificial reefs within Australian Waters. Australian Waters stretch from the low water mark of the Australian shoreline out to 200 nautical miles, but does not include waters within the limits of a state or territory. The Act, therefore, does not need to be adhered to when disposing of dredge spoil within Darwin Harbour limits. However, the same assessment process and methods should generally be applied.	Australian Government Department of Agriculture, Water and the Environment
National Environment Protection Measures (Implementation) Act 1998 and *Regulations 1999*	The objects of this Act are: To make provision for the implementation of national environment protection measures in respect of certain activities carried on by or on behalf of the Commonwealth and Commonwealth authorities; and	Australian Government Department of Agriculture, Water and the Environment

	To protect, restore and enhance the quality of the environment in Australia, having regard to the need to maintain ecologically sustainable development; and To ensure that the community has access to relevant and meaningful information about pollution.	
National Environment Protection (Assessment of Site Contamination) Measure 1999	The purpose of the Measure is to establish a nationally consistent approach to the assessment of site contamination to ensure sound environmental management practices by the community which includes regulators, site assessors, environmental auditors, land owners, developers and industry. The desired environmental outcome for this Measure is to provide adequate protection of human health and the environment, where site contamination has occurred, through the development of an efficient and effective national approach to the assessment of site contamination.	Australian Government Department of Agriculture, Water and the Environment

1.2.1 EP Act – Environmental Referral

As the dredging and disposal actions have the potential to lead to significant environmental impact, they require risk assessment and referral to the NT EPA as per the *EP Act*. This risk assessment and referral has been undertaken for the project as a whole. The assessment of environmental risk relating to dredging and disposal actions is summarised herein (Section 4) and detailed in the project's *Environmental Referral Report* (Cardno, 2022a). Dredging cannot take place without EPA approval.

1.2.2 *EPBC Act* and *TPWC Act*

Actions that have the potential to impact matters of national environmental significance (MNES) require assessment under the *EPBC Act*. The proposed actions have been self-assessed as part of risk assessment for the project under the *Territory Parks and Wildlife (TPWC) Act*, which provides similar safeguards for matters of environmental significance at the Territory level. With appropriate management and mitigation, the actions are not expected to have a significant impact on matters described by these Acts.

1.2.3 *Sea Dumping Act*

As spoil is proposed to be disposed of to Darwin Harbour the *Sea Dumping Act* does not apply to the disposal activities. Nevertheless, the required investigations (e.g. NAGD) and assessment prescribed by the *Sea Dumping Act* to obtain a sea dumping permit will be adhered to for the proposed disposal actions.

1.2.4 *Water Act* – Waste Discharge Licence

A Waste Discharge Licence is required for the proposed actions pursuant to Section 74 of the *Water Act*. This has yet to be obtained and dredging and disposal cannot commence until this is in place.

1.3 Purpose of this Document

The purpose of this *Draft DSDMP* is to outline the activities required to minimise the environmental impact of dredging and spoil disposal activities associated with the project. It provides management frameworks, methods, locations and triggers for monitoring, as well as assigning responsibility for the activities. This operational document accompanies the referral of the project under the *EP Act*, to demonstrate tangible mitigation measures to reduce environmental impact and risk. It also supports application for a Waste Discharge Licence under the Water Act. The *Draft DSDMP* will be incorporated into the final Dredging and Disposal Management Plan (DDMP), the latter of which is the responsibility of the dredging contractor.

1.4 Reference Documents

Various studies have been carried out as part of the overall development and design project to date. The following documents are referenced in, or should be given due consideration when reading, this report:

Environmental Referral Report (Cardno, 2022a): This document provides the necessary details to refer the project to the NT EPA. This *Draft DSDMP* is an appendix to the referral document, detailing management measures to minimise environmental risk associated with dredging and disposal;

Sediment Transport Report (Cardno, 2022b): Details siltation, sedimentation and plume dispersion investigations associated with the project. The results of sedimentation and plume dispersion investigations are used to characterise potential risk and impact associated with dredging and disposal;

Marine Environment Report (Cardno, 2022c): Details the marine environment ecology relevant to the project site. This establishes the sensitive environmental receptors to which impact must be minimised for dredging and disposal activities;

SAP Implementation Report (Cardno, 2022d): Details marine sediment quality investigations undertaken to understand any contamination within the dredging and disturbance area and guide proper handling and disposal of dredge material;

Draft Construction Environmental Management Plan (CEMP) (Cardno, 2022e): Defines likely construction activities and controls required to avoid or minimise environmental impact. The plan details management for actions not covered by the *Draft DSDMP*, including marine actions such as piling and rock placement;

Design Report (Cardno, 2022f): Details the design requirements, basis, inputs, calculations and outcomes for the new proposed infrastructure. Includes details of the dredge design;

Geotechnical Report (Cardno, 2022g): Details the geotechnical information and investigations for the project site that inform design of the new proposed infrastructure. Important to understand the geology of the dredge area;

Metocean Report (Cardno, 2022h): Details the metocean information and investigations for the project site that inform design of the new proposed infrastructure and underpin processes such as dredge plume dispersion; and

Mandorah Marine Facilities – Supplementary Environmental Report (Stantec 2023): Provides the results of further studies and analysis as requested by the NT EPA.

2 Dredging Program

2.1 Scope and Volumes

The project will involve the dredging and disposal of between 85,000 to 100,000 m^3 of unconsolidated sand and rock. Dredging will be conducted in two stages, as follows:

Stage 1: Between 15,000 – 30,000 m^3 of unconsolidated marine sediments.

Stage 2: Approximately 70,000 m^3 of rock material.

The dredge layout design is depicted in Figure 2-1 and dredging design drawings with set out points are provided in Appendix A, for reference. The dredging and disposal localities are presented in Figure 2-2. The dredging layout showing the depth below seabed is depicted in Figure 2-3.

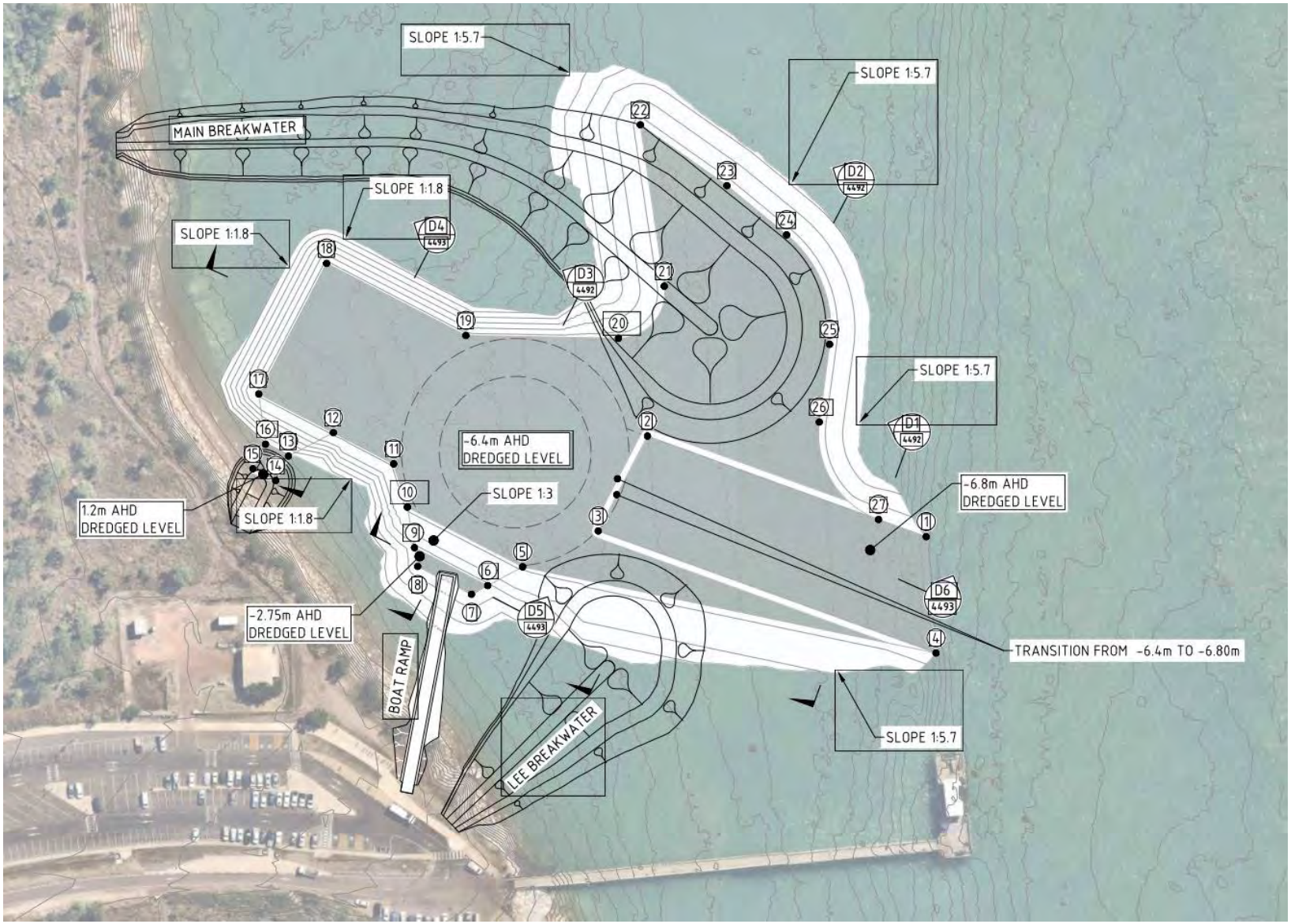

Figure 2-1. Dredge design layout

130°46'0"E

12°26'0"S

12°26'30"S

692284, 8625178

692334, 8625178

692284, 8625100

692334, 8625100

NORTH

691867, 8624045

691969, 8624042

691867, 8623966

691970, 8623932

RWA1

RWA2

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Onshore Handling Area (Rock)
- Offshore Disposal Area (Sediments)
- Breakwater
- Dredge Area
- Restricted Work Area 1 (AAPA)
- Restricted Work Area 2 (AAPA)
- Exclusion Zone (Aboriginal Sacred Site)

Cardno

Darwin, Northern Territory

Date
19/01/2022

Size
A3

Scale
1:4,500

0 100 200Meters

DREDGING AND DISPOSAL AREAS

MANDORAH MARINE FACILITIES

DRAFT DSDMP

FIGURE 2-2

130°45'55"E
130°46'0"E
130°46'5"E
12°26'30"S
12°26'35"S

NORTH

Stage 2
(May also extend
beneath Stage 1)

Stage 1

Legend

Breakwaters

Dredge Stages

Stage 1 (approx 15,000m3)

Stage 2 (approx 70,000m3)

Depth Below Seabed (m)

-7.5 - -7
-7 - -6.5
-6.5 - -6
-6 - -5.5
-5.5 - -5
-5 - -4.5
-4.5 - -4
-4 - -3.5
-3.5 - -3
-4 - -2.5
-2.5 - -2
-2 - -1.5
-1.5 - -1
-1 - -0.5
-0.5 - 0

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Cardno

Darwin, Northern Territory

Date
13/01/2022

Size
A3

Scale
1:1,106

0 0.015 0.03km

DREDGING LAYOUT

MANDORAH MARINE FACILITIES

DRAFT DSDMP

FIGURE 2-3

2.2 Sequence

The proposed sequence and estimated timeframes of dredging and related activities are outlined below. A precise dredging schedule will be developed by the dredging contractor and incorporated in the final DSDMP.

Preliminaries and setup

- Submission of final Dredging and Spoil Disposal Management Plan (DSDMP), supporting HSE and management documentation - 2 months prior to mobilisation;
- Initial hydrographic survey - at least 1 month prior to dredging commencement;
- Confirm templates for daily/weekly logs, incident reporting, environmental monitoring - 1 month prior to dredging commencement; and
- Setup of environmental monitoring equipment and activities (baseline data collection) – 1 month prior to dredging commencement.

Mobilisation of dredgers and equipment to Darwin Harbour

- CSD - already expected to be available within Darwin Harbour - 1 month prior to commencement;
- CSD disposal pipeline and booster pump/barges if necessary - 1 month prior to commencement;
- BHD and transport barges (as required) - 1 month prior to commencement; and
- Initial hydrographic survey – within 1 month prior to commencement.

Stage 1

- Dredging of unconsolidated sediments using CSD – estimated to take approximately 4 weeks, based on daytime operations, assuming operational production rate of 200 m3/hr and accounting for downtime; and
- Transfer and disposal of material to offshore disposal area via a hydraulic pipeline.

Stage 2

- Dredging of rock material using BHD land-based excavation, or a combination of both to required dredge design – estimated to take approximately 2-3 months, based on daytime operations, assuming operational production rate of 120 m3/hr and accounting for downtime. Note that this may need to be revised based on the handling process/time from extraction to placement within the breakwater cores;
- Note that Stage 2 can commence concurrently with Stage1 within the Stage 2 area only (see Figure 2-3). Removal of rock within the Stage 1 area (i.e. beneath sediment) cannot commence until all unconsolidated sediments have been removed; and
- Transfer of dredged rock onshore for reuse in breakwater cores for this project or for use in other Darwin projects.

Demobilisation

- Final hydrographic survey to confirm completion of works – within 2 weeks of completion;
- Demobilisation of dredging vessels and transfer systems – once final completion of the works is confirmed; and
- Cease environmental monitoring and remove monitoring equipment – 2 weeks after confirmation of completion.

2.3 Hydrographic Survey

Prior to the commencement of dredging, a hydrographic survey will be undertaken to accurately estimate the total volume to be dredged. Upon completion of dredging works, a second hydrographic survey will be undertaken to ensure the dredge footprint and finished levels have been achieved. Additional surveys may be

required as per the construction contract documents. The hydrographic surveys may also be used to calculate final dredge volumes.

2.4 Methods

2.4.1 Equipment

2.4.1.1 Cutter suction dredger

Unconsolidated sediment will be dredged using a Cutter Suction Dredger (CSD). CSDs may be self-propelled or stationary and use a rotating cutter head to loosen the seabed before drawing the sand/water mixture to the surface. A network of pipes will pump the slurry to the offshore disposal location. Due to the dredging area's relatively close proximity to the disposal site, booster pumps are unlikely to be needed.

2.4.1.2 Backhoe dredger

Dredging of rock will be undertaken with a backhoe dredger (BHD). The majority of the rock will be reused as core material in construction of the breakwaters, causeway and boat ramp. BHDs are mechanical dredgers that use a hydraulic arm and bucket system to excavate material from the sea floor. The dredger is fixed in place during dredging works using a number of spuds driven into the seabed, preventing movement due to wind, waves and currents. BHDs are capable of achieving precise finished level but are limited in achievable dredge depth and have relatively slower production rates when compared to hydraulic, cutter suction-based dredgers.

2.4.1.3 Long-reach excavator

There is potential for a portion of the dredging area to be dredged by a land-based long reach excavator situated at ground level on a barge/pontoon and/or upon filled rock bunds with some tidal restrictions. Such equipment is likely to be operating as part of the overall project and this would be at the discretion of the contractor. The actions and effects of a long-reach excavator are comparable to a BHD.

2.4.2 Schedule Constraints

- The works are to adhere to the following time constraints:
- Dredging activities are limited to daylight hours between 7am and 7pm;
- Dredging activities shall pause during slack tide of 60 minutes (to avoid excessive sediment plume concentrations); and
- BHD and CSD may operate simultaneously, noting that certain areas require removal of marine sediments prior to dredging of rock by BHD.

2.5 Dredge Material Management

Dredged sediment will be disposed to an offshore location shown in Figure 2-2. The offshore disposal site is located approximately 1.2 km north-east of the dredge site with an average depth of -13.5 mAHD. Current speeds at the site are relatively high, reaching approximately 1.5 m/s in a spring tide ebb flow and 0.5 m/s in a spring tide flood flow. Dredged caprock is to be transferred onshore directly from the backhoe dredger or via barge, dependant on dredging location. Dredged rock will be assessed on the barge or onshore to determine its suitability for reuse in breakwater cores. If suitable, rock can then be transferred to a stockpile or directly to the breakwater cores. Once material has been deposited on land, its handling managed under the Draft Construction Environmental Management Plan (CEMP) (Cardno, 2022e).

3 Environmental Setting

3.1 Climate

Darwin has a tropical climate with distinct wet and dry seasons and a similar average maximum temperature throughout the year. The driest period of the year, with an average of approximately 5 mm of monthly rainfall on average, is between May and September. The extreme temperature range at Darwin airport station is between 10.4 °C and 38.9 °C. Mean annual maximum and minimum temperature at the Darwin Airport station are 32.1 °C and 23.2 °C, respectively. The average temperature of the sea ranges from 25.8 °C in July to 31.5 °C in December.

The wet season is associated with tropical cyclones and monsoon rains. The majority of rainfall occurs between December and March (the southern hemisphere summer), when thunderstorms are common and afternoon relative humidity averages over 70 percent during the wettest months. The dry season runs from about May to September, during which nearly every day is sunny, and afternoon relative humidity averages around 30%.

3.2 Wind Conditions

The average wind speed at Darwin Airport is relatively constant throughout the year, ranging from 6.7 m/s in April to 7.7 m/s in January and February. The average annua l wind speed is 7.2 m/s. The maximum wind speeds during the wet season (1st of November to 30th of April) are generally higher than those during the dry season (1 of May to 31 of October). This is to be expected due to the cyclonic activity and tropical lows that occur during the wet season. The wind direction also varies throughout the year, displaying a seasonal variation. The winds are predominantly from the west to north (270-360 °N) from the start of September to the end of February (spring and summer) and predominantly from the east to the south east (90-135 °N) from the start of March to the end of August (Autumn and Winter). The months of March, August and September show the transition from the easterly winds to the westerly winds. This variation in winds is consistent with the formation of the Indo – Australian monsoon. See Figure 3-1 for seasonal wind roses.

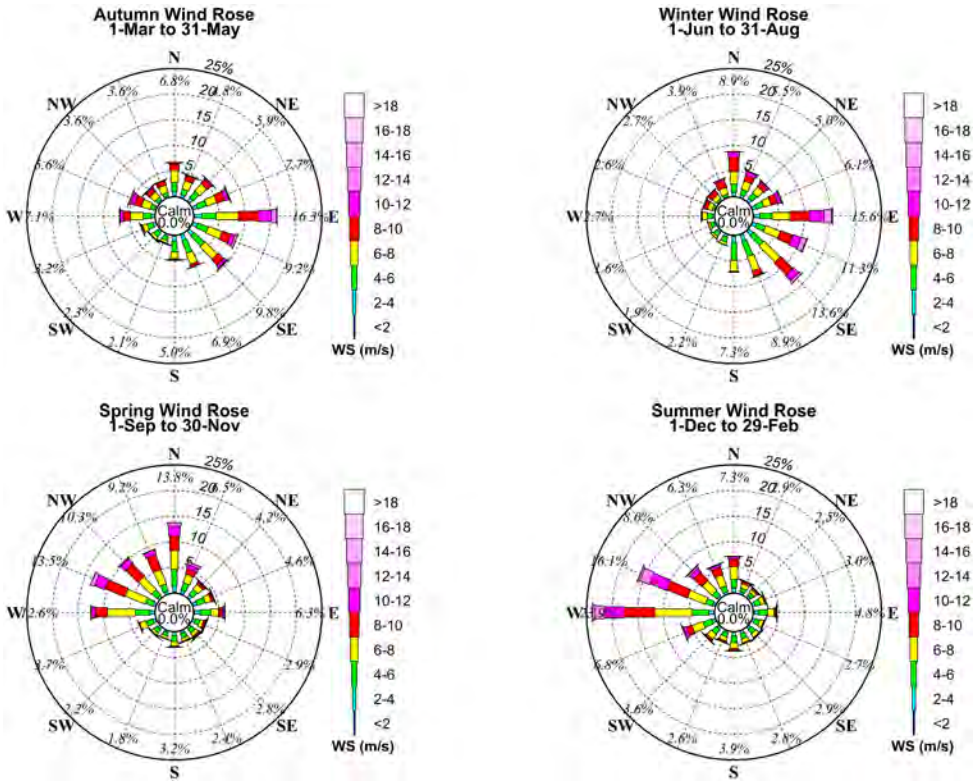

Figure 3-1. Seasonal wind roses based on Darwin airport wind data (1985 to 2019)

3.3 Metocean Climate

3.3.1 Water Levels

Tides in Darwin Harbour are semi-diurnal, with two high tides and two low tides per day. Tidal planes for Darwin Harbour (National Tides Centre, pers. Comm 2020) are presented in Table 3-1, relative to Australian Height Datum (AHD) and Chart Datum (CD).

Table 3-1. Tide planes for Darwin Harbour (National Tides Centre, 2020)

Tidal Plane	Level (m, CD)	Level (m AHD)
Highest Astronomical Tide (HAT)	8.17	4.07
Mean High Water Springs (MHWS)	7.05	2.94
Mean High Water Neaps (MHWN)	5.13	1.02
Mean Sea Level (MSL)	4.24	0.13
Australian Height Datum (AHD)	4.10	0.00
Mean Low Water Neaps (MLWN)	3.34	-0.76
Mean Low Water Springs (MLWS)	1.42	-2.68
Lowest Astronomical Tide (LAT)	-0.01	-4.11

3.3.2 Waves

Wave conditions at Mandorah are driven by two forces:

- Longer period oceanic swell waves from the Beagle Gulf that penetrate into the Darwin Harbour (Mandorah project area); and
- Shorter period local wind waves generated locally by winds blowing across Darwin Harbour.

An annual wave rose for Mandorah is provided in Figure 3-2.

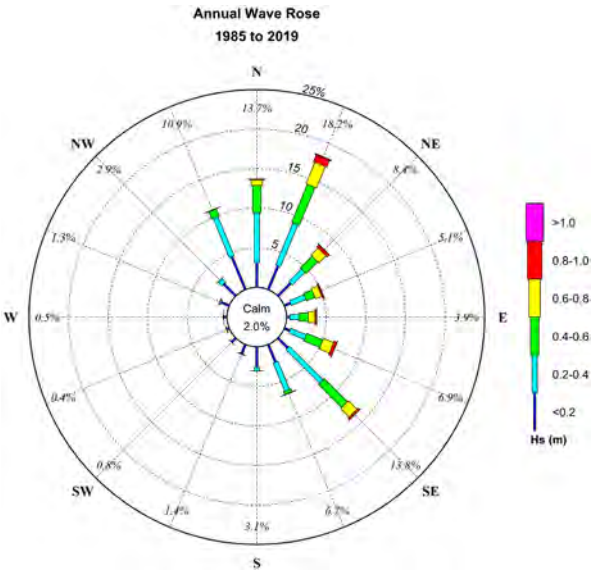

Figure 3-2. Annual total wave rose at Mandorah site (1985 to 2019)

The following wave conditions are present at the site:

- Swell waves typically approach the site from the north to north east, however wind sea waves approach the site from different directions, ranging from north-north-west to south-east.
- The seasonal distribution of swell waves is almost the same throughout year, but the wind sea waves typically approach the site from the north-north-east to south east during autumn and winter, and from the north-north-west to north-north-east during spring and summer.

3.3.3 Cyclones

Being close to equator, much of the Northern Territory coastline is in a region where cyclones tend to form. This can be advantageous, as a cyclone forming near the coast will often cross the coast before it has a chance to substantially intensify, however, this also reduces available warning time. Tropical cyclones in the region mostly form from lows pressure systems within the monsoon trough, between November and April. There are on average 7.7 days per season when a cyclone exists in the Northern Territory Region. The north-western Gulf of Carpentaria near Gove has the highest concentration of cyclone days. The Gulf of Carpentaria averages two cyclones a year, while the Arafura and Timor Seas average one a year. Cyclones in the Gulf of Carpentaria move very erratically, whereas those in the Arafura and Timor Seas tend to follow more regular tracks to the southwest. Over half the cyclones generated in the Northern Region move either southwest or southeast into adjoining regions.

3.3.4 Currents

The major causes of currents in the Darwin harbour are the tides. Typically, in the vicinity of the site, currents are directed towards the north during an ebb tide and towards the south during a flood tide. Generally, ebb currents are stronger than flood currents. Ebb tidal currents are predicted to reach up to 1.5 m/s during a spring tide and flood currents approach 0.5 m/s. Vector plots of peak flows for flood and ebb, during the spring tides, are provided in Figure 3-3.

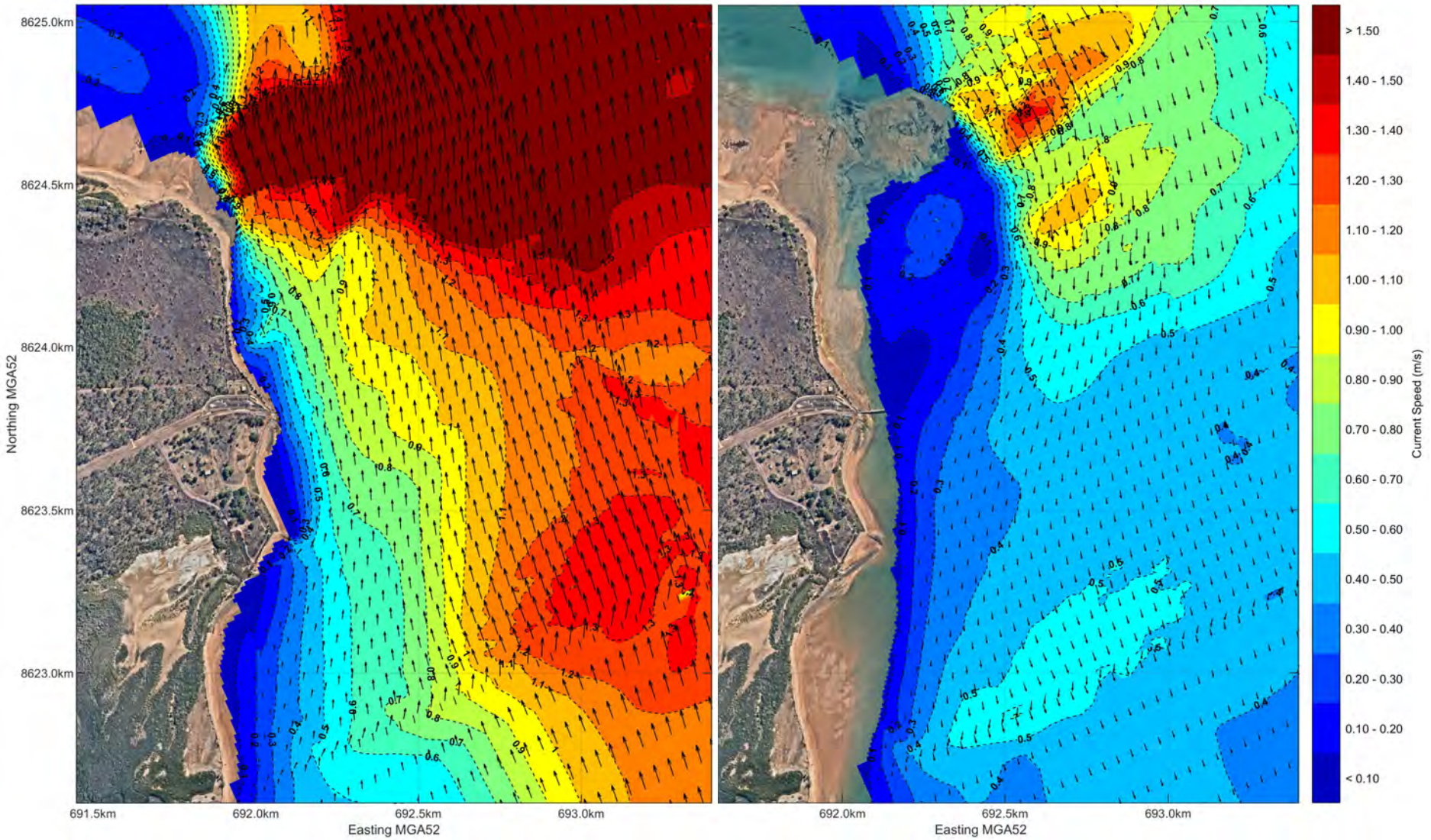

Figure 3-3. Spring tide ebb (left) and flood (right) flow vector plot

3.4 Water Quality

Baseline water quality is well understood following over 2 years of monitoring during the INPEX Nearshore Environmental Monitoring Program (Inpex Browse, 2011a). Changes to suspended sediment concentrations at the site are associated with tidal flow, wave action and seasonal rainfall runoff from Woods Inlet. Ongoing water quality monitoring of Darwin Harbour is undertaken by the Department of Environment, Parks and Water Security's (DEPaWS) Aquatic Health Unit. The water quality monitoring has been ongoing since 2009 and includes the following categories/parameters:

- Algae – Chlorophyll-a;
- Dissolved Oxygen;
- Water Clarity – Turbidity (NTU); and
- Nutrients – Filterable Reactive Phosphorus, Ammonia as N and NOx.
- Supplementary parameters include:
- Salinity;
- Temperature; and
- pH.

Mandorah lies within 'Zone 5 – Middle Harbour' for the monitoring program, which was reported as 'very good' for all parameters except nutrients ('good') for the annual 2020 report card (DEPaWS, 2022). Historically, water quality has been reported as 'very good' overall for the zone, sporadically dropping to 'good'.

3.5 Sediment Quality

Baseline sediment quality sampling was undertaken as per NAGD (2009) guidance. A total of nineteen (19) sediment quality cores were advanced to a maximum depth of 0.8 m below the seabed, with a full range of contaminants of potential concern (CoPC) analysed by NATA accredited laboratories. The results of the baseline assessment are summarised below:

- All concentrations of metals and metalloids were below the assessment criteria for offshore and onshore disposal of sediments;
- Two locations returned concentrations of Tributyltin (TBT) above the limit of reporting (LOR) – one of these was outside of the proposed dredge footprint. Further sampling and analysis around this site demonstrated that it was an isolated event, rather than representative of a contamination hotspot;
- The 95% UCL for Tributyltin corrected for 1% TOC (9.5 µg/kg), for samples collected within the proposed dredge footprint, marginally exceeded the NAGD low screening level of 9 µg/kg;
- No other samples recorded concentrations of organotin compounds above the LOR;
- Additional investigations at 12 samples sites surrounding the site with elevated TBT found all to be below the LOR. This suggested the previous detection was an isolated occurrence, not representative of a contamination hotspot. The recalculated 95% UCL for TBT, incorporating the additional sampling, was well below the NAGD low screening level;
- No organic compounds were detected, with all BTEX, TRH, PAH and organochlorine pesticide concentrations were below their respective LORs in all samples; and
- Two samples were found to have Net Acidity values above the recommended management action criteria (Simpson et al., 2018) for the dredging of sands to loamy clays; > 1000 tonnes.
- The sampling and analysis concluded that the unconsolidated layer of soft sediments, overlaying natural geological material, is considered to be 'clean' and, therefore, suitable for open ocean disposal. The underlying geological material is considered 'clean natural material', suitable for the intended reuse as core material for the breakwaters.

3.6 Bathymetry

In 2017, a hydrographical survey was undertaken by Astute Surveying covering the footprint of the proposed facility. The nearshore area of the site is relatively flat and shallow (approximately LAT or -4 m AHD) to a distance approximately 150m offshore. After this flat, intertidal area the seabed drops off steeply into deeper water.

The proposed marine facilities are within the shallow intertidal region of Darwin Harbour. Whilst Darwin Harbour is greater than 20 m deep in the main channel, the footprint of the main breakwater extends to approximately -4 m AHD with the dredge footprint (access channel) extending to approximately -7 m AHD. Bathymetry is presented in Figure 3-4.

3.7 Geology

Geological observations of the site are as follows:

- A thin Porcelanite 'shelf' (generally 1 to 1.5 metres thick, but up to 3 metres thick) is present at the surface of the site's nearshore area, extending offshore to where the seabed bathymetry is between -3.2 m AHD and -3.4 m AHD;
- Underlying this caprock is weathered rock that is suitable for reuse as core fill. A portion of the underlying geology may comprise softer materials;
- There is a small portion of the site that may contain high strength rock to depth; and
- Directly offshore (east) of the edge of the Porcelanite shelf is a deep layer of soft muds / marine deposits, extending from the seabed surface to depths between -6 m AHD and -9 m AHD.
- There is limited marine bed sediment in the area, the deepest refusal depth for push coring was 0.8 metres and for most sample locations the refusal depth was less than 0.5 metres;
- Field observations did not identify any visual signs of contamination;
- Field observations noted unconsolidated sediment largely as marine sand; and
- Field pH testing reported material between 8.7 and 9.1 (alkaline).
- A summary of the laboratory results of sediment chemical testing is presented in the following sub-sections. A preliminary geological site model is included in Figure 3-5.

130°45'55"E
130°46'0"E
130°46'5"E
12°26'25"S
12°26'30"S
12°26'35"S
12°26'40"S

NORTH

Legend

- Boat Ramp
- Breakwater Footprint
- Dredge Footprint
- Carpark Layout
- Maritime Infrastructure

Elevation (mAHD)

- -12 - -11
- -11 - -10
- -10 - -9
- -9 - -8
- -8 - -7
- -7 - -6
- -6 - -5
- -5 - -4
- -4 - -3
- -3 - -2
- -2 - -1
- -1 - 0
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10

Cardno

Date
22/12/2021

Size
A3

Scale
1:1,500

0 12.5 25 50 m

SITE TOPOGRAPHY AND BATHYMETRY

MANDORAH MARINE FACILITIES

DRAFT DSDMP

FIGURE 3-4

130°45'55"E
130°46'0"E
130°46'5"E
12°26'25"S
12°26'30"S
12°26'35"S

NORTH

Porcelanite caprock to approximately 1.5m below seabed. Weathered rock anticipated below this

Approximate extent of porcelanite shelf

Area potentially contains high strength rock to depth

Soft alluvial mud between -5m and -9m

Main Breakwater

Boat Ramp

Lee Breakwater

Area potentially contains softer materials below porcelanite

Legend
- Dredging Footprint
- New Infrastructure
- Bathymetry mAHD

Cardno

Darwin, Northern Territory

Date
1/12/2021

Size
A3

Scale
1:1,500

0 50Meters

PRELIMINARY GEOLOGICAL SITE MODEL

MANDORAH MARINE FACILITIES

DRAFT DSDMP

FIGURE 3-5

3.8 Marine Ecosystems

3.8.1 Benthic Communities and Habitats

Mapping of benthic communities and habitats (BCH) was undertaken utilising historical (Geoscience Australia, AIMS and DEPaWS, 2021)) and contemporary data sets, including the results of a multibeam, side scan sonar and towed video survey undertaken in November 2022. Bathymetric data from the multibeam survey was combined with backscatter data from the side scan survey to determine the slope of the reef and differentiate between hard and soft features (i.e. coral versus sand) (Figure 3-6, Figure 3-7). The resulting outputs were ground truthed using imagery from the towed video survey to produce representations of areas containing >10% coral coverage and BCH generally (Figure 3-8, Figure 3-9). Figure 3-6, Figure 3-7 and Figure 3-8 were derived from the contemporary data set, while Figure 3-9 was derived using historical and contemporary data sets.

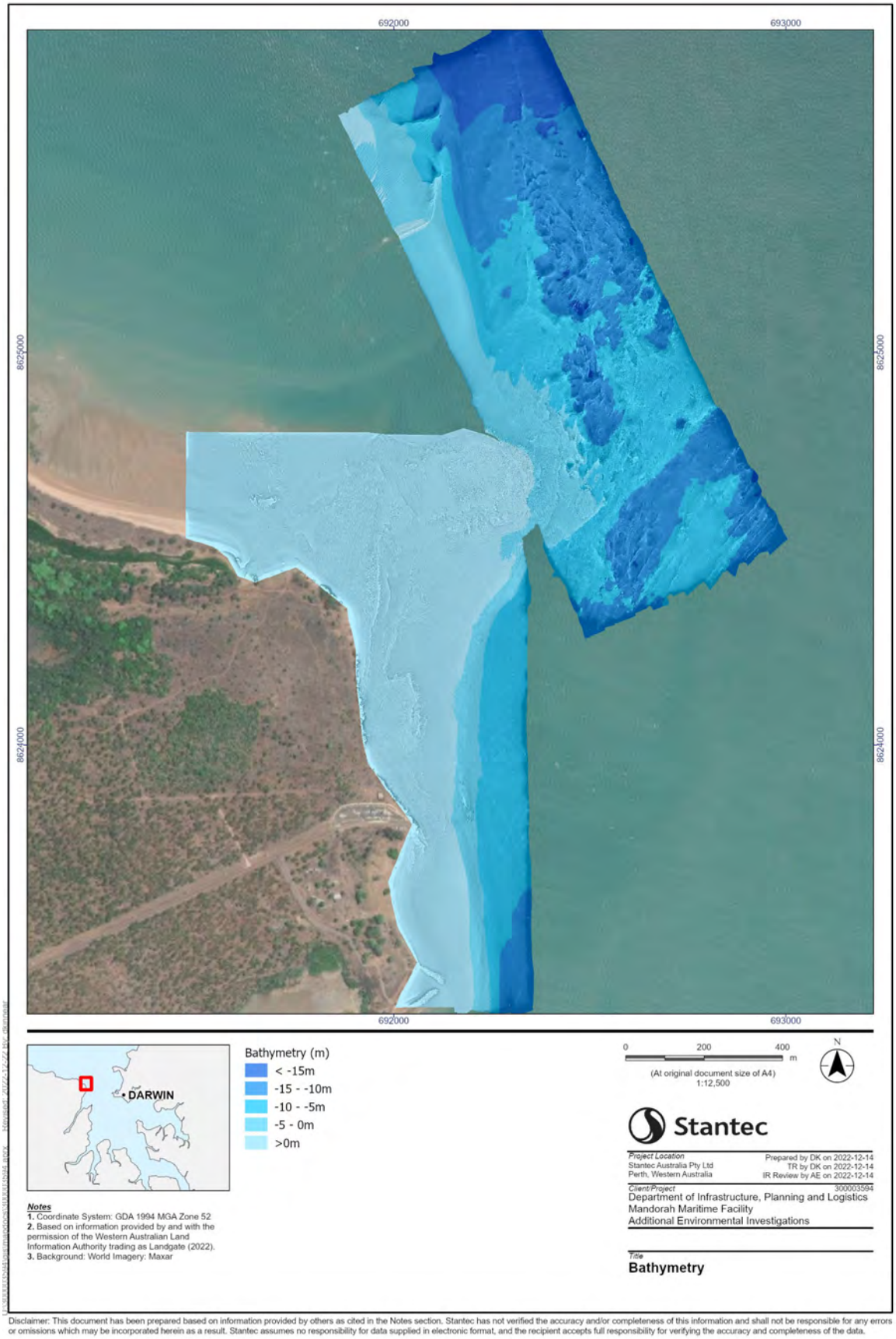

Figure 3-6. Bathymetry of the project area determined using multibeam backscatter data

Figure 3-7. Slope of the project area, focussing on reef features

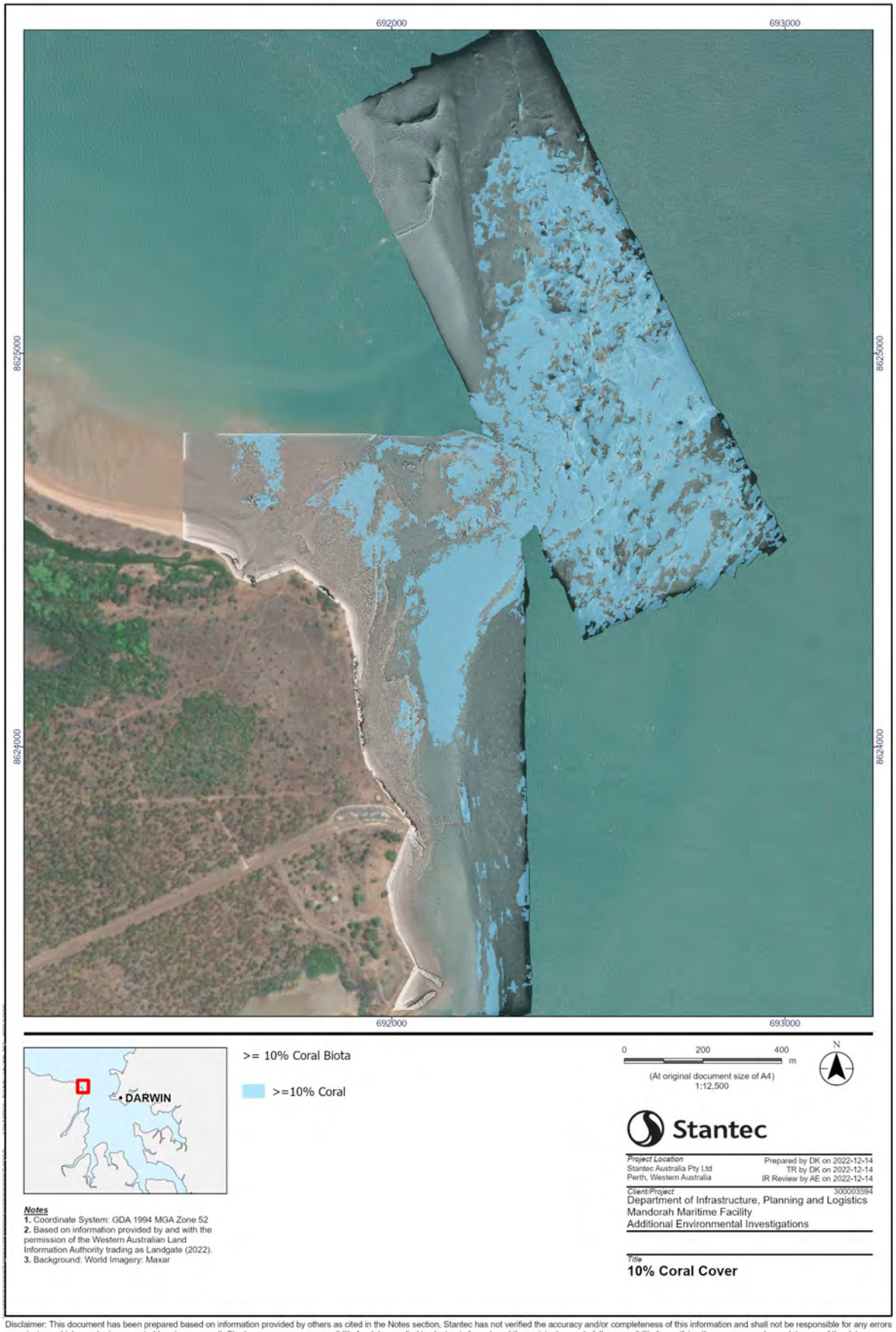

Figure 3-8. Areas containing greater than 10% coral coverage

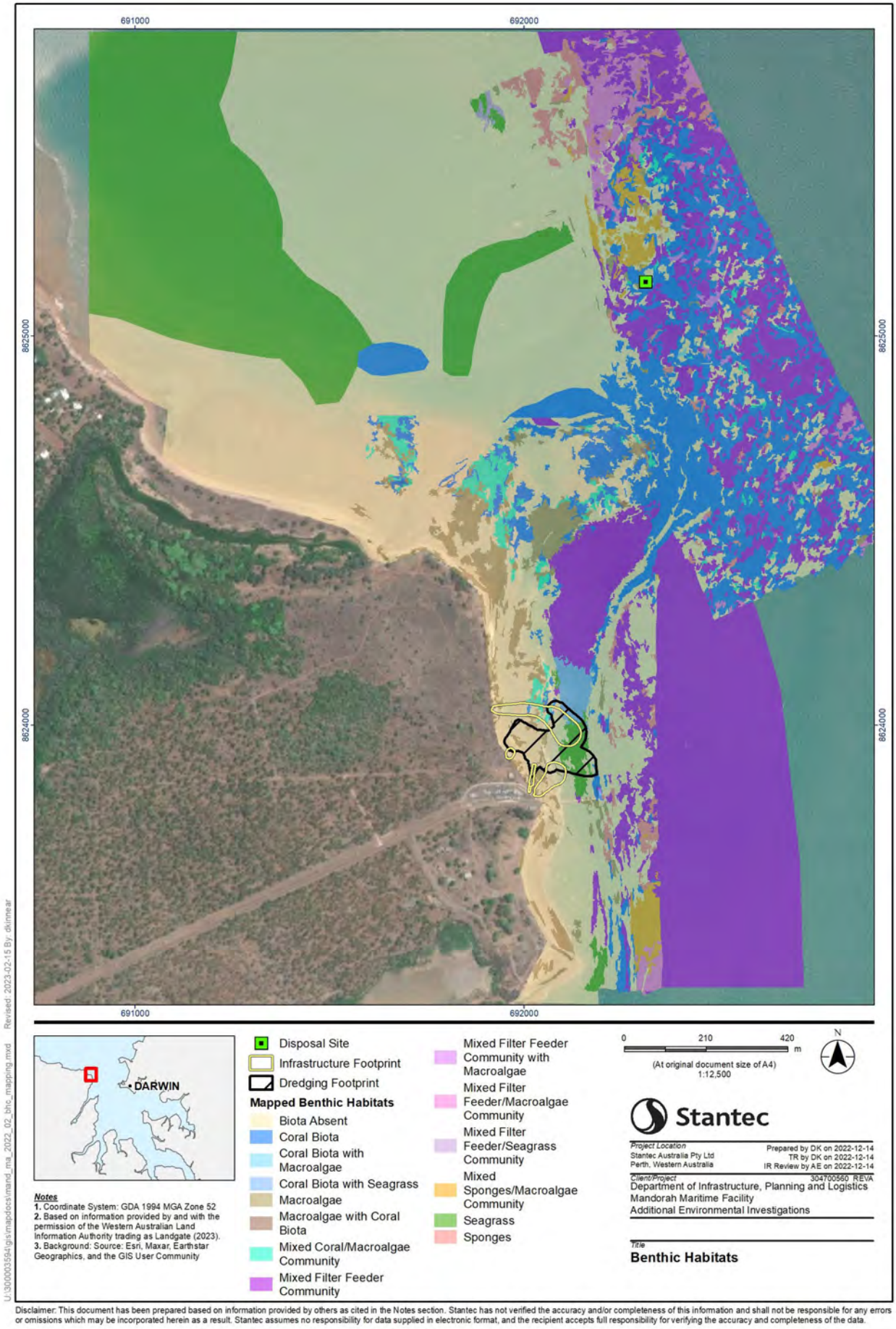

Figure 3-9. Predicted extent and type of BCH in the project area

The project area features a range of physical habitats from sand and low to high relief reef features. Seagrass and macroalgal communities are prominent on the low relief reef and sandy habitats in the western regions of the project area (Figure 3-9). Extending to the deeper waters east of the project footprint, the complexity of habitats increases on a bathymetric and biological scale. Benthic habitats northeast of the project area and immediately adjacent to the disposal site consist of a network of filter feeder habitats, comprising coral and mixed filter feeder communities. Low density seagrass is present within the project footprint, with additional communities to the south and north of the project area (Figure 3-9).

3.8.2 Marine Fauna

The project has the potential to house a significant number of marine fauna, some of which are listed as MNES under the EPBC Act. The species that required further environmental risk assessment ('species of concern') for the project were those that are both listed as Threatened or Migratory and have moderate to high likelihood of occurring in the project area, are detailed in Table 3-2.

Table 3-2. Marine species of concern for the project

Scientific name	Common name	EPBC Act	TPWC Act
Birds			
Actitis hypoleucos (M)	Common Sandpiper	-	-
Arenaria interpres (M)	Ruddy Turnstone	-	-
Calidris acuminata (M)	Sharp-tailed Sandpiper	-	-
Calidris alba (M)	Sanderling	-	-
Calidris canutus (T, M)	Red Knot	E	V
Calidris ferruginea (T, M)	Curlew Sandpiper	C	V
Calidris melanotos (M)	Pectoral Sandpiper	-	-
Calidris tenuirostris (T, M)	Great Knot	C	V
Charadrius leschenaultia (T, M)	Greater Sand Plover, Larger Sand Plover	V	V
Charadrius mongolus (T, M)	Lesser Sand Plover, Mongolian Plover	E	V
Charadrius veredus (M)	Oriental Plover, Oriental Dotterel	-	-
Fregata ariel (M)	Lesser Frigatebird, Least Frigatebird	-	-
Hirundo rustica (M)	Barn Swallow	-	-
Limosa lapponica baueri (M)	Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed	V	V
Limosa limosa (M)	Black-tailed Godwit	-	-
Numenius madagascariensis (T, M)	Eastern Curlew, Far Eastern Curlew	C	V
Numenius phaeopus (M)	Whimbrel	-	-
Pandion haliaetus (M)	Osprey	-	-
Pluvialis squatarola (M)	Grey Plover	-	-
Sternula albifrons (M)	Little Tern	-	-
Tringa nebularia (M)	Common Greenshank, Greenshank	-	-
Fish, Sharks & Rays			

Scientific name	Common name	EPBC Act	TPWC Act
Pristis zijsron (T, M)	Green Sawfish, Dindagubba, Narrowsnout Sawfish	V	V
Mammals and Cetaceans			
Dugong dugon (M)	Dugong	-	-
Orcaella heinsohni / brevirostris (M)	Australian Snubfin Dolphin, Irrawaddy Dolphin	-	-
Sousa chinensis (M)	Indo-Pacific Humpback Dolphin	-	-
Tursiops aduncus (M, C)	Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin	-	-
Reptiles			
Chelonia mydas (T, M)	Green Turtle	V	-
Crocodylus porosus (M)	Salt-water Crocodile, Estuarine Crocodile	-	LC
Eretmochelys imbricata (T, M)	Hawksbill Turtle	V	V
Lepidochelys olivacea (T, M)	Olive Ridley Turtle, Pacific Ridley Turtle	E	V
Natator depressus (T, M)	Flatback Turtle	V	DD

Key:

C = Critically endangered, DD = Data deficient, E = Endangered, LC = Least concern, N = Near Threatened, V = Vulnerable, *EPBC Act:* M = Migratory, T = Threatened

3.8.3 Invasive Marine Pests

Invasive marine pests are plants or animals that are not native to a region that may have a significant impact on marine industries and environment. Marine pests are typically introduced is via large vessels, either attached to the submerged surfaces of ships ('biofouling') or in the ballast water of ships. Marine pests considered a significant threat to NT waters include:

- Asian bag mussel (*Arcuatula senhousia*);
- Asian green mussel (*Perna veridis*); and
- Black-striped mussel (*Mytilopsis sallei*).

3.9 Social Environment and Communities

There are two communities in proximity to the project site, Wagait and Belyuen, with small commercial operations including the Wagait Beach Supermarket and Cox Country Club. The resident population of Cox Peninsula is estimated at around 600 people. Commercial opportunities are currently limited due to poor potable water supply infrastructure and the area's isolation. Previously, the Mandorah Beach Hotel operated to the south of the site, approximately 350 m from the jetty, from the 1970s until it's closure in 2013.

3.9.1 Ferry Operations

The Mandorah Ferry, operated by Sealink, services the area with at least a dozen ferry services per day, with more frequent servicing in the morning and afternoon for patrons to get to and from work and school. The service is essential for many Cox Peninsula residents to complete everyday activities in Darwin.

3.10 Cultural Heritage

DIPL has received an Authority Certificate from the Aboriginal Areas Protection Authority (AAPA) for works associated with the Project. The Authority Certificate identifies two Restricted Works Areas (RWA's) that protect known Aboriginal Sacred Sites. Both sites and RWAs are located on land south of the existing jetty.

The defined RWAs have the following conditions:

- RWA1 – No works shall take place or damage can occur within this area; and
- RWA2 - No ground disturbing works is permitted beyond the depth of 600mm.

Recorded and registered sacred sites also exist to the north of the project area, associated with water flows from the tidal creek approximately 500 metres to the north of the project site. One of these is located in the nearshore zone and should be avoided (including buffer zone) as part of the project. These zones are depicted in Figure 2-2.

The proposed project area does not intersect any sites listed under the NT Heritage Register. Nearby heritage sites include World War II Gun Emplacements at Wagait Beach and the Delissaville (Belyuen) Cemetery. Although not listed, the existing Jetty itself is considered by many local residents to have heritage value. The project does not plan to impact the jetty.

4 Environmental Risk Assessment

The full environmental risk assessment is provided in Appendix B and summarised in Table 4-1. The nature of the risks and the investigations undertaken to inform the risk assessment, are summarised in the sub-sections below.

Table 4-1. Risk assessment summary table relevant to dredging and disposal actions

Environmental Aspect	Risk Pathway(s)	Potential Impacts	Risk Rating	Risk Management / Mitigation	Residual Risk Rating
Environmental Factor: Marine Environmental Quality					
Disturbance of marine sediments (fines)	Dredging actions, spoil transfer and disposal, rock placement and piling	> Elevated suspended sediment concentration in marine water > Sedimentation in marine environment > Potential impact to benthic communities and other biota	**High**	> Model dredging and disposal actions to properly understand dredge plume dispersion > Gain an understanding of sensitive marine environmental receptors and their tolerance > Control actions to maintain water quality below appropriate triggers (i.e. altering dredging activities [e.g. volumes, locations] to limit sediment resuspension, dredging only on certain tides etc.)	**Low**
Release of contaminants from marine sediments	As per actions above - predominantly dredging and disposal	> Toxic contaminants made available to marine ecosystem for biological uptake and bioaccumulation > Potential impact to ecosystem health	**Medium**	> Characterise material to be disturbed to understand locations and levels of contamination > Assess levels of contamination against appropriate thresholds, given the nature of the receiving environment > Isolate, remove and confine areas where contamination is potentially toxic to the marine environment	**Low**
Introduction of contaminants/pollution to marine environment	Construction activities - inappropriate waste disposal, accidental oil/chemical spill	> Toxic contaminants introduced to marine ecosystem for biological uptake and bioaccumulation > Potential impact to ecosystem health	**Medium**	> Inspection / audit / washdown of vessels and plant, outlined in DSDMP and CEMP > Reporting and response protocols should a spill occur - oil/chemical spill response etc.	**Low**
Environmental Factor: Marine Ecosystems					
Dredger/vessel movement	> Vessel strike of marine fauna such as dugongs, turtle, dolphins > Underwater noise impacts due to dredging and piling	> Vessel strike of marine fauna > Injury to marine fauna > Damage to ecosystems > Removal of marine fauna habitat	**Medium**	> Vessel movement controls, speed limits, no-go zones > Marine Fauna Observer (MFO) on board dredger at all times during dredging > Piling controls (soft start) to allow fauna to leave area	**Low**

Environmental Aspect	Risk Pathway(s)	Potential Impacts	Risk Rating	Risk Management / Mitigation	Residual Risk Rating
	> Direct impact to seabed - marine ecosystems			> Monthly environmental monitoring reports	
Dredging	Direct removal of benthic communities and habitat	Permanent removal/destruction of BCH such as seagrass and coral	**Very High**	> Characterise BCH in direct impact footprint > Minimise footprint and avoid sensitive receptors/important BCH where possible > Contractor to implement monitoring program of BCH within the surrounding area to detect changes in sensitive, important habitats	**High**
	Elevated suspended sediment concentration (turbidity) in vicinity of project	> Impact to sensitive BCH such as coral and seagrass (blocking of light) > Impact to marine fauna due to ingestion/dermal contact	**High**	> Characterise BCH in vicinity of project > Characterise dredge plume dispersion to understand changes to water quality with respect to tolerance of BCH/fauna > Implement dredging controls and reactive monitoring to maintain levels below thresholds	**Low**
	Sedimentation of seabed in vicinity of project	Impact to sensitive BCH such as coral and seagrass (smothering)	**High**	> Characterise BCH in vicinity of project > Characterise dredge plume dispersion to understand sedimentation levels with respect to tolerance of BCH/fauna > Implement dredging controls and reactive monitoring to maintain levels below thresholds (i.e. altering dredging activities [e.g. volumes, locations] to limit sediment resuspension, dredging only on certain tides etc.).	**Low**
Dredge spoil disposal	Elevated suspended sediment concentration (turbidity) at disposal site	> Impact to sensitive BCH such as coral and seagrass (blocking of light) > Impact to marine fauna due to ingestion/dermal contact	**High**	> Select disposal area for optimum dispersion and minimum sensitive receptors > Characterise disposal dispersion to understand changes to water quality with respect to tolerance of BCH/fauna > Implement dredging disposal controls and reactive monitoring to maintain levels below thresholds (i.e. altering dredging activities [e.g. volumes, locations] to limit sediment	**Low**

Environmental Aspect	Risk Pathway(s)	Potential Impacts	Risk Rating	Risk Management / Mitigation	Residual Risk Rating
				resuspension, dredging only on certain tides etc.).	
	Sedimentation of seabed at disposal site	Impact to sensitive BCH such as coral and seagrass (smothering)	**High**	> Select disposal area for optimum dispersion and minimum sensitive receptors > Characterise disposal dispersion to understand sedimentation levels with respect to tolerance of BCH/fauna > Implement dredging controls and reactive monitoring to maintain levels below thresholds (i.e. altering dredging activities [e.g. volumes, locations] to limit sediment resuspension, dredging only on certain tides etc.).	**Low**
Environmental Factor: Culture & Heritage					
Cultural heritage sites / artefacts	Dredging, disposal and associated actions	Disturbance of known or unknown cultural heritage areas during dredging	**Medium**	> Gain understanding of cultural heritage of the site through magnetometer survey and investigative diving to identify and retrieve any potential heritage artefacts. > Response and reporting procedures should a site or object be encountered	**Low**
Environmental Factor: Human Health					
Dredging and disposal of contaminated sediments	> Disturbance/release during extraction, transport and placement stages > Release to the marine environment following placement, then bioaccumulation and biomagnification in the food chain	> Dermal contact > Inhalation > Ingestion	**Medium**	See management measures relating to marine environmental quality. These apply to risk to humans also, with risk to human health considered a lower risk.	**Low**

Environmental Aspect	Risk Pathway(s)	Potential Impacts	Risk Rating	Risk Management / Mitigation	Residual Risk Rating
Dredging and disposal of fine sediments	Disturbance/release during extraction, transport and placement stages	> Dermal contact > Inhalation	**Medium**	> Sediments to remain wet or be contained as part of disposal > Segregation of work area and material from general public	**Low**

4.1 Marine Environmental Quality

4.1.1 Marine Sediment Quality

The potential for changes to marine sediment quality, including potential release of contaminants during the dredging phase was examined via a desktop assessment. Risks were assessed in the context of background contamination levels together with the risk of spillages to the marine environment. Given the documented efficiency of CSD with respect to spillage rate (see *Sediment Transport Report* [Cardno, 2022b]) and the very low levels of contamination in the project area, the potential for bioaccumulation of contaminants during the dredging phase was considered very low.

Analysis shows there is potential for acid sulphate soils (PASS) in surface-level seabed sediments rather than in those at depth. It was conservatively assumed that all sediments within the top 0.5m contain PASS and should be managed as such. Risks are nonetheless considered negligible given the opportunity for oxidisation is low due to an inadequate supply of oxygen.

4.1.2 Marine Water Quality

The potential for changes to water quality during the dredging campaign was investigated using a calibrated hydrodynamic and sediment transport model. Scenarios proceeded based on the predicted worst-case mobilisation of 30,000 m^3 and 70,000 m^3 during the cutter suction and backhoe dredging phases, respectively, under neap and spring tide conditions. Results are presented in Figures 4.1 and Figure 4-2 under possible and probable scenarios based on the 95th and 50th percentile TSS values respectively.

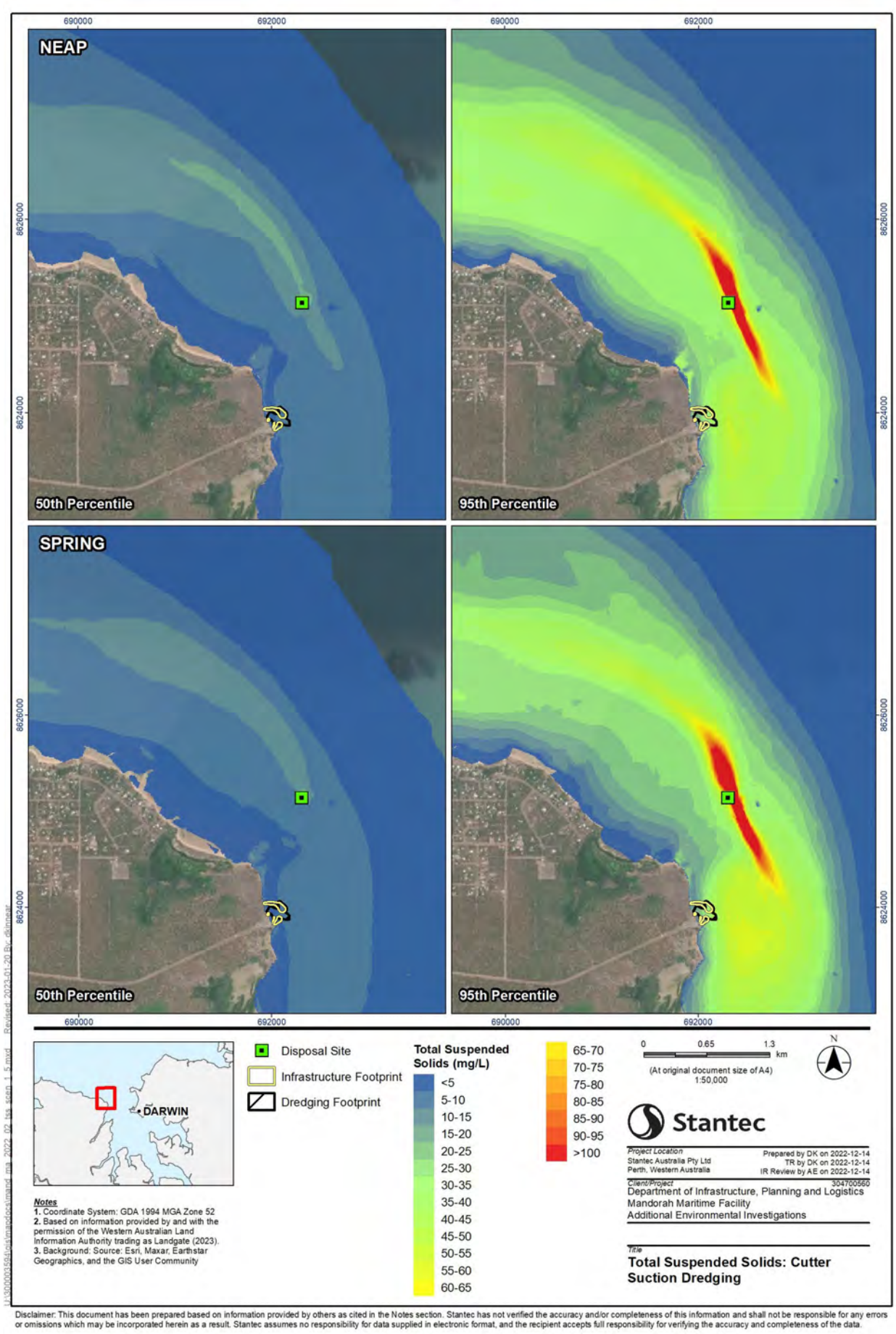

Figure 4-1. Predicted elevations in TSS due to cutter suction dredging

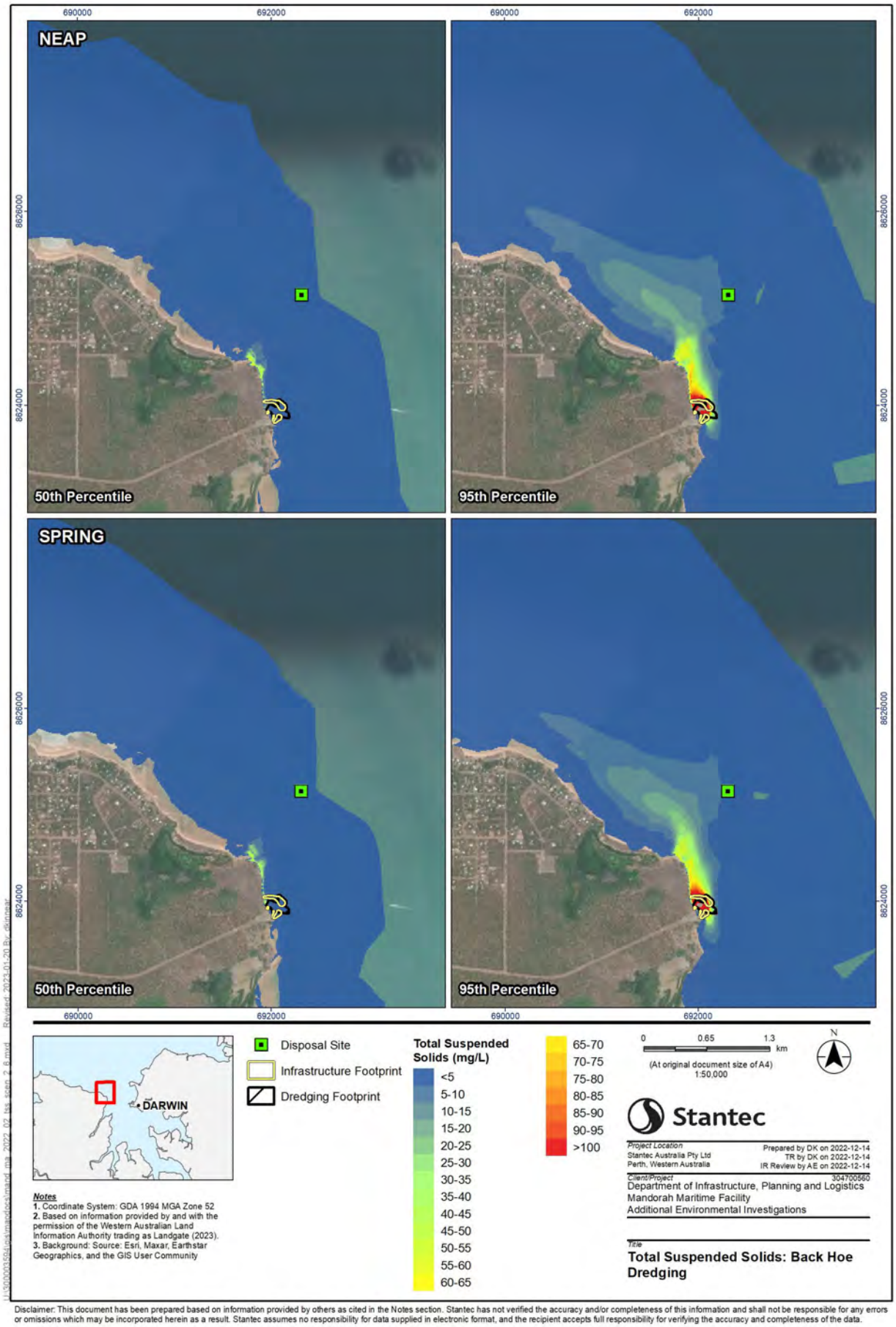

Figure 4-2. Predicted elevations in TSS due to backhoe dredging

The mobilisation, resuspension and settlement of dredge spoil was simulated based on the known particle size distribution and density of particles determined by geotechnical investigations. The amount of TSS in the water column due to dredging and dredge spoil disposal activities varied depending on the tidal cycle, with greater dispersion under spring tide conditions. Modelling suggested there is potential for 50th and 95th percentile TSS concentrations to reach 15-20 mg/L and >100 mg/L, respectively, at the dredging and dredge spoil disposal sites over the course of the dredging programs, which are anticipated to proceed over a 14-30 day period. The 50th percentile values are within the range experienced under typical dry season conditions, and the 95th percentile values are within the upper ranges experienced under wet season conditions, when TSS concentrations exceed 100 mg/L for extended periods (i.e. up to 30 days during storm events).

4.2 Marine Ecosystems

4.2.1 Benthic Communities and Habitats

4.2.1.1 Modelled Zones of Influence and Impact

The thresholds for the respective zones were established based on the upper ranges of TSS concentrations tolerated by local coral communities over a 7-day period in the wet and dry seasons, following the analysis of 2.5 years of baseline turbidity data from the Mandorah area. New thresholds were developed and interrogated using the revised hydrodynamic and sediment transport models to re-map the zone of influence and the zones of impact, under wet and dry season conditions. Modelling outputs were interpreted in the context of the NT EPA's (2021) guidance for assessing the potential impacts of dredging on the marine environment, which requires the spatial delineation of three levels of disturbance.

The resulting Zone of Influence (ZoI) and the Zones of Moderate (ZoMI) and High Impact (ZoHI) are illustrated in Figure 4-3 to Figure 4-6 and Figure 4-7.

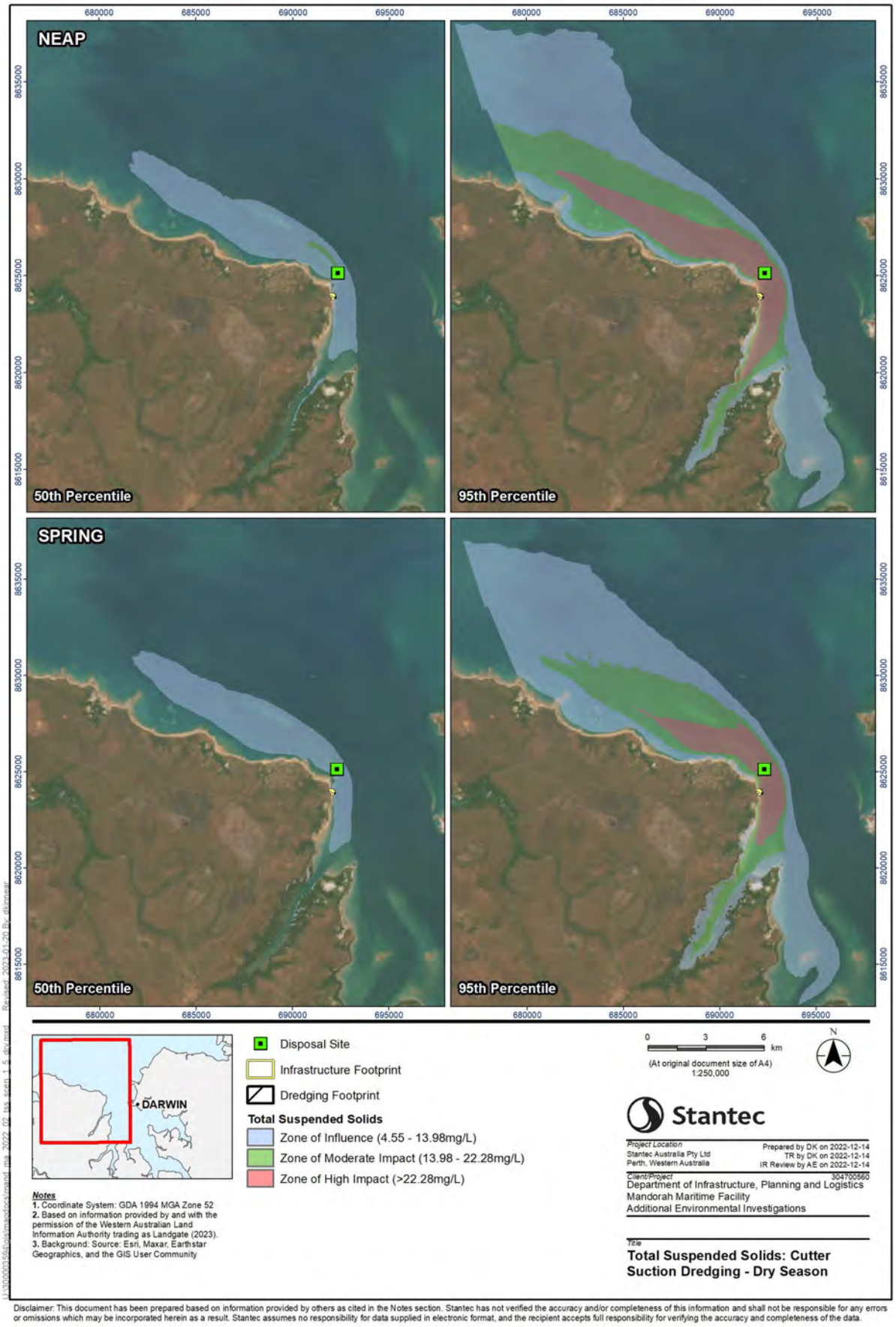

Figure 4-3. Cutter suction dredging zones of impact – Dry season

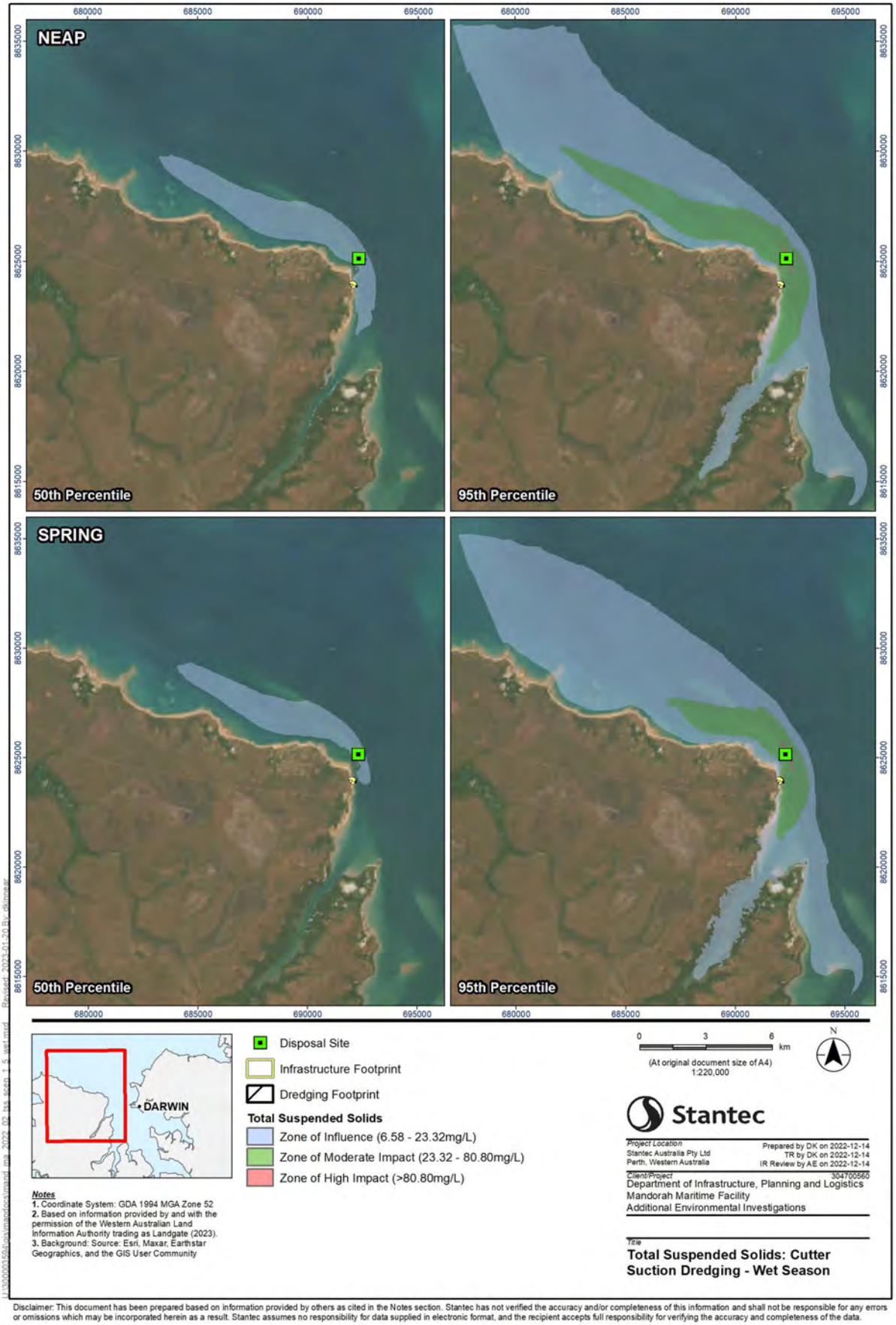

Figure 4-4. Cutter suction dredging zones of impact – Wet season.

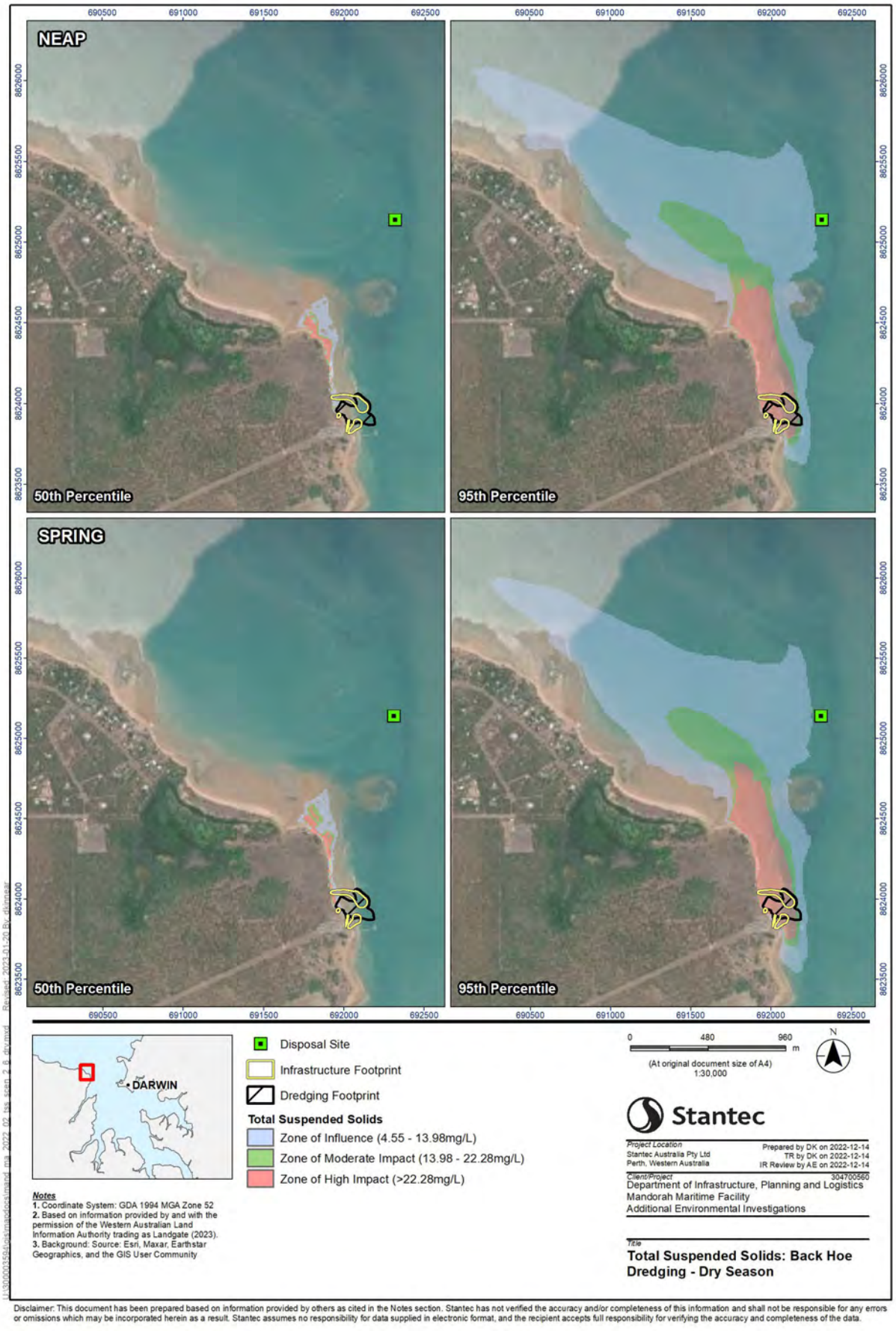

Figure 4-5. Backhoe dredging zones of impact – Dry season

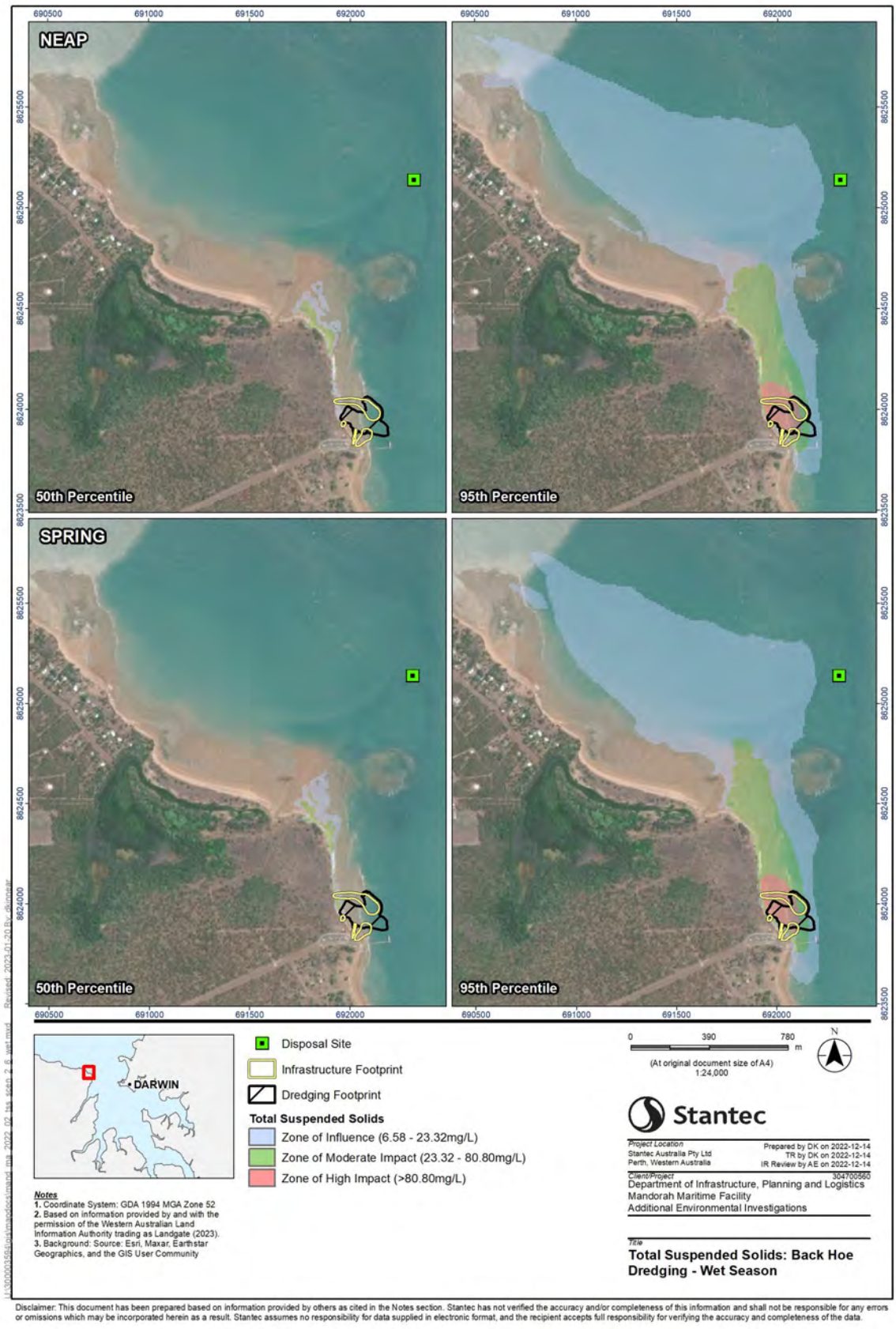

Figure 4-6. Backhoe dredging zones of impact – Wet season

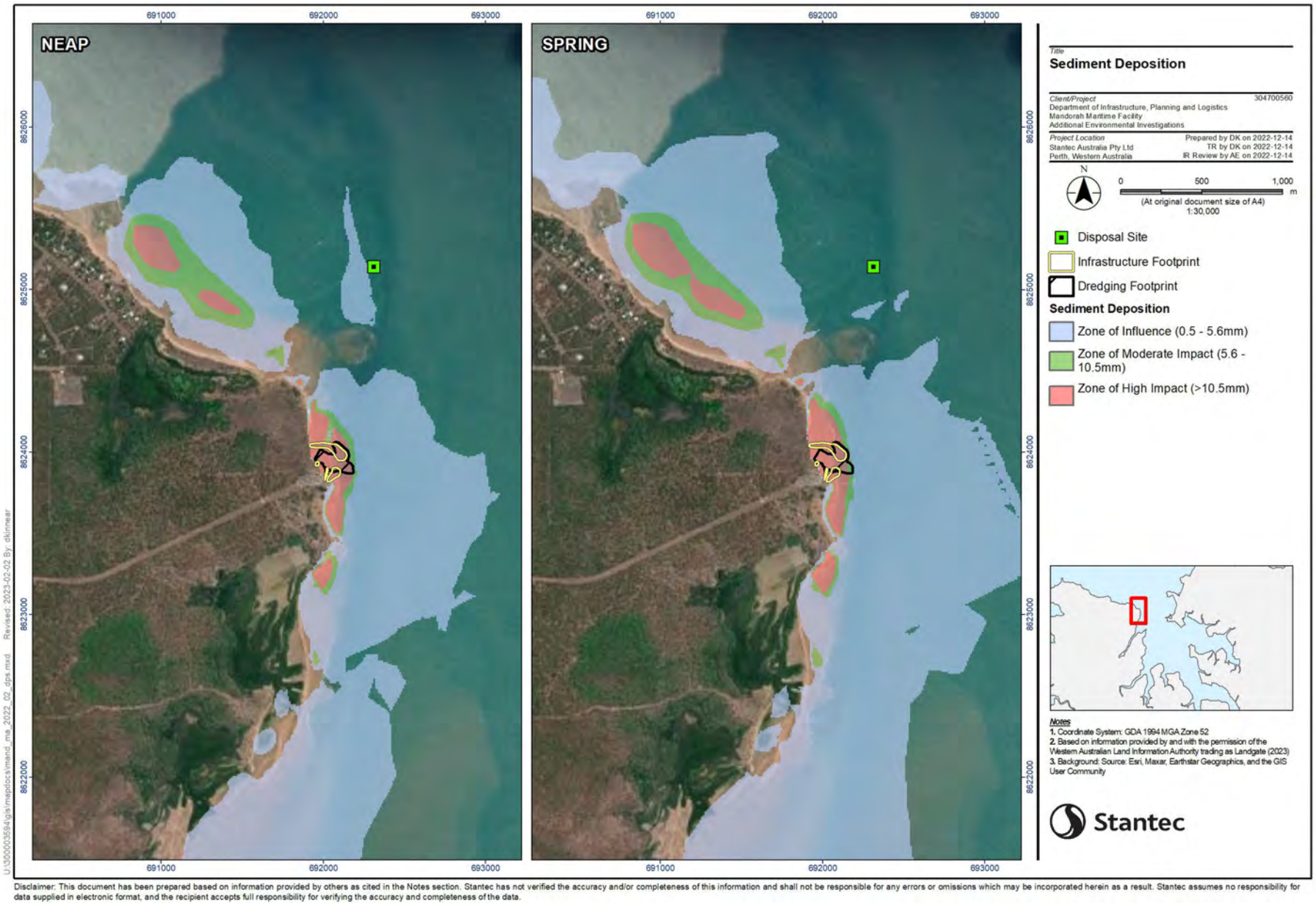

Figure 4-7. Cumulative sedimentation related zones of impact map (cutter suction dredging, backhoe dredging and rock wall placement)

4.2.2 Marine Fauna

4.2.2.1 *Underwater noise impacts*

Noise pollution from vessel movement, dredging and piling activities has the potential to affect individuals and populations of marine mammals which rely upon acoustics for navigation, hunting and communication. Sound pollution with similar frequencies to those of marine mammals has the potential to temporarily or permanently damage hearing (temporary/ permanent threshold shift), change the animals own acoustic signal or induce stress which can affect feeding and reproduction. Todd et al. (2014) note that noise emitted from dredging is lower energy and unlikely to cause damage to marine mammal auditory systems, but may cause behavioural changes. Sounds and vibrations emitted from vessels, dredge machinery and piling activities are transmitted through seabed sediments and the water column, where they may be perceived by marine fauna. Underwater noise may result in the following:

i. behavioural responses;
ii. masking of natural sounds;
iii. stress and physiological responses;
iv. hearing loss and damage to auditory tissues;
v. structural and cellular damage of non-auditory tissues and total mortality;
vi. impairment of lateral line functions; and
vii. particle motion-based effects on eggs and larvae (Popper and Hastings, 2009; Popper et al., 2014).

Although not modelled directly, risks associated with underwater noise are expected to be manageable via the implementation of standard mitigation approaches, such as soft start procedures and the implementation of marine mammal exclusion areas.

4.2.2.2 *Direct impact/collision from vessel plant and equipment*

Potential impacts due to vessel impacts include injury, death or behavioural changes. Marine mammals and reptiles are the most likely to be impacted due to their size, slow speed and reliance on acoustics. The risk of such impacts may be minimised by observation (i.e. Marine Fauna Observers (MFO's)) and avoidance procedures, and by reducing transit speeds. Whilst dredging, the BHD and CSD remain stationary, and while steaming move slowly. Due to these operating speeds, risk of vessel strike of marine mammals is low, however, if a strike does occur, death or severe injury is possible (Todd et al., 2014). Risk of direct impact to marine fauna is considered low (additional information in **Monitoring and Management of Marine Fauna - Section 5.4**).

4.2.3 Invasive Marine Species

The potential for introduction of invasive marine species arises when marine vessel are imported from other areas. The contractor shall be aware of such risks and ensure proper import procedures have been adhered to by all equipment operating on the project, especially if vessel or other equipment are sourced from foreign ports.

4.3 Cultural Heritage

Sites of known aboriginal cultural heritage and significance have been identified for the project and permissible work areas (including the dredging footprint, have been captured in an Aboriginal Areas Protection Authority (AAPA) Certificate, or defined as exclusion zones for the project (see Figure 2-2). Strict avoidance of the restricted work areas (RWA) and exclusion zone will minimise the risk of impact. Only one of the sacred sites is in the marine environment (nearshore area to the north of the project site), with the potential to be impacted by dredging and disposal actions. Sedimentation at this site has been modelled as minimal (less than 2.5 mm) and predicted changes to suspended sediment concertation in the vicinity of the sacred site is expected to be

isolated and temporary (i.e. during outgoing tide). Risk to known sacred sites associated with dredging and disposal actions is considered to be low.

There is a very low to negligible risk of encountering an object or area of significance as part of the dredging works. This is unlikely as the dredging area has been surveyed and objects identified have been removed. The area is also known to be predominantly rock, with a thin layer of sediment overlain. Nevertheless, appropriate response and reporting of any such encounter is required to minimise this risk.

4.4 Human Health

The risk to human health is considered low, due to the following factors:

- Contaminant levels were found to be low and below relevant thresholds for human health risk;
- Any fines released from the dredging or dredge spoil disposal areas will disperse rapidly ; and
- The work areas are not in close proximity to the general public.

5 Monitoring & Management

The proposed monitoring and management strategies for protecting the NT EPA's environmental elements are detailed below.

5.1 Dredging Footprint

The targets, actions and individual responsibilities, relevant to managing the dredging footprint are summarised in Table 5-1.

Table 5-1. Management actions to limit dredging to proposed footprint.

Management Target	Management Actions	Responsibility	Reporting	Frequency
Dredging activities are confined to the proposed footprint and levels	Dredge vessel to navigate using on-board GPS with appropriate accuracy	Contractor	Navigation equipment inspection and testing	Prior to commencement of dredging operations
			Daily Log Sheets. Log sheets shall contain the following as a minimum: • Date; • Vessel and operator name; • Vessel track logs; • Commencement and finish times, including breaks during day for slack water etc.; • Dredged footprint and levels; • Total production and average production rates; • Disposal, location and rates; • Safety incidents or near misses; • Marine fauna observations, strikes or near misses; • Water quality baseline and trigger exceedances; • Significant delays and/or cessation of dredging for environmental reasons; • Adverse interactions with public; • Any environmental incidents such as chemical spills, oil leaking, dredge pipe leaks/spills etc.; and	Daily

			• 48-hour look-ahead dredging plan	
			Weekly Log Sheets. The reports shall contain the following as a minimum: • Operating dates, daily commencement and finish times, including breaks during day for slack water etc.; • Dredged footprint and levels; • Total production and average production rates; • Total disposal and average production rates; • Assessment of progress relative to overall campaign; • Anticipated delays or changes to the dredge plan; • Safety incidents or near misses; • Marine Fauna strikes; • Significant delays and/or cessation of dredging for environmental reasons; • Adverse interactions with the public; • Any environmental incidents such as chemical spills, oil leaking, dredge pipe leaks/spills etc.; and • Weekly look-ahead dredging plan	Weekly
Dredging activities conform with monitoring and response requirements of *Draft DSDMP*	As defined in this *Draft DSDMP*	Contractor	Daily and weekly reporting Trigger/incident response reporting	As stipulated
	Audit	Principal	Audit report, daily review	Daily

5.2 Marine Environmental Quality

5.2.1 Trigger development

The triggers for the dredging and dredge spoil disposal activities were developed following the analysis of the long-term water quality data collected at Mandorah during the Ichthys Nearshore Monitoring Program. Triggers for operational monitoring were developed based on Section 4.2.1 of EPA (2021) which recommends the use of the percentile approach. The (PX) percentile approach was selected for its conservatism relative to the laboratory derived triggers developed during the WAMSI DSN.

The triggers for Mandorah were developed based on the assumption that corals are tolerant of short-term TSS elevations above background, but experience stress if they persist. The long term TSS data from Mandorah is indicative of a highly variable system with alternating peaks and troughs corresponding to spring and neap tide conditions respectively. Under the ANZWQG (2018) approach if the P50 value of an impact site exceeds the P80 value of a suitable reference site, it is considered commensurate with an environmental perturbation. For this reason, the P80 value was set as the trigger for the ZoMI, and the P99 value the trigger for the ZoHI. In total, three trigger levels, comprising early warning, primary and secondary triggers, were developed based on the P80 and P99 seven 7- and 14-day moving averages for TSS (subsequently converted to NTU), specific to the wet and dry seasons.

An exceedance of the early warning trigger results in further assessment against the primary trigger, and an exceedance of the secondary trigger requires a compulsory management response, including monitoring of BCH or possibly, cessation of dredging

5.2.2 Trigger values

A range of trigger values have been developed, that if exceeded, will trigger management responses to mitigate potential impacts to corals and seagrasses (Table 5-2). TSS concentrations in the water column will be extrapolated from real time NTU data, which will be monitored hourly during the dredging campaign, at a suite of impact and reference sites (Figure 6-3). The extrapolation will proceed using the relationship developed by Stantec (Formerly Cardno) (2022) for the Mandorah area, based on field studies completed throughout the project footprint and local area:

$$TSS = 1.8167 * NTU\ ; R2 = 0.90$$

The data collected previously at Mandorah is a reliable baseline dataset, due to its long duration and high measurement frequency. The newly developed relationships between TSS and NTU, and between near bed NTU and depth averaged TSS, are based on site-specific data and bring a high level of confidence to these triggers.

Table 5-2. Proposed water quality triggers

MONITORING LOCATION	EARLY WARNING TRIGGER	PRIMARY TRIGGERS	SECONDARY TRIGGERS
ZOHI / ZOMI BOUNDARY	Rolling 7-day median NTU to remain below the 80th percentile of reference data for the same period.	Median DLI to remain above the 20th percentile of reference site data for the same period. AND Rolling 14-day median NTU to remain below the 80th percentile of reference data for the same period.	Median DLI to remain above the 5th percentile of reference site data for the same period. AND Rolling 14-day median NTU to remain below the 95th percentile of reference data for the same period.
ZOMI / ZOI BOUNDARY	Rolling 7-day median NTU to remain below the 50th percentile of reference data for the same period.	Median DLI to remain above the 20th percentile of reference site data for the same period. AND Rolling 14-day median NTU to remain below the 50th percentile of reference data for the same period.	Median DLI to remain above the 20th percentile of reference site data for the same period. AND Rolling 14-day median NTU to remain below the 80th percentile of reference data for the same period

5.2.3 Monitoring

Turbidity and Photosynthetically Active Radiation (PAR) will be measured on an hourly basis at sites within and adjacent to the dredging footprint and disposal site (Figure 5.1 and Table 5-3). Monitoring sites were chosen based upon the predicted zones of impact under worst case conditions, based on the 95th percentile TSS values. Monitoring instruments will be installed a minimum of one month prior to the commencement of dredging allowing for verification, calibration (if needed) and background data to be recorded at each of the monitoring sites. Ideally, instruments shall be telemetered with technology to allow immediate notation of trigger exceedances via the 4G or 5G network.

Table 5-3. Proposed water quality monitoring sites and details

Area	Site ID	Purpose	Parameters	Timing	Compare against	Eastings[1]	Northings[1]
Cutter Suction Phase	ZoHIN(P50) ZoHIN(P95) ZoHIS(P50) ZoHIS(P95) ZeMIN(P50) ZoMIN(P95) ZoMIS(P50) ZoMIS(P95) RefE RefN RefS	Measure turbidity at the boundaries of the ZoHI/MI, ZoMI/ZoI and at appropriate Reference sites (Figure 5.1).	Realtime turbidity PAR	Hourly. Commence 1 month before dredging commences and finish 2 weeks after completion of dredging.	Triggers (Table 5-2)	692326 681558 692360 692984 690704 678280 692400 693495 691591 676869 697242	8625197 8630450 8625145 8621671 8626748 8632865 8625075 8621033 8629668 8638964 8614101
Backhoe Phase	ZoHIN(P50) ZoHIN(P95) ZoHIS(P50) ZoHIS(P95) ZoMIN(P50) ZoMIN(P95) ZoMIS(P50) ZoMIS(P95) RefE RefN RefS	Measure turbidity at the boundaries of the ZoHI/MI, ZoMI/ZoI and at appropriate Reference sites (Figure 5.1)	Realtime turbidity PAR	Hourly. Commence 1 month before dredging commences and finish 2 weeks after completion of dredging.	Triggers (Table 5-2)	691760 691812 691910 692129 691750 691319 691920 692137 692640 690976 692354	8624515 8624780 8624335 8623792 8624535 8625260 8624315 8623741 8624592 8626073 8623542

[1] GDA 94 MGA Zone 52

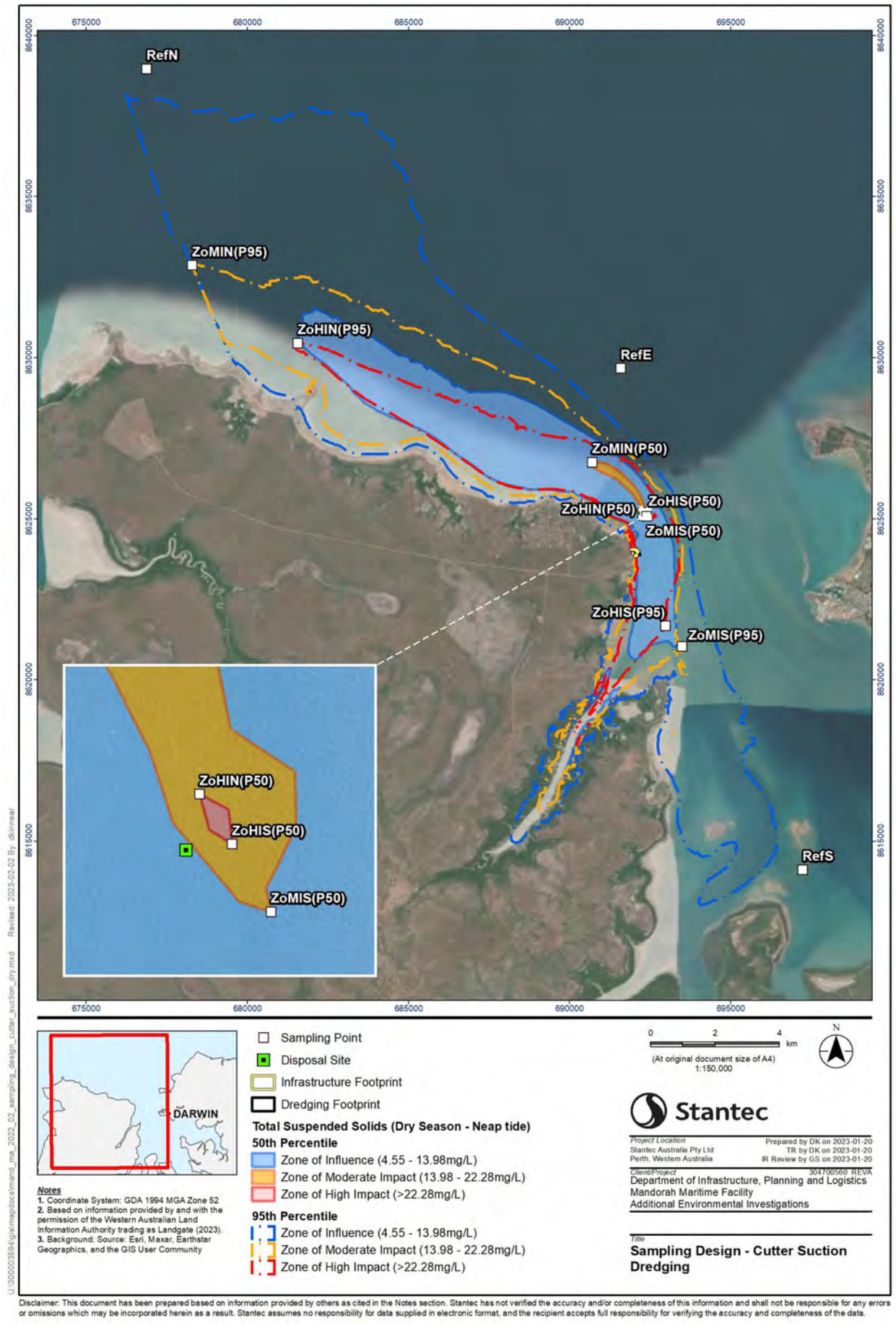

Figure 5-1. Proposed monitoring locations for the cutter suction dredging phase

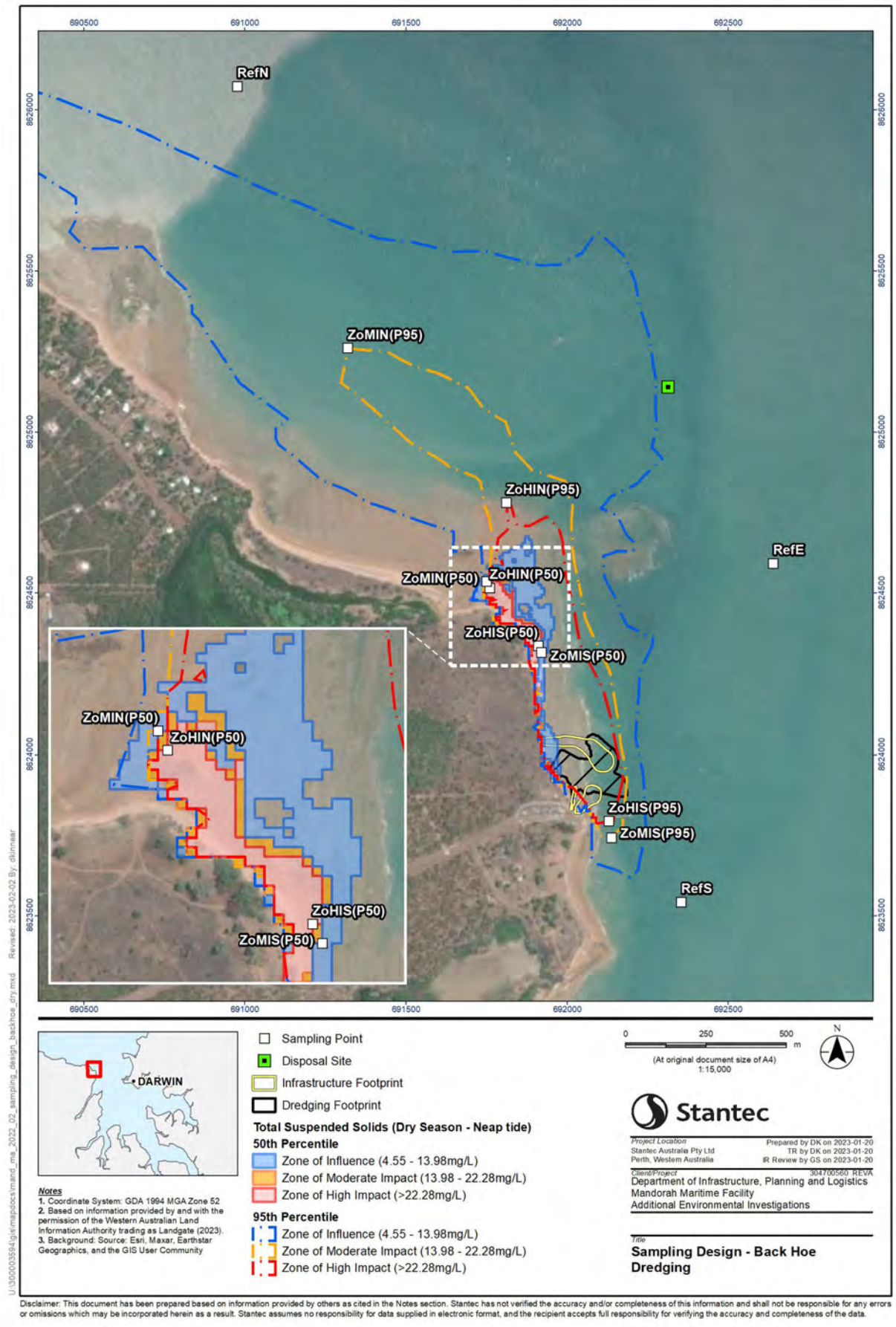

Figure 5-2. Proposed monitoring locations for the backhoe dredging phase

5.2.4 Management Response

Should a trigger be exceeded, the following response protocol shall be followed:

- Immediately report primary trigger exceedance to the Principal;
- Investigate background levels, data quality, dredging logs/activities and natural conditions at the reference sites to ensure the exceedance is genuine within 12 hours of exceedance; and
- If genuine, investigate changes to dredging and disposal activities that may avoid further trigger exceedance. Including:
  - Dredge in different area if related to dredging actions;
  - Dispose in different portion of disposal site if related to disposal actions;
  - Dispose on incoming or outgoing tide only, dependant on the location of exceedance; and
  - Increase designated dredging down-time at slack water to greater than 1 hour.

If the secondary triggers are exceeded, commence monitoring BCH as per the approach described in Section 5.3, and discontinue dredging and disposal until the 24-hour rolling mean is below the primary trigger levels. If secondary triggers are not exceeded BCH monitoring and BCH surveys during and post dredging are not required.

5.3 Benthic Communities and Habitats

5.3.1 Monitoring

BCH monitoring shall commence upon an exceedance of the secondary triggers at to-be-determined sites. Sampling is likely to be conducted at:

- Four (4) sites within the ZoMI, to assess recoverable impacts;
- Four (4) sites within the ZoI to assess no change from baseline condition; and
- Three (3) reference sites which will target areas to the north of the project area and to the west of the Harbour (areas known to support important BCH habitats, i.e. seagrass, sponges and corals).

A survey will be undertaken during/following the dredging campaign, with the survey method (drop camera/ROV) to be confirmed prior to commencement. BCH monitoring will continue throughout the dredging campaign, and continue for 12 months post-dredging, or up until BCH potentially impacted by dredging has recovered to pre-dredge condition.

5.3.2 Management Response

Following each BCH survey, BCH condition reports will be prepared and submitted to the Principal. Condition reports shall comprise the following:

- Summary of data collected during the survey;
- Comparison of BCH condition with baseline;
- Discussion of observed impacts and the likelihood they are attributable to dredging; and
- Recommendations for management/remediation (if required).

5.4 Marine Fauna

To mitigate and manage noise impacts generated from dredging, marine construction and piling works on marine fauna, noise impacts will be managed according to both activity and water depth. A suitable trained Marine Fauna Observer (MFO) will conduct visual observations on the dredging platform / piling platform and for shore-based dredging / construction activities monitoring will be conducted from the shoreline or from a roaming vessel. Piling activities have added depth considerations with shallow water being defined as (<3m Depth – Low Tide) or deeper water (>3m Depth). Within each depth range corresponding observation zones will be applied.

The MFO will perform visual observations within a 2000 m observation zone (distance from dredging, piling or construction works). A 1 km exclusion zone shall apply to whales and dugongs, and a 500 m exclusion zone shall apply to turtles. The MFO will commence visual observations for 30 minutes prior to piling or dredging.

1. If target marine fauna are observed within the exclusion zone, construction activities shall be delayed until target marine fauna have exited the zone or have not been seen for 20 minutes.
2. If target marine fauna are not observed in the exclusion zone, soft start procedures may commence, building to maximum over a 30 min period.
3. MFOs are to keep daily records of:

> All target marine fauna observations within the observation zone.
> Any records of observed cetaceans in a format consistent with the National Cetacean Sighting and Stranding's Database;
> Other target marine fauna observations within the observation zone;
> Fauna behaviours that may be attributed to construction activities; and
> Management responses in relation to dead and injured wildlife, including suspension of dredging, piling or construction activities.

5.4.1.1 Soft-Start Piling

Soft-start procedures involve increasing the piling impact energy over a 30-minute period. The approach will alert marine mammals to the presence of the piling activity and enable animals to move away to distances where injury is unlikely. The MFO will continually monitor the observation zones prior to and during soft-start procedure.

5.4.1.2 Normal Piling

Where target marine fauna are not present in observation zones during soft start procedures then normal piling can commence. The MFO will continually monitor the observation zones during normal piling. If while piling target marine fauna are observed then following procedure shall be applied:

> If it is evident that the marine fauna are in distress then piling operations shall cease until marine fauna have exited the observation zones or have not been seen for 20 minutes. Once marine fauna have exited the observation zone, soft-start piling may used to recommence piling activities;
> If target marine fauna are not showing signs of distress, piling operations will continue and the MFO will continue to monitor the marine fauna.
> Where target marine fauna are observed within the exclusion zone, the following procedure shall be applied:
> Piling operations shall cease until target marine fauna have exited the observation zone or have not been seen for 20 minutes. Once target marine fauna have exited the management zone, soft-start piling may be used to recommence piling.

5.4.1.3 Low-Visibility Conditions

During periods of low visibility (i.e. where the required observation distance of 500 m cannot be clearly viewed), then piling operations may commence with soft-start procedures provided that during the preceding 24-hour period:

> There have not been three or more circumstances where marine fauna have been observed which resulted in ceasing of piling operations;
> A 2-hour period of continual observations was undertaken in good visibility within the 24-hour period prior to proposed piling and no marine fauna sighted; and
> Piling should occur during daylight hours.

5.4.2 Monitoring

Before the commencement of dredging, construction or piling the MFO is responsible will conduct a visual assessment. An visual exclusion zone is to be maintained around the dredging vessel, piling equipment and/or other construction equipment for the following marine fauna at all times:

- Dolphins;
- Whales;
- Turtles;
- Dugongs;
- Sawfish; and
- Sharks.

The frequency and duration of this monitoring is provided in Table 5-4.

Table 5-4. Visual assessment frequency

Stage	Timing	Responsibility	Observation Zone	Exclusion Zone	Observation Duration
Pre-commencement	Starting 30 minutes prior to dredging	Contractor (MFO)	500 m	300 m	10 minutes
Whilst dredging	Every 30 minutes	Contractor (MFO)	500 m	300 m	5 minutes
Whilst Piling Shallower Water (<3m Depth – Low Tide)	Starting 30 minutes prior to piling	Contractor (MFO)	500 m	100 m	Continual
Whilst Piling Deeper Water (>3m Depth – Low Tide)	Starting 30 minutes prior to piling	Contractor (MFO)	2 km	1 km (whales & dugongs) 500 m turtles	Continual

5.4.3 Management Response

Trigger exceedances (Table 5-5) are to be recorded in the daily dredge log submitted to the Principal. Daily MFO logs shall be compiled and submitted to the Proponent on a monthly basis.

Table 5-5. Response to triggers

Trigger	Response	Cease response
Sighting of marine fauna including whales, sharks, dolphin, dugong, marine reptiles or sawfish within exclusion zone during transit.	Limit dredge vessel speed to 6 knts and report observance in daily log.	When MFO has sighted fauna leaving the exclusion zone.
Sighting of marine fauna including whales, sharks, dolphin, dugong, marine reptiles or sawfish within exclusion zone in the 30 minutes before commencing dredging, piling or other construction activities.	Do not commence work.	No sighting within exclusion zone for 20 minutes.
Marine fauna strike	Halt activity and report to injured wildlife number immediately. Report incident to DIPL to report to Northern Territory	Appropriate care has been given to animal and MFO is confident there is no fauna within the exclusion zone.

Trigger	Response	Cease response
	Parks and Wildlife within 48 hours. Report in daily and weekly logs.	Corrective action undertaken to prevent further incidence.

5.5 Invasive Marine Species

Table 5-6 contains management options and triggers related to the transfer of invasive marine species by dredging vessels.

Table 5-6. Management actions for the prevention of invasive species

Trigger	Management Action
Any dredging works	• Determine vehicle risk of introducing invasive marine species due to previous dredging activities or movement referring to the National biofouling management guidelines for recreational vessels (Marine Pest Sectoral Committee, 2018). • Regular maintenance of vehicle including the application of biofouling paint within its recommended lifespan. • Maintenance of 10 km buffer between vessel and commercial oyster farms.
Dredger determined to be 'high risk' in risk assessment	• Vessel will require inspection, hull cleaning, dry docking and/or treatment of internal seawater systems dependant on reason for 'high' rating.
Dredger has been overseas	• If vessel has been procured overseas, it is required that it undergoes cleaning in dry-dock before arrival in Australia. • Ballast water from overseas waters must be exchanged at least 200 nautical miles from Australia's coastline in waters > 200 m deep (DAWE, 2020). • Ballast exchange much replace at least 95% of their volume via flow-through or emptying and refilling. To achieve this the IMO (2004) recommends that three times the capacity of ballast tanks is pumped through the system.

5.5.1 Management Response

The following reporting related to invasive marine species is required:

> Inspection report of dry-dock cleaning by specialised consultant (overseas vessels only) is to be submitted to the NT EPA before mobilisation of dredge; and

> Prior to mobilisation, logs detailing vehicle loads, exchanges or discharges of ballast water shall be submitted to the NT EPA.

> Should an invasive species be detected or is suspected, the following actions should be undertaken:

> Notification of the Department of Agriculture Water and the Environment (DAWE) including location of dredger when discovered, suspected species and sample of species; and

> Development of action plan to remove invasive species from vessel and any necessary remediation of the affected marine environment. Plan is to be drafted in consultation with DAWE.

5.6 Cultural Heritage

The targets, actions and individual responsibilities, relevant to managing cultural heritage are summarised in Table 5-7.

Table 5-7. Management actions to control impacts to cultural heritage

Management Target	Management Actions	Responsibility	Reporting	Frequency	Contingency
No dredge plant, material or workers to enter RWAs or exclusion zone.	No works can occur south of the northern extent of RWA1, this will be implemented in the construction environmental management plan. Complete avoidance of exclusion zone for all vessels, plant and personnel.	Contractor	Breaches to be noted in daily and weekly logs. Vessel paths/logs to be provided.	Daily Immediately if breach.	Stop dredging activities for further investigation.
No damage or destruction of cultural/heritage artefacts within Darwin Harbour.	Immediate investigation if object/artefact encountered.	Contractor	Report detailing detected objects.	Immediately	Stop dredging activities for further investigation.

5.7 Human Health

The targets, actions and individual responsibilities, relevant to managing human health are as per the Marine Environmental Quality management actions.

6 Reporting

6.1 Daily Reporting

Daily reports (succinct) shall be provided by the Contractor to the Superintendent including:

- Dredge log, as per **Section 5.1**;
- Turbidity data recorded at monitoring locations for the 24-hr period preceding reporting, including 24-hour rolling mean (**Section 5.2**);
- Water quality triggers exceeded (**Section 5.2**);
- Encounters with marine fauna (**Section 5.4**); and
- Any changes to weekly dredge plan.
- Any secondary trigger exceedances in water quality will result in reactive monitoring of the BCH.

6.2 Weekly Reporting

Weekly reporting shall be provided by the contractor to the Superintendent including:

- Weekly dredge report, as per **Section 5.1**;
- Turbidity data recorded at monitoring locations for the one-week period preceding reporting, including 24-hour rolling mean (**Section 5.2**);
- Responses to any secondary trigger level exceedances or marine fauna sightings (**Section 5.4**);
- Discussion of marine fauna encountered (**Section 5.4**); and
- Any changes to overall dredge plan.
- Any trigger exceedances in water quality will result in reactive monitoring of the BCH.

6.3 Monthly and Annual Reporting

Monthly and annual reporting shall be provided by the contractor to the Principal and will include:

- Discussion of marine fauna encountered, including a summary of the MFO logs (**Section 5.4**);
- Summary of the water quality data collected pre, during and post-dredging (**Section 5.2**); and
- Results and discussion of the bi-annual BCH surveys during and post-dredging (up to 12 months post-dredging), detailing any reactive monitoring results following any trigger value exceedances (**Section 6.2**).

6.4 Compliance Monitoring

A Waste Discharge Licence (WDL) will be required for the disposal of soil material in Darwin Harbour. As the proponent of the dredging works, DIPL or its representative is responsible for the submission of any logs, reports or data required by the WDL to NT EPA. DIPL or its representative will also be responsible for reporting any non-compliance with the requirements of the WDL to NT EPA.

6.5 Public Complaints

Complaints by the public made to the Contractor are to be reported to the Superintendent in the daily dredging log with the following information:

- Date and time of complaint;
- Description of complaint;
- Complaint details (may be anonymous); and

> Perceived cause of complaint and proposed action, including complaint owner and action date.

> The Superintendent is to determine the validity of the complaint, if deemed valid, the contractor is to initiate proposed action to complaint.

6.6 Summary of Reporting

Table 6-1 summarises required reporting associated with the dredging program.

Table 6-1. Summary of reporting.

Reporting	Responsibility	Timing	Recipient	Content
General				
Daily reporting	Contractor	Daily	Principal	See **Section 5.1.2** and **7.1.1**
Weekly monitoring report	Contractor	Weekly	Principal	See **Section 5.1.3** and **7.1.1**
End of dredging phase reporting	Contractor	Within four weeks of the conclusion of dredging activities	Principal	Summary of dredging activities including footprint, levels, turbidity, exceedances, complaints and environmental and safety incidences.
Compliance reporting	Proponent	As per WDL	NT EPA	As per WDL.
Environmental Reporting				
Water quality data	Contractor	Ongoing, daily, weekly and monthly	Principal	Provision of and access to real-time data, and a monthly summary of water quality data during and post-dredging. See **Section 6.1.5**
Water quality exceedance	Contractor	Daily	Principal	Description of trigger exceeded. See **Section 6.1.5**
BCH bi-annual surveys and/or reactive monitoring	Contractor	Monthly, annual (post-dredging)	Principal	Summary of BCH impacts within the project footprint and across the wider area. See **Section 6.2**
Death or injury of a protected marine species	Contractor (MFO to assist)	Within 24 hours (with daily dredge log)	Principal	Time, location, species and statement from MFO. See **Section 6.3**
Environmental monitoring report	Contractor (MFO to assist)	Monthly	Principal	Summary of MFO logs, detailing marine fauna movements and presence within the project footprint. See **Section 6.3**
Dredger history	Contractor	Prior to mobilisation	NT EPA	Vehicle locations, loads, exchanges or discharges of ballast water. See **Section 6.4**

Reporting	Responsibility	Timing	Recipient	Content
Dredger cleaning	Contractor	Prior to mobilisation (if overseas vessel)	NT EPA	Inspection and cleaning report. Statement from qualified inspector. See **Section 6.4**
Invasive species detection	Contractor	Immediately	DAWE	Time, location, suspected species, sample, remedial actions. See **Section 6.4**
Chemical, oil spills etc	Contractor	Immediately	24-hour spill report line	Time, location, substance, quantity, cause, clean up attempts.
		Within 24 hours (with daily dredge log)	Principal	
Complaints Reporting				
Complaints	Contractor	Within 24 hours (with daily dredge log)	Principal	See **Section 7.3**

7 Roles and Responsibilities

To ensure the objectives of this *Draft DSDMP* are met, defined roles and responsibilities for the Principal, Contractor and wider project team are listed in **Table 7-1**.

Table 7-1. Responsibilities

Position	Responsibilities
Principal (DIPL / NTG)	> Enforcing the requirements of the *Draft DSDMP* in the construction contract. > Implementing, monitoring, reporting and enforcing (where applicable) all the legal requirements under the project's approval and relevant legislation. > Ensure environmental factor objectives are met. > Overall responsibility for the project. > Review of ongoing reporting and routine auditing of contractor. > Overall responsibility for monitoring, reporting and enforcing (where applicable) relevant legislation, standards and guidelines. > Engagement with stakeholders regarding environmental impacts and progress of dredging plan including reporting and monitoring.
Contractor(s)	> Implementing, monitoring, reporting and enforcing (where applicable) the requirements of the *Draft DSDMP.* > Implementing, monitoring, reporting and complying with all the legal requirements under the project's approval and relevant legislation. > Ensure environmental factor objectives are met. > Complete dredging works as per technical specifications. > Completion of final DDMP incorporating management actions contained in this *Draft DSDMP.* > Compliance with monitoring and reporting requirements of DDMP. > Safety of staff, public and the environment. > Reporting daily/weekly reports, incidents, complaints to the relevant bodies. > Implementing, monitoring and reporting relevant legislation, standards and guidelines

8 Recommendations

The marine impact assessment for the Mandorah Proposal proceeded using a coupled hydrodynamic and sediment transport model. Modelling predicted that sedimentation, if it occurs at all, will be restricted to the dredge footprint, with 100% dispersal at the offshore disposal site. The differences are attributable to the gradient in current speeds between the dredging area, situated in the shallow near shore region, and the disposal site, situated in deeper water. Sediments within the dredging footprint do not disperse and instead remain in the area, until the completion of dredging each day. Sediments at the disposal site remain suspended and disperse rapidly owing to the higher current speeds.

The above outcomes assume the sediments in the pipe remain in ‘slurry’ form, with little to no ‘clumping’ of material. Even a small amount of clumping may result in increased sedimentation at the disposal site. It is imperative therefore the dredging contractor takes the necessary engineering steps to ensure the dredged material maintains the characteristics needed for 100% dispersal at the disposal site. If the contractor proposes an alternative method to that simulated in the model, the contractor shall re-evaluate the potential for impacts in consultation with the NT EPA, and update the DSDMP to ensure there are no permanent impacts to BCH at the disposal site.

9 References

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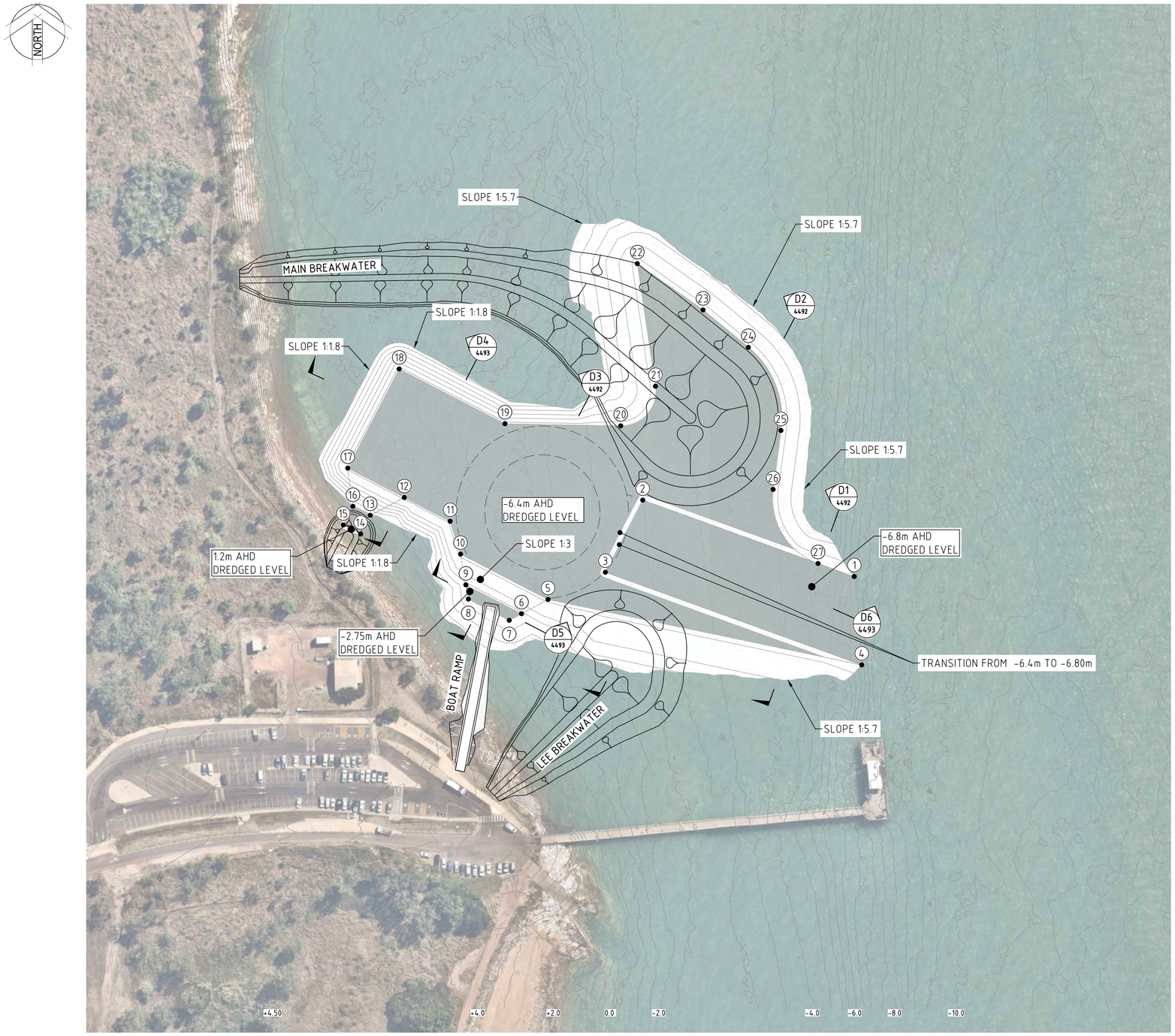
APPENDIX

A

DREDGING DESIGN DRAWINGS

PRINT IN COLOUR



DREDGED LAYOUT
SCALE A

IMAGE SOURCE: WWW.NEARMAP.COM, 2020

LEGEND

-4.0 EXISTING CONTOUR (0.5m) (BATHYMETRIC SURVEY)

NOTES:

1. BATHYMETRIC SURVEY CONTOURS SHOWN m AHD
2. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
3. ALL LEVELS ARE IN METRES AND RELATIVE TO AHD UNLESS NOTED OTHERWISE.

DREDGE SETOUT POINTS

PT No.	EASTING	NORTHING	RL.
1	692183.168	8623912.273	-6.800
2	692091.253	8623945.494	-6.800
3	692075.007	8623914.150	-6.800
4	692186.403	8623873.888	-6.800
5	692050.091	8623902.330	-6.400
6	692038.568	8623896.139	-2.750
7	692033.232	8623893.272	-2.750
8	692015.476	8623902.475	-2.750
9	692014.401	8623908.664	-2.750
10	692012.079	8623922.032	-6.400
11	692007.550	8623936.307	-6.400
12	691987.662	8623946.614	-6.400
13	691972.844	8623938.886	1.200
14	691968.647	8623930.789	1.200
15	691961.101	8623934.700	1.200
16	691965.297	8623942.797	1.200
17	691963.069	8623959.361	-6.400
18	691985.421	8624002.488	-6.400
19	692031.380	8623978.668	-6.400
20	692081.678	8623977.759	-6.400
21	692096.787	8623994.957	-6.400
22	692088.886	8624048.230	-6.400
23	692117.449	8624028.127	-6.400
24	692137.134	8624011.880	-6.400
25	692151.323	8623975.753	-6.400
26	692147.912	8623950.126	-6.400
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No.	AMENDMENT DESCRIPTION	DATE	INIT.	DEPT/COMPANY
0	ISSUED FOR TENDER	30/11/21	A.P	CARDNO
B	ISSUED FOR 50% DESIGN REVIEW	06/08/21	T.S	CARDNO
A	ISSUED FOR 25% DESIGN APPROVAL	30/06/20	I.C	CARDNO

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Level 6, 93 Mitchell Street
Darwin NT 0800
Tel: 08 8942 8200 Fax: 08 8942 8211
Web: www.cardno.com.au

Drawn A.PEARCE Date: 19/11/2021	Checked P.RODRIGUEZ Date: 19/11/2021	
Designed T.STEDMAN Date: 19/11/2021	Checked R.AKROUSH Date: 19/11/2021	
Design Project Leader D.STRICKLAND Date: 19/11/2021	NTG Project Manager S. DUNKERTON Date: 19/11/2021	

Northern Territory Government

DARWIN
CHARLES POINT ROAD, MANDORAH
NEW MARINE FACILITIES TO SERVICE MANDORAH AND COX PENINSULA
DREDGING LAYOUT

NTG Project No.	NTG Asset No.	Sheet Reference	NTG Drawing No.	Amendment	
ZMD01890	MD067	06 OF 24	R21-4491	0	A1

Version: March 2021

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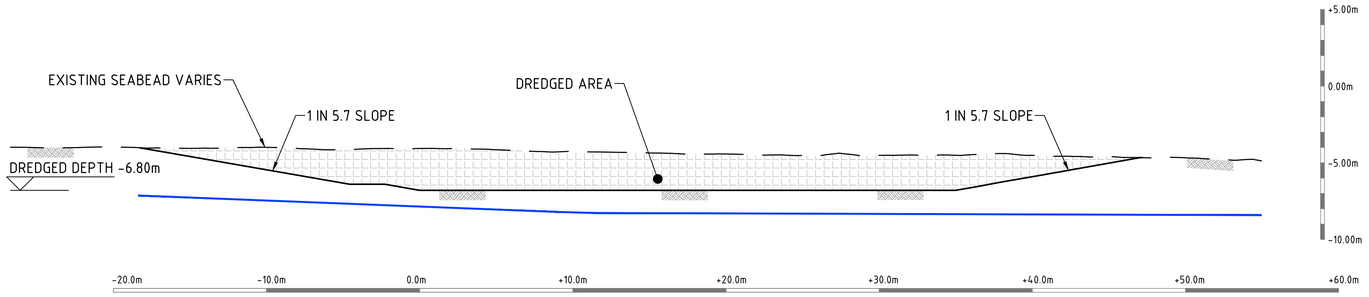
PRINT IN COLOUR

DATUM & TIDAL LEVELS

CD	AHD
8.17m (HAT)	4.07m
7.05m (MHWS)	2.94m
5.13m (MHWN)	1.02m
4.24m (MLS)	0.13m
4.105m (AHD)	0.00m
3.34m (MLWN)	-0.76m
1.42m (MLWS)	-2.68m
-0.01m (LAT)	-4.11m

LEGEND

- PORCELANITE CAPROCK (APPROXIMATELY 1.5m BELOW SEABED)
- POTENTIALLY CONTAINS HIGH STRENGTH ROCK BELOW PORCELANITE
- POTENTIALLY CONTAINS SOFTER MATERIALS BELOW PORCELANITE
- BASE OF SOFT ALLUVIAL MUD



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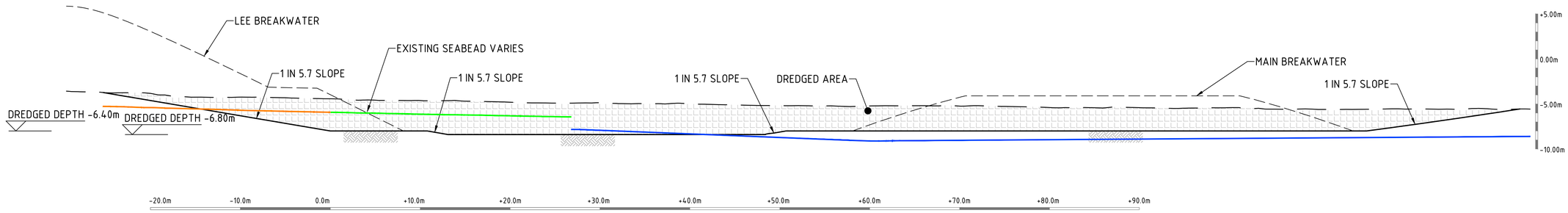

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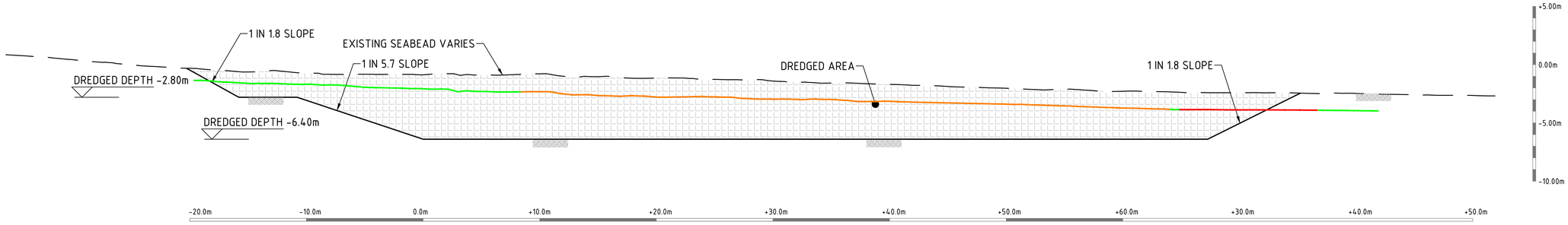

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SCALE 1:250 @A1

NOTES:

1. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
2. ALL LEVELS ARE IN METRES AND RELATIVE TO AHD UNLESS NOTED OTHERWISE.

No.	AMENDMENT DESCRIPTION	DATE	INIT.	DEPT/COMPANY
0	ISSUED FOR TENDER	30/11/21	A.P	CARDNO
B	ISSUED FOR 50% DESIGN REVIEW	06/08/21	T.S	CARDNO
A	ISSUED FOR 25% DESIGN APPROVAL	30/06/20	I.C	CARDNO

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Designed: A.PEARCE Date: 19/11/2021	Checked: R.AKROUSH Date: 19/11/2021
Design Project Leader: D.STRICKLAND Date: 19/11/2021	NTG Project Manager: S. DUNKERTON Date: 19/11/2021

Northern Territory Government

DARWIN
CHARLES POINT ROAD, MANDORAH
NEW MARINE FACILITIES TO SERVICE MANDORAH AND COX PENINSULA

DREDGING DETAILS - SHEET 1

NTG Project No.	NTG Asset No.	Sheet Reference	NTG Drawing No.	Amendment	
ZMD01890	MD067	07 OF 24	R21-4492	0	A1

Version: March 2021

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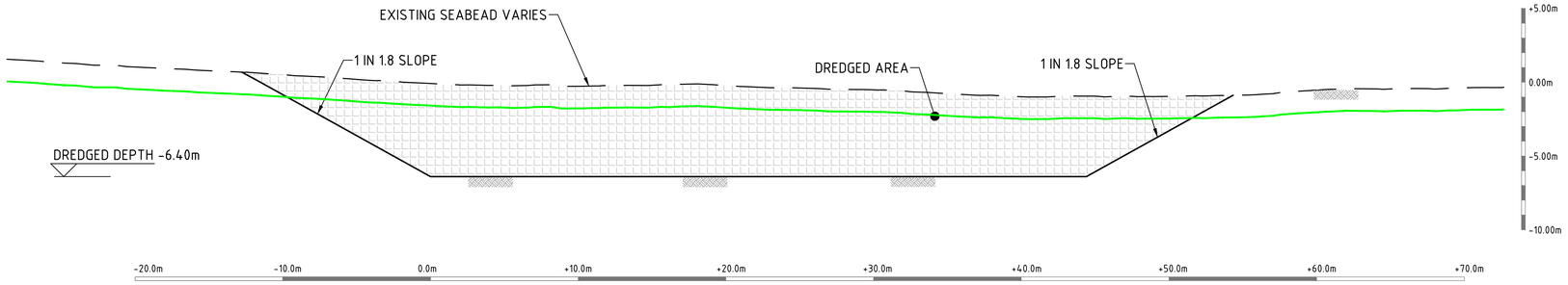
DATUM & TIDAL LEVELS

8.17m (HAT)		4.07m
7.05m (MHWS)		2.94m
5.13m (MHWN)		1.02m
4.24m (MLS)		0.13m
4.105m (AHD)		0.00m
3.34m (MLWN)		-0.76m
1.42m (MLWS)		-2.68m
-0.01m (LAT)		-4.11m
CD		AHD

LEGEND

- PORCELANITE CAPROCK (APPROXIMATELY 1.5m BELOW SEABED)
- POTENTIALLY CONTAINS HIGH STRENGTH ROCK BELOW PORCELANITE
- POTENTIALLY CONTAINS SOFTER MATERIALS BELOW PORCELANITE
- BASE OF SOFT ALLUVIAL MUD



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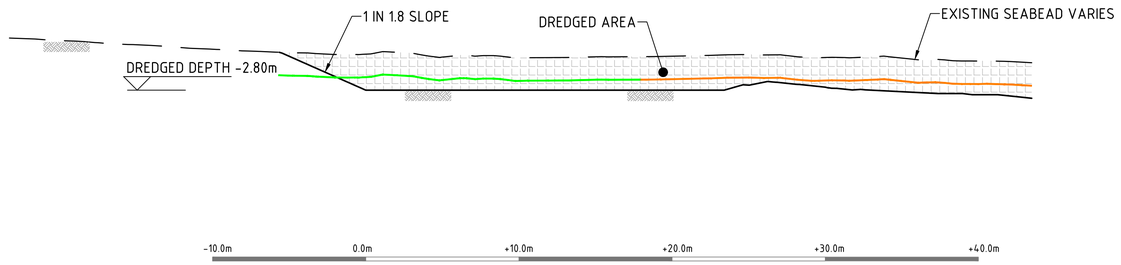

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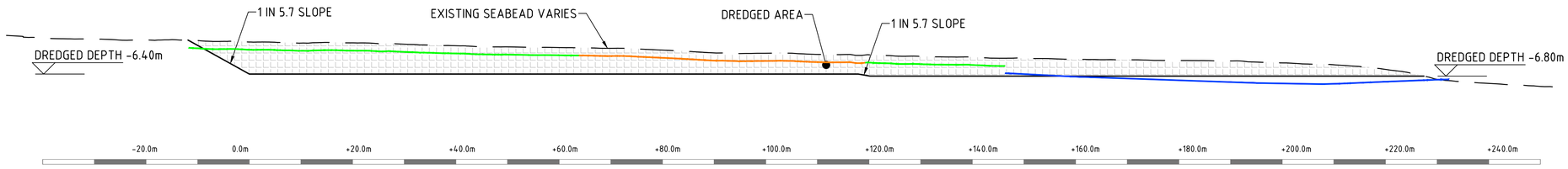

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NOTES:

1. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
2. ALL LEVELS ARE IN METRES AND RELATIVE TO AHD UNLESS NOTED OTHERWISE.

No.	AMENDMENT DESCRIPTION	DATE	INIT.	DEPT/COMPANY
0	ISSUED FOR TENDER	30/11/21	A.P	CARDNO
B	ISSUED FOR 50% DESIGN REVIEW	06/08/21	T.S	CARDNO
A	ISSUED FOR 25% DESIGN APPROVAL	30/06/20	I.C	CARDNO

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Designed: A.PEARCE Date: 19/11/2021	Checked: R.AKROUSH Date: 19/11/2021
Design Project Leader: D.STRICKLAND Date: 19/11/2021	NTG Project Manager: S. DUNKERTON Date: 19/11/2021

Northern Territory Government

DARWIN
CHARLES POINT ROAD, MANDORAH
NEW MARINE FACILITIES TO SERVICE MANDORAH AND COX PENINSULA

DREDGING DETAILS - SHEET 2

NTG Project No.	NTG Asset No.	Sheet Reference	NTG Drawing No.	Amendment	
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Version: March 2021

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LEGEND

~4.0 EXISTING CONTOUR (0.5m) (BATHYMETRIC SURVEY)

NOTES:

1. BATHYMETRIC SURVEY CONTOURS SHOWN m AHD
2. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
3. ALL LEVELS ARE IN METRES AND RELATIVE TO AHD UNLESS NOTED OTHERWISE.

SITE GEOLOGY LAYOUT
SCALE A

IMAGE SOURCE: WWW.NEARMAP.COM, 2020

SCALE A 0 20000 40000 60000 80000 100000mm
SCALE 1:1000 @A1

No.	AMENDMENT DESCRIPTION	DATE	INIT.	DEPT/COMPANY
0	ISSUED FOR TENDER	30/11/21	A.P	CARDNO
B	ISSUED FOR 50% DESIGN REVIEW	06/08/21	T.S	CARDNO
A	ISSUED FOR 25% DESIGN APPROVAL	30/06/20	I.C	CARDNO

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Design Project Leader: D.STRICKLAND Date: 19/11/2021	NTG Project Manager: S. DUNKERTON Date: 19/11/2021

Northern Territory Government

DARWIN
CHARLES POINT ROAD, MANDORAH
NEW MARINE FACILITIES TO SERVICE MANDORAH AND COX PENINSULA
SITE GEOLOGY LAYOUT

NTG Project No.	NTG Asset No.	Sheet Reference	NTG Drawing No.	Amendment	
ZMD01890	MD067	09 OF 24	R21-4494	0	A1

Version: March 2021

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APPENDIX

B

RISK ASSESSMENT TABLE

Table 1: Consequence categories and ratings

Score	Consequence or severity of impacts	Description
5	Severe	A Severe impact has two or more of the following characteristics: Widespread - Impact occurs at a NT, national, international or global scale High Intensity - Impact irreversibly compromises the integrity of environmental values Permanent - environmental values will not recover on human time scales
4	Major	A Major impact has two or more of the following characteristics: Regional - Impact extends to the Darwin/ Palmerston region, and/ or greater Darwin Harbour Moderate - Integrity of environmental values altered but impact can practicably be reversed Long term - Impact that is measurable post-Project
3	Moderate	A Moderate impact has two or more of the following characteristics: Localised - Impact is confined to the Site and areas directly adjacent to the Site, such as other allotments, Elizabeth River, and estuarine watercourses adjacent to the S Low - Impact alters the quality, abundance or distribution of environmental values without compromising their integrity, and can be easily and cheaply reversed Medium term - Impact that is felt up to completion of operations
2	Minor	A Minor impact has two or more of the following characteristics: Limited - Impact limited to the Site Very Low - Impact does not significantly alter the quality, distribution or abundance of environmental values Short term - Impact that is felt up to completion of construction
1	Insignificant	Insignificant No noticeable/ measurable impact to values

Table 2: Likelihood categories

Liklihood Category	Description
Almost certain	The event/ impact will occur or is expected to occur. The impact occurs regularly in association with similar projects and/ or in similar environments.
Likely	The impact will probably occur in most circumstances but there is some uncertainty about the likelihood. The impact has occurred on more than one occasion in association with similar projects and/ or in similar environments.
Possible	The impact could occur in some circumstances. The impact has occurred infrequently on similar projects and/ or in similar environments.
Unlikely	The impact is not expected to occur. The impact occurs very infrequently on similar projects and/ or in similar environments.
Rare	The impact is very unlikely to occur. The impact has not occurred on similar projects and/ or in similar environments.

Table 3: Risk level definitions and responses

Risk Level	Response
Very High	*Risk is unacceptable. Specific action plans required to reduce risk to an acceptable level. Director/ CEO level management attention required.*
High	*Risk is generally unacceptable without action. Specific action plans required to reduce risk to 'as low as is reasonably practicable' (ALARP). Senior management attention r*
Medium	*Risk is generally acceptable. Proactive action is required to reduce risk to ALARP. Requires routine monitoring and adaptive management in accordance with Environmenta Management Plan. Line management attention required.*
Low	*Risk is acceptable. Management by routine policies and procedures.*

Table 4: Risk rating matrix

Likelihood		Consequence				
		1	2	3	4	5
		Insignificant	Minor	Moderate	Major	Severe
5	Almost Certain	Medium	Medium	High	Very High	Very High
4	Likely	Medium	Medium	High	Very High	Very High
3	Possible	Low	Medium	Medium	High	Very High
2	Unlikely	Low	Low	Medium	Medium	High
1	Rare	Low	Low	Low	Medium	High

Table 5: Level of certainty categories

Level of Certainty	Description
High	Risk rating is based on testing, modelling or experiments. Baseline information is complete and an appropriate level of analysis has been undertaken. Proposed mitigation were recommended by technical specialists and are well developed with demonstrated efficacy. Minimal further work is required to adequately understand risk.
Medium	Risk rating is based on similar conditions being observed previously on a similar project and/ or in a similar environment. Baseline information has some gaps that are cons minor, and further work is unlikely to significantly alter the risk rating. While the efficacy of proposed mitigation measures has been demonstrated, some further work is req provide details of implementation prior to commencement of the Project.
Low	Risk rating is based on professional opinion. Limitations in baseline information require that some assumptions are made, which introduces a level of uncertainty. Effectiver proposed controls and/ or the likelihood of implementation cannot be reliably assessed at this point in time. A substantial amount of further work is required to adequately m prior to commencement of the Project.

Consequence or severity of Impacts	Score	Terrestrial Environmental Quality	Terrestrial Ecosystems	Coastal Processes	Marine Environmental Quality	Marine Ecosystems	Community and the Economy	Cultural and Heritage
Severe	5	Soil disturbance, erosion or contamination that is measurably and permanently impacting environmental values that rely on good soil quality throughout the NT	Extinction of terrestrial flora, vegetation or fauna	Permanent and widespread disturbance to the coastal processes within Darwin Harbour, such as tides and currents	Exceedance of baseline water quality that permanently alters the ecological functioning and/ or amenity of Arafura Sea	Complete loss of a benthic habitat or community type	Permanent impact that is felt by the majority of the NT population Unauthorised destruction of Aboriginal heritage item and/ or sites of world or national heritage significance	Unauthorised destruction of Aboriginal heritage item and/or sites of world or national heritage significance
Major	4	Soil disturbance, erosion or contamination that compromises regional environmental values that rely on good soil quality, and would be costly and technically challenging to remediate	Regional scale impacts on terrestrial flora, vegetation or fauna that compromise post-Project biodiversity and/ or ecological integrity	Permanent and localised disturbance to the coastal processes within Darwin Harbour, such as tides and currents	Exceedance of baseline Darwin Harbour water quality that continues for many years post-Project	Regional scale impacts on benthic habitat or community that compromise post-Project biodiversity and/ or ecological integrity	Impact that is felt by a majority of the regional population post-Project Unauthorised damage/ desecration of Aboriginal heritage item and/ or sites of regional heritage significance such that integrity is lost	Unauthorised damage / desecration of Aboriginal heritage item and/or sites of regional heritage significance such that integrity is lost
Moderate	3	Medium term soil disturbance, erosion or contamination in the vicinity of the Site that that alters soil characteristics but with no measurable impact to environmental values that rely on good soil quality, and can be remediated	Localised impact to flora, vegetation or fauna that alters the quality, abundance or distribution but with no measurable impact on biodiversity and/ or ecological integrity within months of the Project concluding	Permanent localised disturbance to the sediment transport within Darwin Harbour, temporary distrubance to tides and currents in Darwin Harbour	Localised exceedances of baseline marine water quality that occurs throughout operations but ceases within months of the Project concluding	Localised impact to benthic habitat or community that alters the quality, abundance or distribution but with no measurable impact on biodiversity and/ or ecological integrity within months of the Project concluding	Impact that is felt by a small number of people during the Project, ceasing within months of the Project concluding Unauthorised activity but with no physical impact to a heritage item, or minor physical impact such that integrity is not lost	Unauthorised acitvity but with no physical impact to a heritage item, or minor physical impact such that integrity is not lost
Minor	2	Short term soil disturbance, erosion or contamination in the vicinity of the Site that is reversible without significant remedial works	Impacts on flora, vegetation or fauna that do not measurably alter environmental values outside of the Site after construction concluding	Short term soil disturbance of coastal	Exceedances of baseline marine water quality at the Site ceasing within months of construction concluding	Impacts on benthic habitat or community that do not measurably alter environmental values outside of the Site after construction concluding	Impact felt by a small number of people at the Site during construction Unauthorised activity but with no physical impact to a heritage item	Unauthorised activity but with no physical impact to a heritage item
Insignificant	1	No measurable soil disturbance, erosion or contamination	No measurable impact on terrestrial flora, vegetation or fauna	No measurable impact on coastal processes	No significant change to baseline marine water quality	No measurable impact on benthic habitat or communities	No noticeable impact to stakeholder or community values No impact to Aboriginal Sacred or other heritage sites	No impact to Aboriginal sacred or other heritage sites

Theme	Environmental Aspect	Risk Pathway(s)	Potential Impacts	Likelihood	Potential Consequence	Inherent Risk Rating	Risk Management/Mitigation	Residual Likelihood	Residual Consequence	Residual Risk Rating	Level of Certainty	Project Phase
LAND	*Environmental Factor: Landforms*											
	Construction of landforms	Breakwaters (and to a lesser degree, causeway and boat ramp) are large structures that could be considered as new landforms	Significant change to the existing nearshore morphology at the site	Almost Certain (5)	Moderate (3)	Very High	> Design to minimise size of breakwaters, causeway and boat ramp limited to maintaining functionality and safety.	Possible (3)	Insignificant (1)	Low	Medium	Operations
	Changes to local shoreline	Construction of breakwaters disrupts the natural longshore drift of sediment down the adjacent coastline	> Disruption of net south migration of sediment > Increase in beach width north of the facilities, smothering the existing benthic communities > Erosion immediately south of the facilities due to blocking of usual sediment feed	Likely (4)	Moderate (3)	High	> Design to maximise natural bypassing mechanism > Understanding (investigation and modelling) of expected sedimentation volumes and locations > Allowance for ongoing sand bypassing that transfers sand past the marine facilities maintaining the net annual sediment transfer volumes	Possible (3)	Insignificant (1)	Low	Medium	Operations
	Environmental Factor: Terrestrial Environmental Quality											
	Exposure of contaminants during earthworks	> Exposure of potential Acid Sulfate Soils (ASS) > Exposure of potential metals or hydrocarbons > Exposure of asbestos containing soil	> Negative impacts to soil quality, stability and fertility > Acidic runoff discharging into Darwin Harbour > Invasion of acid-tolerant water plants and plankton species	Unlikely (2)	Major (4)	Medium	> Stop works if ASS is encountered, implement ASS management measures before works continue > Stop works if suspected asbestos material is encountered, implement asbestos removal management measures before works continue > Limit the area of exposed earth and period of exposure.	Rare (1)	Moderate (3)	Low	Medium	Construction
	Contaminants released during construction activities	Spills/leaks of petrol, oils, lubricants, hazardous materials, paints, thinners and litter	Adverse impact on soil quality within and adjacent to project footprint	Possible (3)	Moderate (3)	Medium	Contractor to develop a Hazardous Material Management Procedure including but not limited to the following: > Ensure stockpiles of bulk materials are well contained separated from exposed soils; > Training for personnel in implementation of safe work practices to minimise risks and impacts of spillage of fuels, chemicals and other contaminants; > Record and report all POL, chemical and hazardous substance spills; and > Ensure personnel have access to spill kits that contain an absorbent material and contaminated disposal sites.	Unlikely (2)	Minor (2)	Low	High	Construction
	Clearing areas of existing vegetation	Removal of vegetation and topsoil leaves area susceptible to erosion	> Loss of topsoil during overland flows > Eroded topsoil causing sedimentation in Darwin Harbour	Possible (3)	Minor (2)	Medium	> All clearing to be undertaken in accordance with Land Clearing Guidelines (DENR, 2019) > Cleared land outside of the direct footprint is to be rehabilitated using appropriate soils and vegetation	Rare (1)	Moderate (3)	Low	Medium	Construction
	Contaminants released during operations	> Chemical toilet leak to environment > Fly tipping	> Hazardous substances contaminating soils	Possible (3)	Moderate (3)	Medium	> Regular maintenance to be carried out on toilets > Adequate lighting and cctv to prevent illegal disposal	Unlikely (2)	Minor (2)	Low	Medium	Operations
	Environmental Factor: Terrestrial Ecosystems											
	Removal of vegetation due to land clearing of site for construction footprint and temporary work areas	Removal of native flora including: Eucalyptus spp over woodland over grassland	Loss of biodiversity on the Cox Peninsula	Unlikely (2)	Moderate (3)	Medium	> Land clearing only to be undertaken in approved areas and as per NT land clearing guidelines > Avoidance of significant and valuable vegetative communities > Any areas temporarily cleared are to be rehabilitated using native seed	Rare (1)	Moderate (3)	Low	Medium	Construction
	Clearing of potential fauna habitat for construction footprint and temporary work areas	Removal of fauna habitat	Injury of death of fauna or destruction of habitat	Unlikely (2)	Moderate (3)	Medium	> Land clearing only to be undertaken in approved areas and as per NT land clearing guidelines > Pre-clearance trapping and relocation of identified fauna	Rare (1)	Moderate (3)	Low	Medium	Construction
	Noise, vibrations and lighting at Mandorah due to construction activities	Noise, vibrations and lighting impacting fauna	Loss of habitable area for fauna	Unlikely (2)	Minor (2)	Low	> Contractor to develop a Noise Management Plan > Lighting only focused on works, not surrounding habitat, light shields if needed	Rare (1)	Minor (2)	Low	Medium	Construction
	Fire ignition due to construction activities	Uncontrolled fire	Loss or damage to terrestrial ecosystems	Possible (3)	Minor (2)	Medium	Contractor to develop a Fire Management Plan	Unlikely (2)	Minor (2)	Low	Medium	Construction
	Dust generation due to construction activities	Generated dust settling on terrestrial ecosystems	Adverse health impacts to local flora if dust settles on foliage	Likely (4)	Minor (2)	Medium	Contractor to develop a Dust Management Plan including but not limited to the following: > Watering of temporary roads and stockpile areas; > Watering down affected vegetation; > Use of dust suppression equipment; and > Speed limits within on site roads.	Unlikely (2)	Minor (2)	Low	Medium	Construction

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LAND	Vehicular movement into site carrying weed species	Introduction of weeds to site	Loss of native biodiversity on the Cox Peninsula due to pressure from introduced species	Possible (3)	Moderate (3)	**Medium**	Contractor to develop a Weed Management Plan including but not limited to the following: > Review and relevant weed mapping and signpost areas of significant weed infestation; > Vehicle washdown stations; and > Routine monitoring of infestations and controls.	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Application of water as a dust control measure	Contaminated water from water storage facilities or dust suppression measures adversely impacting vegetation	Loss of vegetation if contaminants leach into soils	Unlikely (2)	Minor (2)	**Low**	> Water storage facilities to be located away from vegetation > Water used for dust suppression shall be of suitable quality	Rare (1)	Minor (2)	**Low**	Medium	Construction
	Increased vehicle traffic during construction activities	Increased likelihood of vehicle strike	Death or injury to fauna	Possible (3)	Moderate (3)	**Medium**	> Training for all drivers and operators on local fauna most likely to be encountered > Suitable speed limits into and around site	Rare (1)	Moderate (3)	**Low**	Medium	Construction
	Increased vehicle traffic during operations	Increased likelihood of vehicle strike	Death or injury to fauna	Possible (3)	Moderate (3)	**Medium**	> Signage to watch out for wildlife > Suitable speed limits into and around site	Rare (1)	Moderate (3)	**Low**	Medium	Operations
	Asbestos contamination encountered on Lot 50	Expose asbestos fibres to ecosystems	Adverse health impacts to local fauna	Unlikely (2)	Minor (2)	**Low**	> If asbestos is encountered when clearing Lot 50, material is to be removed and disposed of by trained personnel	Rare (1)	Minor (2)	**Low**	Medium	Construction
	Increase in noise due to increased patronage	Noise impacting fauna	Loss of habitable area for fauna	Possible (3)	Minor (2)	**Medium**	> Fencing/pathways designed to keep pedestrians away from bush	Rare (1)	Minor (2)	**Low**	Medium	Operational
	Increase in litter due to increased patronage	Fauna mistaking little for food source	Death or injury to fauna	Possible (3)	Minor (2)	**Medium**	> Adequate number of well lit bins provided	Rare (1)	Moderate (3)	**Low**	Medium	Operational
	Lighting at extended car park and ferry terminal	Light impacting fauna	Loss of habitable area for fauna	Possible (3)	Minor (2)	**Medium**	> Lights to focus on car park and ferry terminal > Minimise light intrusion into surrounding environment	Rare (1)	Minor (2)	**Low**	Medium	Operational
WATER	*Environmental Factor: Hydrological Processes*											
	Construction of expanded carpark and ferry terminal adding to the impermeable surfaces	Increase in the quantity of surface water runoff	Localised flooding	Rare (1)	Insignificant (1)	**Low**	No treatment needed. Runoff flows directly into Darwin Harbour in pre- and post-development scenarios	Rare (1)	Insignificant (1)	**Low**	Medium	Construction and Operations
	Environmental Factor: Inland Water Environmental Quality											
	Construction activities including earthworks and building works	Construction materials, sediment and / or contaminants entering surface water features or groundwater	No notable surface water features in proximity to works, runoff to be discharged directly to Darwin Harbour and not expected to infiltrate into groundwater	Rare (1)	Insignificant (1)	**Low**	No treatment needed. Runoff flows directly into Darwin Harbour in pre- and post-development scenarios	Rare (1)	Insignificant (1)	**Low**	High	Construction
	Environmental Factor: Aquatic Ecosystems											
	N / A											
	Environmental Factor: Coastal Processes											
	Changes to local coastal processes	> Installation of breakwaters will interrupt nearshore hydrodynamics, wave and sediment transport, altering erosion > Localised changes to nearshore hydrodynamic wave climate due to installation of the harbour	> Changes to local hydrodynamics and wave climate may impact marine ecosystems, flora and fauna.	Possible (3)	Minor (2)	**Medium**	Intended effect of facility. Design to minimise footprint and interruption of coastal processes outside of harbour.	Unlikely (2)	Minor (2)	**Low**	Medium	Operations
	Environmental Factor: Marine Environmental Quality											
	Disturbance of marine sediments (fines)	Dredging actions, spoil transfer and disposal, rock placement and piling	> Elevated suspended sediment concentration in marine water > Sedimentation in marine environment > Potential impact to benthic communities and other biota	Likely (4)	Moderate (3)	**High**	> Model dredging and disposal actions to properly understand dredge plume dispersion > Gain an understanding of sensitive marine environmental receptors and their tolerance > Control actions to maintain water quality below appropriate thresholds (i.e. altering dredging activities [e.g. volumes, locations] to limit sediment resuspension, dredging only on certain tides etc.)	Unlikely (2)	Minor (2)	**Low**	High	Construction

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SEA	Release of contaminants from marine sediments	As per actions above - predominantly dredging and disposal	> Toxic contaminants made available to marine ecosystem for biological uptake and bioaccumulation > Potential impact to ecosystem health	Possible (3)	Moderate (3)	**Medium**	> Characterise material to be disturbed to understand locations and levels of contamination > Assess levels of contamination against appropriate thresholds, given the nature of the receiving environment > Isolate, remove and confine areas where contamination is potentially toxic to the marine environment	Unlikely (2)	Minor (2)	**Low**	High	Construction
	Introduction of contaminants/pollution to marine environment	Construction activities - inappropriate waste disposal, accidental oil/chemical spill	> Toxic contaminants introduced to marine ecosystem for biological uptake and bioaccumulation > Potential impact to ecosystem health	Possible (3)	Moderate (3)	**Medium**	> Inspection and audit of vessels and plant, controlled via DSDMP and CEMP > Reporting and response protocols should a spill occur - oil/chemical spill response etc.	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Release of sediments from land	Disturbance/stockpiling of material on land, lost due to run-off, wind etc.	> Elevated suspended sediment concentration in marine water > Sedimentation in marine environment > Potential impact to benthic communities and other biota	Possible (3)	Minor (2)	**Medium**	> Controlled by CEMP > Appropriate stockpiling technique and location > Prevention by bunding, erosion control etc. > Response plan for release of material	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Disturbance of marine sediments (fines)	Rock placement and piling	> Elevated suspended sediment concentration in marine water > Sedimentation in marine environment > Potential impact to benthic communities and other biota	Almost Certain (5)	Minor (2)	**Medium**	> Model dredging and disposal actions to properly understand dredge plume dispersion > Gain an understanding of background conditions > Gain an understanding of sensitive marine environmental receptors and their tolerance > Control actions to maintain water quality below appropriate thresholds	Possible (3)	Insignificant (1)	**Low**	High	Construction
	Release of contaminants from marine sediments	Rock placement and piling	> Toxic contaminants made available to marine ecosystem for biological uptake and bioaccumulation > Potential impact to ecosystem health	Possible (3)	Moderate (3)	**Medium**	> Characterise material to be disturbed to understand locations and levels of contamination > Assess levels of contamination against appropriate thresholds, given the nature of the receiving environment > Isolate, remove and confine areas where contamination is potentially toxic to the marine environment	Possible (3)	Insignificant (1)	**Low**	High	Construction
	Introduction of contaminants/pollution to marine environment	Construction activities - inappropriate waste disposal, accidental oil/chemical spill	> Toxic contaminants introduced to marine ecosystem for biological uptake and bioaccumulation > Potential impact to ecosystem health	Possible (3)	Moderate (3)	**Medium**	> Inspection and audit of vessels and plant, controlled via DSDMP and CEMP > Reporting and response protocols should a spill occur - oil/chemical spill response etc.	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Release of sediments from land	Disturbance/stockpiling of material on land, lost due to run-off, wind etc.	> Elevated suspended sediment concentration in marine water > Sedimentation in marine environment > Potential impact to benthic communities and other biota	Possible (3)	Minor (2)	**Medium**	> Controlled by CEMP > Appropriate stockpiling technique and location > Prevention by bunding, erosion control etc. > Response plan for release of material	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Siltation of harbour	Proposed breakwaters lower velocities in the harbour and allow the settlement of suspended particles	> Smothering of seabed with fine particles impacting marine flora / fauna	Almost Certain (5)	Minor (2)	**Medium**	> Siltation modelling undertaken to estimate rates of accumulation > Benthic habitat has already been identified and removed as part of initial dredging campaign	Unlikely (2)	Minor (2)	**Low**	High	Operations
	Introduction of contaminants/pollution to marine environment	Boat ramp use - inappropriate waste disposal, accidental oil/chemical spill	> Toxic contaminants introduced to marine ecosystem for biological uptake and bioaccumulation > Potential impact to ecosystem health	Possible (3)	Moderate (3)	**Medium**	> Inspection and audit of vessels and plant, controlled via DSDMP and CMP > Reporting and response protocols should a spill occur - oil/chemical spill response etc.	Unlikely (2)	Minor (2)	**Low**	Medium	Operations
	Environmental Factor: Marine Ecosystems											
	Dredger/vessel movement	> Vessel strike of marine fauna such as dugongs, turtle, dolphins > Underwater noise impacts due to dredging and piling > Direct impact to seabed - marine ecosystems	> Vessel strike of marine fauna > Injury to marine fauna > Damage to ecosystems	Possible (3)	Moderate (3)	**Medium**	> Vessel movement controls, speed limits, no-go zones > Marine fauna observation and avoidance > Piling controls (soft start) to allow fauna to leave area	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Dredging	Direct removal of benthic communities and habitat	> Permanent removal/destruction of BCH such as seagrass and coral	Almost Certain (5)	Major (4)	**Very High**	> Characterise BCH in direct impact footprint > Minimise footprint and avoid sensitive receptors/important BCH where possible	Likely (4)	Moderate (3)	**High**	High	Construction
	Dredging	Elevated suspended sediment concentration (turbidity) in vicinity of project	> Impact to sensitive BCH such as coral and seagrass (blocking of light) > Impact to marine fauna due to ingestion/dermal contact	Likely (4)	Moderate (3)	**High**	> Characterise BCH in vicinity of project > Characterise dredge plume dispersion to understand changes to water quality with respect to tolerance of BCH/fauna > Implement dredging controls and reactive monitoring to maintain levels below thresholds	Unlikely (2)	Minor (2)	**Low**	Medium	Construction

Theme	Environmental Aspect	Risk Pathway(s)	Potential Impacts	Likelihood	Potential Consequence	Inherent Risk Rating	Risk Management/Mitigation	Residual Likelihood	Residual Consequence	Residual Risk Rating	Level of Certainty	Project Phase
SEA	Dredging	Sedimentation of seabed in vicinity of project	> Impact to sensitive BCH such as coral and seagrass (smothering)	Likely (4)	Moderate (3)	**High**	> Characterise dredge plume dispersion to understand sedimentation levels with respect to tolerance of BCH/fauna > Implement dredging controls and reactive monitoring to	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Dredge spoil disposal	Elevated suspended sediment concentration (turbidity) at disposal site	> Impact to sensitive BCH such as coral and seagrass (blocking of light) > Impact to marine fauna due to ingestion/dermal contact	Likely (4)	Moderate (3)	**High**	> Select disposal area for optimum dispersion and minimum sensitive receptors > Characterise disposal dispersion to understand changes to water quality with respect to tolerance of BCH/fauna > Implement dredging disposal controls and reactive monitoring to maintain levels below thresholds	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Dredge spoil disposal	Sedimentation of seabed at disposal site	> Impact to sensitive BCH such as coral and seagrass (smothering)	Likely (4)	Moderate (3)	**High**	> Select disposal area for optimum dispersion and minimum sensitive receptors > Characterise disposal dispersion to understand sedimentation levels with respect to tolerance of BCH/fauna > Implement dredging controls and reactive monitoring to maintain levels below thresholds	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Dredger/vessel movement	> Vessel strike of marine fauna such as dugongs, turtle, dolphins > Underwater noise impacts due to dredging and piling > Direct impact to seabed - marine ecosystems	> Vessel strike of marine fauna > Injury to marine fauna > Damage to ecosystems	Possible (3)	Moderate (3)	**Medium**	> Vessel movement controls, speed limits, no-go zones > Marine fauna observation and avoidance > Piling controls (soft start) to allow fauna to leave area	Unlikely (2)	Minor (2)	**Low**	Medium	Operations
	Construction activities including earthworks, building works and transport to site	Construction materials and /or general litter entering marine environment	> Ingestion/injury of waste by marine fauna > Damage to marine ecosystems	Possible (3)	Moderate (3)	**Medium**	> Control of waste as per CEMP > Reporting and response to pollution events > Control of construction access/activities	Rare (1)	Moderate (3)	**Low**	Medium	Construction
	Rock placement and piling	Direct removal of benthic communities and habitat	> Permanent removal/destruction of BCH such as seagrass and coral	Almost Certain (5)	Moderate (3)	**High**	> Characterise BCH in direct impact footprint > Minimise footprint and avoid sensitive receptors/important BCH where possible	Likely (4)	Minor (2)	**Medium**	High	Construction
	Rock placement and piling	Elevated suspended sediment concentration (turbidity) in vicinity of project	> Impact to sensitive BCH such as coral and seagrass (blocking of light) > Impact to marine fauna due to ingestion/dermal contact	Likely (4)	Moderate (3)	**High**	> Characterise BCH in vicinity of project > Characterise dredge plume dispersion to understand changes to water quality with respect to tolerance of BCH/fauna > Implement dredging controls and reactive monitoring to maintain levels below thresholds	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Rock placement and piling	Sedimentation of seabed in vicinity of project	> Impact to sensitive BCH such as coral and seagrass (smothering)	Likely (4)	Moderate (3)	**High**	> Characterise BCH in vicinity of project > Characterise dredge plume dispersion to understand sedimentation levels with respect to tolerance of BCH/fauna > Implement dredging controls and reactive monitoring to maintain levels below thresholds	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
AIR	*Environmental Factor: Air Quality*											
	Dust generated by construction activities including earthworks, building works and transport to site.	Decrease in local air quality	Impacts to local fauna and human health through inhalation of particles	Almost Certain (5)	Minor (2)	**Medium**	Integration of dust management measures in construction management plan including: > Watering of temporary roads and stockpile areas; > Use of dust suppression equipment; and > Speed limits on site roads.	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Mobile plant at site and trucking of materials to site	Carbon dioxide emissions	Impacts to local fauna and human health through inhalation of emissions	Almost Certain (5)	Minor (2)	**Medium**	Integration of air quality measures in construction management plan including: > Isolating plant from workers where possible; and > PPE	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Environmental Factor: Atmospheric Processes											
	Energy usage during construction of facilities	Direct emissions from mobile plant, dredger, generators etc.	Cumulative impact of carbon emissions to global climate change	Likely (4)	Insignificant (1)	**Medium**	> Effeciency in design to minimise quantity of rock needed in breakwaters, causeway and boat ramp; > Materials should be transported to site with the minimum number of vehicles required; and > Reuse of existing building onsite for ferry terminal to reduce new materials required;	Possible (3)	Insignificant (1)	**Low**	Medium	Construction
	Future power usage at the ferry terminal	Indirect emissions from use of electricity	Cumulative impact of carbon emissions to global climate change	Likely (4)	Insignificant (1)	**Medium**	Integration of electricity reduction measures in construction management plan including: > Energy saving devices; and > Consideration of alternative energy sources where possible	Possible (3)	Insignificant (1)	**Low**	Medium	Operations
	Environmental Factor: Community and Economy											

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PEOPLE	Construction activities including earthworks and building works	Noise generated	Decrease in liveability for nearby residents, ferry users or tourists	Possible (3)	Minor (2)	**Medium**	Integrate noise management measures within the construction management plan	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Trucking in of construction materials	Increase in traffic along Cox Peninsula Road and Charles Point Road	Traffic delays and increased risk of accident for local residents of the Cox Peninsula	Likely (4)	Minor (2)	**Medium**	> Traffic management plan to be implemented to manage any disruptions to local traffic > Staggering of heavy vehicles throughout the day to minimise congestion	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Construction activities including earthworks and building works	Loss of access to existing carpark	Decrease in liveability for users of existing boat ramp or carpark	Almost Certain (5)	Minor (2)	**Medium**	> Stakeholder engagement with current uses of facilities to inform of access issues during construction	Almost Certain (5)	Minor (2)	**Medium**	High	Construction
	Environmental Factor: Culture & Heritage											
	Aboriginal sacred sites	Construction activities disturbing or destroying Aboriginal Sacred Sites south of the works	Permanent or temporary damage or contamination of Sites	Possible (3)	Moderate (3)	**Medium**	> Response and reporting procedures should a site or obje	Rare (1)	Moderate (3)	**Low**	High	Construction
	Cultural heritage sites / artefacts	Dredging, disposal and associated actions	Disturbance of known or unknown cultural heritage areas during dredging	Possible (3)	Moderate (3)	**Medium**	> Gain understanding of cultural heritage of the site and establish no work areas around heritage sites > Response and reporting procedures should a site or object be encountered	Unlikely (2)	Moderate (3)	**Medium**	High	Construction
	Increased patronage in the area due to upgraded marine facilities	Disturbance or destruction of Aboriginal Sacred Sites south of the works	Permanent or temporary damage or contamination of Sites	Unlikely (2)	Moderate (3)	**Medium**	> Signage to alert the public of private driveways and land to the south of the carpark	Rare (1)	Moderate (3)	**Low**	Medium	Operations
	Environmental Factor: Human Health											
	Asbestos contamination encountered on Lot 50	Inhalation of airborne asbestos	Adverse health impacts to site workers and users of facility	Possible (3)	Moderate (3)	**Medium**	> Staff to have sufficient training in handling asbestos > Appropriate PPE provided to all staff working with, or suspected to be working with asbestos	Rare (1)	Moderate (3)	**Low**	Medium	Construction
	Personnel working outside	Exposure	> Sunburn and heat stress > Injury due to cyclone or storm whilst on site	Likely (4)	Moderate (3)	**High**	> Staff to have appropriate PPE (long sleeved shirt, pants, hats, sunscreen etc.) to minimise risk of sunburn and heat stress > First aid kits located around site for initial response > Development of a cyclone response plan and regular monitoring of local news channels	Possible (3)	Moderate (3)	**Medium**	Medium	Construction
	Personnel working outside	Biting insects, snakes, crocodiles	> Injury due to bite/attack > Disease transmitted by biting insect	Possible (3)	Moderate (3)	**Medium**	> Staff to have appropriate PPE (long sleeved shirt, pants, repellent etc.) to minimise risk of biting insects > Staff to have sufficient training on the identification of reptiles likely to be encountered on site > If a problem crocodile is encountered it should be reported to (08) 8983 2475 > First aid kits located around worksite to provide initial response to incidents	Unlikely (2)	Moderate (3)	**Medium**	Medium	Construction
	Construction activities including earthworks and building works	Open fire ignited by construction activities	> Minor, serious or fatal burns to personnel > Smoke inhalation	Unlikely (2)	Moderate (3)	**Medium**	> Staff to have sufficient training in fire management > Fire extinguishers located around site > Smoking and hot works in permitted areas only	Rare (1)	Major (4)	**Medium**	Medium	Construction
	Proximity to vegetation	Exposure to bushfire	> Minor, serious or fatal burns to personnel > Smoke inhalation	Unlikely (2)	Major (4)	**Medium**	> Creation of a bushfire evacuation plan > Staff to have sufficient training in fire management > Regular monitoring of local news channels	Rare (1)	Moderate (3)	**Low**	Medium	Construction
	Public accessing breakwaters and / or jetty during construction	Slip, trip or fall into water above head height	> Accidental entry to deeper water leading to drowning hazard	Unlikely (2)	Major (4)	**Medium**	> Fencing and signage to prevent public access to breakwater and jetty	Rare (1)	Major (4)	**Medium**	Medium	Construction
	Dredging and disposal of contaminated sediments	> Disturbance/release during extraction, transport and placement stages > Release to the marine environment following placement, then bioaccumulation and biomagnification in the food chain	> Dermal contact > Inhalation > Ingestion	Possible (3)	Moderate (3)	**Medium**	See management measures relating to marine environmental quality. These apply to risk to humans also, with risk to human health considered a lower risk.	Rare (1)	Moderate (3)	**Low**	Medium	Construction
	Dredging and disposal of fine sediments	> Disturbance/release during extraction, transport and placement stages	> Dermal contact > Inhalation	Possible (3)	Moderate (3)	**Medium**	> Sediments to remain wet or be contained as part of disposal > Segregation of work area and material from general public	Rare (1)	Moderate (3)	**Low**	Medium	Construction
	Public accessing breakwaters and / or jetty during construction	Slip, trip or fall into water above head height	> Accidental entry to deeper water leading to drowning hazard	Unlikely (2)	Major (4)	**Medium**	> Fencing and signage to prevent public access to breakwater and jetty	Rare (1)	Major (4)	**Medium**	Medium	Operations

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	Emissions from construction plant	Exposure of workers to emissions	Irritation to workers	Possible (3)	Minor (2)	**Medium**	> Avoiding idling of construction plant > Isolating workers from fumes > PPE such as masks and faceshields > Alternative power source	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Public access to breakwaters and jetty	Slip, trip or fall into water above head height	> Accidental entry to deeper water leading to drowning hazard	Possible (3)	Major (4)	**High**	> Signage to notify public of dangers and that the breakwaters should not be accessed during dangerous conditions	Unlikely (2)	Major (4)	**Medium**	Medium	Operations