Mandorah Marine Facilities: Supplementary Environmental Report

Prepared for DEPARTMENT OF INFRASTRUCTURE, PLANNING AND LOGISTICS

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Revision schedule

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Quality statement

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Abbreviations

Enter Abbreviation	Enter Full Name
AAPA	Aboriginal Areas Protection Authority
BCH	Benthic Community Habitat
CEMP	Construction Environmental Management Plan
CMC	Department of the Chief Minister and Cabinet
CPMMP	Coastal Processes Monitoring and Management Plan
CRS	Chromium Reducible Sulfur
DEPWS	Department of Environment, Parks and Water Security
DIPL	Department of Infrastructure, Planning and Logistics
DLI	Daily Light Integral
DSDMP	Dredge and Spoil Disposal Management Plan
EIA	Environmental Impact Assessment
EP Act	Environmental Protection Act
EPBC Act	Environment Protection and Biodiversity Conservation Act
ERA	Emergency Response Area
MCA	Multi-criteria Assessment
NT EPA	Northern Territory Environmental Protection Authority
NTFRS	Northern Territory Fire and Rescue Service's
NTG	Northern Territory Government
NTPFES	Northern Territory Police, Fire and Emergency Services
NTU	Nephelometric Turbidity Units
OBIA	Object-Based Image Analysis
PAR	Photosynthetically Active Radiation
PASS	Potential Acid Sulfate Soils
REC	Remote Engagement and Coordination
RMSD	Root-Mean-Square-Deviation
RWAs	Restricted Work Areas
SER	Supplementary Environmental Report
SSC	Suspended Sediment Concentrations

Enter Abbreviation	Enter Full Name
SVP	Sound Velocity Probe
TBT	Tributyltin
TSS	Total Suspended Solids
WAMSI	Western Australian Marine Science Institution
WHS	Work Health and Safety
ZoHI	Zone of High Impact
ZoI	Zone of Influence
ZoMI	Zone of Moderate Impact

1 Background & Purpose

The Northern Territory Government (NTG), Department of Infrastructure, Planning and Logistics (DIPL), proposes to develop marine facilities at Mandorah (the Proposal), located near the eastern tip of the Cox Peninsula, approximately 6 km west of Darwin (the Proposal). NTG has identified the need to develop a safer, Disability Discrimination Act 1992 compliant and more weather-resistant ferry berthing facility, to improve transport connectivity between Cox Peninsula and Darwin. The proposal 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. DIPL, as the proponent for the Mandorah New Marine Facilities, is seeking the endorsement of the Northern Territory Environment Protection Agency (NT EPA) for the Proposal, which is anticipated to improve transport connectivity and disability access between Cox Peninsula and Darwin city.

The Proposal was referred to the NT EPA on the 23/03/2022 in accordance with the *Environmental Protection Regulations 2020* (EP regulations). Following the public consultation period, the NT EPA deemed the Proposal would be assessed in accordance with section 55 of the *Environmental Protection Act 2019* (EP Act) and regulation 57(2)(b)(i) of the EP Regulations, by way of a supplementary environmental report (SER) pursuant to regulation 57(2)(b)(ii) (this document).

The NT EPA deemed the Proposal has the potential to significantly impact three themes and six environmental factors (**Table 2-1**). For each of the factors, the EPA has directed DIPL to provide supplementary information (SER) to inform their decision on whether to grant environmental approval.

Table 1-1: Statement of Reasons (sensu NT EPA, 2022a).

Theme	Factors (with Statements of Reasons)
Land	• **Landforms** – Two large rock armoured breakwaters will be constructed to form a safe harbour protecting ferry berthing and new passenger boarding infrastructure. The construction of these structures is a physical change to the terrestrial landform, and may alter nearby coastal landforms due to their effect on coastal processes. The long-term evolution of the shoreline and foreshore could be impacted by altered rates and patterns of erosion and accretion
	• **Terrestrial ecosystems** – A temporary 30,000 m^2 area for stockpiling up to 70,000 m3 of dredge spoil will be utilised. Saline run-off from dredge spoil has the potential to contaminate soil in the storage area and surrounding environment.
Sea	• **Coastal processes** – The installation of two large rock armoured breakwaters will interrupt nearshore hydrodynamics, waves, and sediment transport, altering erosion and accretion patterns leading to ongoing physical impacts along the coastline.
	• **Marine environmental quality** – The marine environment including water quality and biota will be impacted by construction of breakwaters, dredging and dredge spoil disposal. There is currently insufficient information to assess cumulative impacts of the proposal's construction and dredging activities, with other activities in Darwin Harbour.
	• **Marine ecosystems** – Changes to longshore drift and sediment transport has the potential to have a significant impact on sensitive receptors and benthic habitats. Additionally, impacts from changes in turbidity/total suspended solids can adversely impact sensitive receptors such as benthic primary producer habitats, corals and seagrass habitats, and can result in potential loss of ecosystem function and marine fauna.
People	• **Culture and heritage** – There is potential for significant impacts to known and unknown Aboriginal sacred sites, heritage sites and objects directly during construction, dredging and maintenance activities, as well as indirectly through altered coastal processes.

Stantec Pty Ltd (Stantec) has been engaged by DIPL to prepare this SER in accordance with the Environment Protection Act 2019 (EP Act) and the Environment Protection Regulations 2020 (EP regulations). The intent of the SER is to address each of the factors identified by the EPA to provide confidence to the Minister that the Proposal is manageable under the EPA's environmental management framework.

At the request of the NT EPA, the details contained herein (a) provide more detail around the approaches to modelling (b) describe the results of the additional studies undertaken in fulfilment of the SER, (c) detail the approach to developing locally relevant thresholds and triggers and (d) describe how the Proposal will be monitored and managed to achieve the NT EPA's environmental objectives for each of the relevant factors. Details relating to (d) are reflected in the revised Construction Environmental Management Plan (CEMP), Dredging and Spoil Disposal Management Plan (DSDMP) and the newly developed Coastal Processes Monitoring and Management Plan (CPMMP).

2 Proposal Description

Key Proposal characteristics are detailed below and summarised in **Table 2-1** and **Figure 2-1**.

- 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, as well as safe navigation of recreational vessels to and from the boat ramp;
- 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 causeway inside the harbour to allow passengers including persons with disabilities to access the ferry from land;
- 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 maneuvering for the new boat ramp, as well as allow additional trailer parking.
- The dredging and disposal of between 85,000 to 100,000 m^3 of unconsolidated sand and rock, in two stages: (1): Between 15,000 – 30,000 m^3 of unconsolidated marine sediments, and (2), approximately 70,000 m^3 of rock material.

Table 2-1 Summary of Key Proposal characteristics.

Project Element	Component	Approximate area / volume / quantity
Landside (generally above high tide)		
Pavement (additional to existing)	Paths	~600 m^2
	Carparking and Roads	~1945 m^2
Terminal Building	Structure (Existing building repurposed or reconstructed)	~150 m^2
	Rainwater tanks	< 30,000 L
	Toilet block	< 40 m^2
Earthworks	Boat ramp connection	≈ 100 m^3
	Causeway connection	≈ 100 m^3
Stormwater Drainage	Pits	~4
	Pipe network	~115 m
Landscaped areas	Minor native	~150 m2
Construction disturbance areas	Laydown and transit	~30,000 m2
Total new terrestrial infrastructure footprint		**3,000 m^2**
Marine (generally below high tide)		
Main breakwater	Imported rock material	45,000 m^3
	Reused dredge material	19,700 m^3
	Footprint	10,800 m^2
Lee breakwater	Imported rock material	8,500 m^3

Project Element	Component	Approximate area / volume / quantity
	Reused dredge material	8,200 m^3
	Footprint	4,400 m^2
Boat ramp	Concrete pavement	16 m^3
	Imported rock material	170 m^3
	Reused dredge material	760 m^3
	Footprint	650 m^2
Maritime facilities	Pontoon	500 m^2
	Gangway	125 m^2
	Causeway	400 m^2
	Mechanical lift	1
	Piles	Up to 10
Dredging	Unconsolidated sediment	15,000-30,000 m^3
	Rock	70,000 m^3 (note volumes to be reused above)
	Dredge footprint (excluding breakwater footprint)	20,200 m^2
Total new marine facilities footprint		37,000 m^2

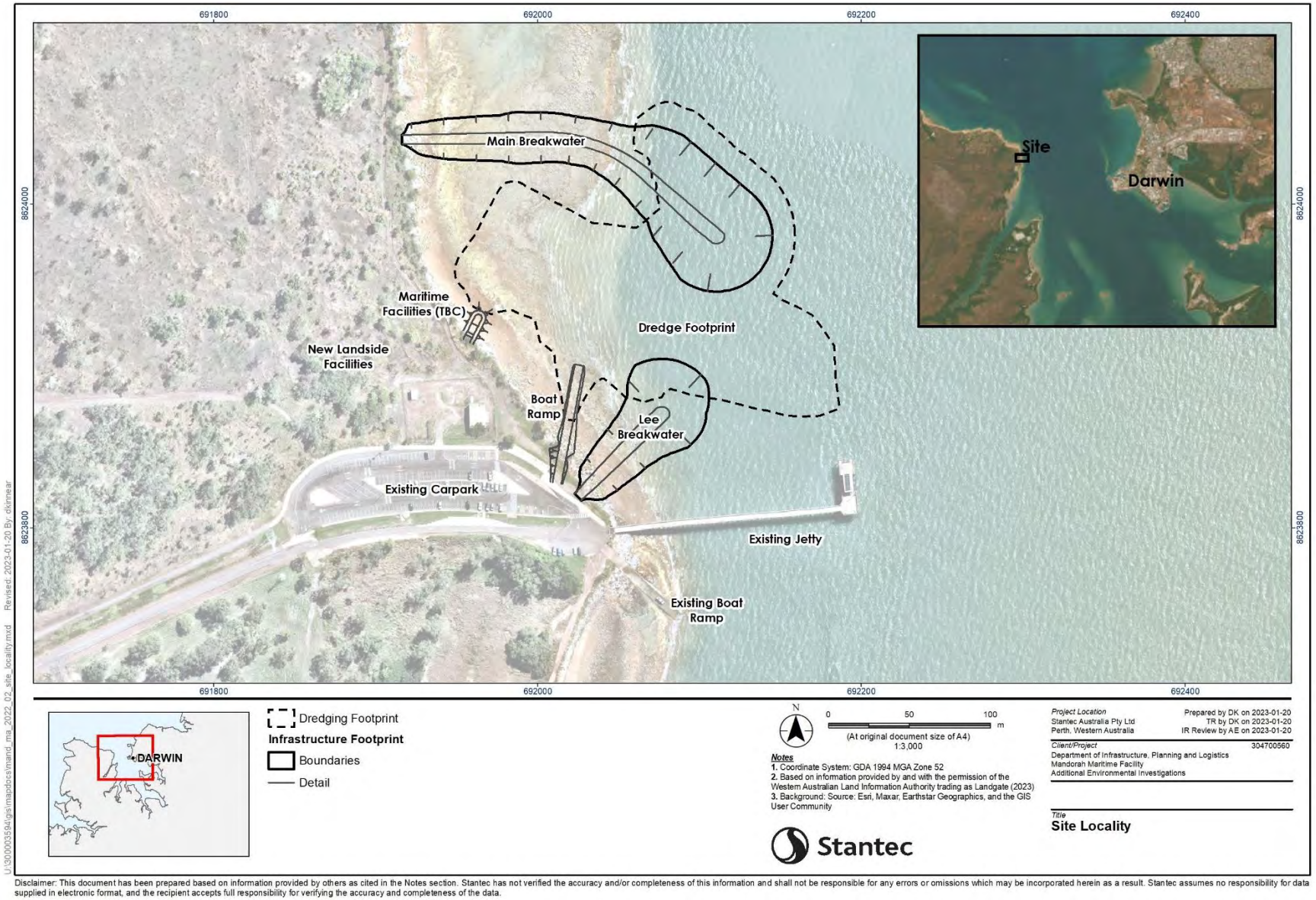

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Figure 2-1 Existing and proposed marine facilities at Mandorah.

3 Alternative Proposals

The EP Act requires consideration of alternative, less environmentally damaging approaches, methods and technologies. DIPL considered several construction options during the planning process. A key element of the planning process was to develop a cost effective and practical facility, while meeting the requirements of the Disability Discrimination Act 1992 and the EP Act (2019). The approaches and outcomes of the planning processes, including the extent of alternative options considered, are outlines in the following reports.

- Mandorah Jetty and Boat Ramp – Assessment and Upgrade Concept Study (Jacobs, 2016)
- Mandorah Jetty and Boat Ramp Engineering Studies – Coastal Modelling and Preliminary Design Report (Jacobs, 2019).
- Concept Design Options Report (Cardno, 2020).

Given the requirement for dredging, due consideration was also given to the selection of a suitable disposal site. The final disposal site was chosen from a short list of eight potential sites, both on- and off-shore, using an objective Multi-criteria Assessment (MCA). The MCA included the following categories:

- NT EPA's Environmental Factors;
- Technical Feasibility;
- Financial Feasibility;
- Hazards;
- Dispersion Performance; and
- Legislative Impacts.

The outcomes of the MCA are detailed in **Section 8.3.1** and **Appendix F**.

4 Stakeholder Engagement

Throughout the Proposal's planning and development, extensive ongoing consultations were undertaken with the local community and relevant stakeholders. Formal consultations have occurred in line with the Stakeholder Engagement Plan (Cardno, 2019) and have been documented in the original environmental referral (**Section 7**).

Table 4-1 outlines the stakeholder engagement conducted in response to submissions received on the referral, including engagement with persons or entities who have made the submissions, and any engagement undertaken following any direction given to include additional information in the SER.

Table 4-1: DIPL Key Stakeholder Consultation Activities

Date	Stakeholder	Details of Engagement
17/05/2022 - 18/05/2022	Aboriginal Areas Protection Authority (AAPA)	Email correspondence with AAPA to provide response to the comments and queries raised in the referral. Confirming that coastal erosion will be monitored and managed to avoid any contact with restricted works areas. Details of this management included in the newly completed CPMMP (**Appendix D**).
16/06/2022	NT EPA	Meeting to discuss feedback received for the referral and the most appropriate actions with Lisa Bradley, Kylie Fitzpatrick and Roland Lee (NT EPA). Details information was subsequently requested via a Direction to Provide Additional Information in the SER.
11/07/2022	DEPWS – Flora and Fauna Division	Meeting to discuss feedback to referral with Neil Smit - 11 July 2022 Flora and Fauna Division, DEPWS. Key outcomes were: • A request for more detailed BCH mapping within modelled ZoI at selected disposal site through additional real-time BCH data collection and detailed mapping; • A request for additional modelling outputs to better understand the cumulative effects of the various dredging activities; • A request for additional information on trigger values and rational for their use in modelled ZoI; and • A request for further information on the plan for the rehabilitation and closure of disturbances that includes the closure objectives, and criteria to measure success of rehabilitation, supported with appropriate evidence.
25/08/2022	DEPWS – Flora and Fauna Division	Tech Memo - Mandorah Marine Facilities - Disposal Site Memo - 25 August 2022 Flora and Fauna Division, Department of Environment, Parks and Water Security & NT EPA. Detailed information provided on the outcome of the MCA of potential disposal sites and justification for the selected site.
02/09/2022	DEPWS – Flora and Fauna Division	Tech Memo - Mandorah Marine Facilities - Construction Program and Proposed Marine Numerical Modelling– 02 September 2022 Flora and Fauna Division, DEPWS & NT EPA Detailed information provided on the additional hydrodynamic modelling regimes that were to be completed for the project.

Date	Stakeholder	Details of Engagement
25/10/2022 - 27/10/2022	DEPWS – Rangelands Division	Email correspondence with DEPWS to provide response to the comments and queries raised in the referral. Confirming the suggested updates to the Terrestrial Environmental Management Plan (**Appendix E**) and CEMP (**Appendix C**) would be actioned.
01/11/2022	NT Worksafe	Email correspondence with NT Worksafe to provide response to the comments and queries raised in the referral. Confirming the following action: Include NT *WHS (National Uniform Legislation) Act 2011* and its regulations in the legislation references, also noting any notification requirements. Anthony Waite (NT Worksafe).
01/11/2022	(NT PFES)	Email correspondence with NT PFES to provide response to the comments and queries raised in the referral. Confirming the following action: The contractor is to consider this as part of their Work Health Safety Management Plan and Emergency response procedures. Also, The WHS plan and Emergency procedures will be reviewed by the DIPL Compliance team and audited as part of the project. They have confirmed this action is acceptable.
01/11/2022	CMC	Email correspondence with CMC to provide response to the comments and queries raised in the referral. Confirming the following actions: · Include item on risk assessment on potential impact on commercial and recreational fishing as a result of the project. · Include clause and risk assessment on impact on Darwin Port Shipping channel during construction · Include clause and risk assessment on Aboriginal employment which is included in tender documents Risk assessment available **Section 9.2.**
1/12/2022	Belyuen Community Government Council	Meeting between Belyuen Community Government Council and DIPL in line with the stakeholder consultation plan. Confirming the following actions: • Belyuen can help with providing an employment/capability register for local people to access employment opportunities. • Provide information on how the risk to local recreational fishermen has been assessed. See risk assessment available **Section 9.2.**

Date	Stakeholder	Details of Engagement
30/11/2022	Sealink	Meeting between Sealink and DIPL inline with the stakeholder consultation plan. Confirming the following actions: • DIPL to discuss further with Sealink regarding timing of tours/access required when construction contractor is on board/when tour dates are known by Sealink in 2023. • DIPL to provide design information to Sealink
09/11/2022	Wagait Shire Council and Wagait Progress Association	Meeting between the Wagait Shire Council, Wagait Progress Association and DIPL in line with the stakeholder consultation plan. DIPL outline: • Potential early works and local opportunities; • Project timelines; and • Local area access.

4.1 Future Opportunities for Engagement

A Stakeholder Engagement Plan (Cardno, 2019) has been prepared as a key component of the Social Impact Management for the Project. Following submission of this SER, DIPL will reconnect with stakeholders and encourage all to engage with the public comment process run by the NT EPA. Key stakeholders will be engaged throughout the life of the project using the following communication tools:

- Complaints, concerns, feedback and grievance hotline platform
- Social media and local job portals to communicate employment opportunities
- Regular meetings with relevant Aboriginal stakeholder groups, DIPL and necessary local Governments, to discuss the highest priority stakeholder concerns:
    - Road safety and traffic;
    - Local content for jobs and contracts; and
    - Environmental monitoring results (i.e., air quality, water quality etc).

5 Responding to Submissions

The NT EPA published a statutory notice on 24 March 2022 inviting public comment on the referral until 22 April 2022. This notice was published in accordance with regulation 52(1) of the Environment Protection Regulations 2020 to identify issues of concern and potential impacts, as well as get feedback from stakeholders on project options or potential mitigation measures. **Table 5-1** details the submissions received by the NT EPA from stakeholders during this period. Eight submissions were received: one from the AAPA, six from NT Government agencies and one from a private individual.

In addition to public comment, the NT EPA provided a Direction to Provide Additional Information in the SER, directing DIPL to address all submissions (received in relation to the referral information) in the SER; and provide additional information in the SER (NT EPA, 2022b).

Direction to Provide Additional Information in the SER (NT EPA, 2022b) (NT EPA Reference EP2022/014) and appended additional information required is available online [Here].

5.1 Key Environmental Factors

Table 5-1: Summary Responses to Key Areas of Concern.

Theme	Environmental Factor	Environmental Objective	Summary of Issues Raised in Submission / Stakeholder	Proponent Response
Land	Landforms	Conserve the variety and integrity of distinctive physical landforms.	The referral documentation states that "beaches" are not a significant landform as these areas do not hold significant cultural or ecological value (page iv, Environmental Referral Report). The Flora and Fauna Division disagrees with this assumption, as these transitional environments can support both marine and terrestrial fauna, provide feeding habitat for migratory birds, provide nesting for marine turtles, and have a specific infauna community. In the case of the area relevant to the proposal, the intertidal beach impacted by the works is not known to provide important nesting habitat for marine turtles or important foraging, staging or roosting habitat for migratory waders and shorebirds. **DEPWS - Flora and Fauna Division**	Clarification provided to DEPWS in stakeholder consultation 19 July 2022. No further action required.
	Terrestrial Environmental Quality	Protect the quality and integrity of land and soils so that environmental values are supported and maintained.	A temporary 30,000 m^2 work area for the temporary stockpiling of dredge spoil (rock) is proposed, and the disturbed area will be rehabilitated when the site is no longer required. At most, 70,000 m^3 of rock will be stored at the site, of which approximately 28,000 m^3 will be reused locally for construction of breakwaters. Saline and sediment laden run-off from dredge spoil has the potential to contaminate the soils in the storage area and surrounding environment. The referral has not assessed the potential impacts from soil salinisation, and how this may influence the rehabilitation of this area. **NT EPA**	Provide further information that demonstrates: there is a plan for the rehabilitation and closure of disturbances that includes: The closure objectives; and Criteria to measure success of rehabilitation. See **Section 7.1** and CEMP – **Appendix C**.
			The disturbance of land with an acid sulfate soil risk should be avoided, however if disturbance is necessary for a proposed development area, then an acid sulfate soil field investigation will be required. The investigation must be undertaken by a suitably qualified and experienced professional, in accordance with the Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines v4.0 (Dear et al. 2014) or the Western Australian Acid Sulfate Soils Guideline Series (DER 2015). Essential to an investigation is the requirement for CRS soil testing at an appropriate site density and to a soil depth immediately below the proposed disturbance.	Clarification provided to DEPWS in stakeholder consultation 27 October 2022. The Terrestrial Environmental Report has been updated to reflect feedback – **Section 4.3 - Appendix E.**

Theme	Environmental Factor	Environmental Objective	Summary of Issues Raised in Submission / Stakeholder	Proponent Response
			If acid sulfate soils are detected through CRS testing, and exposure of these soils is still unavoidable then an acid sulfate soil management plan is required. The acid sulfate soil management plan will include the following: • Exact location of the proposed disturbance; • Depth and volume of soil to be disturbed (m^3); • Clearly presented CRS results; • Acid base accounting results which clearly indicate an accurate liming rate; • Appropriately designed treatment pads; • Lime/soil mixing regimes; and • An appropriate monitoring program. **DEPWS – Rangeland Division**	
			It is highly likely that gamba grass will be brought into the site despite the proponent's assurance that clean fill will be used. Any weed management plan must have contingencies in place to respond to (eradicate) any gamba incursions on the site. *Cenchrus polystachion* and *Cenchrus pedicellatus* (perennial and annual mission grass) are subject to a threat abatement plan under the EPBC Act *1999* as they have been identified as a key threatening process. Consideration should be given as to any requirements under an applicable threat abatement plan. This section should also address the Key Threatening Process of *Cenchrus polystachion* and *Cenchrus pedicellatus* relative to the EPBC Act. Proponent should note that *Cenchrus spp.* Mission grass (annual) has wrongly been identified as a Class A weed. *Cenchrus pedice/latus* is not declared in the NT. Section should list the EPBC Act relative to Threat Abatement Plan for the 5 listed grasses as a Key Threatening Process. **DEPWS - Rangeland Division**	Success criteria and closure objectives for weeds added to the CEMP to ensure adequate monitoring and management of weeds. **Section 15 - Appendix C** The Terrestrial Environmental Report has been updated to reflect feedback – **Section 2.1.1.3 - Appendix E**
	Terrestrial ecosystems	Protect terrestrial habitats to maintain environmental values including	The proponent has accurately described the terrestrial biodiversity values for the project area and wider region. The Flora and Fauna Division agrees with the proponent's assessment that land-based construction activities will occur within cleared and disturbed lands and therefore the construction and operation is considered to be low risk to terrestrial biodiversity. **DEPWS - Rangeland Division**	No additional information required.

Theme	Environmental Factor	Environmental Objective	Summary of Issues Raised in Submission / Stakeholder	Proponent Response
		biodiversity, ecological integrity and ecological functioning		
			A temporary 30,000 m^2 work area for the temporary stockpiling of dredge spoil (rock) is proposed. It is noted that the Proponent has not assessed the terrestrial biodiversity and environmental values of this area. **NT EPA**	Provide further information that demonstrates: 1. Clearing is consistent with the NT Land Clearing Guidelines. (See **Section 7.2**) 2. The temporary work area is assessed for its biodiversity and environmental values in accordance with the NT EPA's hierarchies for environmental protection and management (Part 2 of the *Environment Protection Act 2019*). (See **Section 7.2** and the Revised Terrestrial Environmental Report – see **Appendix E**) 3. There is ongoing monitoring and inspection/reporting of threatened species to ensure protection of environmental values. (See **Section 7.1, 7.2** and the Revised CEMP– **Appendix C**) 4. Weed control is undertaken. (See **Section 7.1, 7.2** and the Revised CEMP – **Appendix C**) 5. Lighting design for above water infrastructure complies with the National Light Pollution Guidelines (See **Section 7.3**) 6. The CEMP is revised to address the management of these issues (See **Section 7.1, 7.2** and the Revised CEMP – **Appendix C**).

Theme	Environmental Factor	Environmental Objective	Summary of Issues Raised in Submission / Stakeholder	Proponent Response
Sea	Coastal processes	Protect the geophysical and hydrological processes that shape coastal morphology so that the environmental values of the coast are maintained.	The proposal will result in changes to coastal processes. There will be a modification to the existing open shoreline environment with substantial changes to currents and sediment characteristics and transport. A suite of models has been constructed for impact assessment that includes sediment transport and plume modelling supported by hydrodynamic modelling. There is uncertainty about where direct and indirect impacts are likely to occur, post-construction, as a result of altered coastal processes including accretion to the north of the facility and erosion to the south. There are information gaps regarding management of potential impacts to the beach and shoreline, and their inherent physical, ecological and cultural values. The change to conditions may have a significant impact and consequences for the beach structure and benthic community and ecosystem. To improve confidence in sediment transport and plume modelling, and hydrodynamic model outputs, results, and impact predictions, the models should be calibrated and validated, with clearly stated assumptions. Consider a peer review of the models. Wave modelling The hydrodynamic model and wave model have not been qualitatively or quantitatively assessed and should include robust sensitivity analysis and statistical metrics, such as RSME, and average bias to demonstrate certainty of prediction and overall model performance. Model calibration should be against an appropriately representative dataset encompassing both the wet and dry season as the wind climate and forcing function for wave action in Darwin Harbour differs considerably between the wet and dry season. The combined effect of the wave regime and currents is one of the key parameters for characterising the physical environment and a driver for the distribution of sediments and occurrence of benthic communities. *Sediment transport model* The proponent has developed a non- calibrated and unvalidated sediment transport model with outputs that indicate net sediment transport is in a southerly direction, and estimated to be between 2,000 and 20,000 m3/year. The modelling also shows that beach nourishment (accretion) will occur to the north of the project and beach erosion will occur to the south and that it will take approximately 11 years for sediment to bypass the development.	As noted by the Flora and Fauna Division of DEPWS, additional information is required to improve confidence in model outputs, results, and impact predictions, and to assess behavior of suspended and deposited sediments. 1. Evaluate the combined effect of the current and wave regime by modelling maximum bed shear strength (the energy at the seafloor due to bottom currents), orbital velocity (wave energy at the seafloor) and their combined effects on sediment movement, deposition and re-suspension. This is missing from the referral and should be incorporated into the assessment (**Section 8.1.1**). 2. To ensure that there is a clear understanding of the changes to hydrodynamic and wave conditions, provide a comparison of pre-development and post-development scenarios, and the net change at the appropriate spatial scale and detail for: a. Current strength and direction for spring tide incoming and outgoing tides, and wave regime for wet and dry season conditions. b. Bed shear stress, orbital velocity and combined effect for wet and dry season conditions. (**Section 8.1.1**). 3. Review the methodology used to determine the sediment budget, and revise inputs so that sediment movement is modelled with a high degree of confidence. Consider the use of sediment tracers coupled with a standard suite of

Theme	Environmental Factor	Environmental Objective	Summary of Issues Raised in Submission / Stakeholder	Proponent Response
			The Flora and Fauna Division of DEPWS has concerns around the sediment transport model's ability to accurately estimate the volume of sediment transported for wet season and dry season conditions. Revisions to the model are required to improve confidence in predictions, and to better understand and evaluate: • Transport pathways, fate and deposition for both coarse and finer fractions of sediment • Likely consequences of changes to sediment transport characteristics, and • Indirect impacts to environmental and ecosystem values. **NT EPA**	conventional hydrographic survey techniques. (**Section 8.1.1**). 4. In addition to modelling the shoreline sediment transport of coarse sand, also include sediment transport of finer sediments (sandy muds and muds), which are more likely to impact lower intertidal and shallow subtidal environments that support benthic primary producer habitats. (**Section 8.1.3**) 5. Ensure that the models are constructed, calibrated and validated in order to assess sediment behaviour, transport pathways, fate, and deposition with a high degree of confidence. (**Section 8.1**) 6. Review and update the (DSDMP – **Appendix B**) 7. Consider a beach management plan for maintenance and bypass operations. (**Appendix D** – CPMMP). 8. Apply the research and resources developed by WAMSI under the NESP Dredging node: Dredging Science Program – WAMSI (wamsi.org.au). (**Section 8.2** and the revised DSDMP – **Appendix B**) 9. Apply the NT EPA's hierarchies for environmental protection and management (Part 2 of the Environment Protection Act 2019).

Theme	Environmental Factor	Environmental Objective	Summary of Issues Raised in Submission / Stakeholder	Proponent Response
			The proponent aims to build two breakwaters to create a protected harbour to facilitate ferry terminal facility. Further, the project Processes will dredge the newly created harbour to a depth of -4 m AHO, so it can be accessed during spring low tides. The breakwaters will alter coastal processes in the western nearshore marine environment of Darwin Harbour. In particular, it will irreversibly change environmental conditions that drive geophysical processes, coastal morphology, hydrodynamics, and sediment transport and hence will impact on the coastline, the near shore environment and the values they support. These changes also have the potential to influence the composition and distribution of benthic communities within the project's ZoI (see further section Marine Ecosystems). Supported by hydrodynamic modelling, plume modelling, sediment transport modelling and wave modelling the referral concludes that whilst the project's intention is to deliberately change environmental conditions to facilitate an all-weather ferry facility it considers the changes to coastal processes to be small, inconsequential and will have negligible impact to the environment. Under the proposed development coastal processes will change from that of an open shoreline environment to a protected harbour environment, with associated changes to the currents and sedimentary characteristics, and a subsequent shift in benthic community structure. The Flora and Fauna Division considers that impacts from these changes within the newly created harbour will likely be localised and most likely will not be significant in the context of Darwin Harbour, although there are uncertainties associated with this conclusion due to information gaps described below. **DEPWS - Flora and Fauna Division**	No additional information required, information gaps that are referred to are addressed below.
			The hydrodynamic model and wave model have not been qualitatively or quantitatively assessed. It relies on a visual assessment by using graphs that represent observed and modelled data. The referral should at least provide statistical metrics, such as skill, RSME and average bias, of the predictive power of the used models. The Flora and Fauna Division considers that the project may not significantly affect the broader Darwin Harbour hydrodynamics and metocean regime. However, the referral has	Provide further information that demonstrates: 1. Qualitatively or quantitatively assessment of the hydrodynamic model. Providing statistical metrics for the model, such as skill, RSME and average bias, of the predictive

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			not provided sufficient evidence to adequately demonstrate that the impacts are insignificant and will not affect what is referred to as Darwin Harbour's "compartments". For example, it provides only a single figure (Figure 9-3) for an outgoing tide (ebb tide), at a scale that is only useful at the whole of Darwin Harbour scale. This map seems to infer that post development the changes to current strength on an outgoing tide are localised; decrease nearshore and increase within the shallow subtidal area south of the rocky reef at West Point, north of Mandorah. The referral does not provide any results for spring flood tides post development. **DEPWS - Flora and Fauna Division**	power of the used models.(**Section 8.1**) 2. Provide additional figures to increase confidence that changes to tidal flow are localised and not significant. (**Section 8.1.1**)
			The referral states that the sediment deposition from dredging and dredge spoil disposal activities outside the direct footprint of the project is less than 2 mm. However, the sediment transport report (Figure 6-3) clearly shows that deposition of sediments could be above 20 mm in certain areas. Given that the estimate is based solely on a model runtime of 15 days - when dredging and dredge spoil disposal concurrently occur - deposition of 20 mm of sediment within the 15 day timeframe could have large impacts to benthic fauna not considered in this referral. Further, the referral does not model potential sediment deposition from backhoe dredging, rock wall placement, handling of backhoe material to land based dredge spoil storage area or piling. Consequently, estimates of sediment deposition and extent could be significantly larger than the referral estimates. The Flora and Fauna Division recommends that plume modelling and sediment deposition modelling includes the cumulative effects of all project activities that have to potential to affect sediment deposition. **DEPWS - Flora and Fauna Division**	Provide further information that demonstrates: 1. Updated copies of Figures 9-7 and Figures 9-8 of the original referral document at a localised scale with the project footprint overlayed to show that these areas of higher sedimentation fall within the project footprint. (**Section 8.1.2**) 2. Additional plume modelling and sediment deposition modelling to include all activities i.e. backhoe dredging, rock wall placement, handling of backhoe material to land based dredge spoil storage area or piling.(**Section 8.1.2**) 3. New sediment deposition thickness figures to be provided at both a localised footprint scale and a model extent scale. (**Section 8.1.2**)
			The referral notes that there will be beach erosion south of the proposal. This was not discussed further and no information was provided on the predicted fate of sediment eroded from the beach. Natural features that support aquatic fauna (seagrass meadows, drainage channels) are known to occur to the south of the proposal. However, the fate of eroded sediment on these features/habitats is likely to be localised and is unlikely to impact on the availability of these habitats for aquatic fauna in Darwin Harbour. **DEPWS - Flora and Fauna Division**	Additional modelling of coastal processes (**Section 8.1**).
			The referral acknowledges that the installation of breakwaters (shown at right in black dashed lines; extract of Figure 9-2 of referral) will interrupt nearshore hydrodynamics,	Provide further information that demonstrates:

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			waves and sediment transport, altering erosion and accretion patterns either side of the facility. This is expected to result in accretion of the shoreline to the north of the facility (blue on map at right) and erosion of the shoreline to the south of the facility (red on map at right). The area of predicted erosion so the south of the breakwaters overlaps RWA1 in Authority Certificate C2019/067, and the Authority considers that such erosion could be considered 'damage' and therefore contravene condition 5 of the Authority Certificate. In addition, the accretion of sediments to the north of the breakwaters could constitute damage to the recorded sacred site to the north of the project area. These potentially significant impacts were not addressed in the issuing of Authority Certificate C2019/067 as the application for it did not include any information about these altered coastal processes. Section 9.2.6 of the referral clarifies that the shoreline changes discussed above are difficult to predict with certainty. The referral recommends shoreline monitoring and then subsequent 'sediment bypassing' (sand movement) if required. Such sediment bypassing may require work to occur within RWA1 of Authority Certificate C2019/067 and could result in 'damage' to sacred sites. Neither work nor damage is permitted in accordance with condition 5 of the certificate. **AAPA**	1. AAPA confirmed that the comment highlighted is incorrect and the predicted erosion in fact overlaps with RWA2 and therefore condition 5 is not relevant. Condition 6 is relevant to RWA2 which is the coastline south of the project. 2. A CPMMP to be developed to show how erosion and accretion will be monitored and managed post construction ensuring that Condition 6 of RWA2 is not contravened. (See **Section 8.1.5** and **Appendix D**).
			If the entrance to this new facility is from the south east and the roaring south east trade winds blow straight into this opening at times if 40 knots what's to stop very uncomfortable swells entering this new marina causing havoc to berthing vessels and pontoon movements? Are the Hydrology experts aware that currents around the existing jetty flow in a opposite direction to the tides? i.e. when tide is coming in the water flows out to sea at the jetty and vice versa. Just an observation from a yachtie of 60 years on Darwin harbour. **Bill (Member of the Public)**	See **Sections 8.1**
	Marine Environmental Quality	Protect the quality and productivity of water, sediment and biota so that environmental values are maintained.	There is a high likelihood that changes in turbidity/TSS will be significant. This is likely to be through successive, incremental, and combined sources of contamination such as run-off and the release of contaminants as a result of dredging, dredge disposal, and construction activities. Modelling was conducted to assess changes in turbidity/TSS by modelling sediment plume dispersal as a result of the dredging activities.	Provide further information that demonstrates: 1. Revise the site conceptual model to include all potential contamination sources (e.g. from transport, handling and stockpiling of dredged rock, and construction of breakwaters and pile-driving). (**Section 8.1.2**)

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			Plume modelling DEPWS has noted the plume modelling was only run for the period that the cutter suction dredge and the backhoe dredge were working simultaneously. The referral estimated this duration to be about ten days. However, it is noted that the backhoe dredge is required to excavate about 70,000 m3 at a rate of about 121 m3/hour, which is equivalent to about 70 backhoe days of dredging, and not the stated ten days. Consequently, the time duration of elevated turbidity will be seven times longer than assumed, which may have a significant impact on the receiving environment and sensitive receptors. It follows that the accuracy of the estimates of the predicted amount of sediment deposition derived from dredging induced turbidity is questioned, and requires clarification. Light availability. The light availability at the seafloor (which is a physical environmental parameter that drives a number of ecosystem processes) will be influenced by sediment plumes and has not been discussed in the referral. To inform the risk assessment for benthic primary producer habitats from elevated suspended sediments, there is need to understand the changes in light intensity and duration at the seafloor. To complete the assessment there is a need to understand the turbidity/TSS and light intensity relationship, which is then coupled with the plume modelling to develop the triggers for mitigation and management actions. *ZoI, thresholds and triggers* Trigger values (above background) have been developed for both wet and dry seasons (Table 7-3 of the Sediment Transport Report) and assigned to the three zones of impact: high (ZoHI), medium (ZoMI) and ZoI, applying the 85, 90, and 95th percentiles respectively. In all three case the TSS concentrations of 11 Mg/L during the dry season and 49 Mg/L in the wet is applied. It is noted that: • the ZoI should be at the lower end of the percentile range, and not the higher TSS concentrations for each of the impact zones cannot be the same for each percentile classes (as in Table 7-2)	2. Improve the accuracy of the estimates for the amount of sediment deposition that will be derived from dredging induced turbidity (from operating the cutter suction dredge and the backhoe dredge) and ensure this is included in the modelling (**Section 8.1.2**). 3. Review and revise the models to improve confidence in the evaluation of the proposal's cumulative impacts to marine environmental quality, including ensuring the sediment transport and plume models include source terms for all potential sources of contamination (**Section 8.1.2**). 4. Provide additional information on triggers to provide additional information supplementary to the information provided Section 7.3 Dredge Plume Dispersion (**Section 8.2**). 5. Establish the turbidity/TSS and light intensity relationship, and apply this to develop the appropriate triggers for mitigation and management actions (**Section 8.2.2**). 6. Review and update the DSDMP (**Appendix B**), 7. Review and update the CEMP (**Appendix C**). 8. Apply the NT EPA's hierarchies for environmental protection and management (Part 2 of the *Environment Protection Act 2019*).

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			• the severity of the impact is solely dependent on TSS values, rather than the combined effect of sediment deposition and TSS values • the derived layer for light availability at the seafloor should be included in the derivation of the impact zones/thresholds. The derivation of the triggers informs and influences the DSDMP, and the CEMP for the Proposal. **NT EPA**	
			In summary the referral identifies the following potential environmental risks and impacts associated with the proposed action: • Impacts to sensitive receptors such as coral and seagrass habitats from elevated suspended sediments and excessive sedimentation; • Direct loss of habitat through dredging and placement of breakwaters; • Indirect impacts from decline in water and sediment quality with potential loss of ecosystem function; and • Potential impacts from vessel interaction and underwater noise on marine megafauna such as turtles, dugong and coastal dolphins. The Flora and Fauna Division accepts the referral's conclusion that with proposed mitigation actions (e.g. vessel speed, soft starts when piling, lighting design) risks to migratory species is low. There is potential for turtle and dugong habitat to be directly impacted through sediment transport and sedimentation. The risks to these habitats from a regional context is likely to be low, however there is potential for local impacts which may alter the use of the area by individual marine megafauna. There are some information gaps that reduce the certainty associated with impact assessment and these are described further below. **DEPWS - Flora and Fauna Division**	No additional information required, information gaps referred to are addressed below.
			The referral has considered the potential release of contaminants from seabed sediments into the marine environment, potential turbidity and sediment plumes from dredging and dredge spoil disposal activities; run-off of waste and pollutants from terrestrial activities and the siltation of the marine facility. The referral considers with appropriate mitigation, the residual risk for all environmental aspects to be low. The Flora and Fauna Division agrees with most of these conclusions, with the exception of turbidity and plume modelling impacts. The referral has assessed changes in turbidity/TSS	Provide further information that demonstrates: 1. Establish the turbidity/TSS and light intensity relationship, and apply this to develop the appropriate triggers for mitigation and management actions (Section 8.2.2).

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			by modelling sediment plume dispersal from dredging of unconsolidated sediments and rock and dredge spoil disposal of unconsolidated sediments. However, there are a number of other pathways that sediment plumes can occur that have not been considered, such as potential plumes from the handling of dredged rock and transfer to land based storage site, and the building of the breakwaters or piling. To inform the risk assessment for benthic primary producer habitats (see section Marine Ecosystems) from elevated suspended sediments there is need to understand the changes in light intensity and duration at the seafloor. To undertake this assessment there is a need to understand the TSS / turbidity - light intensity relationship which can then couple with the plume modelling. **DEPWS - Flora and Fauna Division**	2. Additional plume modelling and sediment deposition modelling to include all activities i.e. backhoe dredging, rock wall placement, handling of backhoe material to land based dredge spoil storage area or piling (Section 8.1.2).
			To allow for a risk assessment the referral has calculated three zones of impact: high (ZoHI), medium (ZoMI) and ZoI for wet and dry season conditions. They are predominantly defined by the level of impact to benthic communities (irreversible impact, recoverable within five years and undetectable impact). There are a number of technical inadequacies identified in the Sediment Transport Report, particularly around the proposed trigger values for impact in the ZoI, which need to be resolved. The referral outlines the determination of total suspended sediment (TSS) values for 50th, 90th, 95th and 99th percentile and the duration of exceedances above background levels (Table 7-2, Sediment Transport Report). There seems to be an error in table 7-2: it is unclear how for wet season conditions the exceedance duration for them 95th percentile can be smaller than the 99th percentile. If this is correct, then this should be explained in the text. Trigger values were developed for both wet and dry seasons (Table 7-3, Sediment Transport Report). However, Table 7-3 is missing. In the following section (p 27 of the Sediment Transport Report) assigns the trigger values to the zones of impact, using the 85th percentile for the ZoHI the 90th percentile for the Zone of medium impact and 95th percentile as the ZoI. In all three case it uses the TSS concentrations: 11 mg/L during the dry season and 49 mg/Lin the wet. It is unclear why this approach is taken. Firstly, the ZoI would be at the lower end of the percentile range, not the highest.	Provide further information that demonstrates: 3. Provide additional information on triggers to provide additional information supplementary to the information provided Section 7.3 Dredge Plume Dispersion (**Section 8.2** and the Revised DSDMP – **Appendix B**). 4. Include a table showing Trigger values for both wet and dry seasons (**Section 8.2.5** and **Appendix B**) 5. Revised CEMP and DSDMP to incorporate any changes derived from additional modelling (**Appendix B & C**).

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			The TSS concentrations for each of the impact zones cannot be the same for each percentile classes (Table 7-2 clearly shows this is not the case). Finally, the referral arbitrary assigns a percentile class to a Zone of impact. There is no supporting evidence that links TSS values, exceedance durations to the definitions used for impact zones. Further, the severity of the impact is solely dependent of TTS values, rather than combined effect of sediment deposition and TSS values. This assessment should also include the derived layer for light availability at the seafloor (see Marine Environmental Quality). As the DSDMP relies heavily on these triggers to inform management actions, it is critical that this section is well documented and reasoned. Clear supporting evidence should be provided that links total suspended solid (TSS) values, and exceedance durations to the definitions used for impact zones. Further, the severity of impact should consider the combined effect of sediment deposition, TSS values and the derived layer for light availability at the seafloor (see Marine Environmental Quality). Given there is a need for further information which may change CEMP and DSDMP mitigation actions, it is recommended that these two management plans are revised with the additional information before works can commence. **DEPWS - Flora and Fauna Division**	
	Marine Ecosystems	Protect marine habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning.	*Benthic habitat* Benthic primary producer habitats and filter feeder habitats can be impacted by suspended sediment through three primary cause effect pathways: • Light reduction; • Increased SSC; and • Sediment deposition (smothering). It is critical that appropriate triggers discussed above are appropriately developed to minimise risk to these habitats, and it is recommended best practice that the proponent inform the approach using the research and resources developed by WAMSI under the NESP Dredging node: Dredging Science Program – WAMSI (wamsi.org.au). As part of the site selection process and risk assessment for the disposal of dredged material into the water column, a benthic survey using video was conducted to verify the modelled benthic habitat data and mapping/presence of sensitive receptors e.g. seagrass, coral, macro algae communities. Additionally, the preferred disposal site is in close proximity to the occurrence of subtidal rocky reefs, which generally are high biodiversity areas. In contrast, the spoil disposal site has been:	Provide further information that demonstrates: 1. Review and revise the modelling of the zones of impact, and the risk assessment for dredge spoil disposal and site selection (**Section 8.2**). 2. Demonstrate that the site selection process is robust, and the potential impacts to marine ecosystems from the disposal of dredge material are acceptable (**Section 8.2, Section 8.3**). 3. Provide a seagrass health monitoring program which includes assessing environmental conditions such as light availability at the seafloor, sedimentation rates, wave and current energy (**Appendix B**).

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			• Located outside and adjacent to the benthic survey area, and critically i.e. Located outside the area of ground-truthing; • Located based on modelled data, rather than verified habitat data; and • Located in close proximity to subtidal rocky reefs, which generally are high biodiversity areas. *Seagrass meadows* Seagrass meadows on the western side of Darwin Harbour are not extensive, compared to the eastern side, and are only known to occur in small areas, (e.g. between Weed Reef and Stokes Point, the mouth of Woods Inlet, Mandorah, and some small patches between West Point and Charles Point). However, these meadows may assist dugong movement between Darwin Harbour and Bynoe Harbour and the loss of seagrass habitat within the ZoI could influence feeding dugong and hinder movement. The potential loss or decline in health of seagrass on the western side of Darwin Harbour could be considered significant. *Cumulative impacts* There are several existing, ongoing and proposed dredging and dredge disposal activities in Darwin Harbour that includes the Mandorah Marine Facilities, with potential significant impacts to the environmental values of Darwin Harbour and the Beagle Gulf. **NT EPA**	4. Provide a plan for monitoring dugong movement patterns along the western side of Darwin Harbour (**Appendix B – Section 7.3**). 5. Review and revise the DSDMP and include provisions for management, monitoring, and reporting of seagrass and dugong (**Appendix B**). 6. Provide an assessment of the potential direct, indirect and cumulative (successive, incremental, and combined) impacts from the existing, ongoing and proposed dredging and dredge disposal activity (**Section 8.1.2**). 7. Apply the NT EPA's hierarchies for environmental protection and management (Part 2 of the *Environment Protection Act 2019*). 8. Demonstrate benthic surveys have been completed on the disposal site including ground truthing (**Section 8.3**).
			The Division agrees with the proponent's conclusion that current characteristics are unlikely to be impacted over the broader Darwin Harbour. The proposal will alter the current changes within the local area (ZoI) which will alter the benthic habitat and ecosystems locally. These changes are not considered to be a significant risk as there is unlikely to be critical habitat or important populations of aquatic species within the ZoI. **DEPWS - Flora and Fauna Division**	No additional information required

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			Benthic primary producer habitats and filter feeder habitats can be impacted by suspended sediment through three primary pathways: light reduction, increased SSC, and sediment deposition (smothering). The level of risk to these habitats is unknown but is likely to be localised due to the scope of works and the extent of dredging/disposal. Impacts to these habitats can be reduced through the development of appropriate triggers which are informed using research by WAMSI and the NESP Dredging node1. **DEPWS - Flora and Fauna Division**	Provide further information that demonstrates: 1. Triggers have been developed using appropriate background data and the research by WAMSI and the NESP Dredging node (**Section 8.2** and **Section 7** of the DSDMP – **Appendix B**).
			The Flora and Fauna Division considers the approach for identifying sensitive receptors acceptable, in that it used modelled data to underpin ground truthing of benthic habitats at a finer scale. The Flora and Fauna Division notes a preference for towed video to be used in such assessments, rather than drop down camera, especially where benthic cover is low. The referral could have tried to model survey results to get a better estimate of the extent of sensitive habitats, rather than drawing polygons around sites with similar community types. Udyawer et al. (2021) provides a method how to derive predicted habitat maps. The Flora and Fauna Division questions why the spoil disposal site lies outside the benthic survey area. Consequently the risk assessment relies on modelled data, rather than verified habitat data. The Division also queries why the dredge spoil area was placed just north of a subtidal rocky reef, which generally are high biodiversity areas, and not directly west of project area, closer to the main channel of Darwin Harbour, which would most likely evade impacts to sensitive receptors. The distance from the project site would have been approximately the same as the current chosen disposal site. The Flora and Fauna Division recommends that the proponent fills the habitat mapping gap within the ZoI of the dredge spoil disposal plume, or reassess the placement of the dredge spoil disposal site. **DEPWS - Flora and Fauna Division**	Provide further information that demonstrates: 1. BCH mapping and demonstrated ground truthing for the Zones of impact for both the project and disposal sites (**Section 8.3** and **Section 7** of the DSDMP – **Appendix B**).

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			Seagrass meadows on the western side of Darwin Harbour are not extensive and are only known to occur in small areas, between Weed Reef and Stokes Point, the mouth of Woods Inlet, Mandorah, and some small patches between West Point and Charles Point. These seagrass meadows do not seem to be as extensive as those on the eastern side of Darwin Harbour. Woods Inlet is a known feeding ground for Dugong, even though percentage cover of seagrass is low (less than 5% cover). Even though the meadows along the western side may not be the main feeding grounds for dugong in Darwin Harbour, they may assist dugong movement between Darwin Harbour and Bynoe Harbour. In that respect the loss of seagrass habitat within the ZoI could influence feeding dugong and hinder movement. **DEPWS - Flora and Fauna Division**	Review and revise the DSDMP and include provisions for management, monitoring, and reporting of seagrass and dugong (Revised DSDMP – **Section 7.2, Appendix B**)
People	Community and Economy	Enhance communities and the economy for the welfare, amenity and benefit of current and future	*Economic assessment* The referral includes a high level risk assessment of identified potential impacts on the economy. Preliminary mitigation and management options are supported (Table 9-10); and the Terms of Reference should consider an economic assessment in accordance with the EP Act. **CMC.**	**Section 9.2**
			Potential impacts on fishing and shipping. The Terms of Reference should consider potential impacts on:	**Section 9.2**

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		generations of Territorians.	• Commercial and recreational fishing industries as a result of the project's construction and operation; and • The Darwin Port Shipping Channel during construction. **CMC.**	
			The Terms of Reference would benefit from including consideration of Aboriginal employment. **CMC.**	**Section 9.2**
			Tourism NT commends the new facilities and the focus on accessibility and safety. Accessible tourism is a growing part of the tourism market and Tourism NT supports this project for providing better access for people with disabilities and the elderly. • There is a minor reference to 'visitors' in these sections primarily to say that "it is expected that this project will improve accessibility to the area and increase economic opportunities for residents and visitors to the area". • It is worth noting that one of the key things for tourists to do when visiting Mandorah is fishing and if you do not have a boat the existing Mandorah ferry berthing structure is a great place to fish. There is shade and multiple places to sit which provides an activity for both day and weekend visitors. The shade coupled with the multiple levels of the pontoon are interesting for children (under supervision) which provides an enjoyable outdoor fishing activity for visiting families exploring the region. • It is recommended that access to shaded fishing areas be considered as part of this project to ensure there are accessible activities for visitors to Mandorah. • Tourism Top End and Tourism NT have been identified as Stakeholders with the 'recommended type of consultation' identified as 'inform'. It is recommended that this be changed to 'consult' for Tourism Top End. **Tourism NT**	DIPL acknowledge that Tourism Top End will be 'consulted' as opposed to informed'.
		Protect culture and heritage.	The referral states that DIPL has received an Authority Certificate from AAPA for works associated with the project and this includes two RWAs to protect known Aboriginal sacred sites. The Authority confirms that it has issued two relevant Authority Certificates to DIPL (including its predecessor), shown in red, that cover the area of proposed works, roughly shown in yellow in accordance with figure 1-1 of the referral: • C2019/067, explicitly relating to road works, car park, a new ferry pontoon or jetty, and earth and rock groynes (i.e. breakwaters). It doesn't explicitly address a new boat ramp or a passenger terminal. • C2012/267 for the existing car park and jetty.	Provide further information that demonstrates: 1. CPMMP will be developed to show how erosion and accretion will be monitored and managed post construction ensuring no 'damage' to sacred sites (**Section 8.1.5** and **Appendix D**).

Theme	Environmental Factor	Environmental Objective	Summary of Issues Raised in Submission / Stakeholder	Proponent Response
			The referral states that project has been constrained so that no works will occur in the RWAs to the south of the proposed works area. It also acknowledges that recorded and registered sacred sites exist more than 500m north of the project site. The Authority clarifies that the sacred site to the north is about 250 to 300m distant from the proposed works area. The Authority considers that avoiding RWAs is appropriate for avoiding direct impacts on sacred sites, but that this does not address potential indirect impacts to sacred sites both north and south of the works area due to indirect impacts associated with altered coastal processes. (See Coastal Processes). **AAPA**	
			The referral states that strict avoidance of the RWAs will minimise the risk of impact to sacred sites. As noted above, the Authority considers this is appropriate for avoiding direct impacts. This section of the referral also notes potential for the sacred site north of the project area to be indirectly impacted by dredging and disposal actions. It states that sedimentation at this site has been modelled as minimal (less than 2.5mm) and predicted changes to the suspended sediment concentration in the vicinity of the sacred site is expected to be isolated and temporary (i.e. during outgoing tide). It therefore concludes that the risk to known sacred sites associated with dredging and disposal actions is considered to be low. The Authority considers that this conclusion seems appropriate. This section of the referral did not address the additional risk of indirect impact to sacred sites associated with altered coastal processes and associated mitigation measures discussed above. The Authority considers that this poses a risk of significant impact and that the appropriate mechanism to address this risk is for DIPL to engage directly with the Authority and likely obtain and comply with a varied Authority Certificate for the proposed works. **AAPA**	Provide further information that demonstrates: 1. CPMMP will be developed to show how erosion and accretion will be monitored and managed post construction ensuring that Condition 6 of RWA2 is not contravened. (**Section 8.1.5** and **Appendix D**).
			The table lists the potential impact of damage or contamination and sites to the south of the project area during construction activities, with an inherent risk rating of medium. The listed management/mitigation measure is 'response and reporting procedures should a site or object be encountered', making the residual risk low. The Authority considers that this measure would not effectively lower the risk of impact to the sacred sites. Firstly, the sacred site locations are explicitly shown on Authority Certificate C2019/067 so their location is already known and new sites are unlikely to be 'encountered'. Secondly, if contamination did occur in the vicinity of a sacred site it may immediately cause damage which may not be rectified through reporting. The referral has	Provide further information that demonstrates: CPMMP will be developed to show how erosion and accretion will be monitored and managed post construction ensuring that Condition 6 of RWA2 is not contravened. (**Section 8.1.5** and **Appendix D**).

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			not addressed how potential contamination of this area would be avoided. This issue could be addressed through obtaining further information from DIPL or in a condition on an environmental approval. **AAPA**	
			In the Draft CEMP there is a section titled 14.2.4 Cultural Heritage Management. It refers to the known heritage sites (including sacred sites) and identified Restricted Works Areas and exclusion zones, and refers to the possible historic significance of the existing jetty. It is worth noting that in the last eight years there have been numerous discoveries of skeletal remains in the area directly to the south of the project area, and further south along the dunes and intertidal zone. There is a known burial site/sacred site in that area. While it should not be directly impacted by the project, it is possible that skeletal remains can be washed out of the dune areas and into the proposed project area. In the event that any skeletal/ancestral remains are discovered during the construction part of the project, all works in the immediate vicinity should cease and the NT Police and Heritage Branch contacted for an assessment. I have attached a map extract showing the areas where skeletal remains have been discovered (red dots). Please do not make this image public. • In the Draft CEMP Table 14-2 Risk assessment summary table relevant to construction activities only refers to Aboriginal sacred sites, but should also refer to the heritage/archaeological sites (which include skeletal remains), protected by the NT Heritage Act 2011. • Table 14-6 lists a number of controls or mitigation strategies in the event that any heritage items are discovered and Heritage Branch are satisfied with these measures. • The Draft Dredging and Spoil Disposal Management Plan refers to sacred sites and Restricted Works Areas in the vicinity of the project area but does not refer to possible underwater cultural heritage sites that may be discovered in the proposed dredging areas. There may be a requirement for the dredge spoil heaps to be monitored for underwater cultural heritage items such as shipwrecks, isolated artefacts (anchors etc), historic infrastructure (pylons, cables etc), unexploded ordnance, or other objects fallen or thrown from boats. The areas immediately surrounding the existing jetty are the most likely to contain those cultural heritage items referred to above, but if there is no dredging planned around it and it won't be impacted by the project, then there should be no issues from a heritage perspective for that particular area. The other larger area to be dredged should still be monitored though. **Territory Families, Housing and Communities**	Provide further information that demonstrates: 1. CEMP Table 14-2 has been updated to include heritage/ archaeological sites (**Appendix C**, **Table 14-2**) 2. DSDMP revisions including: a. References to sacred sites and Restricted Works Areas in the vicinity of the project area, changed to include underwater cultural heritage sites that may be discovered in the proposed dredging areas. b. Dredge spoil heap monitoring for underwater cultural heritage items such as shipwrecks, isolated artefacts (anchors etc), historic infrastructure (pylons, cables etc), unexploded ordnance, or other objects fallen or thrown from boats (DSDMP **Appendix B.** c. Conduct a Magnetometer survey to identify any potential underwater cultural items. (**Appendix H** - Marine Magnetic survey).
	Human Health	Protect the health of the Northern	Officers of NT WorkSafe have no comment to make at this time. The only minor comment is that while this document is primarily used for environmental risk, safety is discussed in Chapter 9.12. It is suggested that recognition of the NT WHS (National Uniform Legislation) Act 2011 (WHS) and its Regulations be incorporated into the legislation	Clarification provided to NT Worksafe in stakeholder consultation 01 November 2022.

Theme	Environmental Factor	Environmental Objective	Summary of Issues Raised in Submission / Stakeholder	Proponent Response
		Territory population.	references. It is also noted that Hazardous Chemicals is also included in 9.6.4.5 and that there are some requirements under the WHS legislation with respect to these. **NT WorkSafe**	Action: Include *NT Work Health and Safety (National Uniform Legislation) Act 2011* and it's Regulations in the legislation references, also noting any notification requirements.
			Issue: The remote location of the operation is outside the NTFRS ERA, which limits the ability to respond to an emergency in a timely manner. **How to address:** If the timeliness of response does not adequately mitigate the risk for Mandorah Marine Facilities then self-funded measures should be implemented. The NTFRS is happy to advise Mandorah Marine Facilities on current capabilities in the vicinity of their operations to inform their risk assessment. **NT PFES**	Clarification provided to NT PFES in stakeholder consultation 01 November 2022. The outcomes were as follows: • The contractor is to consider the limited access to emergency services as part of their Work Health Safety Management Plan and Emergency response procedures. • The Work Health Safety Management Plan and Emergency response procedures will be reviewed by the DIPL Compliance team and audited as part of the project.
			Issue: With regards to road crash/response the NTFRS crews will respond as required within existing capacity as with any other crash. **How to address:** If the timeliness of response does not adequately mitigate the risk for Mandorah Marine Facilities then self-funded measures should be implemented. The NTFRS is happy to advise Mandorah Marine Facilities on current capabilities in the vicinity of their operations to inform their risk assessment. **NT PFES**	Clarification provided to NT PFES in stakeholder consultation 01 November 2022. • The contractor is to consider the limited access to emergency services as part of their Work Health Safety Management Plan and Emergency response procedures. • The Work Health Safety Management Plan and Emergency response procedures will be reviewed by the DIPL Compliance team and audited as part of the project.

6 Supplementary Environmental Information

Section 6 provides the body of the responses to the NT EPA's request for supplementary information. It presents new data and information in addition to those submitted in the referral to progress the environmental assessment process and address issues raised in public submissions and NT EPA directions.

Investigations undertaken in addition to those in the referral have been advanced as a result of NT EPA directions, public submissions, new potential environmental impacts and data made publicly available since the referral was published. The NT EPA considers that the Proposal has the potential to significantly impact six environmental factors and requested that DIPL provide supplementary environmental information, as detailed in **Table 6-1**.

Table 6-1: Summary of the Additional Information Requested by the NT EPA.

Environmental factor	Additional information required	SER Section
Terrestrial environmental quality	Provide further information that demonstrates there is a plan for the rehabilitation and closure of disturbances that includes: • the closure objectives, and • criteria to measure success of rehabilitation.	**Section 7.1**
Terrestrial ecosystems	Provide further information that demonstrates: • Clearing is consistent with the NT Land Clearing Guidelines. • The temporary work area is assessed for its biodiversity and environmental values in accordance with the NT EPA's hierarchies for environmental protection and management (Part 2 of the Environment Protection Act 2019). • There is ongoing monitoring and inspection/reporting of threatened species to ensure protection of environmental values. • Weed control is undertaken. • Lighting design for above water infrastructure complies with the National Light Pollution Guidelines1 • The CEMP is revised to address the management of these issues.	**Section 7.2** **Section 7.3** **Appendix C**
Coastal processes	As noted by the Flora and Fauna Division of DEPWS, additional information is required to improve confidence in model outputs, results, and impact predictions, and to assess behaviour of suspended and deposited sediments. • Evaluate the combined effect of the current and wave regime by modelling maximum bed shear strength (the energy at the seafloor due to bottom currents), orbital velocity (wave energy at the seafloor) and their combined effects on sediment movement, deposition and re-suspension. This is missing from the referral and should be incorporated into the assessment. • To ensure that there is a clear understanding of the changes to hydrodynamic and wave conditions, provide a comparison of pre-development and post-development scenarios, and the net change at the appropriate spatial scale and detail for: o Current strength and direction for spring tide incoming and outgoing tides, and wave regime for wet and dry season conditions. o Bed shear stress, orbital velocity and combined effect for wet and dry season conditions. • Review the methodology used to determine the sediment budget, and revise inputs so that sediment movement is modelled with a high degree of confidence. Consider the use of sediment tracers coupled with a standard suite of conventional hydrographic survey techniques. • In addition to modelling the shoreline sediment transport of coarse sand, also include sediment transport of finer sediments (sandy muds and muds), which are more likely to impact lower intertidal and shallow subtidal environments that support benthic primary producer habitats. • Ensure that the models are constructed, calibrated and validated in order to assess sediment behaviour, transport pathways, fate, and deposition with a high degree of confidence.	**Section 8.1**

Environmental factor	Additional information required	SER Section
	• Review and update the DSDMP. • Consider a beach management plan for maintenance and bypass operations. • Apply the research and resources developed by WAMSI under the NESP Dredging node: Dredging Science Program – WAMSI (wamsi.org.au). • Apply the NT EPA's hierarchies for environmental protection and management (Part 2 of the Environment Protection Act 2019).	
Marine environmental quality	Additional information required: • Revise the site conceptual model to include all potential contamination sources (e.g. from transport, handling and stockpiling of dredged rock, and construction of breakwaters and pile-driving). • Improve the accuracy of the estimates of the amount of sediment deposition that will be derived from dredging induced turbidity (from operating the cutter suction dredge and the backhoe dredge) and ensure this is included in the modelling. • Review and revise the models to improve confidence in the evaluation of the proposal's cumulative impacts to marine environmental quality, including ensuring the sediment transport and plume models include source terms for all potential sources of contamination. • Establish the turbidity/TSS and light intensity relationship and apply this to develop the appropriate triggers for mitigation and management actions. • Review and update the DSDMP, and the CEMP for the Proposal. • Apply the NT EPA's hierarchies for environmental protection and management (Part 2 of the Environment Protection Act 2019).	**Section 8.2**
Marine ecosystems	Additional information required: • Review and revise the modelling of the zones of impact, and the risk assessment for dredge spoil disposal and site selection. • Demonstrate that the site selection process is robust, and the potential impacts to marine ecosystems from the disposal of dredge material are acceptable. • Provide a seagrass health monitoring program which includes assessing environmental conditions such as light availability at the seafloor, sedimentation rates, wave and current energy. • Provide a plan for monitoring dugong movement patterns along the western side of Darwin Harbour. • Review and revise the DSDMP and include provisions for management, monitoring, and reporting of seagrass and dugong. • Provide an assessment of the potential direct, indirect and cumulative (successive, incremental, and combined) impacts from the existing, ongoing and proposed dredging and dredge disposal activity. • Apply the NT EPA's hierarchies for environmental protection and management (Part 2 of the Environment Protection Act 2019).	**Section 8.3**

The approach for evaluating the risks to each of the factors is summarised in **Sections 7** to **Section 9**. Several desktop, modelling and associated field sampling investigations were undertaken to support the SER, as summarised in **Table 6-2**. The detailed findings and outputs of these studies are provided herein and/or appended to this document.

Table 6-2: Studies undertaken since submission of original referral accepted March 2022.

Study	Summary	Purpose	Reference
Dredging disposal site assessment and selection	Multi criteria assessment of several new potential dredge spoil grounds. Extensive desktop investigation into the preferred disposal options. Key areas addressed: • EPA environmental factors • SSC and corresponding environmental tolerances • Technical feasibility • Legislative impacts • Sediment dispersion performance	Provide robust assessment of risks associated with various dredge disposal site options ensuring the most suitable site is selected.	**Section 8.3.1**
Nearshore sedimentation assessment	Desktop analysis of local area long term water quality data, historical aerial imagery and hydrographic survey data.	To develop local area relationships for model validation and application: • NTU to TSS, • TSS concentration through the water column • TSS and PAR	**Section 8.1.3**
Nearshore sediment transport & Deposition modelling	Detailed assessment of the changes to sedimentation and erosion around the facility once installed.	To develop well founded and validated models of the changes to sedimentation post installation including rates of accretion and erosion (compared to pre-construction) and spatial mapping of areas of change under various seasonal conditions.	**Section 8.1.3**
Dredge plume dispersion modelling	Detailed assessment of the Dredge Plume Dispersion for the updated dredging and construction schedule including additional cumulative impacts from potential concurrent dredging activities.	To develop refined plume dispersal models for various spillage and re-suspension rates for the various construction activities for longer term durations and both spring and neap tides.	**Section 8.2.1, 8.2.4**
Shoreline evolution modelling	Detailed assessment of the potential changes to the shoreline around Mandorah post construction.	To develop a model up to five shore normal profiles, representative of the various alignments of the Mandorah shoreline. The simulation is proposed to be undertaken for a 10-year period, based	**Section 8.1.4**

Study	Summary	Purpose	Reference
		on Metocean a timeseries of wave conditions derived in previous stages of the project.	
New Zones of Impact mapping	Revised zones of influence and impact accounting for local area water quality, and then applying techniques developed for the WAMSI Dredging Science Node.	To revise the zones mapped for this dredging campaign. Ensuring new modelling outputs, site specific conditions and long-term data have been used to developed zones that provide increased confidence in the level of risk presented by the proposed dredging campaign.	**Section 8.3.3**
Multi-beam and side scan sonar hydrographic surveys	A multi beam and side scan sonar survey was conducted across the Project area.	To update the local area bathymetry allowing differentiation of key habitat types, based on their rugosity and 'hardness'. Multibeam and backscatter data together with video ground-truthing were used to improve the detail of the habitat mapping.	**Section 8.3.4**
Underwater video ground-truthing	Ground truthing of the extent and type of BCH at the disposal location.	Further evaluate the environmental significance of benthic communities found within preferred spoil grounds	**Section 8.3.4**
Benthic habitat mapping	New BCH mapping developed by using the new bathymetric, backscatter and ground truthing video.	To provide a detailed BCH map and allow for greater certainty in the impact assessment.	**Section 8.3.4**
Water quality and PAR sampling	Water quality profiling and water sampling was undertaken within the modelled dredge plume extent and disposal site plume extent to establish preliminary site-specific relationships.	To allow for the development of site-specific relationships, which were used in combination with long term data for the Nearshore Sedimentation Assessment.	**Section 8.2.3**
Revised dredging and spoil disposal management plan (DSDMP)	DSDMP updated to incorporate newly developed triggers based of the site-specific relationships. Updated seagrass and dugong management strategies.	To allow for a more robust monitoring during the dredging campaign ensuring the protection of sensitive receptors, flora and fauna.	**Section 8.3.6** **Appendix B**
Revised CEMP	CEMP updated to include provisions for the following: • NT Land Clearing Guidelines; • The biodiversity and environmental values of the temporary works area • Weed control; and	To increase confidence in the protection of the terrestrial environment during construction, throughout the rehabilitation of the site and post closure.	**Appendix C**

Study	Summary	Purpose	Reference
	• Lighting design for above water infrastructure complies with the National Light Pollution Guidelines.		
CPMMP	A CPMMP was developed.	To ensure that once the facility is installed the local coastal morphology will be protected.	**Appendix D**

7 Land

7.1 Success criteria and closure objectives

In the initial referral, options were discussed for the rehabilitation of the temporary works area through the development of a risk-based, self-auditing program by the contractor to verify all works comply with the *DIPL Environmental Standard Specification*, relevant legislation, approvals, licenses and permits as detailed in the Draft CEMP. In addition and at the request of the NT EPA, success criteria and closure objectives have been developed for the area affected during the construction phase. These criteria were developed in accordance with Young et al (2019).

Success criteria, also termed completion, closure or performance criteria, are defined as agreed standards or levels of performance that indicate the success of rehabilitation and enable an operator to determine when the liability for an area will cease (Young et al., 2019). Criteria should be defined by objective, achievable and measurable outcomes so that the effectiveness of the rehabilitation and revegetation activities can be assessed over time and reported on for the duration required by environmental approval and DIPL internal rehabilitation standards and monitoring methods, as agreed with the contractor.

It is recommended that progress of the rehabilitated areas towards meeting the rehabilitation objectives should initially be assessed against the proposed criteria in **Table 7-1**. Rehabilitation objectives relating to vegetation establishment, soil, landform stability, weeds and dust levels are each proposed to be supported with specific criteria and standards with defined monitoring approaches as further developed by the contractor to support these outcomes and the requirements in the DIPL Environmental Standard specification relating to rehabilitation. The criteria will focus on early success indicators such as initial establishment and presence of appropriate species. These criteria may be updated in the CEMP to ensure they meet the rehabilitation objectives.

For final closure objective, a suitable approach may be to devise quantitative standards for vegetation and soil parameters as a percentage of the average (e.g. 60-70%) from the most recent current monitoring of analogues, which should be representative of the *Terminalia* spp. open woodland providing for a mixed sparse shrubland understory and *Cenchrus* spp. mixed low tussock grassland communities found onsite. This approach is proposed to maintain consistency with the Draft CEMP and may continue to be refined once the contractor has collected sufficient data over successive monitoring periods.

Table 7-1 outlines the success criteria for the key environmental issues raised in association with rehabilitation and closure of disturbances.

Table 7-1: Proposed success criteria.

Aspect	Objective	Success Criteria	Monitoring Methodology	Timing
Landform	The rehabilitated area is safe and stable	• Rehabilitated area ensures that sufficient vegetation coverage to mitigate erosion of the final surface. • The final surface develops resistance to erosive forces.	• Survey by Contractor Environmental representative of final rehabilitated area for compliance against design specifications and levels. • Erosion monitoring transect where appropriate.	• Survey of rehabilitated area to be undertaken at completion of rehabilitation works. • Erosion assessment conducted annually for 2 years post construction.
Dust	Dust suppression is utilised to prevent negative off-site impacts	• Vegetation coverage or constructed dust mounds capable of trapping dust and sand (if required). • Dust from the development is not affecting adjacent vegetation or off-site areas.	• Visual assessment for presence of dust on surrounding vegetation and of dust lift-off in high wind conditions – Vegetation Assessment (Section 7.1.3). • Photographic monitoring undertaken to determine whether any mounding is effective.	• Annually for 2 years post construction
Soil / Vegetation	Soils and vegetation attributes in rehabilitated areas will have values indicative of target ecosystems	• Native perennial seedlings are recorded on the rehabilitation area and are representative of species found in suitable analogue sites.	• Vegetation assessment (**Section 7.1.3**) to record species density and richness.	• Annually for 2 years post construction
	Weeds (introduced species) do not dominate rehabilitated areas	• No new weed species compared to those in adjacent areas. • The cover and density of weed species does not exceed that of suitable analogue sites.	• Vegetation assessment (**Section 7.1.3**) to record the density and cover of weed species.	• Initial visual assessment for weed seedling emergence and establishment 2 months after the first rainfall event, and full vegetation assessment annually for 2 years post construction.

7.1.1 Measurement Approaches

The contractor will monitor the rehabilitation process to track the trajectory of the rehabilitated areas and identify areas where mitigation measures may be required. Monitoring data from the rehabilitated areas and analogue sites will inform further development of the final success criteria. In addition, visual assessments will be undertaken and documented in a suitable inspection sheet.

7.1.2 Photographic Monitoring

Once the temporary works area has been rehabilitated, photographic monitoring will take place to assess soil loss from the surface and dust deposition in relation to surface features such as constructed mounds, or vegetation across the area as a whole.

7.1.3 Rehabilitation Monitoring

Monitoring of the rehabilitated areas will be compatible with the requirements of the draft CEMP. After construction, monitoring will be conducted along a single transect (50 m) positioned where possible on the middle of the site, aligned in the direction of the prevailing wind. Data will be collected using the following methods:

- Vegetation quadrats (2 x 2 m) at 5 m intervals along the transect (10 per 50m length of transect) for assessment of vegetation parameters including cover of native perennial, annual and introduced species, native perennial plant density and species richness;
- Erosion (rill/gully) assessment where relevant.

We note that although vegetation cover data will be collected, it is not a parameter that is proposed for the success criteria, due to early stages of germination and initial focus on early success indicators of density and species richness instead.

Comparison of this data against that from analogue communities will be undertaken for success criteria. Analogues should represent a suitable land system and vegetation community. Due to the uniform nature of the surrounding *Terminalia* spp. open woodland providing for a mixed sparse shrubland understory and *Cenchrus* spp. mixed low tussock grassland neighboring plots which were surveyed pre-construction may be used as analogues.

7.2 Clearing

The NT Land Clearing Guidelines were applied to the assessment of localised impacts to habitats, flora and fauna, which may occur over 3 ha of land that will potentially be cleared for laydown and construction activities. The actual footprint of the permanent works on the land side is 3000 m^2. This loss of primarily *Terminalia* spp. mid-open woodland and previously cleared land zoned main roads. In accordance with the guideline application for a clearing permit will be administered by DIPL. As a precursor to the clearing application and to inform this environmental assessment the land was assessed to avoid environmental degradation through the clearing of inappropriate areas of land. This assessment considered the following factors:

- Biodiversity
- Cultural heritage
- Land management
- Soil
- Vegetation
- Weeds

Details of the surveys are available in the Terrestrial Environmental Report (Cardno, 2022). Initial assessments determined land suitability were completed and maps of the area were provided indicating the natural resources on the site and surrounding areas. Onsite biodiversity assessment was completed to determine presence of threatened species habitats.

The native fauna survey did not result in any observed fauna though desktop assessment identified a moderate likelihood for several listed fauna species to occur at the project site, predominantly birds. A single disused nest was observed, no presence of roosting and/or other nesting habitat was observed during field surveys. A total of five terrestrial mammal species are considered to have ‘moderate’ likelihood of occurrence at the project site. There are very few or no historical records of these mammals at the site. No mammals, reptiles or evidence of recent occurrence was observed during field surveys, which is likely associated with the proportion of cleared/degraded land and human activity in the area.

The native flora survey was conducted to complied with the Northern Territory Guidelines and Field Methods for Vegetation Survey and Mapping (Brocklehurst et al. 2007). For this risk assessment of the native vegetation a NVIS Level 4 attribute classification system was applied to the area. Preclearing / post clearing photographic monitoring and rehabilitation

monitoring have been developed as part of the CEMP to ensure limited environmental impacts and compliance with the NT EPA's hierarchies for environmental protection and management (Part 2 of the Environment Protection Act 2019).

The native flora survey was also used as a preliminary site survey for weed species as two were identified by the NTG Natural Resource Maps (NR Maps) service as potential weed species for the area. Only the annual mission grass (*Cenchrus* spp.*)* was found during a site survey of the proposed project footprint. While this weed species is not a Class A weed in the NT, it is known that the clearing of native vegetation provides ideal conditions for weed proliferation due to soil disturbance and exposure, increasing the risk of weeds seed contamination. To ensure this potential is managed, the head contractor will develop a weed management plan that ensures they meet the closure criteria outlined in **Section 7.1**. Protocols have been developed to prevent the introduction or spread of weeds within the project site from weed contaminated vehicles and machinery, used to undertake the clearing works (**Appendix C**).

In summary, the proposed clearing is not predicted to affect local biodiversity as surveys have confirmed the area does not provide habitat for threatened species and similar habitats are available in surrounding areas that are undisturbed. The irreversible loss of habitat is limited to the 0.3 ha construction footprint and it is anticipated that the remainder of the temporary work site will recover fully. Details for the monitoring of this rehabilitation process can be found in the revised CEMP (**Appendix C**). The plan details the monitoring activities that will be undertaken to ensure early detection of impacts to local vegetation health, which include monitoring weeds especially post clearing and throughout rehabilitation.

Subject to effective implementation of these commitments, it is likely that the NT EPA's objective for Terrestrial Ecosystems will be met by the proposal.

7.3 Lighting

Artificial lighting related to the Project will comply with the best practice lighting design principles outlined in the National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds 2020 (Commonwealth of Australia, 2020). The objective is to adequately illuminate the work area during the dredging phase of the Proposal, with all lighting implemented following this activity (associated with the current and new infrastructure) designed to adhere to the best practice lighting design principles. These principles are applicable everywhere, and include:

- **Start with natural darkness and only add light for specific purposes:** Artificial light should only be implemented for specific purposes, within a specified location and for the specified duration of human use. An upper limit on the amount (duration and intensity) of artificial light should be considered. Consideration will also be given to designating 'dark places', where outdoor artificial lights are prohibited (in a regional planning context).
- **Use adaptive light controls to manage light timing, intensity and colour:** Current lighting technologies will be considered/implemented to adequately control the timing (instant on-off, timers), light intensity (dimming, motion sensors, directivity of light, flashing rate), light colour and the remote management of artificial lighting to minimise unnecessary light output and energy consumption.
- **Light only the object or area intended:** Light spill (i.e. light that spills above the horizontal plane to contribute to sky glow and light trespass) can be detrimental to wildlife, with all light fittings located (close to ground), directed (downwards, at work area/object) or shielded (to reduced sky glow) in such a manner to avoid lighting anything but the target object or area. Light spill from internal light sources should also be considered under this principle (block out blinds, shutters etc.)
- **Use the lowest intensity lighting appropriate for the task:** Use the minimum number and intensity of lights required (to be assessed during the early design stages) to provide safe and secure illumination for the area at the time required to meet the lighting objective/s. Lighting design models should incorporate wildlife considerations, with motion sensor lighting and low glare alternatives to be considered during the design process in relation to light intensity.
- **Use non-reflective, dark-coloured surfaces:** Reflected light can contribute to sky glow, especially when reflected off polished, shiny, or pale coloured surfaces. The colour of paint required on any new and existing infrastructure will take this into account during final design.
- **Use lights with reduced or filtered blue, violet and ultra-violet wavelengths:** Short wavelength light (blue) scatters more readily and contributes more to sky glow than longer wavelength light. Wildlife are typically sensitive to short wavelength light, with lights of little or no wavelength (blue/violet, 400 – 500 nm) preferable for artificial outdoor lights, however some species are sensitive to longer wavelength light, with consideration to be given on a case by case basis. If colour rendition is required for human use, other mitigation methods (control of light spill, use of head torches, timers/motion sensors) will need to be considered/implemented.

8 Sea

8.1 Coastal Processes

8.1.1 Additional Information and Investigations

The SER addressed the following requests for additional information, relevant to 'coastal processes':

- **Metocean conditions** - The project had previously undertaken a comprehensive assessment of the site's metocean conditions, necessary to inform design of the proposed facilities and understand their interaction with the local hydrodynamic and wave climate once installed. However, the report detailing these investigations was not submitted as part of referral to the NT EPA. Subsequently, details of the model setups, calibration and validation have been requested by the NT EPA, to be provided as part of the SER to establish confidence in the reported outcomes regarding changes to coastal processes. Additional modelling outputs, such as comparison of pre- and post-construction metocean conditions, were also requested by the NT EPA to inform their assessment of the project's potential environmental risk. The updated Metocean Report is now provided as **Appendix K** and a summary of the specific information requested by the NT EPA is contained in **Section 8.1.2**.
- **Nearshore sediment transport** - The nearshore area for the project is defined as the area beyond the intertidal zone, but within the proposed facility's influence on local hydrodynamic and sediment transport regimes. The NT EPA requested that additional investigations be undertaken to understand changes to the local sediment transport regime and, subsequently, quantify potential changes to sediment transport loads and nearshore morphology. Additional sediment transport modelling was completed for a range of metocean conditions typically experienced at the site. These investigations are summarised in **Section 8.1.3** and presented in detail in the updated Sediment Transport Report (**Appendix L**).
- **Shoreline evolution** - The original Environmental Referral and Sediment Transport Report made estimates of potential shoreline change by interpreting the local metocean climate and available sediment and water quality data from the site. These inputs were used to calculate littoral drift sediment loads passing along the site's shoreline. The NT EPA requested that a more sophisticated modelling assessment be undertaken to map and quantify predicted shoreline change, once the facility is installed. Demonstration of the validity and predicted accuracy of this modelling was also requested. Details of the additional data analysis and modelling undertaken to meet this request is summarised in **Section 8.1.4** and presented in the updated Sediment Transport Report (**Appendix L**).
- **Coastal processes monitoring and management** - Given inherent uncertainty in sediment transport modelling, natural variability of the coastline and the prediction of substantial changes to local coastal processes induced by the proposed facility, the NT EPA has requested ongoing monitoring of coastal processes once the facility is installed. The request has been fulfilled by the preparation of a Coastal Processes Monitoring and Management Plan (CPMMP), which is discussed in **Section 8.1.5** and provided as **Appendix D**.

8.1.2 Metocean Conditions

Comprehensive metocean investigations have been carried out to inform design and operability of the proposed marine facilities, as well as to inform investigations into potential environmental risk associated with changes to coastal processes. These investigations are documented in the project's Metocean Report (**Appendix K**) and include the following:

- Development of calibrated and validated physical processes (wave and hydrodynamic) numerical models, including incorporated cyclonic conditions, to determine critical metocean design constraints;
- Joint probability analysis to assess likelihood and severity of extreme water levels occurring with extreme wave conditions, informing design levels for infrastructure; and
- Modelling of ambient wave and current conditions to assess operability of the proposed harbour and to compare pre- and post-construction wave and current conditions.

Hydrodynamic Conditions

To determine the operational tidal currents and extreme storm surge levels at the site, detailed hydrodynamic modelling has been undertaken. The model was used to define the sea-level and currents under spring and neap tides, and with tropical cyclone wind and pressure forcing in addition to the tides, utilising the Delft3D hydrodynamic model system. The arrangement of the hydrodynamic modelling grids and associated bathymetry is shown in **Figure 8-1**.

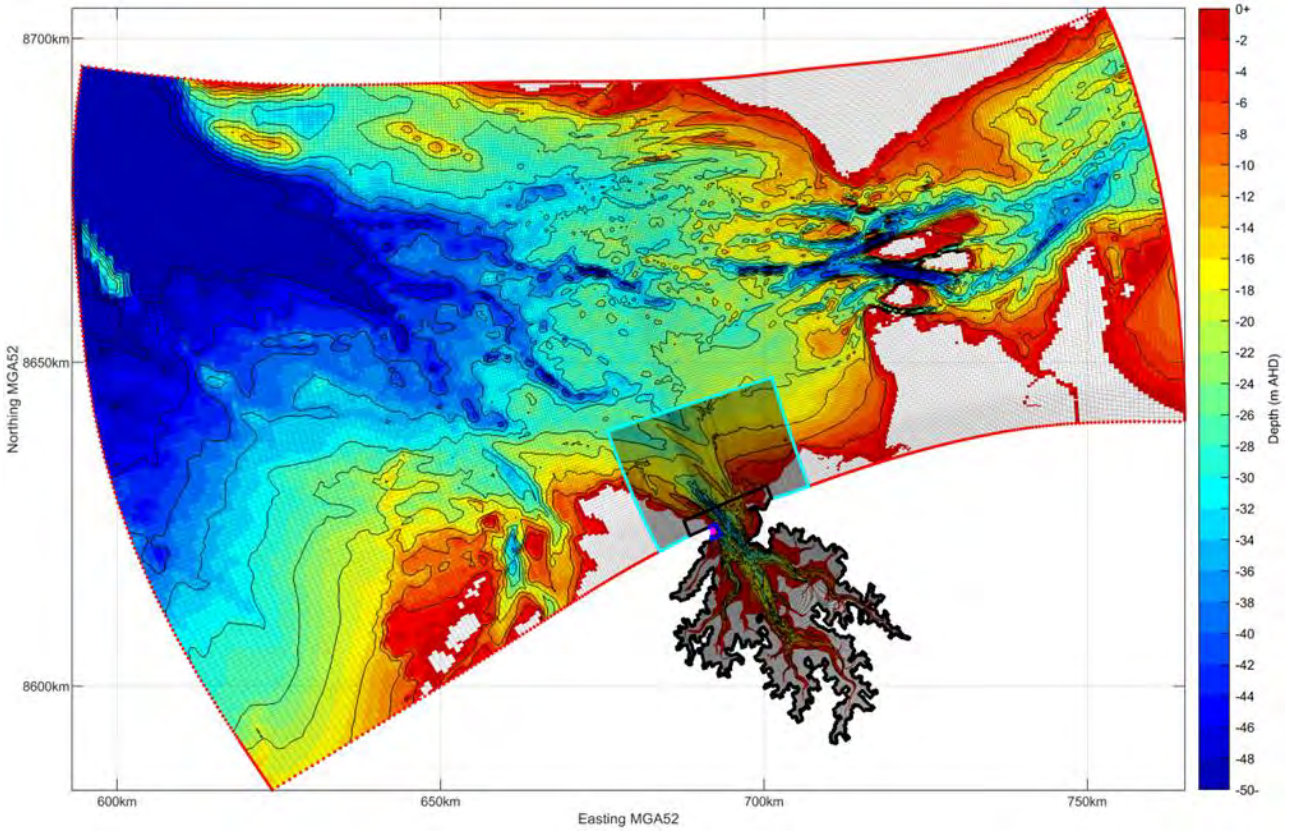


Figure 8-1: Physical processes model grids and bathymetry: Beagle Gulf (red), Entrance (cyan), Darwin Harbour (black), Mandorah (blue) & Mandorah Local (magenta).

The hydrodynamic model was calibrated and validated against datasets from several data collection campaigns undertaken at the site, dating back to 2013. An example comparison plot showing modelled and measured water level, current speed and current direction at Mandorah is presented in **Figure 8-2**.

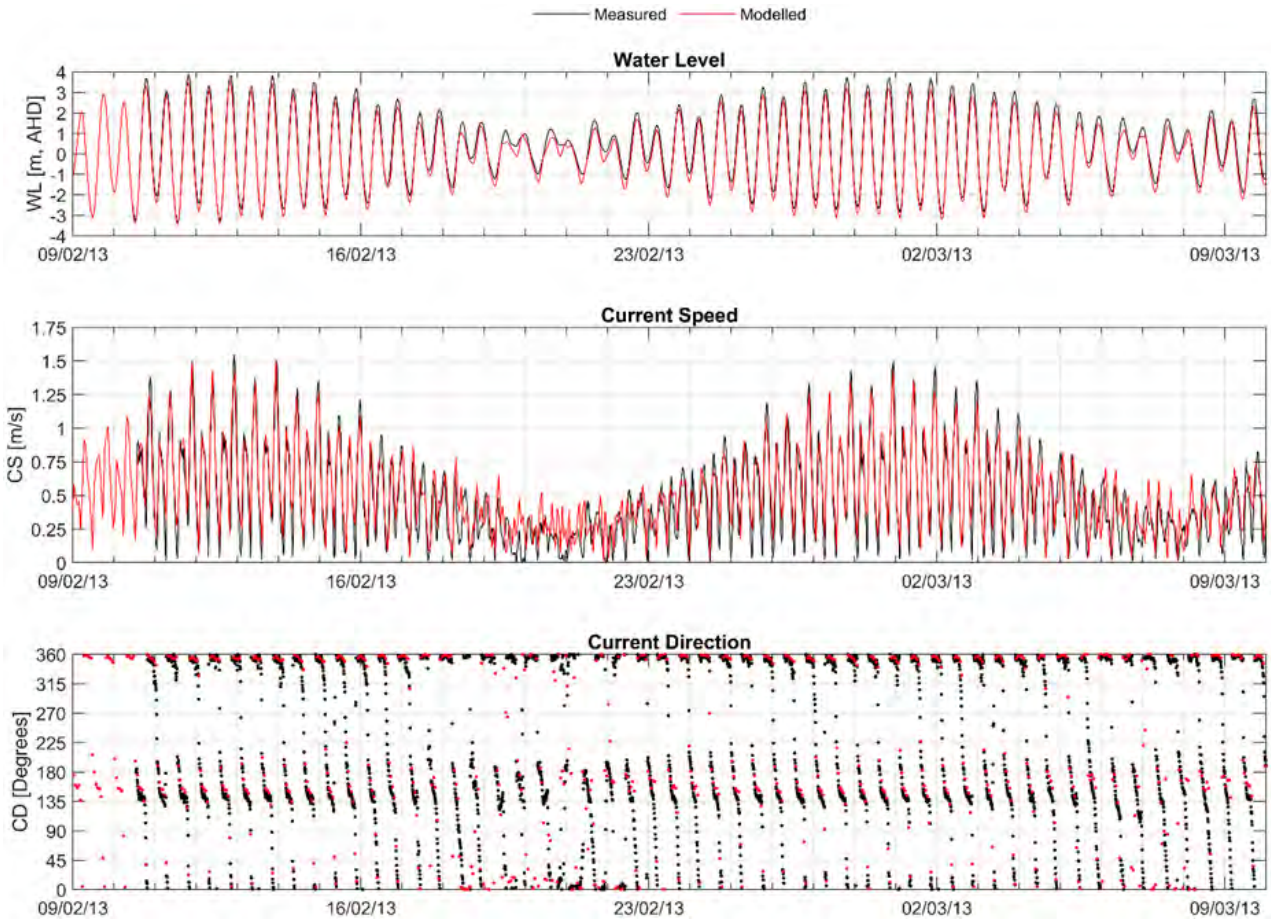


Figure 8-2: Comparison of measured and modelled water level, current speeds and directions at Mandorah.

Pre vs Post-Development Current Patterns

The hydrodynamic model was forced to assess the expected changes to local current patterns once the proposed facility is installed. Under existing conditions, offshore the site, currents are typically directed towards the north during an ebb tide and towards the south during a flood tide. In general, ebb currents are stronger than flood currents. Near the proposed harbour entrance, ebb tidal currents at the output location are predicted to reach up to 1.1 m/s during a spring tide and flood currents approach 0.4 m/s. Tidal asymmetry and circulation means that, in the nearshore waters adjacent the proposed harbour, the flood current direction can flow toward the north (i.e. opposite to the offshore direction).

The proposed harbour design and bathymetry was incorporated into the hydrodynamic model to demonstrate its effect on local currents. **Figure 8-3** and **Figure 8-4** provide an example of the difference between pre- and post-development current magnitude and direction during the peak of a spring tide flood and ebb flow, respectively.

The installation of the proposed facilities has a localised impact on tidal currents. The interaction between the harbour and net northerly current circulations creates a sheltered environment in the lee of the northern breakwater, which extends approximately 500m alongshore. Such environments are conducive to low sediment mobility, leading to the accumulation of material on the seabed. A similar, though less pronounced interaction is evident in the lee of the southern breakwater, leading to a reduction in current speeds in the nearshore waters to south of the harbour. Within the harbour, as expected, the current vectors show a reduction in peak tidal current speeds up to approximately 80%. In general, the installation of the harbour is predicted to reduce current speeds in its direct vicinity. The effect of focusing and increasing water flows is not noticeable, due to the harbour sitting predominantly in the intertidal area with already relatively low flow speeds. There is also a large expanse of deep water offshore of the project site to accommodate in- and out-flow volumes.

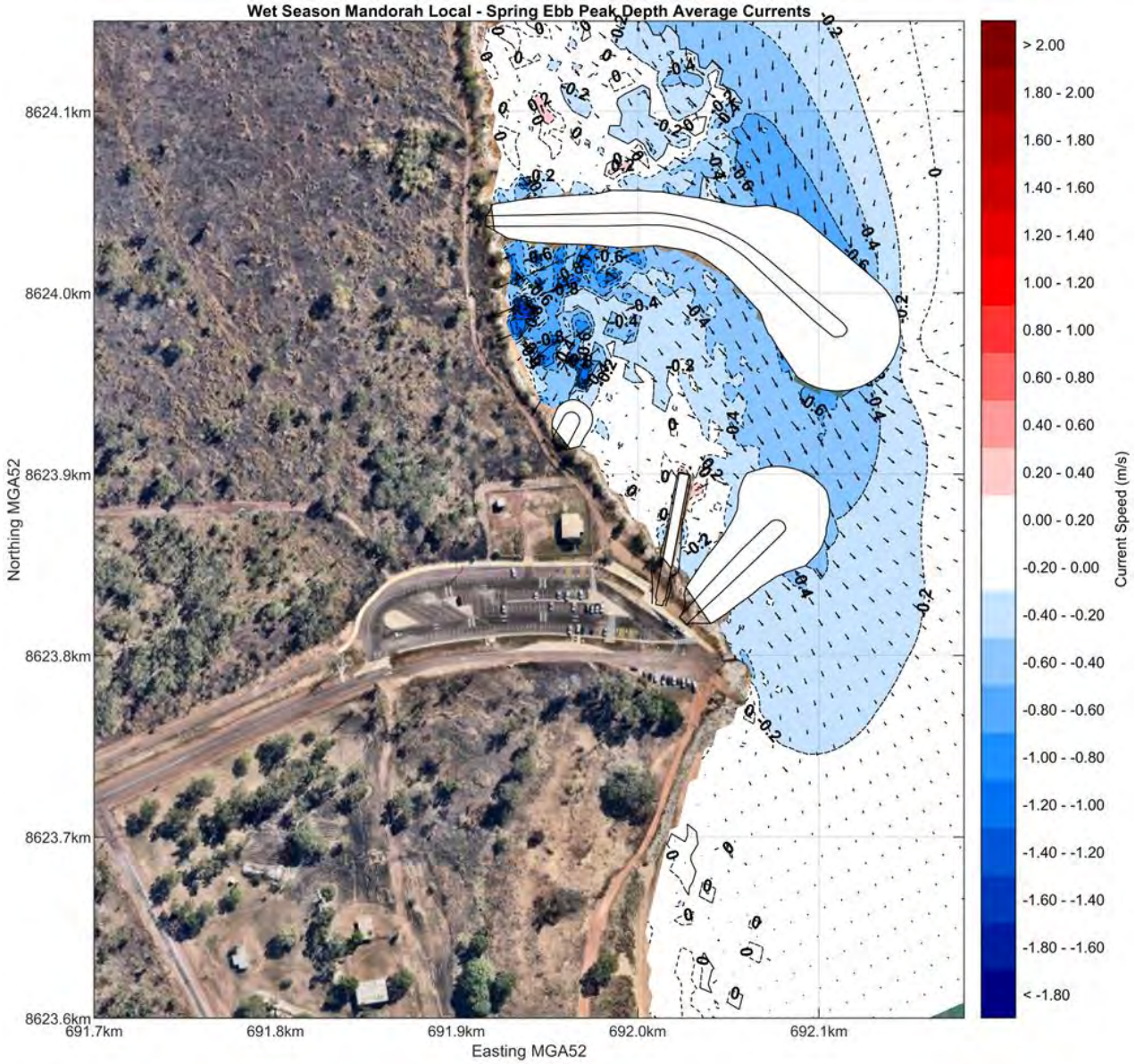


Figure 8-3: Spring tide ebb flow difference vector plot – Pre vs post development

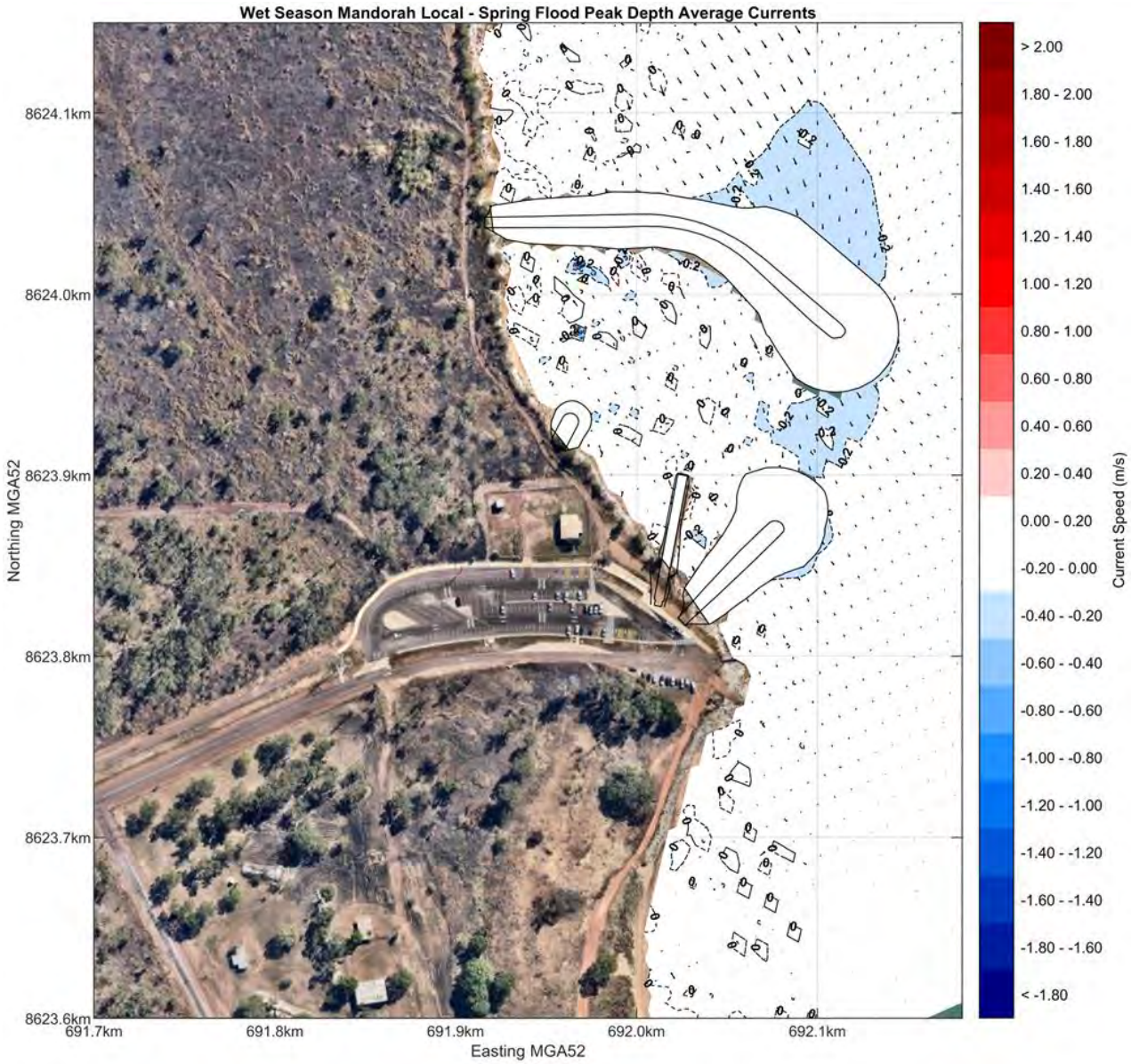


Figure 8-4: Spring tide flood flow difference vector plot – Pre vs post development

Wave Conditions

To understand the wave climate at Mandorah, including design wave conditions, it was necessary to interrogate and apply a long-term historical time series of wave data for Darwin Harbour. Measured wave data does not exist for sufficient length of time for such purposes. As such, numerical wave modelling has been undertaken using the Deflt3D-Wave (SWAN) modelling package. The arrangement of the wave model grids and associated bathymetry is provided in **Figure 8-5**.

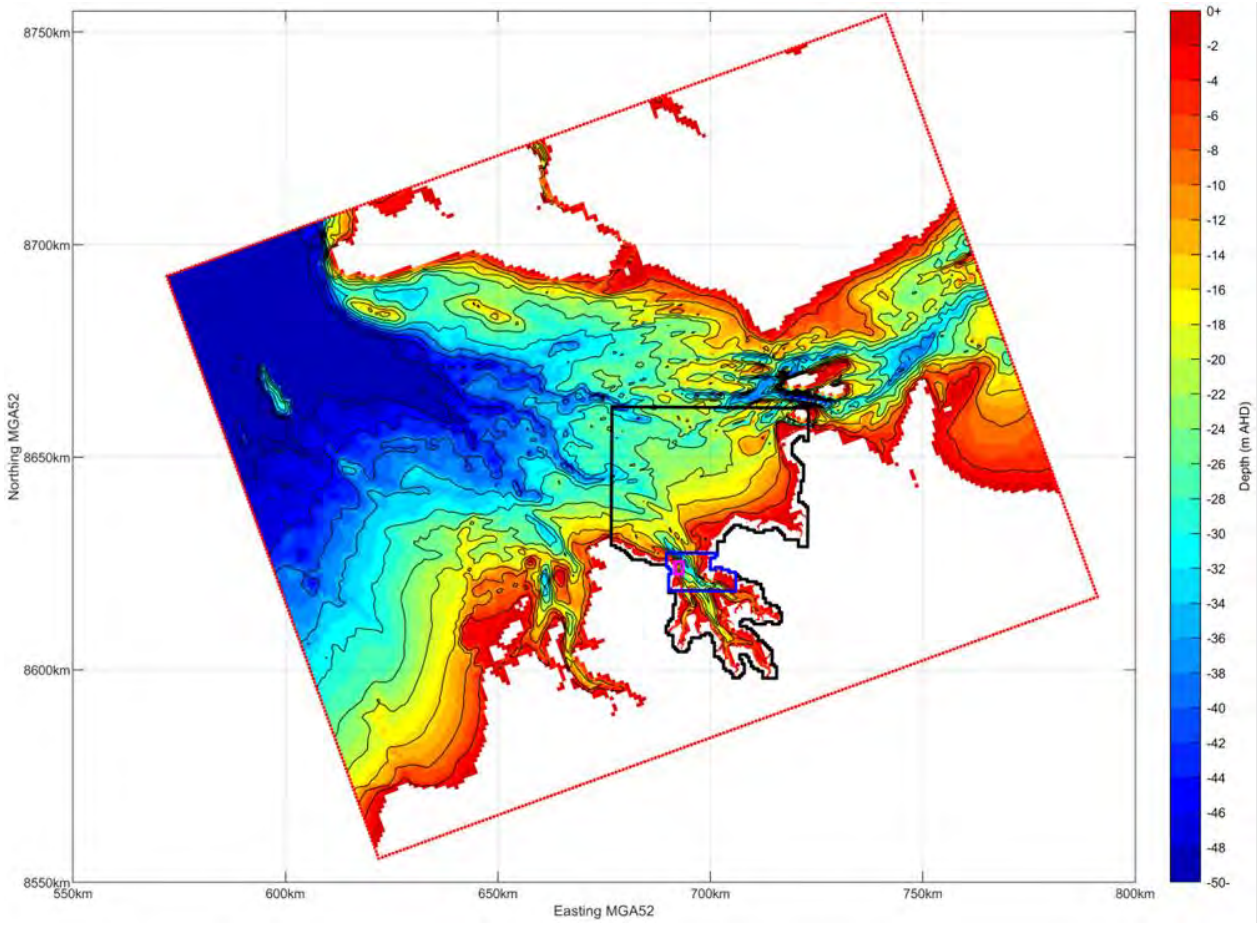


Figure 8-5: SWAN model grids: Beagle Gulf (red), Darwin Harbour (black), Mandorah (blue) & Mandorah Local (magenta). Colour contours showing Beagle Gulf bathymetry

The model was validated and calibrated against various short-term wave datasets collected at Mandorah, as well as throughout the harbour. An example comparison plot showing modelled and measured statistical wave parameters at Mandorah is presented in **Figure 8-6**.

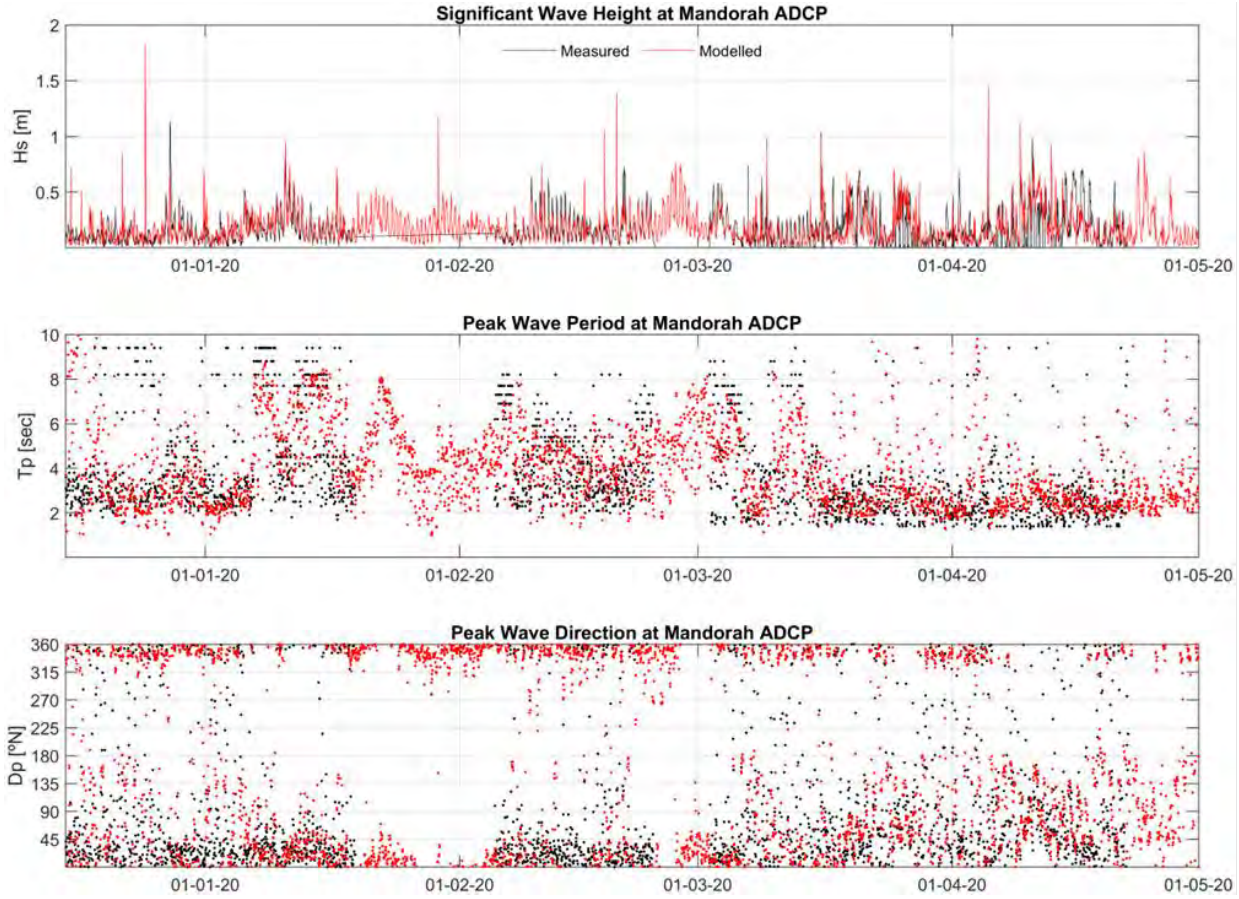


Figure 8-6: Comparison of measured and modelled wave statistics at Mandorah

Pre vs Post-Development Wave Conditions

The local wave climate at Mandorah is a combination of swell waves, which typically approach the site from the north to north-east, and locally generated wind waves approaching the site from different directions; but mainly 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.

Swell waves at the site are typically small, and significant wave heights of the order of 5cm or less occurs for nearly 69% of the time. Swell significant wave height is predicted to be limited to less than 1.0 m offshore the project site. Only around 3.5% of the time the swell significant wave height is higher than 0.25m. The wind-wave climate is more energetic. Wind waves are predicted to approach 2.0 m (significant height) in very rare events, and for over 55% of the time locally generated wind waves exceed 0.25 m.

The proposed harbour layout and bathymetry was incorporated into the SWAN wave model to demonstrate its effect on typical and extreme local wave conditions. Representative wave conditions during spring/summer and autumn/winter have been extracted from the operational wave climate study. **Figure 8-7** and **Figure 8-8** show the difference between pre- and post-development wave magnitude during typical northerly and south-easterly conditions, respectively. Waves approaching the site from these directional sectors are representative of the prevailing wave conditions during spring and summer, and autumn and winter, respectively.

The installation of the proposed harbour is predicted to have a relatively localised impact on the wave climate. The aim of the harbour is to create a sheltered internal basin, which is noticeable in the comparison plots. Outside of the harbour the influence on the local wave climate is minimal. The extent of the local external sheltering is most pronounced during south-easterly wave conditions, with lower wave heights extending to the north of the harbour's footprint by approximately 250m.

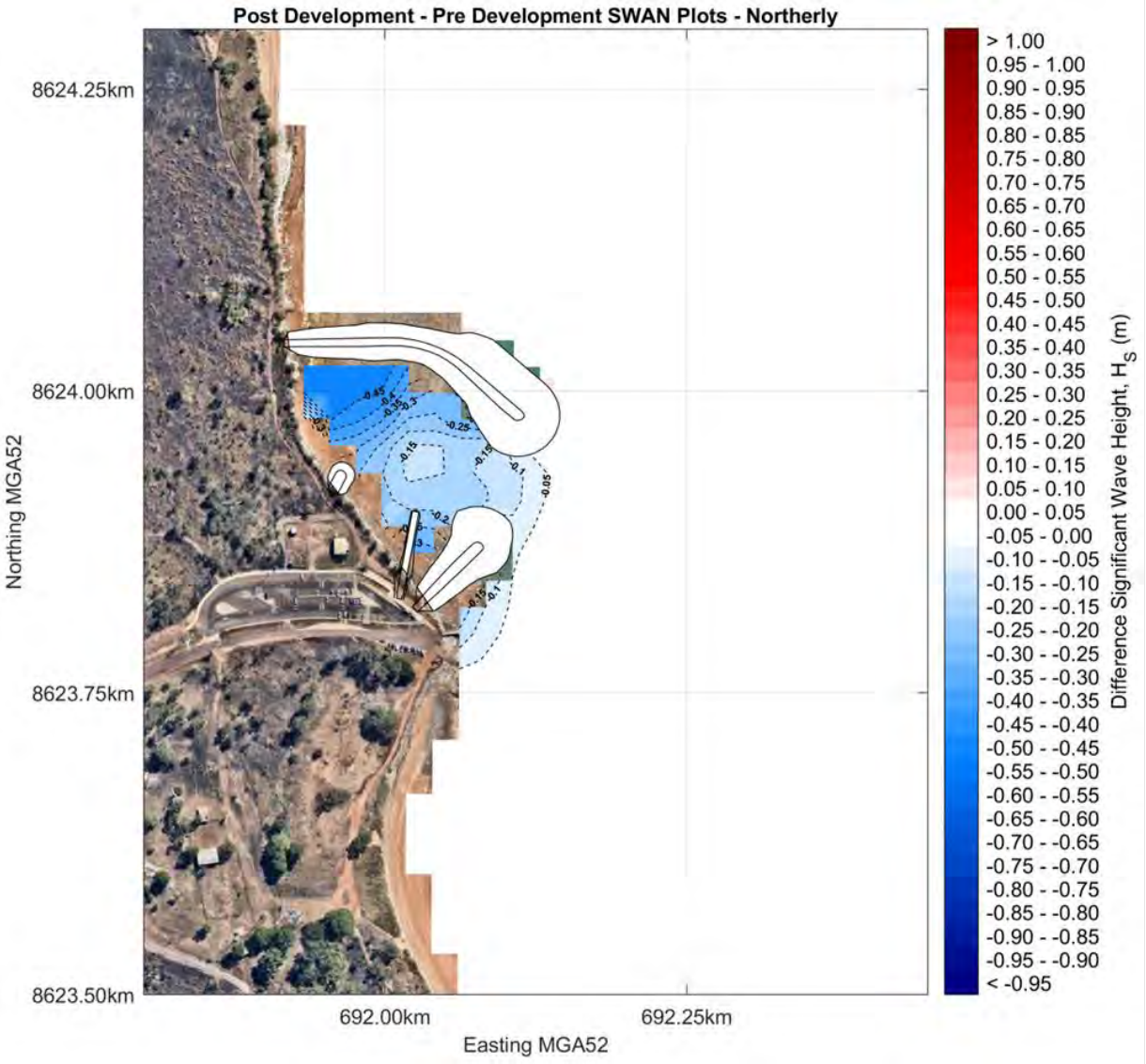


Figure 8-7: Wave vector plot during spring and summer, northerly conditions – Pre vs post development.

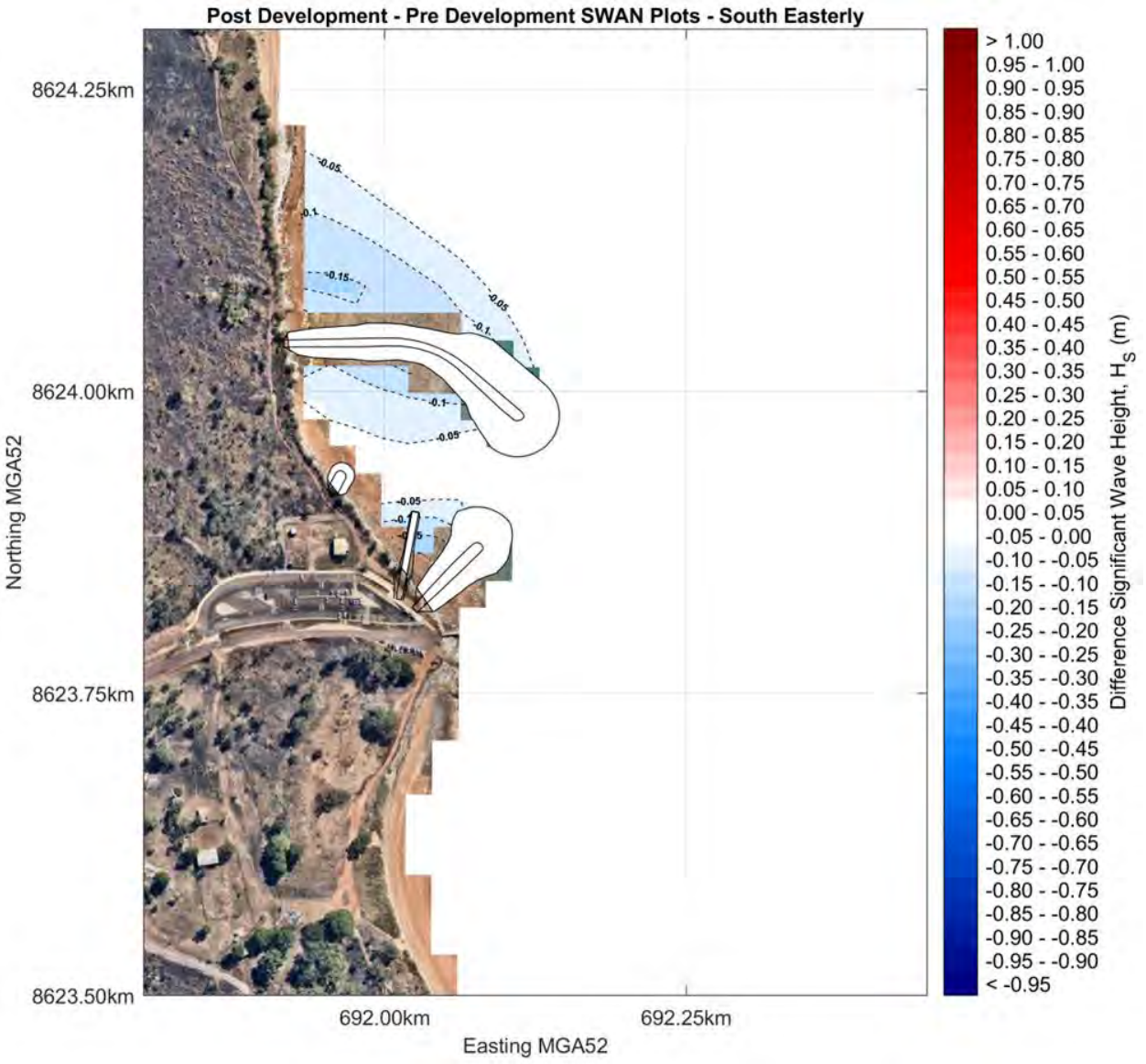


Figure 8-8: Wave vector plot during autumn and winter, south-easterly conditions – Pre vs post development

8.1.3 Nearshore Sediment Transport

Once installed, the breakwaters are expected to alter the local hydrodynamic and wave conditions in their vicinity (see **Section 8.1.2**) and, in turn, alter local patterns of sediment movement, deposition and re-suspension. Detailed assessments of these potential changes are documented in the Sediment Transport Report provided in **Appendix L**. In the nearshore area (defined as being beyond the intertidal zone) this is expected to result in changed sediment transport patterns and a reorganisation of available sediment, resulting in morphological change.

In order to assess changes in sedimentation and erosion patterns, the project's existing hydrodynamic and wave model was applied incorporating a sediment transport module. This module makes it possible to undertake time-series sediment transport modelling using combined tide, wind and wave processes. The bed levels, water levels and currents within the wave module are updated every 30 minutes and the calculated wave conditions (wave heights and radiation stress maps) are used for the next hydrodynamic phase.

Morphological Simulations

Five general morphological modelling scenarios were investigated, selected to be representative of the seasonal metocean conditions that characterise the region. Each of these five scenarios were simulated for pre- and post-development conditions, and included the combined influence of waves, winds, and tides. These input parameters were required to describe the physical processes that are typically experienced on an annual basis at Mandorah. The scenario modelling approach has been adopted to optimise the simulation time, given how computationally 'expensive' this form of sediment transport modelling is. The five general morphological modelling scenarios investigated include:

- 1-month of typical dry season conditions;
- 1-month of typical wet season conditions;
- 1-month of typical shoulder season (wet to dry) conditions;
- 1-month of typical shoulder season (dry to wet) conditions; and
- 2-weeks of storm conditions.

Sediment Transport Pathways

To investigate the potential sediment transport pathways, and the likely source(s) of the sediment that may be mobilised at Mandorah, the east/west and north/south directed sediment transport rates predicted by the model have been integrated over the morphological simulation periods. This provides an indication of the net sediment transport rate and its corresponding direction across the simulation periods. **Figure 8-9** and **Figure 8-10** present examples of net sediment transport vectors for the post development conditions across the wet and dry morphological modelling scenarios, respectively. Results for all modelling scenarios are included in **Appendix L**.

The potential sediment transport pathways indicate the residual direction and intensity of the sediment flux, should sediment be available on the seabed. Sediment transport pathways were generally consistent throughout the year, indicating strong dependency between morphological response and tidal currents. The majority of strong sediment mobility occurs offshore from the proposed harbour, in water depths exceeding -10 mAHD. Notable areas of high sediment mobility include the water column adjacent to the nearshore reef immediately north of harbour. Conversely, the potential sediment transport pathways show low sediment mobility in the nearshore area, surrounding the proposed harbour.

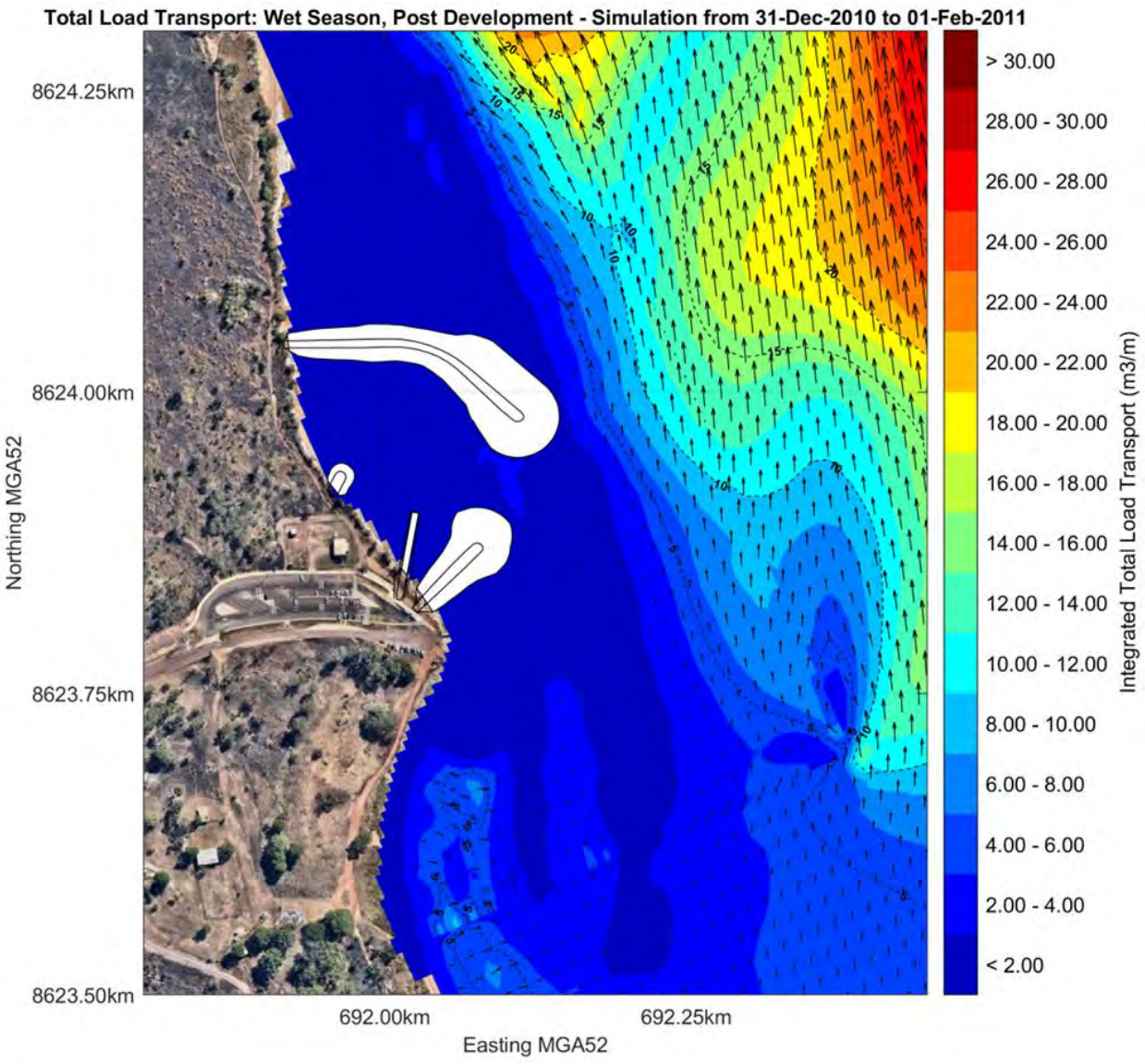


Figure 8-9: Total sediment transport vectors – 1 month, wet season.

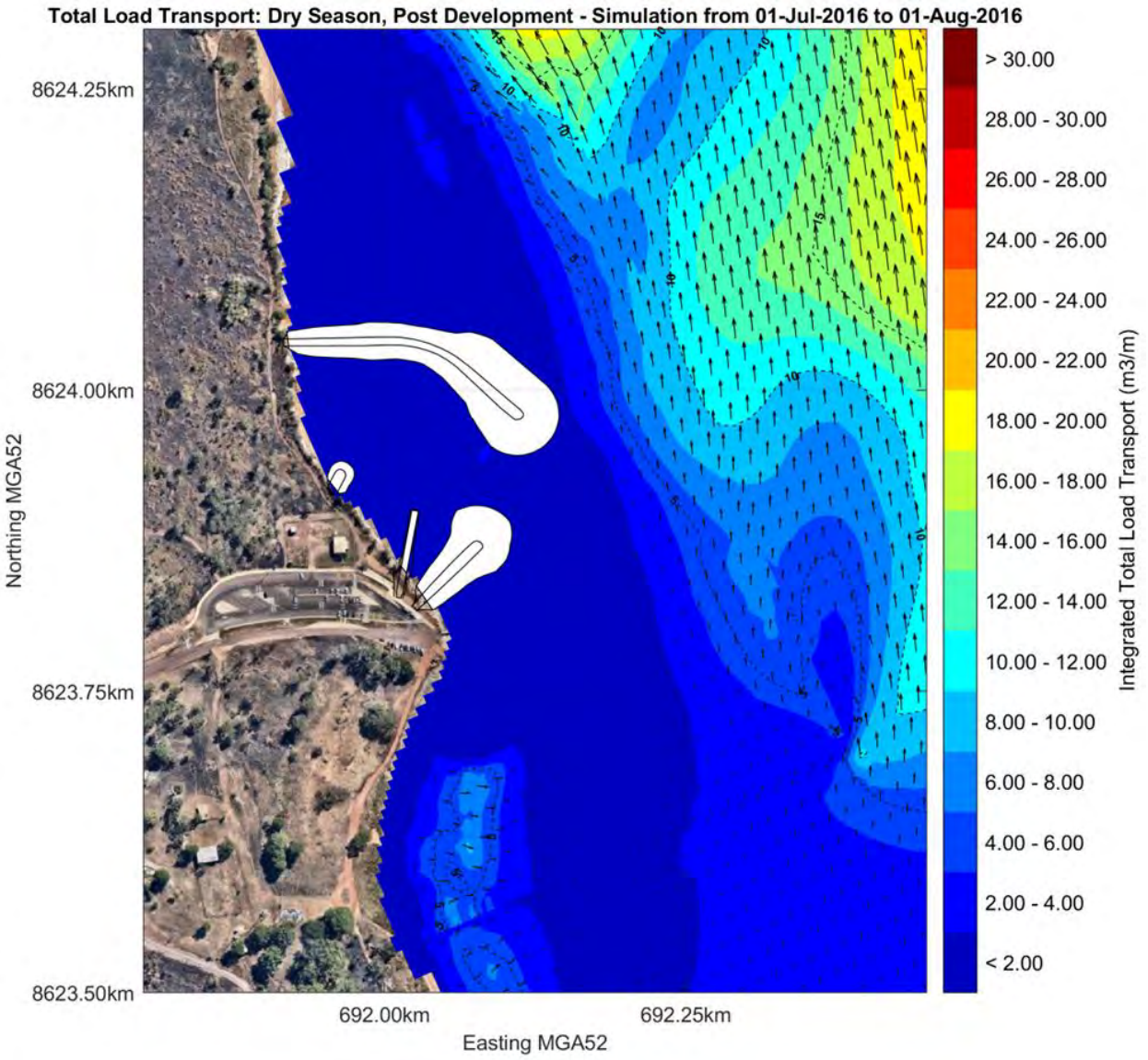


Figure 8-10: Total sediment transport vectors – 1 month, dry season conditions.

Changes to Nearshore Sedimentation and Morphology

Morphological simulations across the five modelling scenarios were undertaken to investigate the combined influence of tides, wind and waves on local sedimentation and erosion patterns. An initial investigation was carried out to validate the morphological modelling results, based on available bathymetric datasets within the modelling domain. The bathymetric datasets used for comparison were dated approximately three-years apart, at similar times in the annual cycle (September 2017 and October 2022). A comparison of the surveys shows that the nearshore seabed is relatively stable, with localised elevation changes rarely exceeding ±0.2 m.

An example of the modelled baseline (pre-development) net sediment deposition, across the wet season is provided in **Figure 8-11** below, where the most 'natural' morphological change was demonstrated. Results for all modelling scenarios are included in **Appendix L**. Comparisons between the five morphological simulations suggest that seasonality has minimal impact on sedimentation and erosion patterns. This is likely attributable to tidal currents being the dominant mechanism for sediment resuspension and transport in the area.

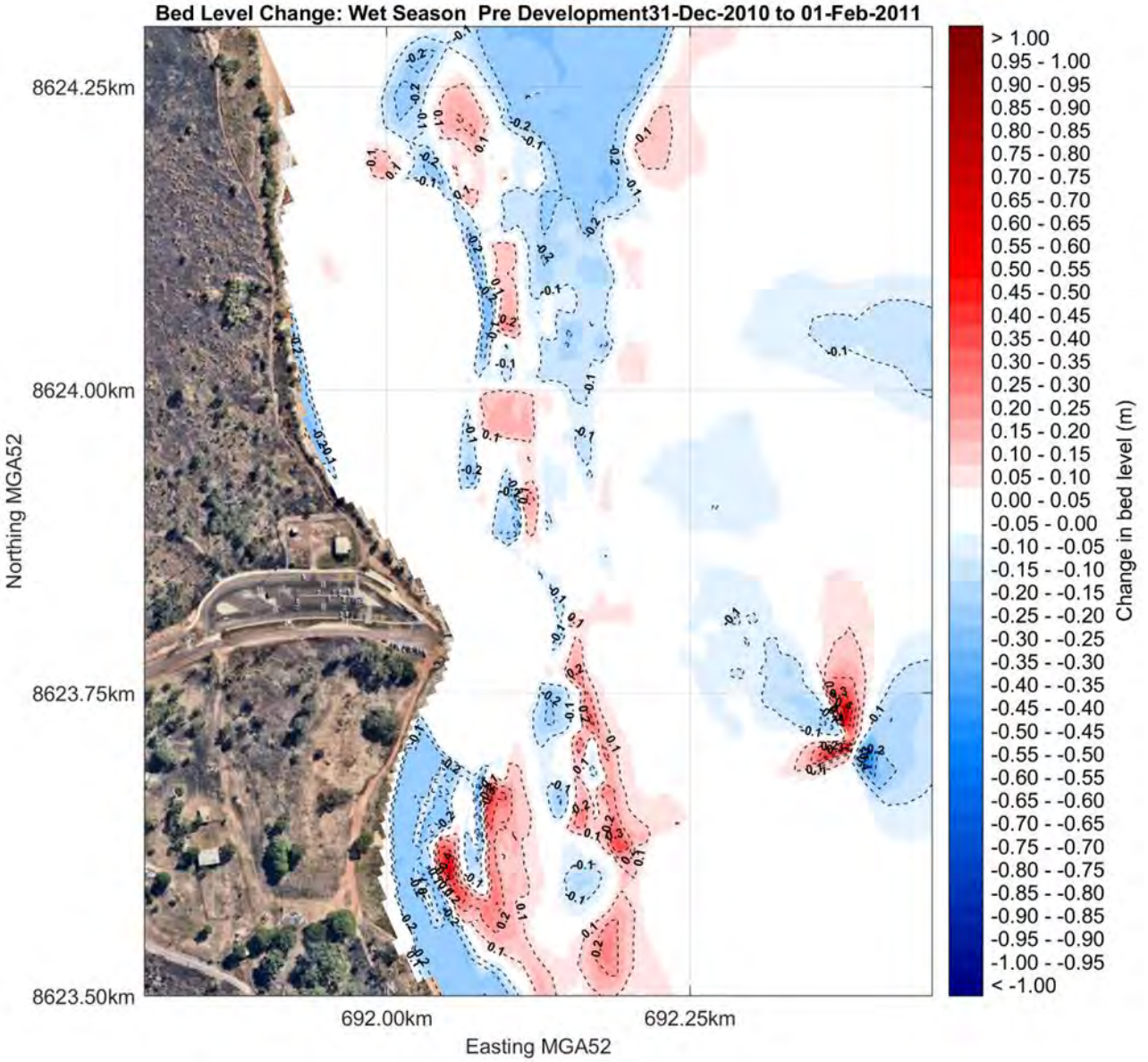


Figure 8-11: Baseline sediment deposition and scour: 1-month, wet season

Figure 8-12 presents an example of pre- and post-development difference plots of net sedimentation and erosion across the five morphological modelling scenarios investigated. Results of comparison for all modelling scenarios are included in **Appendix L**. the modelling outputs demonstrate that changes to local sedimentation and erosion patterns, attributed to the harbour, are relatively small and localised. There is also minimal seasonal variability, demonstrated by the comparable results across the five morphological simulations. During all modelling simulations, net changes to the seabed elevation were observed prior to the end of the modelling period. This indicates that the seabed reaches a state of equilibrium, based on available sediment volumes within the modelling domain.

Notable changes, attributed to the harbour, include an accumulation of sediment in the nearshore area to the north of the main breakwater. At times, this material may be expected to be deposited at the entrance/approach of the harbour. The interaction between the breakwater structures and net northerly currents during both ebb and flood flows, creates a sheltered environment in the lee of the northern breakwater. Such environments are conducive of low sediment mobility, leading to the accumulation of material on the seabed. Based on the modelling results and comparisons between bathymetric surveys taken three-years apart, at similar times in the annual cycle, these changes are anticipated to occur relatively soon following construction of the harbour, assuming sediment is available for transport and deposition

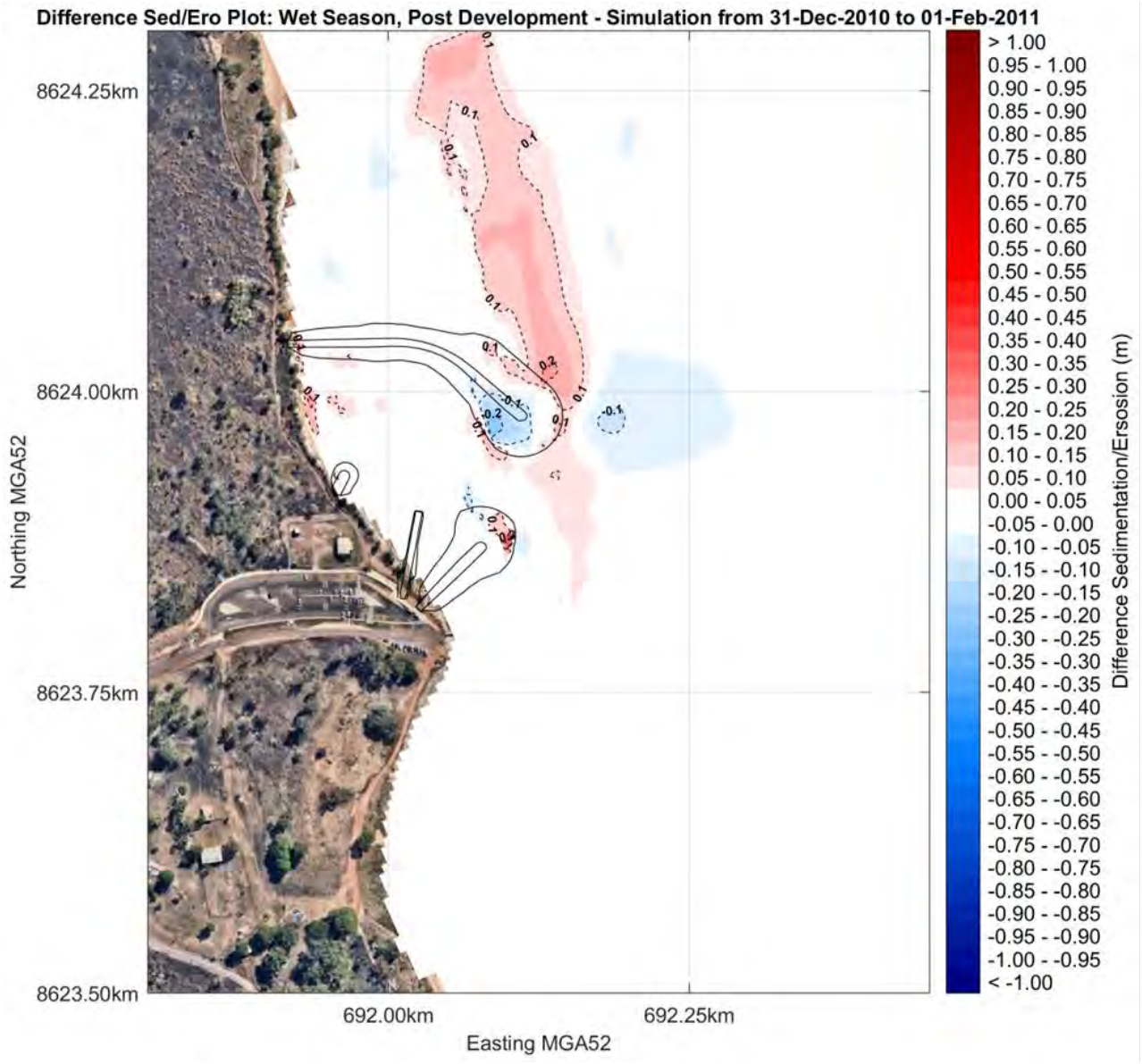


Figure 8-12: Pre vs post development changes in bed level: 1-month, wet season.

8.1.4 Shoreline Evolution

Shoreline evolution predictions presented in the original referral were derived from the model LITDRIFT, which estimates the volumes of longshore sediment transport ('littoral drift') along a coastline. The output volumes were then interpreted to make predictions of shoreline change adjacent the harbour over time.

To fulfill the NT EPA's request to improve accuracy and spatial predictions for shoreline evolution, the LITLINE model has been applied for this SER. LITLINE is the shoreline plan-form, evolution module of LITPACK and applies the Pennard-Considered 1-line method of analysis. The model includes shoreline structures such as the proposed breakwaters, applying the computational results of LITDRIFT at a number of shoreline locations to assess long term changes to the surrounding coastline. Curved-in-plan alignments are modelled as a straight coastline, but with appropriate wave directions applied at the seaward ends of the profiles. An active beach face height extending from an adopted closure depth to the top of wave run-up is used to calculate the changes in the shoreline (at the position of the mean sea level contour).

Model Setup

For this study, shoreline evolution has been modelled using two representative shore normal profiles as indicated in **Figure 8-13.** The bathymetric details of these profiles have been derived from the consolidated bathymetric and topographic data and are presented in **Figure 8-14.**

Figure 8-13: LITLINE profile locations.

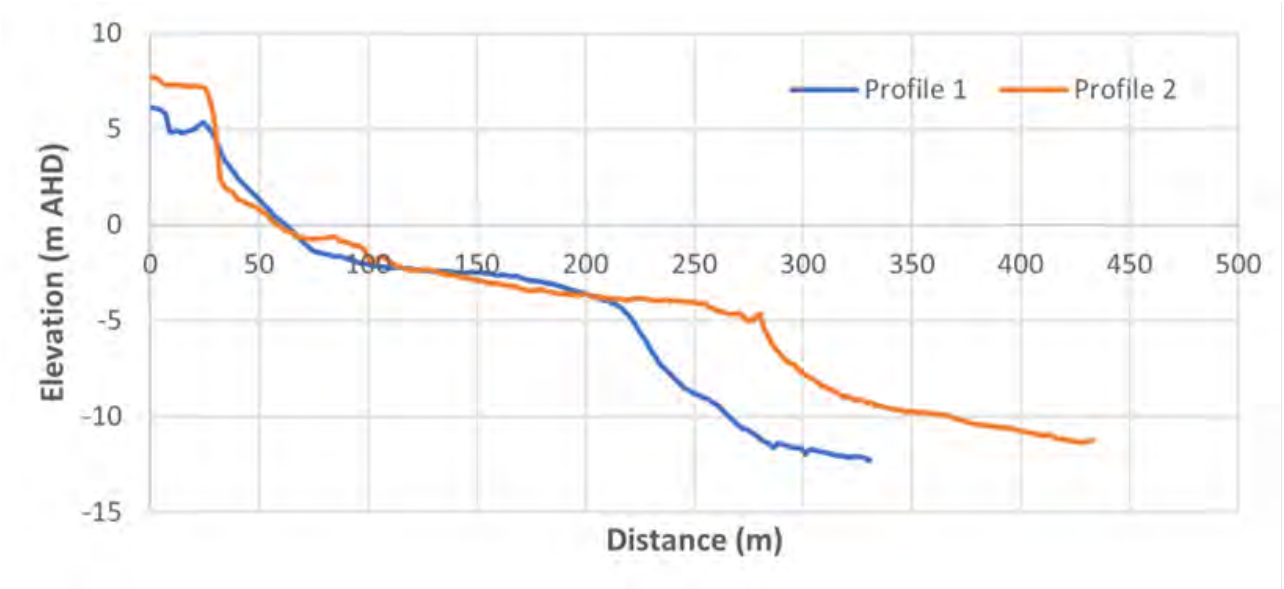


Figure 8-14: LITLINE profile cross sections.

Duration

The LITLINE models were run for a period of 10 years (2000-2010) using wave climate data developed from SWAN wave modelling for the selected shore normal location and corresponding hindcast water level from the developed Delft3D hydrodynamic model constituents (see **Section 8.1.2**).

Results

Two scenarios were run in LITLINE, modelling both the existing (undeveloped) site and proposed developed site, with the inclusions of the breakwaters acting as barriers to littoral drift. **Figure 8-15** displays the present-day (baseline) shoreline as well as the modelled change in shoreline, with and without construction of the marine facilities, over a 10-year historical period of wave and water level conditions. A widened beach profile north of the facilities is visible due to the main breakwater disrupting the net southerly transport of sediment. The accretion to the north of the facilities reduces the sand feed available to the south, resulting in a small area of erosion approximately 350 m south of the lee breakwater. It should be noted that the substantial erosion shown on the beach to the south of the facility in **Figure 8-15** has resulted from the modelling both with and without the structures. I.e., it is a result of the 10-year period of coastal conditions rather than the influence of the structures. Predicted erosion and accretion to the south of the facility is also uncertain, due the presence of rock along the coastline. Geotechnical information collected at the project site suggests underlying rock may be present at the back of the beach, inhibiting the modelled erosion. The 'down-drift' effects of the proposed maritime facilities on the surrounding shoreline are limited to within 400 m south of the lee breakwater, due to coastal structures and a sharp change in shoreline orientation.

Figure 8-15: Shoreline evolution results

Shoreline Change

Accretion and erosion volumes have been estimated for the shoreline adjacent to the proposed facilities. Volumes were derived using topographic data (beach slope) and the area bound by the change in shoreline position between model runs, with and without development. Volumes are tabulated in **Table 8-1,** expressed as an annual change, averaged over the 10-year model runs to remove interannual variability. **Figure 8-16** displays the sections of the coastline which have the potential for shoreline change once the facility is installed**.**

Figure 8-16: Areas of potential shoreline change

Table 8-1: Estimated volume change by zone.

Zone	Rate (m^3/yr)
Accretion – North of facilities	1,300 – 1,900
Erosion – South of facilities	200 - 600

8.1.5 Coastal Processes Monitoring and Management Plan

A Coastal Processes Monitoring and Management Plan (CPMMP) was developed to ensure that once the facility is installed the local morphology of the coastline will be observed to ensure any risks associated with changes to sedimentation and coastal processes regimes are identified, and risk mitigation strategies established. The CPMMP is provided in **Appendix D**.

8.1.6 Updated Bathymetry

To strengthen the bathymetric information available for the Project and disposal site, DIPL commissioned a detailed multibeam and side scan sonar study over the previously un-surveyed area, as well as surrounding areas to verify chart soundings and bottom 'hardness'. The hydrographic survey was carried out on the survey vessel with the following equipment installed:

- Norbit Winghead i77h
- Trimble POSMV Oceanmaster
- Hypack Acquisition and Processing Software (2022)
- AML SVP
- 2 × Panasonic Toughbooks

The aerial survey was undertaken with a Phantom 4 RTK and post processed using Rec Catch. A detailed Hydrographic and Aerial Survey Report is provided in **Appendix G**. The outputs from the survey were used to update the local area bathymetry allowing differentiation of key habitat types, based on their rugosity and 'hardness'. Multibeam and backscatter data together with video ground-truthing were used to significantly improve the detail of the habitat mapping (**Section 8.3.2**).

8.2 Marine Environmental Quality

8.2.1 Dredge and Disposal Plume Dispersion

The existing sediment plume model used to predict the suspended sediment load and sedimentation thickness has been updated with the following refinements:

- Additional sources of sediment into the marine environment including:
  - Fines released from rock used in the main and lee breakwaters, causeway and boat ramp; and
  - Fines released due to the disturbance of the seabed during rock placement of the main and lee breakwaters, causeway, boat ramp and piling activities.
- Dredging of rock has been conservatively assumed to be undertaken simultaneously by backhoe dredge and landside excavator, effectively doubling the production rate;
- Entire duration of Cutter Suction Dredge (CSD) and backhoe / landside dredging modelled;
- Dredge volume of soft sediment has been increased to 30,000 m^3 to ensure a conservative approach;
- Inclusion of maintenance dredging model runs; and
- Inclusion of potential overlap between construction of main breakwater and backhoe / landside dredging.

See **Section 8.3.1** for the dredge disposal site selection or, for a full description of model inputs and assumptions, refer to **Appendix L.**

Scenarios

The model was partitioned into several scenarios spanning the entire dredging and construction program for both a typical spring, and neap tide. Due to the long duration of Scenarios 3 and 7 (**Table 8-2**), modelling proceeded over a 28 day as TSS concentrations are expected to stabilise in that time. Sedimentation rates feeding into other parts of the project have been scaled to reflect the full construction program. **Table 8-2** contains the variables altered in each of the eight scenarios modelled.

All modelling scenarios are conservative in terms of schedule and the potential generation of turbid plumes, with multiple dredging and construction activities occurring in tandem. In reality these activities are likely to be sequenced over a longer time period, than modelled in these examples. Results are therefore conservative.

Table 8-2: Scenario inputs

Scenario	Description	Tidal cycle	Working hours	Model duration (days)	Percentage of program modelled
1	• Cutter suction dredge of soft sediments (30,000 m^3); and • Offshore disposal (30,000 m^3).	Neap	• 8 hrs per day (excluding ~2 hr break for slack tide); and • 7 days a week.	22	100%
2	• Backhoe dredge rock from barge (35,000 m^3); • Land based excavation using long reach excavator from beach at low tide (35,000 m^3); and • Construction of the main breakwater.	Neap	• 8 hrs per day; and • 7 days a week.	18	100%
3	• Construction of the main breakwater (potential overlap); • Construction of lee breakwater; • Construction of causeway and boat ramp; and • Installation of piles.	Neap	• 8 hrs per day; and • 7 days a week.	28	62.2%
4	• Maintenance dredging; and • Disposal of dredged material.	Neap	• 12 hrs per day.	4.5	100%
5	• Cutter suction dredge of soft sediments (30,000 m^3); and	Spring	• 8 hrs per day (excluding ~2 hr	19	100%

Scenario	Description	Tidal cycle	Working hours	Model duration (days)	Percentage of program modelled
	• Offshore disposal (30,000 m^3).		break for slack tide); and • 7 days a week.		
6	• Backhoe dredge rock from barge (35,000 m^3); • Land based excavation using long reach excavator from beach at low tide (35,000 m^3); and • Construction of the main breakwater.	Spring	• 8 hrs per day; and • 7 days a week.	18	100%
7	• Construction of the main breakwater (potential overlap); • Construction of lee breakwater; • Construction of causeway and boat ramp; and • Installation of piles.	Spring	• 8 hrs per day; and • 7 days a week.	28	62.2%
8	• Maintenance dredging; and • Disposal of dredged material.	Spring	• 12 hrs per day.	4.5	100%

Model Results
The modelling of offshore disposal assumes a dispersive technique is applied by the dredging contractor (sediment/water mix ejected at the ocean surface), which represents a 'worst case' scenario in terms of generating turbid plumes and elevated TSS concentrations. Sedimentation from dredging occurs largely within or close to the dredge footprint due to low current speeds reducing dispersion of the sediment. Scenarios 4 and 8 show a wider sedimentation footprint due to all dredged material assumed to be fines during maintenance dredging, increasing dispersive effects.

For more detailed results, including TSS and sediment deposition plots, refer to **Section 8.2.3** and **Appendix L.**

8.2.2 Local Area Relationships (TSS, Turbidity)

Due to recognised limitations in applying the WAMSI thresholds for turbid nearshore waters (sensu EPA WA 2021), thresholds were developed using baseline data collected at the Mandorah site during the INPEX Ichthys Nearshore Environmental Monitoring Program (INPEX, 2014), and more recently as part of a targeted water quality assessment undertaken in October 2022.

Water quality profiling and water sampling was undertaken at 15 sites within the modelled dredge plume extent and 10 sites within the disposal site plume extent to establish site-specific relationships for TSS vs NTU vs Photosynthetically Active Radiation (PAR). The sampling was undertaken during spring tides, over a 12-hour period. The parameters recorded included:

- Vertical profiling of:
  - Turbidity (NTU)
  - PAR
  - Conductivity
  - Temperature
  - Dissolved oxygen
  - Depth; and
- Collection of water samples at targeted locations and depths (near-surface, mid-water and near-bed).

Owing to a very the strong correlation between turbidity (NTU) and TSS, NTU measurements were used to approximate TSS concentrations, using a local area relationship established by collecting water samples directly alongside a turbidity sensor (i.e. during profiling). This data was subsequently analysed to develop an algorithm for converting local turbidity values to TSS concentrations, and depth averaged TSS concentrations to PAR (**Table 8-3**) (For more detail refer **Appendix J**). The relationship was subsequently used for the development of thresholds and triggers for respectively mapping the zones of influence and monitoring the extent and concentration of TSS in the water column, during the dredging phases.

Table 8-3: Local area relationships derived for Mandorah.

Relationship	Equation
TSS to NTU	$TSS = 1.8167 * NTU, R2 = 0.91$
Depth averaged TSS (DA TSS) to NTU	$DA\ TSS = 1.58 * NTU, R2 = 0.99$
Depth averaged TSS to PAR attenuation	$PARZ2 = PARZ1 * \exp[-Kd(Z2 - Z1)]$ $Kd = 0.051 * DA\ TSS\ (between\ Z1\ and\ Z2), R2 = 0.99$

(a) For full details on how these calculations were derived see **Appendix J**.

8.2.3 Revised TSS elevations

A calibrated hydrodynamic and sediment transport model was used to model the release and dispersion of dredge material from the construction footprint and at the proposed disposal zone, under a worst-case scenario. Modelling proceeded assuming the release of 30,000 m^3 of soft sediment during the cutter suction dredging program (approximately double that assessed in the original referral to ensure modelling is conservative) and 70,000 m^3 of consolidated material during backhoe / landside dredging phases.

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. Assuming the dredged material remains in slurry format while under transport to the disposal site, any material released at the surface of the water column is expected to disperse owing to the very high regional current speeds, with negligible deposition to the sea floor.

Based on the modelling, concentrations of TSS varied depending on the tidal cycle, with greater dispersion under spring tide conditions (**Figure 8-17** and **Figure 8-18**). 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. The 50th percentile values are within the range of typical dry season conditions, and the 95th percentile values are commensurate with the upper ranges experienced under wet season conditions, when TSS concentrations may exceed 100 mg/L over extended periods (i.e. 30 days during storm events) (**Figure 8-19**).

Despite the potential for elevations in TSS, the effects were predicted to return to baseline levels shortly following the dredging campaign; owing largely to the flushing compacity of the local environment, which is considerable. Interrogation of both the magnitude and duration of TSS elevations in the Mandorah area, suggests none are of the magnitude or duration required to directly impact the filter feeding mechanisms of benthic invertebrates, or exceed the loadings detrimental to vertebrate fauna.

TSS and PAR will be monitored continuously during the dredging program with the results compared to a series of trigger values with exceedance of stage 1 triggers representing early warning, and exceedance of stage 3 triggers, leading to contingency management (**Section 8.2.4**). Although protective of marine environmental quality generally, the triggers have been developed specifically for the protection of BCH which may be impacted during the dredging program.

Based on the results of the modeling, as depicted in **Figure 8-17** and **Figure 8-18**, the proposal is not expected to compromise the EPA's objective for marine environmental quality, with any residual effects anticipated to be short term and fully reversible.

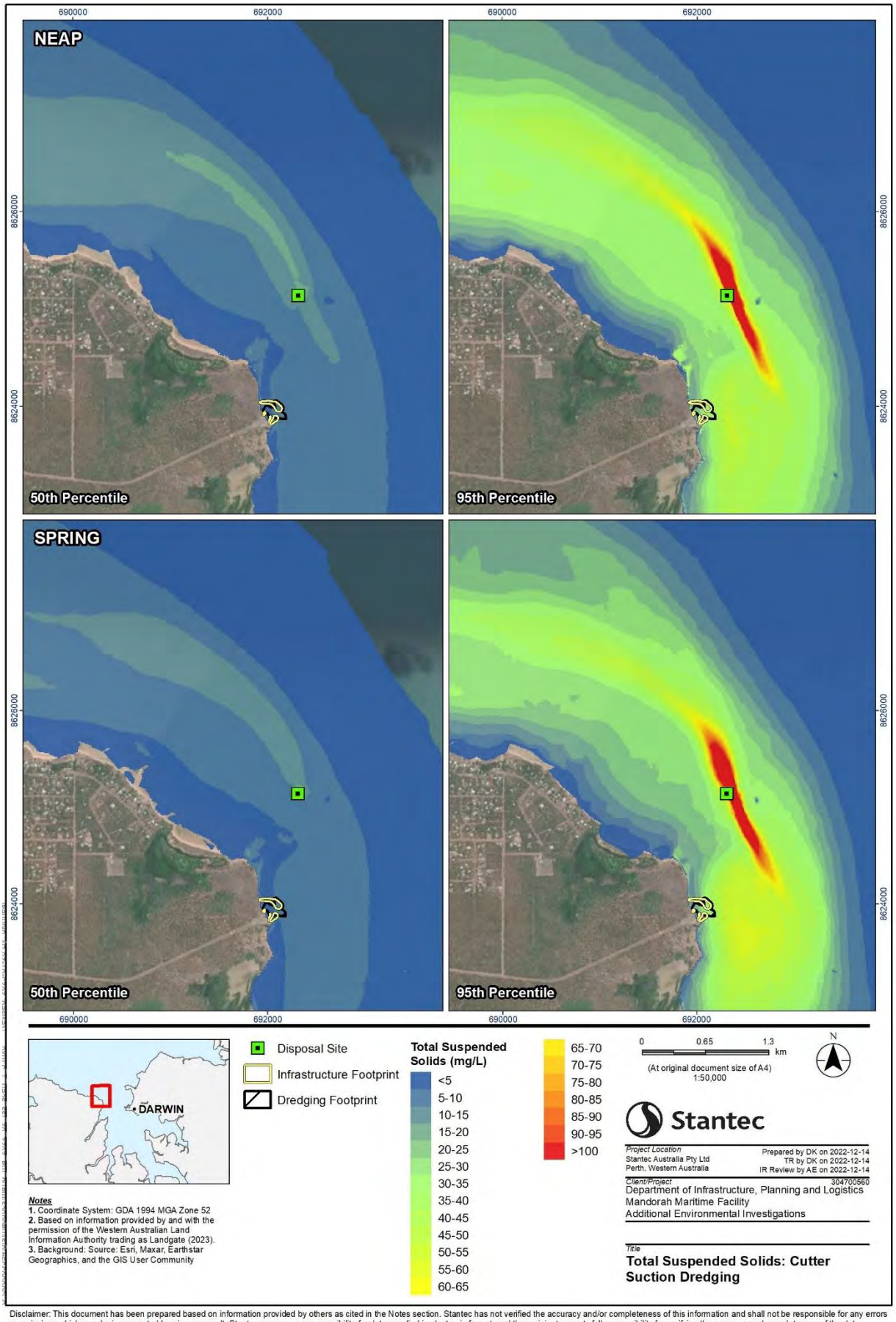


Figure 8-17: Predicted depth averaged TSS concentrations during the cutter suction dredging phase.

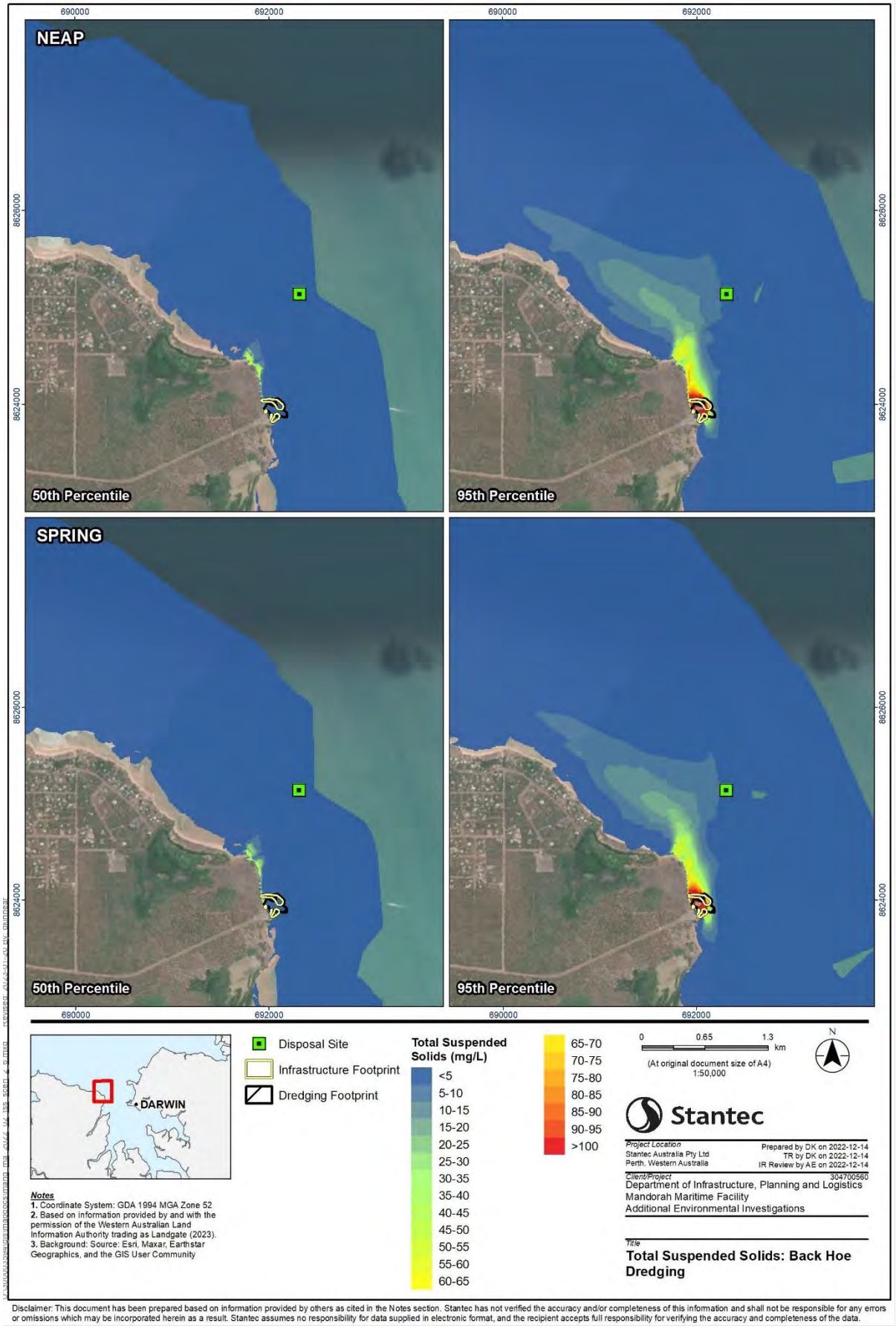


Figure 8-18: Predicted depth averaged TSS concentrations during the back hoe dredging phase.

8.2.4 Operational Monitoring Triggers

A suite of trigger values have been developed, that if exceeded, will trigger management responses (**Table 8-5**). The trigger values and management responses are included in the DSDMP (**Appendix B**). TSS concentrations in the water column will be extrapolated from real time NTU data, which will be monitored (at least) hourly during the dredging campaign, at appropriate impact and reference sites. 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.

8.2.5 Trigger development

Triggers for operational monitoring were developed based on Section 4.2.1 of EPA WA (2021) which recommends the use of the percentile approach. The percentile approach was selected for its conservatism relative to the laboratory derived triggers developed during the WAMSI DSN. Fisher at al. (2019) found that the calculated percentile values required to meet the *strict* and *permissible* impact thresholds for corals at Barrow Island typically exceeded the 99th percentile of the baseline time series data (**Table 8-4**).

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 (**Figure 8-19**). Under the ANZWQG (2018) approach if the median value of an impact site exceeds the 80th percentile value of a suitable reference site, it is considered commensurate with an environmental perturbation. For this reason, the 80th percentile value was set as the trigger for the ZoMI, and the 99th percentile the trigger for the ZoHI. In total, three trigger levels, comprising early warning, primary and secondary triggers, were developed based on the 80th and 99th percentile seven 7- and 14-day moving averages for TSS (subsequently converted to NTU) (**Table 8-4**).

As per the DSDMP, 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 (see the DSDMP, **Appendix B**).

Table 8-4: Estimated percentile value required to reach the permissive and strict possible effects thresholds

	Permissive (probable effects) guideline		**strict (possible effects) guideline**	
Site	Turbidity $log_{10}(NTU+1)$	Light stress: $1-(DLI/30)^{1/3}$	Turbidity: $log_{10}(NTU+1)$	Light stress: $1-(DLI/30)^{1/3}$
AHC	>0.99	>0.99	0.97	0.92
LNG1			>0.99	0.94
MOF1				0.97
SBS	0.98		0.92	0.95
ANT, BAT, DUG, LNG0, LNG2, LNG3, MOF3	>0.99		>0.99	>0.99
DIW, ELS, LNGA, LNGB, LNGC, MOFA, MOFB, MOFC, REFN, REFS, TR		nd		nd
mean	0.996	0.999	0.993	0.979

Table 8-5: 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.

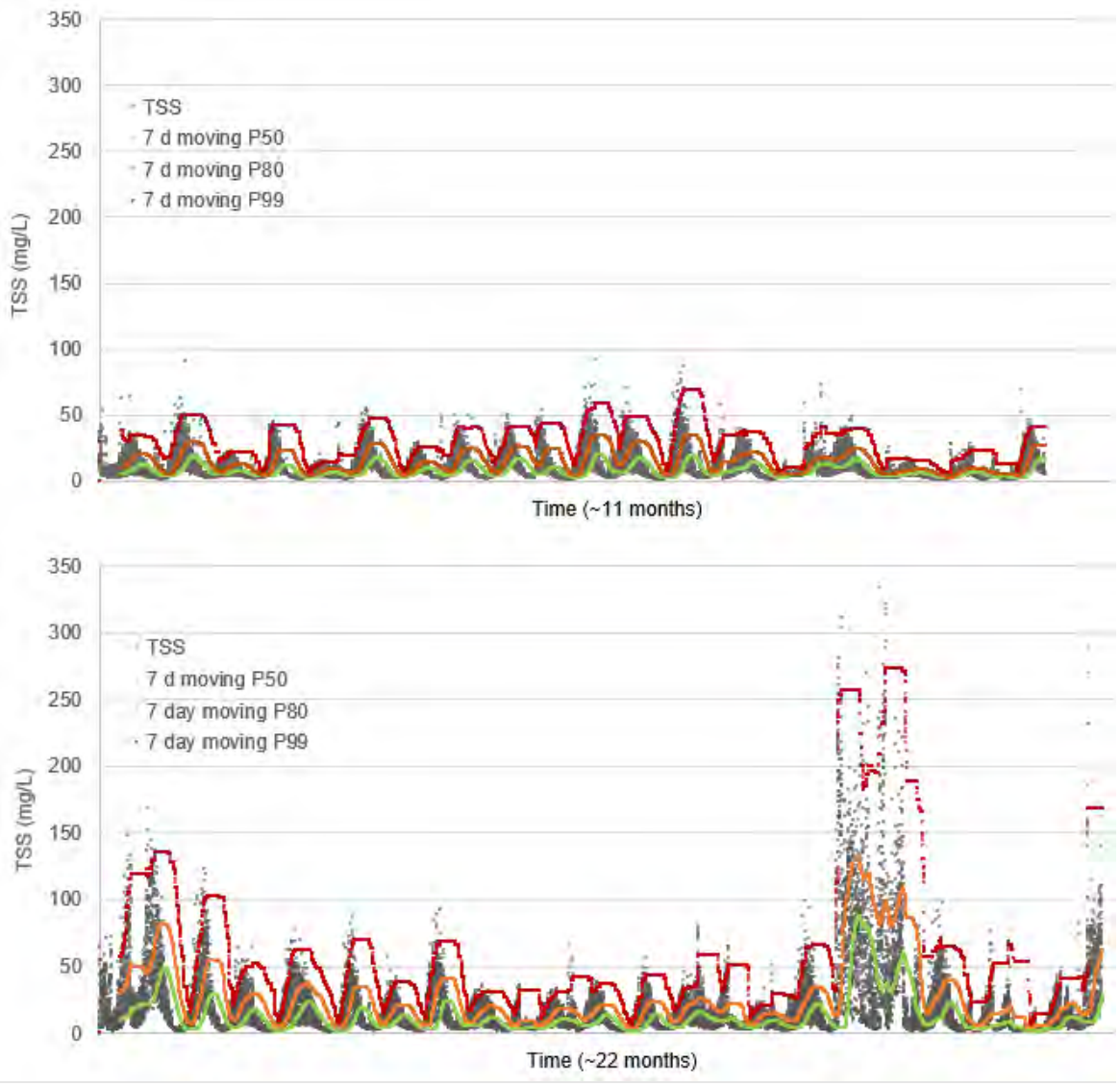


Figure 8-19: Long term TSS concentrations and 7-day moving percentiles under dry (upper) and wet (lower) season conditions.

8.2.6 Monitoring Locations

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, as per the updated DSDMP (**Appendix B**). Monitoring sites were chosen based upon the predicted zones of impact as well as the results of the benthic mapping, specifically considering locations of seagrass, sponge and coral colonies. 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. Instruments shall be telemetered with built in technology to allow immediate notation of trigger exceedances, via the 4G or 5G network.

8.3 Marine Ecosystems

8.3.1 Dredging Disposal Site Assessment and Selection

Eight dredge spoil disposal options, including two on land, six offshore (**Figure 8-21**) were assessed for this SER. The results of the assessment confirmed utilising a deeper offshore disposal location presented a better outcome. Of the eight options, both the land-based options at the Shoal Bay Waste Management Facility and a dedicated local onshore disposal site was immediately eliminated due to the potential for the saline material to impact native flora and fauna, together with logistical complications associated with the remoteness of the project site. Those more remote offshore sites were not selected due to the added complications and potential hazards associated with transporting sediment over long distances. Disposal Sites 1,2 and 3 were subsequently shortlisted (**Figure 8-20**).

Disposal Site 1 was considered unsuitable because of the prevailing currents, and the risk of line displacement under strong lateral currents. Disposal Site 2 was excluded given its proximity to sensitive benthic community habitat including seagrass and macroalgae communities, leaving Disposal Site 3 as the most appropriate option.

Disposal Site 3 lies in deep water, is exposed to strong currents and is optimally located to allow the discharge line to run parallel to the prevailing current, allowing for the precise deposition of the dredge spoil and reducing the likelihood of pipe breakages. Based on the updated habitat map, Disposal Site 3 comprises predominantly bare reef and sponge communities, with occasions coral colonies (<5%), and maintains the lowest diversity of the sites considered. Disposal Site 3 presented a low risk of sedimentation impacts but presented residual concerns around short term changes in water quality (TSS). These concerns were subsequently addressed using a hydrodynamic model, updated to simulate a worst-case scenario based on the mobilisation of 30,000 m^3 of dredge material (see **Section 8.3.3**).

Figure 8-20: Potential alternative disposal locations.

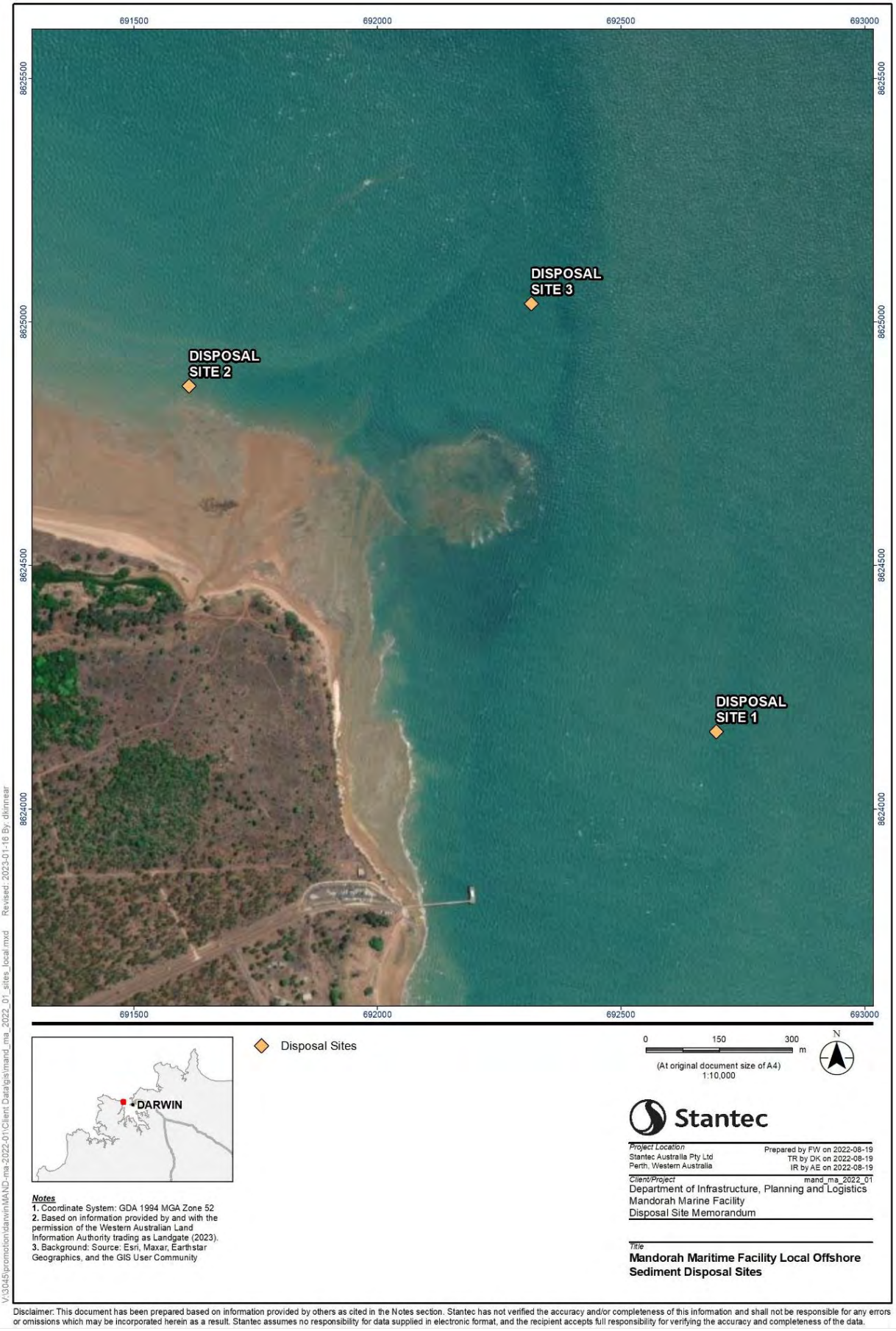


Figure 8-21: Shortlisted disposal sites.

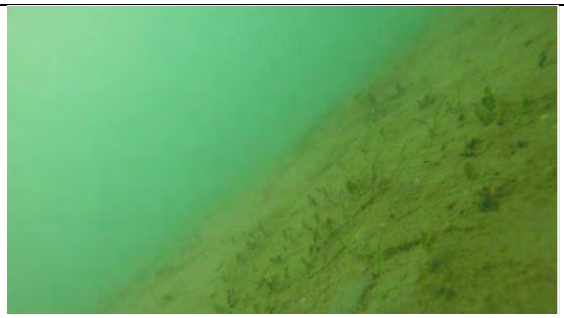
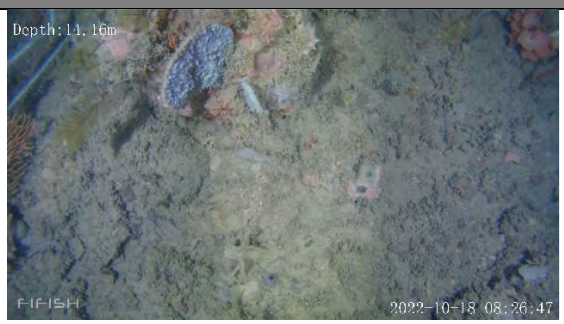
8.3.2 Benthic Community Habitats

To confirm the suitability of Disposal Site 3, and to increase the granularity of mapping to the north and north-east of the Project area, further mapping was conducted in October 2022. Mapping focused specifically on the potential for depth related gradients, and habitat transitions from coral to filter feeder dominated habitats. The type and extent of benthic habitats was mapped using a combination of multi-beam, side scan sonar (**Appendix G**) and underwater video data (**Appendix I**). Benthic habitats were identified and classed by an experienced marine ecologist into eight categories (**Table 8-6**).

The project area comprised of an array of physical habitats from sand and low to high relief reef features (**Figure 8-22**). Seagrass meadows are present within the project footprint, with additional communities to the south and north of the project area (**Figure 8-23**). Extending to deeper waters north east of the project footprint, the complexity of habitats increases. 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 (**Figure 8-23**). The density of coral peaks (>70% coverage) in the central region of the project area at 5 and 10 m water depth, before declining with depth, but with sporadic patches (>60% coverage) of coral throughout the south eastern quadrant of the map (Figure 8-24). Areas north of the dredge area and dredge spoil zone are dominated by sponge communities, with comparatively low coral densities (**Figure 8-23**, **Figure 8-24**).

Table 8-6: BCH classes recorded at Mandorah

BCH Class	Description	Example Image
Biota Absent		
Biota Absent	**Bare Silt / Sand** Typically comprises of silt or sand with no or occasional very sparse macroalgae. This habitat comprised 13% of the mapped subtidal BCH and is also widely dispersed across the region.	 Site: 015 UTM: 692132.493E, 8623466.178N (Zone 52)
Biota Present		
Invertebrates		
Non-Molluscan Filter Feeders		
Mixed Filter Feeder	**Moderate – Dense (>25%) Mixed Filter Feeders** This habitat class occurs on low relief substrate with fine to coarse sands, silt and areas of exposed rocky reef. Moderate to Dense assemblages (25 - 75%) of Sponge and Coral species. Mixed filter feeders comprise 40% of the mapped subtidal BCH.	 Site: 12B UTM: 692251.011E, 8625298.645N (Zone 52)
Coral Biota	**Dense (>25%) Coral Biota** Low relief rock reef and rubble substrate which supports moderate coral cover (25-75%) of diverse coral species, predominately hard corals consisted of *Echinogorgia* and *Turbinaria* spp. Coral biota comprised 21% of the mapped subtidal BCH.	

BCH Class	Description	Example Image
		Site: 33B UTM: 692511.895E, 8624921.109N (Zone 52)
Sponges	**Moderate – Dense (>25%) Sponge Habitat** This habitat class occurs on low relief substrate with fine to coarse sands, silt and areas of exposed rocky reef. Moderate to Dense assemblages (25 - 75%) of Sponge species. Sponges comprised 2% of the mapped subtidal BCH.	 Site: 14B UTM: 692301.843E, 8625252.293N (Zone 52)
Vegetation		
Macroalgae	**Low - Moderate (25 - 50%) Macroalgae Habitat** This habitat class occurs on low relief substrate with fine to coarse sands, silt and areas of exposed rocky reef. Low to Moderate assemblages (25 - 50%) of Macroalgae species. Macroalgae comprised 4% of the mapped subtidal BCH and follows a patchy distribution throughout the region.	 Site: 044 UTM: 692000.279E, 8624541.318N (Zone 52)
Seagrass	**Low (<25%) Seagrass Habitat** Sparse seagrass habitat occurs where the relief is flat and is associated with fine to coarse sands. Although only usually present in low – moderate densities (<25%). Seagrasses comprised 1% of the mapped subtidal BCH.	 Site: 036 UTM: 692139.429E, 8623909.039N (Zone 52)
Mixed Categories		
Mixed Filter Feeder / Macroalgae	**Moderate - dense (>25%) Mixed Filter Feeders / Macroalgae Habitat** Flat to low relief constituting either fine to coarse, fine sans sands, silt and shell grit on occasions. Macroalgae, coral and sponge species are dispersed equally throughout this habitat. Mixed filter feeders with macroalgae comprised 1% of the mapped subtidal BCH and follows a patchy distribution throughout the region.	 Site: 11B UTM: 692299.603E, 8625300.886N (Zone 52)

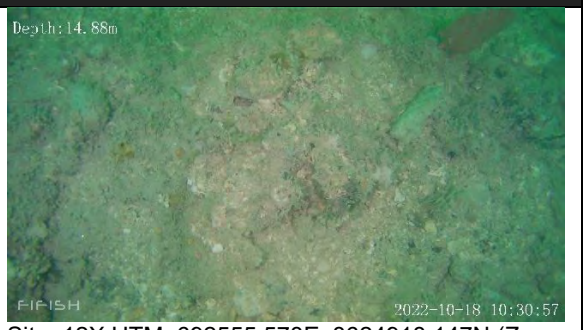
BCH Class	Description	Example Image
Mixed Coral Biota / Macroalgae	**Moderate (10-20%) Coral / Macroalgae Habitat** Flat to low relief constituting either fine to coarse, fine sans sands, silt and shell grit on occasions. Macroalgae, coral and sponge species are dispersed throughout this habitat although benthic cover is low to moderate (10 – 20%). This habitat comprised 0.5% of the mapped subtidal BCH and follows a patchy distribution throughout the region.	 Site: 12X UTM: 692555.578E, 8624918.147N (Zone 52)

Figure 8-22. Benthic habitat relief in the Project area.

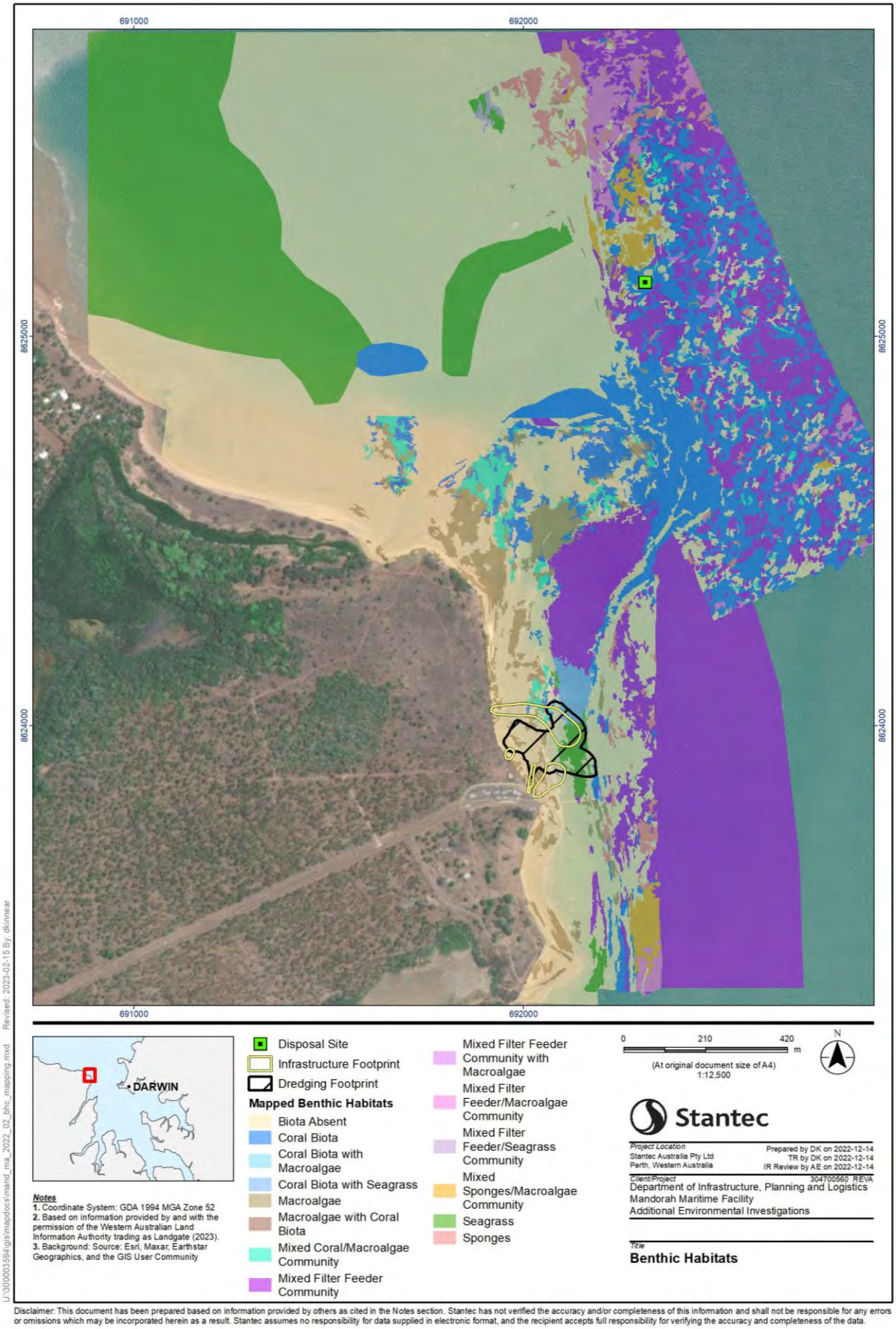


Figure 8-23: Final marine habitat map of the Project area.

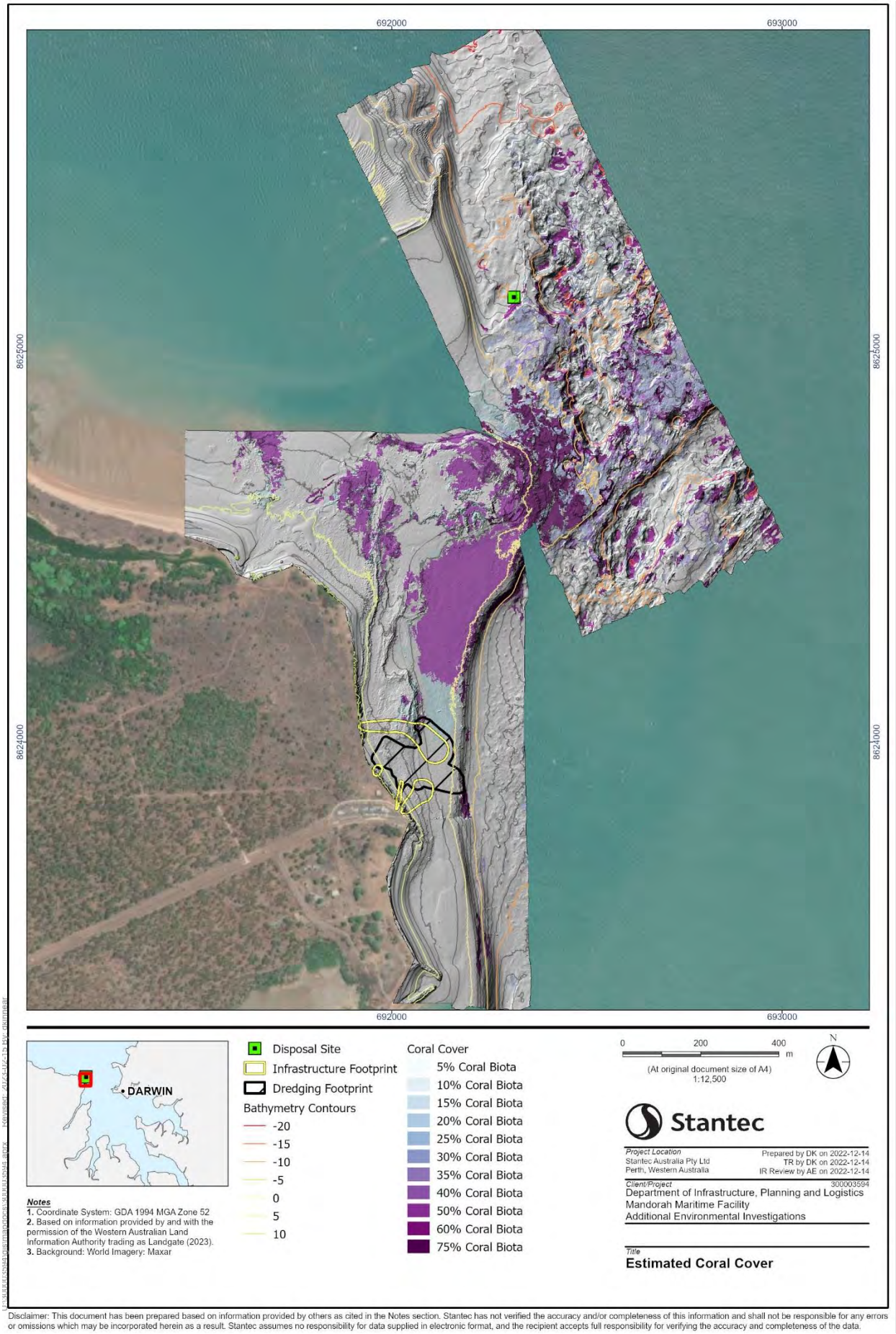


Figure 8-24. Percentage coral cover in the Project area.

8.3.3 Revised Impact Thresholds

Following the observation of corals at the proposed disposal site, the zones of impact were redefined using newly developed thresholds. Thresholds were developed following the analysis of 2.5 years of baseline data collected from the Mandorah area, based on the assumption that sensitive receptors at the site are tolerant of short-term TSS elevations above background, but experience stress if the elevations persist. 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.

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, based on the analysis of 2.5 years of baseline data from the Mandorah area (**Figure 8-19**). Using the same justification as that applied to the water quality triggers, the impact thresholds were developed based on Section 4.2.1 of EPA WA (2021) which recommends the use of the percentile approach. 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. The boundaries for the zones of influence and impact were subsequently determined were the TSS values exceeded the P99 and P80 of background concentrations more than 50% of the time, as per EPA WA (2021). The resulting Zones of HI, MI and the Zones of the Influence are illustrated in **Figure 8-25** to **Figure 8-28**.

Thresholds for application to seagrasses were developed based on the published sedimentation triggers documented in EPA WA (2021) (**Table 8-9**). Results of the modelling investigating the potential impacts of sedimentation in the Project Area are summarised in **Figure 8-29**.

Table 8-7: Dry Season Thresholds for application to the Proposal Area.

	NTU	TSS (mg/L)[d]	SD (mg/cm^{-2}/ d^{-1})
ZOI	3.16[a]	>5.75[a]	>0.5mm
ZOMI	6.74[b]	12.24[b] -14.07[c]	>16[e] (5.6mm/14 days)[f]
ZOHI	7.74[c]	>14.07[c]	>30[e] (10.5 mm/14 days)[f]

(a) Based on the 20th percentile 7 day moving average TSS; (b) Based on the 80th percentile 7 day moving average TSS; (c) Based on the 95th percentile 7 day moving average TSS; (d) Local area NTU / TSS relationship used to derive TSS Values (TSS = NTU x 1.8167); (e) based on Pineda et al. (2017); (f) Converted mg/cm^{-2}/ d^{-1} to mmm based on a 14 day period (DHI, 2010).

Table 8-8: Wet Season Thresholds for application to the Proposal Area.

	NTU	TSS (mg/L)[d]	SD (mg/cm^{-2}/ d^{-1})
ZOI	5.06[a]	>9.20[a]	>0.5mm
ZOMI	11.35[b]	20.61[b] -55.39[c]	>16[e] (5.6mm/14 days)[f]
ZOHI	30.48[c]	>55.39[c]	>30[e] (10.5 mm/14 days)[f]

(a) Based on the 20th percentile 7 day moving average TSS; (b) Based on the 80th percentile 7 day moving average TSS; (c) Based on the 95th percentile 7 day moving average TSS; (d) Local area NTU / TSS relationship used to derive TSS Values (TSS = NTU x 1.8167); (e) based on Pineda et al. (2017); (f) Converted mg/cm^{-2}/ d^{-1} to mm, based on a 14 day period (DHI, 2010).

Table 8-9: Sedimentation thresholds for application to the Proposal Area.

	Light	Burial	Area Loss
ZOMI	<2.45 DLI,	<40mm[a]	<0.25ha
ZOHI	<13.1 DLI,	>40mm[a]	>0.25ha

(a) Over a 6-week period.

The potential for impacts to corals during the cutter suction phase based on the percentile approach was restricted to a <0.087 ha zone of ZoHI and a 2.2 km long ZoMI in the dry season, under neap tide conditions (**Figure 8-25**). Impacts under spring tide conditions diminished significantly, and in this case the effects of dredging were restricted to a zone of influence (ZoI), extending some 12 km north and 4 km south of the dredging area (**Figure 8-26**).

Results for the backhoe dredging followed a similar pattern, with modeling suggesting the highest potential for impact was in the dry season under neap tide conditions (**Figure 8-28**). Despite this, the resulting ZoHI (1.26 ha) was restricted to very small area along the beach front and a moderately sized area north east of the bluff, immediately north of the dredging footprint. Under wet season conditions, the ZoHI disappeared and the ZoMI retracted significantly, to occupy just a fraction of the footprint predicted under dry season conditions (**Figure 8-28**).

Zones of influence and impact were also predicted based on the sedimentation thresholds for coral (based on EPA WA 2021). The ZoHI (equating to permanent loss) was contained within to the construction footprint and small areas

immediately south (**Figure 8-29**). The majority of the ZoMI hugs the exterior of the ZoHI, with the exception of a relatively small area approximately south of the construction zone.

Cumulative impacts to BCH resulting from the combined effects of changes in water quality during the dredging phases together with the direct removal of BCH from the dredging footprint, are summarised in **Table 8-10**, **Table 8-11** and **Table 8-12**. When considering the total area occupied by the ZoHI and the dredging footprint, predicted losses of BCH due to the Proposal are conservatively estimated at 1.08% and 1.13%[1] of the total BCH present across the project area, under neap and spring tide conditions respectively. These numbers are likely over representations given the overlap of the dredge footprint and the ZoHI due to sedimentation.

[1] The differences between tides are unlikely significant given the inherent uncertainty in the method used to calculate the relative proportions of habitat classes. Numbers are also based on dry season conditions when the TSS concentrations in the water column are higher relative to background; these numbers reduce marginally under wet season conditions.

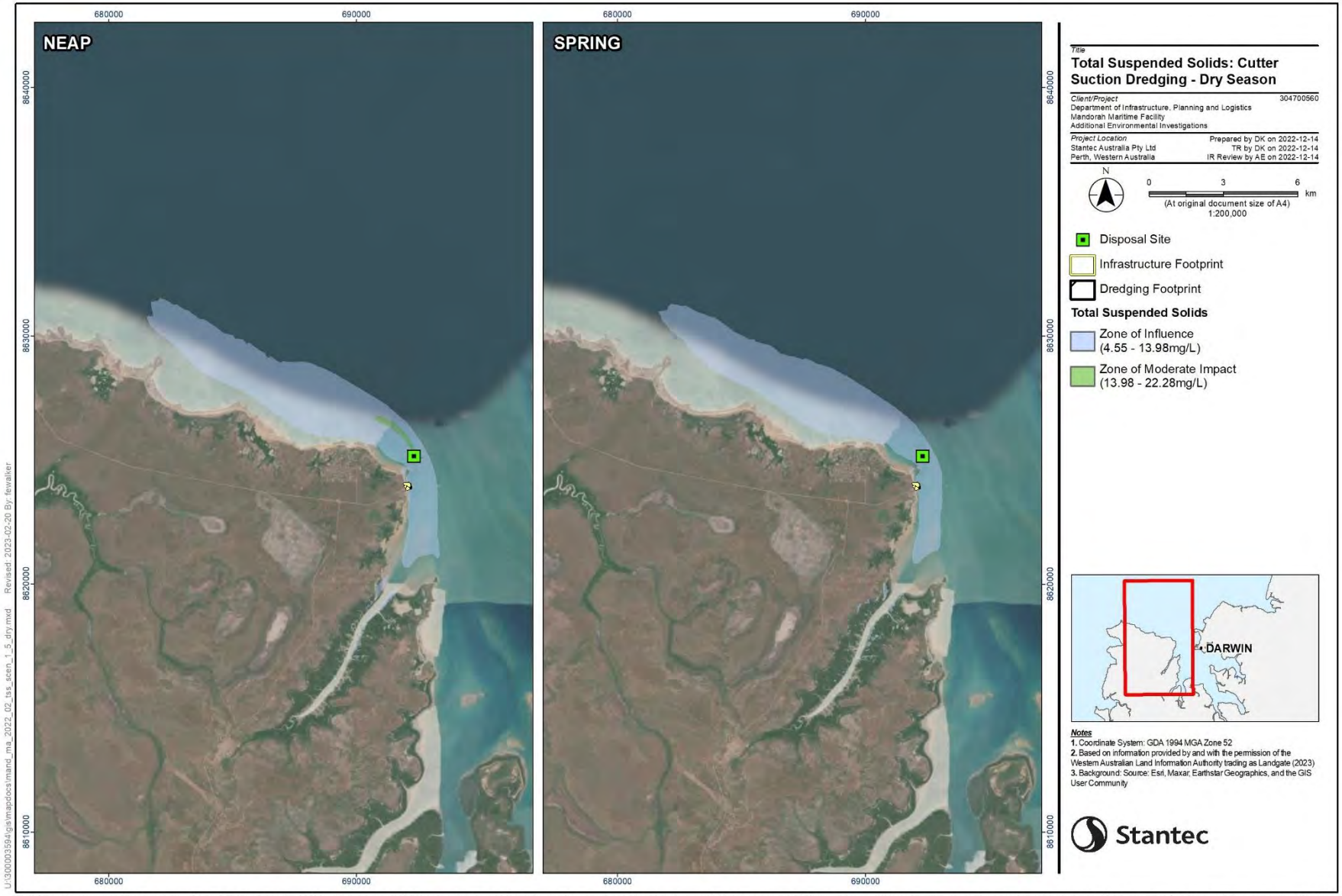


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Figure 8-25: Predicted zones of impact during the cutter suction phase, based on dry season conditions.

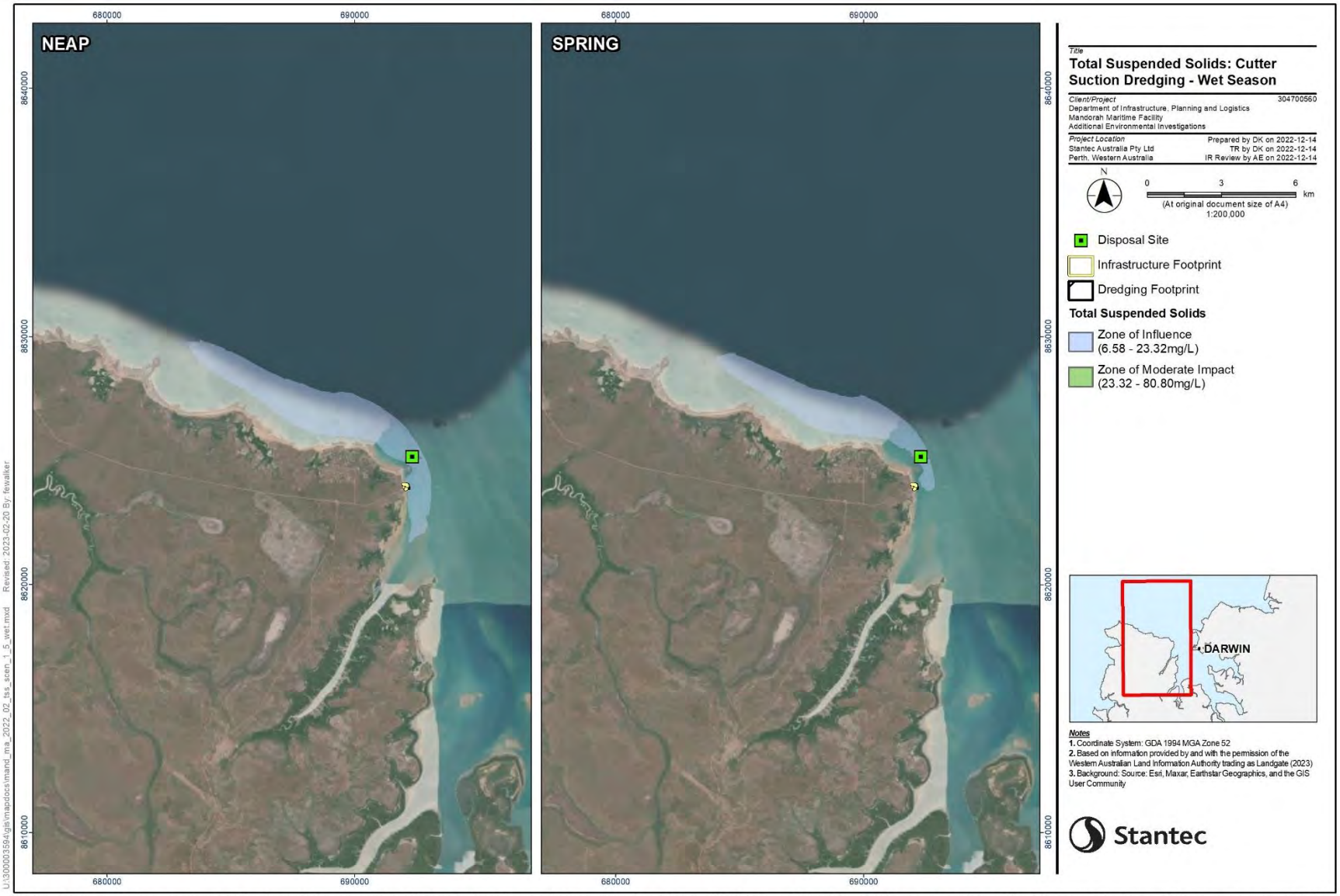

Figure 8-26: Predicted zones of impact during the cutter suction phase, based on wet season conditions.

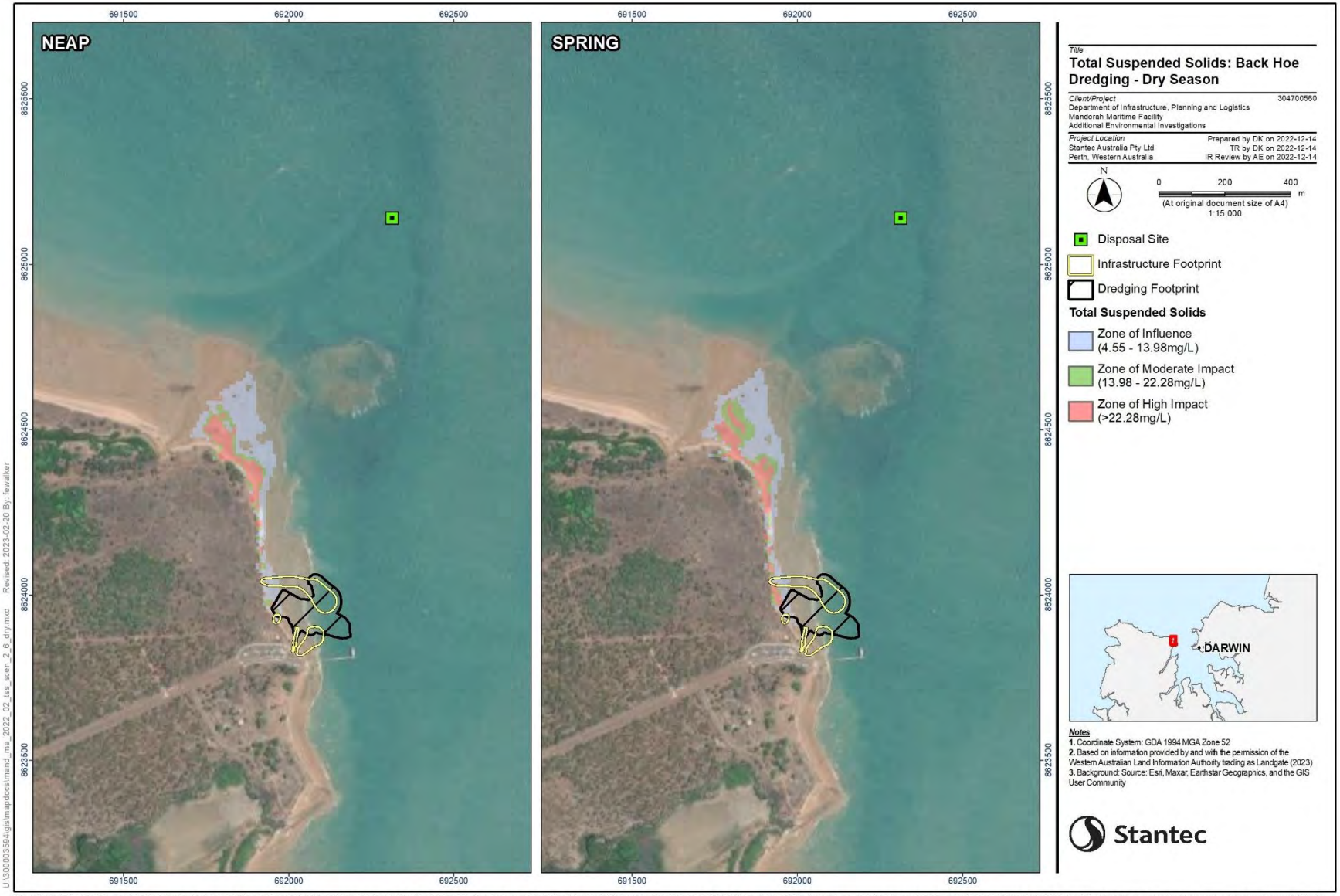

Figure 8-27: Predicted zones of impact during the back hoe phase, based on dry season conditions.

Figure 8-28: Predicted zones of impact during the back hoe phase, based on wet season conditions.

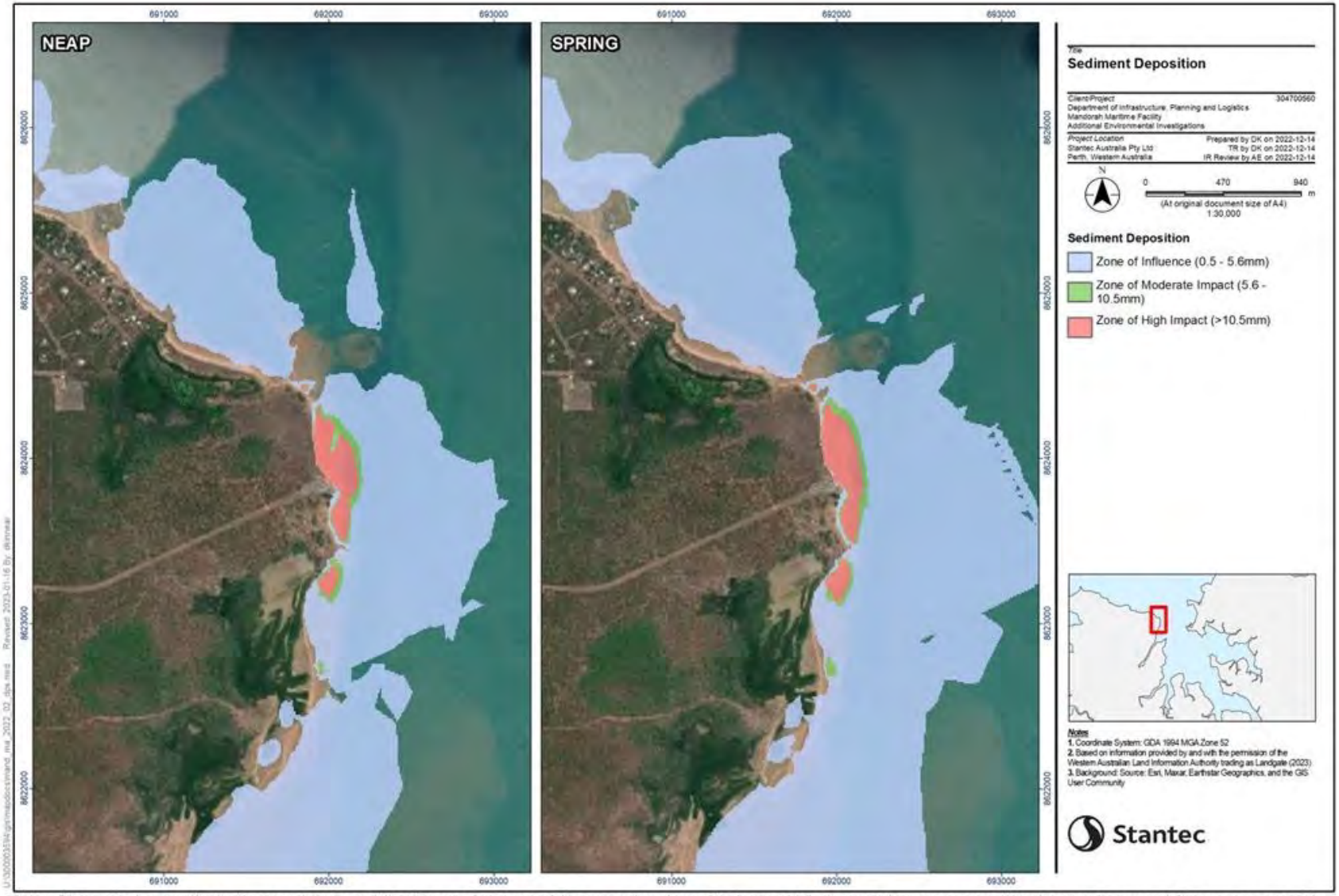

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Figure 8-29: Predicted zone of impact due to sedimentation from the combined cutter suction and back hoe dredging phases.

Table 8-10: Percentage BCH by habitat class recorded in the Proposal area.

Habitat Class	Area (ha)	% of habitat class
Coral Biota	36.785545	0.207592
Coral Biota with Macroalgae	0.04983	0.000281
Coral Biota with Seagrass	1.121921	0.006331
Macroalgae	8.822379	0.049787
Macroalgae with Coral Biota	0.062676	0.000354
Mixed Coral/Macroalgae Community	3.363528	0.018981
Mixed Filter Feeder Community	67.836692	0.382823
Mixed Filter Feeder Community with Macroalgae	0.392467	0.002215
Mixed Filter Feeder/Macroalgae Community	4.891734	0.027606
Mixed Filter Feeder/Seagrass Community	0.271231	0.001531
Mixed Sponges/Macroalgae Community	3.216795	0.018153
Seagrass	45.775421	0.258325
Sponges	4.610895	0.026021
Total BCH	177.201114	

Table 8-11: Percentage loss of BCH based on the cumulative zones of high impact under neap tide conditions.

Disturbance	Habitat Class	Area (ha)	% of total proposal area
Backhoe	Coral Biota	0	-
	Coral Biota	0.041	-
Cutter Suction	Mixed Coral / Macroalgal Community	0.013	-
	Coral Biota	0.122	-
	Coral Biota with Seagrass	0.493	-
Sedimentation	Mixed Coral/Macroalgae Community	0.113	-
	Coral Biota	0.039	-
	Coral Biota with Seagrass	0.122	-
	Macroalgae	0.228	-
	Mixed Coral/Macroalgae Community	0.014	-
	Mixed Filter Feeder/Seagrass Community	0.019	-
Dredge Footprint	Seagrass	0.711	-
Total	**All BCH**	**1.914005**	**1.08%**

Table 8-12: Percentage loss of BCH based on the cumulative zones of high impact under spring tide conditions.

Disturbance	Habitat Class	Area (ha)	% of total area
	Coral Biota	0.157785	-
	Coral Biota with Seagrass	0.410415	-
Sedimentation	Mixed Coral/Macroalgae Community	0.29894	-
	Coral Biota	0.039	-
	Coral Biota with Seagrass	0.122	-
	Macroalgae	0.228	-
	Mixed Coral/Macroalgae Community	0.014	-
	Mixed Filter Feeder/Seagrass Community	0.019	-
Dredge Footprint	Seagrass	0.711	-
Total	**All BCH**	**1.998686**	**1.13%**

8.3.4 Benthic Communities and Habitats and Seagrass Health

Monitoring of BCH will commence upon exceeding the secondary triggers at the to-be-determined sites, as outlined in the DSDMP (refer to **Appendix B**). This includes the provision of assessing the health of important BCH habitats, including seagrass, corals and sponges. The BCH monitoring program will be implemented to assess environmental conditions specific to BCH and seagrass, including:

- Light availability at the seafloor;
- Sedimentation rates; and
- Wave and current energy.

The DSDMP (refer to **Appendix B**) details the risks associated with the dredging campaign and the provisions for risk management and mitigation which detail the development of a BCH health and monitoring program (directly relating to seagrass health).

8.3.5 Marine Fauna

Detailed monitoring and management strategies have been developed to protect marine fauna during the marine construction phase of the project (provided within the DSDMP, **Appendix B**).

8.3.6 Dredge and Spoil Disposal Management Plan (DSDMP)

DIPL's objective to protect marine environmental quality and marine ecosystems is heavily dependent on the successful implementation of the Draft Dredge and Spoil Disposal Management Plan (DSDMP). The Draft DSDMP will be provided to the Head contractor who will be responsible for finalising and implementing DSDMP. The DSDMP contains the management and monitoring approaches required (a) to monitor the spatial extent and concentration of TSS in the plume (b) validate the predictions of the model and (c) detail the contractor's actions in the event any of the early warning, primary of secondary triggers are exceeded.

To that end, the water quality monitoring triggers and the approach to monitoring has been updated in the DSDMP according to the approaches recommended by the WA EPA (2012). The DSDMP also outlines the contractor's obligations with regard to monitoring the health of local BCH and the expectations with regard to marine mammals (especially dugongs), which transit the area. The revised DSDMP is attached to this document (**Appendix B**).

9 People

9.1 Culture and Heritage

The project is subject to an Aboriginal Areas Protection Authority (AAPA) Certificate (C2019/067). No works are proposed within known sites of Aboriginal heritage, although with several Restricted Work Areas (RWAs) adjacent to the project area some concerns have been raised about how altered coastal processes might potentially impact upon these sites post construction via coastal erosion and accretion. In additional to aboriginal sacred sites, concerns were raised regarding the potential risk of encountering an object or area of heritage significance i.e. world war 2 artifacts.

To better inform the impact assessment with respect to culture and heritage two additional studies and an additional management plan were completed to supplement the original information provide with the referral. These studies and plans included:

- Shoreline Evolution Modelling: Using integrated littoral processes and coastline kinetics modelling of the shoreline surrounding the proposed development to establish likely erosion and accretion to determine whether there was the potential for any impacts upon known sacred sites (**Section 8.1.3**); and
- Marine magnetic survey of the area to determine the presence of any unexploded ordinances and to detect any other ferrous material on the seafloor. After processing, the measured values were transformed into a magnetic anomaly map with areas of contact highlighted for further investigation (**Appendix H** and **Section 9.1.2**).
- A CPMMP was developed to ensure that once the facility is installed the local morphology of the coastline will be observed to ensure any risks associated with changes to sedimentation and coastal processes regimes are identified, and risk mitigation strategies established.

The shoreline modelling demonstrated that movement in the shoreline is unlikely to impact upon the RWAs; however to reduce this risk, a CPMMP has been prepared to manage any residual risks, and to ensure the EPA's objective for Culture and Heritage will not be compromised by the Proposal.

9.2 Marine Magnetic Survey

Surrich Hydrographics Pty Ltd was contracted to perform a marine magnetic survey for the purpose of identifying ferrous objects on and beneath the seabed at the proposed project site for the "Mandorah New Marine Facilities to Service Mandorah and Cox Peninsula Communities". In the deeper waters, the survey consisted of towing a Side Scan Sonar (SSS) followed by a towed neutrally buoyant magnetometer. This approach allowed the magnetometer to be towed at a nominal altitude of 2m above the seabed. The altitude of the magnetometer is derived from analysis of the SSS bottom track, and the side scan imagery was navigationally fine-tuned to provide superior positioning for the magnetometer.

In the shallower waters, larger vessel access was restricted, therefore a smaller four-meter vessel was utilized to surface tow the magnetometer. The altitude above the seabed was calculated using tides and supplied bathymetry.

The scope was for a magnetometer survey at Mandorah to target ferrous objects for follow-up investigation by divers experienced in the search, identification, and recovery of objects on and beneath the seabed including cultural heritage objects. The scope also included the requirement to identify hazards that may affect dredging and construction activities including the potential for Unexploded Ordinance (UXO). This survey was completed for an area extending from the north of the existing Mandorah jetty to a distance of 50m beyond the proposed breakwater locations.

The survey found four "contacts" within the construction footprint (Contacts 2, 3, 4 and 6). These areas of interest have since been inspected further by a qualified diving team to inspect the 'contacts' and remove any items that may be of cultural value or considered a hazard. None of the contacts identified or removed are considered to have cultural or heritage value. The complete magnetic survey report is available in **Appendix H**.

9.3 Community and Economy

The Department of the Chief Minister and Cabinet ask for three additional risks to be considered in respect to community and economy. These risks included risks to the following:

- Potential impact on commercial and recreational fishing as a result of the project
- Potential impact on Darwin Port Shipping channel during construction
- Workforce composition

These risk and appropriate mitigations are outlined in **Table 9-1.**

Table 9-1: Summary of environmental impact and risk assessment for Community and Economy.

Theme	Environment Aspect	Risk Pathway(s)	Potential Impacts	Inherent Risk Rating	Risk Management / Mitigation	Residual Risk Rating
PEOPLE	Construction activities including earthworks and building works	• Noise generated	• Decrease in liveability for nearby residents, ferry users or tourists	**Medium**	• Integrate noise management measures within the CEMP	**Low**
	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	**Medium**	• Traffic management plan to be implemented to manage any disruptions to local traffic • Staggering of heavy vehicles throughout the day to minimise congestion	**Low**
	Construction activities including earthworks and building works	• Loss of access to existing carpark	• Decrease in liveability for users of existing boat ramp or carpark	**Medium**	• Stakeholder engagement with current uses of facilities to inform of access issues during construction	**Medium**
	Potential impact on commercial and recreational fishing as a result of the project	• Loss of access to jetty and surrounding area for commercial and recreational fishing	• Decrease in livability for commercial and recreational fishermen	**Medium**	• Commercial fishing does not occur in the project footprint or area of impact. • The Amateur Fisherman's Association NT have been consulted on the project. Their main concern is to keep a land based fishing option in Mandorah. This will be supported initially by keeping the existing jetty for fishing until funding becomes available to	**Low**

					construct a new land-based fishing facility.	
	Potential impact on Darwin Port Shipping channel during construction	• Increase in traffic and construction impacts upon the Darwin Port shipping channel	• Traffic delays and increased risk of accident for Shipping channel users.	**Medium**	• The dredging and construction works are situated away from the Darwin Port Shipping channel and will not have any impact on shipping. There is likely to be some equipment and material transport across the harbour, however the volumes are not large and can be scheduled to ensure no interruptions or issues with normal harbour and shipping channel operations. The contractor will be required to liaise with the harbour master and follow all safety and commercial requirements.	**Low**
	Workforce composition	• Inadequate consideration of Aboriginal employment.	• Potential for unequitable opportunities for employment in the project	**Medium**	• The Contract includes a minimum aboriginal employment requirement of 9% and an Indigenous Business participation minimum requirement of 1% of total spend.	**Low**

10 Summary & Predicted Outcomes

The potential for the Proposal to compromise the EPA's key environmental factors was assessed based on the results of studies undertaken prior to referral, and the findings of additional studies undertaken to support this SER. The results of the studies with respect to the NT EPA values, landforms, terrestrial ecosystems; coastal processes; marine environmental quality; marine ecosystems and culture and heritage, are summarised below.

The potential for impacts to the marine environment were considered in the context of dredging and dredge spoil disposal at a site located approximately 1.2 km north of the construction area (Disposal Site 3). The site was selected following a multicriteria analysis (MCA), based on safety, logistical and environmental criteria. Based on the updated habitat map, the preferred site comprises predominantly bare reef and sponge communities, with occasions coral colonies (<5%). Disposal Site 3 maintains the lowest diversity of the sites considered during the MCA.

In total, the project will involve the dredging and disposal of between 85,000 to 100,000 m^3 of unconsolidated sand and rock, under best and worst-case scenarios, respectively. Based on the outcomes of the studies described herein, DIPL is confident that the potential impacts of the proposal are acceptable under the NT EPA's EIA framework, and satisfied that any residual impacts (if any) can be managed under the revised Dredging and Dredge Spoil Management Plan, the Construction and Environmental Management Plan and the Coastal Processes Monitoring and Management Plan (**Appendices B**, **C** and **D**, respectively).

Marine Environmental Quality / Marine Ecosystems

The potential for impacts to the marine environment were considered in the context of dredging and dredge spoil disposal at a site located approximately 1.2 km north of the construction area (Disposal Site 3). The site was selected following a multicriteria analysis (MCA), based on safety, logistical and environmental criteria. Based on the updated habitat map, the preferred site comprises predominantly bare reef and sponge communities, with occasions coral colonies (<5%). Disposal Site 3 maintains the lowest diversity of the sites considered during the MCA.

Risks to marine environmental quality and marine ecosystems were considered in the context of turbidity and light reduction, and the potential for reversible and irreversible impacts to benthic communities and habitats. The extent and concentration of TSS entrained within the plume varied depending on the tidal cycle, with significantly greater dispersion and lower concentrations during spring tide events. Modelling suggested there is potential for 50^{th} and 95^{th} 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 program which is anticipated to require 14-30 days to complete. The 50^{th} percentile values are within the range experienced under typical dry season conditions, and the 95^{th} 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).

TSS and PAR will be monitored continuously during the dredging program with the results compared to a series of trigger values with exceedance of stage 1 triggers representing early warning, and exceedance of stage 3 triggers, leading to contingency management (see DSDMP, **Appendix B**). Although protective of marine environmental quality generally, the triggers were developed specifically for the protection of corals. Based on the results of the highly conservative modeling process, the Proposal is not expected to compromise the EPA's objective for marine environmental quality, with any effects considered short term and fully reversible.

The potential for impacts to the marine ecosystem within and adjacent to the project area was considered in the context of benthic communities and habitats (BCH). Impacts were assessed using an updated hydrodynamic and sediment transport, together with new impact thresholds developed for local coral communities. Modelling proceeded based on best practice approaches, the best available geotechnical information and the anticipated dredge spoil disposal practices.

The potential for impacts to corals during the cutter suction phase based on the percentile approach was restricted to a <0.087 ha area of high impact (ZoHI) and a 2.2 km long ZoMI in the dry season, under neap tide conditions. Impacts under spring tide conditions diminished significantly. In this case, the effects of dredging were restricted to a zone of influence (ZoI), extending some 12 km north and 4 km south of the dredging area.

Results for the backhoe dredging followed a similar pattern, with modeling suggesting the highest potential for impact was in the dry season under neap tide conditions. Despite this, the resulting ZoHI (1.26 ha) was restricted to very small area along the beach front and a moderately sized area north east of the bluff, immediately north of the dredging footprint. Under wet season conditions, the ZoHI disappeared and the ZoMI retracted significantly, to occupy just a fraction of the footprint predicted under dry season conditions.

Zones of influence and impact were also predicted based on the sedimentation thresholds for coral (based on EPA WA 2021). The ZoHI (equating to permanent loss) was contained within to the construction footprint and small areas immediately south. The majority of the ZoMI hugs the exterior of the ZoHI, with the exception of a relatively small area approximately south of the construction zone.

When considering the total area occupied by the ZoHI and the dredging footprint, predicted losses of BCH due to the Proposal are conservatively estimated at 1.08% and 1.13% of the total BCH present across the project area, under neap

and spring tide respectively. These numbers are likely over representations given the overlap of the dredge footprint and the ZoHI due to sedimentation.

The integrity of marine environmental quality and marine ecosystems will be managed according to the actions and mitigation strategies summarised in the Draft Dredge and Spoil Disposal Management Plan (DSDMP). The Draft DSDMP will be provided to the Head contractor who will be responsible for finalising and implementing DSDMP, based on their intended approach and management of dredge spoil characteristics. The DSDMP contains the management and monitoring approaches required (a) to monitor the spatial extent and concentration of TSS in the plume (b) validate the predictions of the model and (c) detail the contractor's actions in the event any of the early warning, primary of secondary triggers are exceeded. To that end, the water quality monitoring triggers and the approach to monitoring has been updated in the DSDMP according to the approaches recommended by the WA EPA (2012). The DSDMP also outlines the contractor's obligations with regard to monitoring the health of local BCH and the expectations with regard to marine mammals (especially dugongs), which transit the area.

Coastal Processes
Potential changes to nearshore scour and sediment deposition, induced by installation of the Proposal, were assessed using sediment transport modelling for typical seasonal and shoulder season conditions, as well as storm-based conditions. The facility will interrupt long-shore drift, which may result in accretion of sediments directly to the north of the northern breakwater, as well as some build-up directly to the south of the southern breakwater. The interruption of southward moving sediment may create a supply deficit to the beach south of the facility, leading to gradual erosion and shoreline recession. This erosion may be restricted by coastal geology, which is not fully understood along this beach.

In general, conservative modeling predicted that potential risks to the environmental factors are low. However, given the uncertainty in sediment transport modelling and the lack of existing, targeted, long-term validation datasets (e.g., repeated intra-annual and interannual surveying, broad scale characterisation of available sediment volumes and characteristics), it is recommend the Proposal is managed under a Coastal Processes Monitoring and Management Plan (CPMMP), as recommended by the NT EPA. Subject to effective implementation of the CPMMP, the NT EPA's objective for Coastal Processes will be met.

Landforms / Terrestrial Ecosystems
The assessment focused on the potential for temporary stockpiling of saline-soaked dredged rocks to compromise environmental quality within the temporary storage area and the surrounding environment. Impacts associated with saline soil contamination from storage and handling of dredge spoil were considered negligible, with any residual risks manageable under the revised Construction Environmental Management Plan (CEMP) – which includes closure and performance criteria, relating to landforms, dust suppression and soil / vegetation health, and the flexibility for changes to the program should the stockpiling process change.

The proposal is conservatively expected to result in the clearing of 3 ha of mid-open woodland, comprising predominantly Terminalia spp. Irreversible losses of habitat within the broader 3 ha area are expected to be limited to a 0.3 ha terrestrial construction footprint, consisting of the newly constructed facilities. It is anticipated that the remainder of the temporary work site will recover fully.

The recovery of the area to its original baseline condition will be monitored post construction as per the Revised Construction Environmental Management Plan provided in Section 7.1 of the SER. The plan details the monitoring that will be undertaken to ensure early detection of impacts to local vegetation health, including the ingress of weeds especially post clearing and throughout rehabilitation. Success criteria and closure objectives have been developed to ensure the outcomes of the rehabilitation process are clear and effective. Subject to effective implementation of these commitments, it is likely that the NT EPA's objective for Terrestrial Ecosystems will be met.

People
The potential for impacts to Culture and Heritage were assessed with respect to impacts to known or unknown Aboriginal sacred sites and unknown heritage objects or sites (e.g. WWII) during construction. As part of the SER, two additional studies and an additional management plan were completed to supplement the original information provided with the referral. Subject to effective implementation of these commitments, risks to local aboriginal sacred sites are considered low, and the NT EPA's objective for Culture and Heritage is expected to be met by the proposal.

11 References

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Appendices

We design with community in mind

Appendix A Direction to Provide Additional Information (NT EPA)

Appendix B Dredging and Spoil Disposal Management Plan (Updated)

Appendix C Construction Environmental Management Plan (Updated)

Appendix D Coastal Processes Monitoring and Management Plan

Appendix E Terrestrial Environmental Report

Appendix F Multi Criteria Analysis of Proposed Disposal Sites

		DEPWS - Neil Smit, Site 1 (West of Dredge area)	DEPWS - Neil Smit, Site 2 (North of Dredge area)	Mandorah Marine Facilities Referral	Onshore Disposal - Dedicated Disposal Site	Onshore Disposal - Shoal Bay Waste Management Facility (SBWMF)	Inpex Offshore Designated Disposal Site	Cullen Bay Maintenance Dredging	Darwin Port - Harbour Disposal
Location		Pipe discharge point 12°26'23.69"S, 130°46'22.09"E	Pipe discharge point 12°26'0.80"S, 130°45'46.10"E	Pipe discharge point 12°25'51.87"S, 130°46'9.21'E	Onshore Disposal Area 12°26'29.81"S, 130°45'56.14'E	Shoal Bay Waste Management Facility 12°23'18.91"S, 130°55'30.30"E	Inpex Disposal Site 12°13'10.68"S, 130°48'50.09"E	Pipe discharge point 12°26.931'S, 130°48.728'E	East Arm Wharf - 12°29'29.53"S, 130°52'32.77"E Marine Supply Base - 12°29'39.86"S, 130°53'37.97"E Fort Hill Wharf - 12°28'35.98"S, 130°50'48.09"E
Environmental Risk Factors	**Landforms**	N/A	N/A	N/A	> Designated for In situ stockpiling to allow for contamination characterisation and any necessary ASS Pass treatment prior to reuse or disposal > Stockpiled material is temporary not impacting landforms long term	> Established Waste receiving facility operating in accordance with relevant environmental protection licenses administered by the NT EPA to avoid adverse impacts to terrestrial landforms	N/A	N/A	N/A

		DEPWS - Neil Smit, Site 1 (West of Dredge area)	DEPWS - Neil Smit, Site 2 (North of Dredge area)	Mandorah Marine Facilities Referral	Onshore Disposal - Dedicated Disposal Site	Onshore Disposal - Shoal Bay Waste Management Facility (SBWMF)	Inpex Offshore Designated Disposal Site	Cullen Bay Maintenance Dredging	Darwin Port - Harbour Disposal
	Terrestrial Environmental Quality	N/A	N/A	N/A	> Negative impacts to soil quality, stability and fertility via acidic runoff discharging into Darwin Harbour, loss of topsoil during overland flows, eroded topsoil causing sedimentation in Darwin Harbour > CEMP to include Hazardous Material Management to ensure stockpiles of bulk materials are well contained/separated from exposed soils	> ~ 115km material transport distance, large tipping trucks have potential to pollute via noise and dust during transfer > ASS and PASS known to exist in dredge spoil, ASS management plan required in line with DSDMP > Appropriate mitigation administered by contractors CEMP would negate adverse environmental affects	N/A	N/A	N/A

		DEPWS - Neil Smit, Site 1 (West of Dredge area)	DEPWS - Neil Smit, Site 2 (North of Dredge area)	Mandorah Marine Facilities Referral	Onshore Disposal - Dedicated Disposal Site	Onshore Disposal - Shoal Bay Waste Management Facility (SBWMF)	Inpex Offshore Designated Disposal Site	Cullen Bay Maintenance Dredging	Darwin Port - Harbour Disposal
	Terrestrial Ecosystems	N/A	N/A	N/A	> Potential indirect impacts considered negligible where appropriately endorsed DSDMP, ASSMP and CEMPs are administered	> Potential indirect impacts considered negligible where appropriately endorsed DSDMP, ASSMP and CEMPs are administered	N/A	N/A	N/A
	Hydrological Processes	N/A	N/A	N/A	N/A	> SBWMF operating in accordance with relevant environmental protection licenses administered by the NT EPA to avoid adverse impacts to environmental factor affecting water > Robust water sampling and response management in place as part of SBWMF operating and environmental protection licence	N/A	N/A	N/A
	Inland Water Environmental Quality	N/A	N/A	N/A	N/A		N/A	N/A	N/A
	Aquatic Ecosystems	N/A	N/A	N/A	N/A		N/A	N/A	N/A

		DEPWS - Neil Smit, Site 1 (West of Dredge area)	DEPWS - Neil Smit, Site 2 (North of Dredge area)	Mandorah Marine Facilities Referral	Onshore Disposal - Dedicated Disposal Site	Onshore Disposal - Shoal Bay Waste Management Facility (SBWMF)	Inpex Offshore Designated Disposal Site	Cullen Bay Maintenance Dredging	Darwin Port - Harbour Disposal
	Coastal Processes	> Disposal of nominated dredge volumes would not affect coastal processes	> Disposal of nominated dredge volume's potential to affect coastal process given shallow depth and low tidal velocities is unknown	> Disposal of nominated dredge volumes would not affect coastal processes	N/A	N/A	> Disposal of nominated dredge volumes at deep, offshore and high-energy area would not affect coastal processes	> Disposal of nominated dredge volumes would not affect coastal processes	> Disposal of nominated dredge volumes would not affect coastal processes

	Marine Environmental Quality	> Physical - BCH identified as sponges - No significant coral or seagrass communities identified within or adjacent to disposal area - Indirect impacts of turbid plumes increasing sedimentation of sponge communities negated through high dispersion, live monitoring data informing contingency management practices. > Chemical - Toxic contaminants made available to marine ecosystem for biological uptake and bioaccumulation - Isolate, remove and confine areas where contamination is potentially toxic to the marine environment	> Physical - BCH identified as macroalgae - No significant coral communities identified within or adjacent to disposal area - live monitoring of SCC rigger values detailed in DSDMP crucial in areas of lower dispersion outside of high energy tidal currents > Chemical - Toxic contaminants made available to marine ecosystem for biological uptake and bioaccumulation - Isolate, remove and confine areas where contamination is potentially toxic to the marine environment	> Physical - BCH identified as sponges - No significant coral or seagrass communities identified within or adjacent to disposal area > Chemical - Toxic contaminants made available to marine ecosystem for biological uptake and bioaccumulation - Isolate, remove and confine areas where contamination is potentially toxic to the marine environment	N/A	N/A	> Physical - Indirect impacts of turbid plumes reducing light availability and associated sedimentation negated through live monitoring data informing contingency management practices. - No significant coral or seagrass communities identified within or adjacent to disposal area > Chemical - Toxic contaminants made available to marine ecosystem for biological uptake and bioaccumulation - Isolate, remove and confine areas where contamination is potentially toxic to the marine environment	> Physical - No significant coral or seagrass communities identified within or adjacent to disposal area > Chemical - Toxic contaminants made available to marine ecosystem for biological uptake and bioaccumulation - Isolate, remove and confine areas where contamination is potentially toxic to the marine environment	> Physical - Indirect impacts of turbid plumes on hard coral and filter feeder communities identified adjacent to Darwin Port disposal areas - Turbidity tolerance limits for benthic communities (Williams, 2017) and associated management practices incorporated into DSDMP > Chemical - Toxic contaminants made available to marine ecosystem for biological uptake and bioaccumulation - Isolate, remove and confine areas where contamination is potentially toxic to the marine environment

	Marine Ecosystems	> No significant corals and seagrasses identified within disposal area, SSC tolerance levels for sponge communities inform monitoring and management practices > Vessel collision causing injury or mortality to protected marine megafauna	> Light dependent macroalgae identified within disposal area (INPEX, 2018) - Determination of macroalgae SCC thresholds to inform live monitoring trigger values > Vessel collision causing injury or mortality to protected marine megafauna	> Soft Bottom Benthos / silty sediments, sponges, no corals and seagrasses identified within disposal area (INPEX, 2018) > Vessel collision causing injury or mortality to protected marine megafauna	N/A	N/A	> Soft Bottom Benthos / silty sediments, no light dependent communities such as corals and seagrasses identified within disposal area (INPEX, 2018) > Low percentage cover of epifauna within and adjacent to the disposal area accounting for less than 1% of the total mean cover (Cardno 2013c) > Vessel collision causing injury or mortality to protected marine megafauna	> Seagrass communities in Fannie Bay, some 1-6 km to the north-east of the spoil discharge point. > Hard coral communities in the East Point Aquatic Life Reserve, ~ 5 km to the north of the spoil discharge point; and at Weed Reef, Plater Rock and Kurumba Shoal ~ 5 km to the south-west of the spoil discharge point, URS 2010). > Sedimentation tolerance limits for hard corals and seagrasses modelled for Cullen Bay operations would be applied > Vessel collision causing injury or mortality to protected marine megafauna	> Light dependent benthic communities have been identified in disposal areas however are well represented in Darwin harbour. Precedent for benthic community tolerance limits to turbidity which can inform management practices and avoid mortality > No benthic communities of critical importance to protected marine species have been identified during previous investigations

		DEPWS - Neil Smit, Site 1 (West of Dredge area)	DEPWS - Neil Smit, Site 2 (North of Dredge area)	Mandorah Marine Facilities Referral	Onshore Disposal - Dedicated Disposal Site	Onshore Disposal - Shoal Bay Waste Management Facility (SBWMF)	Inpex Offshore Designated Disposal Site	Cullen Bay Maintenance Dredging	Darwin Port - Harbour Disposal
	Air Quality	> Decrease in local air quality via CO2 emissions > Impacts to local fauna and human health through inhalation of emissions	> Decrease in local air quality via CO2 emissions > Impacts to local fauna and human health through inhalation of emissions	> Decrease in local air quality via CO2 emissions > Impacts to local fauna and human health through inhalation of emissions	> Decrease in local air quality via CO2 emissions > Impacts to local fauna and human health through inhalation of emissions and contaminated dust > Dust mitigation facilitated through implementation of CEMP	> Decrease in local air quality via CO2 emissions > Impacts to local fauna and human health through inhalation of emissions and contaminated dust > Dust mitigation facilitated through implementation of CEMP	> Decrease in local air quality via CO2 emissions > Impacts to local fauna and human health through inhalation of emissions	> Decrease in local air quality via CO2 emissions > Impacts to local fauna and human health through inhalation of emissions	> Decrease in local air quality via CO2 emissions > Impacts to local fauna and human health through inhalation of emissions
	Atmospheric Processes	> Direct emissions from dredger > Cumulative impact of carbon emissions to global climate change	> Direct emissions from dredger > Cumulative impact of carbon emissions to global climate change	> Direct emissions from dredger > Cumulative impact of carbon emissions to global climate change	> Direct emissions from excavation plant and support vehicles > Cumulative impact of carbon emissions to global climate change	> Direct emissions from trucks transporting dredge spoil ~115km to SBWMF > Cumulative impact of carbon emissions to global climate change	> Direct emissions from dredger > Cumulative impact of carbon emissions to global climate change	> Direct emissions from dredger > Cumulative impact of carbon emissions to global climate change	> Direct emissions from dredger > Cumulative impact of carbon emissions to global climate change

		DEPWS - Neil Smit, Site 1 (West of Dredge area)	DEPWS - Neil Smit, Site 2 (North of Dredge area)	Mandorah Marine Facilities Referral	Onshore Disposal - Dedicated Disposal Site	Onshore Disposal - Shoal Bay Waste Management Facility (SBWMF)	Inpex Offshore Designated Disposal Site	Cullen Bay Maintenance Dredging	Darwin Port - Harbour Disposal
	Community and Economy	> Close proximity to shipping lane and Inpex Pipeline exclusion zone > Exclusions zones required to prevent collision with sediment piping > Community consultation and complaints handling procedures will be governed by the CEMP	> Closer proximity to beaches used by local community > Valuable benthic communities > Community consultation and complaints handling procedures will be governed by the CEMP	> Close proximity to shipping lane and Inpex Pipeline exclusion zone > Exclusions zones required to prevent collision with sediment piping > Community consultation and complaints handling procedures will be governed by the CEMP	> Decrease in live ability for users of existing natural open areas, carparks and roads > Stakeholder engagement with current uses of facilities to inform of access issues during construction	> Increased localised traffic affecting cox peninsula road (single lane) and Mandorah ferry carpark > Decrease in live ability for users of existing boat ramp or carpark > Stakeholder engagement with current uses of facilities to inform of access issues during construction	> No high value benthic communities to recreational fishing, commercial fishing or tourism Industries	> High value coral and seagrass communities occurring within Zones of influence however potential sedimentation and turbidity impacts considered low > Spoil transiting would occur across designated shipping channels	> Highly productive industrial import/export ports also servicing cruise ships and navy ships > Potential to interrupt agriculture, tourism and trade industries

		DEPWS - Neil Smit, Site 1 (West of Dredge area)	DEPWS - Neil Smit, Site 2 (North of Dredge area)	Mandorah Marine Facilities Referral	Onshore Disposal - Dedicated Disposal Site	Onshore Disposal - Shoal Bay Waste Management Facility (SBWMF)	Inpex Offshore Designated Disposal Site	Cullen Bay Maintenance Dredging	Darwin Port - Harbour Disposal
	Culture & Heritage	> No native title or indigenous land use agreements affected	> Onshore sacred site that could be influenced via a change in coastal processes	> No native title or indigenous land use agreements affected	> No native title or indigenous land use agreements affected > Response and reporting procedures should a site or object be encountered > Strict avoidance of the restricted work areas (RWA) captured in the Aboriginal Areas Protection Authority (AAPA) Certificate	> No native title or indigenous land use agreements affected > Response and reporting procedures should a site or object be encountered > Strict avoidance of the restricted work areas (RWA) captured in the Aboriginal Areas Protection Authority (AAPA) Certificate	> No native title or indigenous land use agreements affected	> No native title or indigenous land use agreements affected	> Culturally significant sites within Darwin harbour

		DEPWS - Neil Smit, Site 1 (West of Dredge area)	DEPWS - Neil Smit, Site 2 (North of Dredge area)	Mandorah Marine Facilities Referral	Onshore Disposal - Dedicated Disposal Site	Onshore Disposal - Shoal Bay Waste Management Facility (SBWMF)	Inpex Offshore Designated Disposal Site	Cullen Bay Maintenance Dredging	Darwin Port - Harbour Disposal
	Human Health and Safety	> High energy currents perpendicular to direction of sediment pipeline creating potential operational risk > Navigational hazards, exclusion zones for recreational and commercial traffic > Emergency Management Plans to be developed by the contractor in accordance with industry standards and guidelines	> Navigational hazards, exclusion zones for recreational and commercial traffic > Emergency Management Plans to be developed by the contractor in accordance with industry standards and guidelines	> Navigational hazards, exclusion zones for recreational and commercial traffic > Emergency Management Plans to be developed by the contractor in accordance with industry standards and guidelines	> Adverse health impacts to site workers and users of facility via dermal contact, ingestion/inhalation of contaminated dust > CEMP to include Hazardous Material Management to ensure stockpiles of bulk materials are well contained/separated from exposed soils	> Adverse health impacts to site workers and users of facility via dermal contact, ingestion/inhalation of contaminated dust > CEMP to include Hazardous Material Management to ensure stockpiles of bulk materials are well contained/separated from exposed soils	> Offshore location and high-energy hydrodynamic conditions means use of equipment requiring anchoring would cause unnecessary safety and operational risk > Potentially restricted to stable placement options i.e. hopper bottom door placement	> Navigational hazards, exclusion zones for recreational and commercial traffic > Emergency Management Plans to be developed by the contractor in accordance with industry standards and guidelines	> Navigational hazards, exclusion zones for recreational and commercial traffic > Emergency Management Plans to be developed by the contractor in accordance with industry standards and guidelines

		DEPWS - Neil Smit, Site 1 (West of Dredge area)	DEPWS - Neil Smit, Site 2 (North of Dredge area)	Mandorah Marine Facilities Referral	Onshore Disposal - Dedicated Disposal Site	Onshore Disposal - Shoal Bay Waste Management Facility (SBWMF)	Inpex Offshore Designated Disposal Site	Cullen Bay Maintenance Dredging	Darwin Port - Harbour Disposal
Technical Feasibility	**Distance from dredge footprint**	0.6km NE	1km NW	1.2km NE	0km (adjacent to dredge area)	> In situ stock piling of material adjacent to dredge footprint within terrestrial footprint of project > ~ 115km from site to SBWMF via Cox Peninsula Road, Charles Point Road and Stuart highway	> ~29km from dredge footprint > North of Darwin Harbour, within the Beagle Gulf, approximately 12 km north-west of Lee Point	> 5 km from dredge footprint > Areas around 500 m from North West of Cullen Bay	> Ranging from 9 to 15 km from dredge footprint > Areas around 500 m from East Arm Wharf/Marine Supply Base and Fort Hill Wharf
	Cross Currents	> Predicted to reach up to 1.2 m/s during a spring tide and flood currents approach 0.5 m/s perpendicular direction of pipeline	> sediment piping in approximate same orientation as tidal currents	> Predicted to reach up to 1.1 m/s during a spring tide and flood currents approach 0.4 m/s perpendicular direction of pipeline	N/A	N/A	> Unanchored disposal methods shipping navigation hazards resulting from accidental disposal of spoil outside of the DSDA	> Strong alignment of tidal flows along an approximate north-north-west to south-south-east axis at the spoil discharge point.	> Unanchored disposal methods shipping navigation hazards resulting from accidental disposal of spoil outside of the DSDA

		DEPWS - Neil Smit, Site 1 (West of Dredge area)	DEPWS - Neil Smit, Site 2 (North of Dredge area)	Mandorah Marine Facilities Referral	Onshore Disposal - Dedicated Disposal Site	Onshore Disposal - Shoal Bay Waste Management Facility (SBWMF)	Inpex Offshore Designated Disposal Site	Cullen Bay Maintenance Dredging	Darwin Port - Harbour Disposal
	Required Equipment Assessment	> 0.6km sediment pipeline with no booster pumps required, anchoring and nav exclusions zones required for pipeline > Dispersal from surface during high energy spring tides would negate sedimentation on benthic communities > Stable placement of material on seafloor (sunken sediment pipeline) reducing navigational hazards but increase sedimentation risk to benthic communities and damage to pipeline	> 1km sediment pipeline with no booster pumps required, anchoring and nav exclusions zones required for pipeline > dispersal from surface during high energy spring tides would negate sedimentation on sponge communities > stable placement of material on seafloor (sunken sediment pipeline) reducing navigational hazards but increase sedimentation risk to benthic communities and damage to pipeline	> 1.2km sediment pipeline with no booster pumps required, anchoring and nav exclusions zones required for pipeline > dispersal from surface during high energy spring tides would negate sedimentation on benthic communities > stable placement of material on seafloor (sunken sediment pipeline) reducing navigational hazards but increase sedimentation risk to benthic communities and damage to pipeline	> In situ ASS treatment > Excavators and large side tip trucks required to transport material from dredge site to SBWMF	> Excavators and large side tip trucks required to transport material from dredge site to SBWMF	> TSHD or CSD/hopper barge to allow easy disposal in deeper high energy waters > Unconfined ocean disposal of dredged sediment in high-energy environments via TSHD or hopper barge bottom doors > Alternative disposal methods such as hydraulic placement of materials unfeasible due to distance from dredge footprint	> TSHD or CSD/hopper barge to allow easy disposal in deeper high energy waters > Unconfined ocean disposal of dredged sediment via TSHD or hopper barge bottom doors > Alternative disposal methods such as hydraulic placement of materials unfeasible due to existing maritime industry actives and exclusion zones throughout Darwin harbour i.e pipes crossing shipping channel to reach spoil ground	> TSHD or CSD/hopper barge to allow easy disposal in deeper high energy waters > Unconfined ocean disposal of dredged sediment via TSHD or hopper barge bottom doors > Alternative disposal methods such as hydraulic placement of materials unfeasible due to existing maritime industry actives and exclusion zones throughout Darwin harbour

		DEPWS - Neil Smit, Site 1 (West of Dredge area)	DEPWS - Neil Smit, Site 2 (North of Dredge area)	Mandorah Marine Facilities Referral	Onshore Disposal - Dedicated Disposal Site	Onshore Disposal - Shoal Bay Waste Management Facility (SBWMF)	Inpex Offshore Designated Disposal Site	Cullen Bay Maintenance Dredging	Darwin Port - Harbour Disposal
Financial Feasibility					> Land placement of PASS I is likely to require management and monitoring to avoid impacts from acidic water discharges. This can be a major logistical and extremely expensive undertaking.	> Cost of disposal determined following Special waste disposal application to SBWMF	> Implications to transporting costs of spoil large distances both capital and maintenance to be considered > Intermittent dredging/disposal activities due to spoil transport and inclement weather delays	> Close proximity to dredge area reducing spoil transit times compared to other sites which also can't adopt hydraulic pumping methods	> Intermittent dredging/disposal activities due to spoil transport, inclement weather delays and larger vessels taking way

		DEPWS - Neil Smit, Site 1 (West of Dredge area)	DEPWS - Neil Smit, Site 2 (North of Dredge area)	Mandorah Marine Facilities Referral	Onshore Disposal - Dedicated Disposal Site	Onshore Disposal - Shoal Bay Waste Management Facility (SBWMF)	Inpex Offshore Designated Disposal Site	Cullen Bay Maintenance Dredging	Darwin Port - Harbour Disposal
Dispersion performance	**Current and Wave Assessment**	> 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 (Cardno 2021d) > Disposal site occurs within northerly ebb and southerly flood direction in excess of 1 m/s during spring ebb tide (Cardno 2021d)	> Disposal site fully exposed to longer period oceanic swell waves from the Beagle Gulf up to 0.9 m and sea waves approaching from north-north-east to south east during dry season, and from the north-north-west to north-north-east during wet season (Cardno 2021d) > Disposal site experiences low energy currents and eddies up to 0.2 m/s though sediment piping operations could experience current velocities up to 1.4 m/s between dredge and disposal areas	> Current speeds at the site are relatively high, reaching 1.5 m/s in a spring tide ebb flow and ~0.5 m/s in a spring tide flood flow > Dry Season - average easterly direction wave height below 0.5 m, increases in the sea state and peak wave heights (up to 0.9 m) in the afternoon before declining again overnight (Cardno 2014b) > Wet Season - average wave heights in the Beagle Gulf are 0.8 to 0.9 m, roughly twice the height of the dry season, arriving from a westerly direction	N/A	N/A	> Dry Season - average easterly direction wave height below 0.5 m, increases in the sea state and peak wave heights (up to 0.9 m) in the afternoon before declining again overnight (Cardno 2014b) > Wet Season - average wave heights in the Beagle Gulf are 0.8 to 0.9 m, roughly twice the height of the dry season, arriving from a westerly direction > Tidal currents occur generally north-south direction towards East point and Fannie Bay up to 1.1 m/s	> Swell waves typically approach the site from the north to north east. > Wind sea waves approach the site from different directions from north-north-west to south-east directions > Tidal currents occur generally north-south direction towards East point and Fannie Bay up to 1.3 m/s	> Large tidal ranges in the harbour produce peak current speeds of up to 2–2.5 m/s. > Tidal flows are also large; peak spring-tide flows have been measured along a line from East Point to Mandorah and are in the order of 120 000 m3 > Waves within Darwin harbour are wind driven requiring SE directional winds to achieve considerable fetch as they enter the harbour mouth /s.

		DEPWS - Neil Smit, Site 1 (West of Dredge area)	DEPWS - Neil Smit, Site 2 (North of Dredge area)	Mandorah Marine Facilities Referral	Onshore Disposal - Dedicated Disposal Site	Onshore Disposal - Shoal Bay Waste Management Facility (SBWMF)	Inpex Offshore Designated Disposal Site	Cullen Bay Maintenance Dredging	Darwin Port - Harbour Disposal
	Depth	> Between 5 m and 10 m LAT	> Between 10 m and 15 m LAT	> ~13.5m AHD	N/A	N/A	> Between 15 m and 20 m below LAT	> These waters are within Port Limits, in a depth of 18m LAT and is clear of existing anchorages	> East Arm Wharf - 10-13 m LAT > Marine Supply Base - 5-8 m LAT > Fort Hill Wharf - 13-15 m LAT
	Sedimentation Assessment	> Specific area not modelled, though lies within very similar physical conditions as the MMF referral sediment transport modelling suggesting similar disposal site dispersion	> Area of low tidal energy > Magnitude and extent of excess(above background) SSC is dominated by oceanic swell and sea waves	> Plume modelling indicates full dispersion of spoil through water column > No sedimentation deposition greater than 1 mm occurs nears the dredge disposal site	N/A	N/A	> Magnitude and extent of excess(above background) SSC is dominated by the tidal flow patterns > Excess SCC range of 3 - 5 mg/L with greater spatial extent during wet season due to increased wave action	> Assessment of dredge volume similar to MMF (90, 000m2) volumes adopted tolerance limits from INPEX Ichthy's project for hard coral, filter-feeder and macroalgae communities, seagrass beds and mangrove communities > Modelled sediment deposition (Williams 2016) indicated sedimentation did not pose a significant risk to benthic communities in the vicinity of the Project.	> Assessment of ~8,000m3 dredge spoil found no net sedimentation of >2.5 mm within the hard coral and filter-feeder communities in East Arm. Posing negligible risk of significant impacts these communities. > Further understanding of sedimentation from larger quantities is required

		DEPWS - Neil Smit, Site 1 (West of Dredge area)	DEPWS - Neil Smit, Site 2 (North of Dredge area)	Mandorah Marine Facilities Referral	Onshore Disposal - Dedicated Disposal Site	Onshore Disposal - Shoal Bay Waste Management Facility (SBWMF)	Inpex Offshore Designated Disposal Site	Cullen Bay Maintenance Dredging	Darwin Port - Harbour Disposal
	Background Suspended Sediment Conc. (SSC)	> SSC (turbidity) corresponds to tidal current speed – more turbid in spring tides, and seasonality – higher background turbidity during the wet season. > Expected to be consistent with Darwin Harbour Background TSS: - Spring tides - between 10 - 15 mg/L - Neap tides - Between 2 - 5 mg/L	> SSC (turbidity) corresponds to tidal current speed – more turbid in spring tides, and seasonality – higher background turbidity during the wet season. > Expected to be consistent with Darwin Harbour Background TSS: - Spring tides - between 10 - 15 mg/L - Neap tides - Between 2 - 5 mg/L	> Median (50th percentile) concentrations: - Wet season 7 mg/L - Dry season 3 mg/L	N/A	N/A	> Spring tides - between 10 - 15 mg/L > Neap tides - Between 2 - 5 mg/L	> 9.7 mg/L Dry Season > 12.5 mg/L Wet Season	> 5 mg/L Dry Season > 10-15 mg/L Wet Season

		DEPWS - Neil Smit, Site 1 (West of Dredge area)	DEPWS - Neil Smit, Site 2 (North of Dredge area)	Mandorah Marine Facilities Referral	Onshore Disposal - Dedicated Disposal Site	Onshore Disposal - Shoal Bay Waste Management Facility (SBWMF)	Inpex Offshore Designated Disposal Site	Cullen Bay Maintenance Dredging	Darwin Port - Harbour Disposal
Legislative Implications		> Located within Northern Territory waters and consequently the Environment Protection (Sea Dumping) Act 1981 (Cwlth) does not apply, negating the need for a sea dumping permit. > Proximity to INPEX gas pipeline and shipping channel	> Located within Northern Territory waters and consequently the Environment Protection (Sea Dumping) Act 1981 (Cwlth) does not apply, negating the need for a sea dumping permit.	> Located within Northern Territory waters and consequently the Environment Protection (Sea Dumping) Act 1981 (Cwlth) does not apply, negating the need for a sea dumping permit.	> National Environment Protection Measure (soil screening criteria) for contaminated sites must be adhered to. > Appropriately endorsed ASS management plan > Waste classification of dredge spoil material provided to SBWMF prior to disposal	> National Environment Protection Measure (soil screening criteria) for contaminated sites must be adhered to. > Waste classification of dredge spoil material provided to SBWMF prior to disposal	> Located within Northern Territory waters and consequently the Environment Protection (Sea Dumping) Act 1981 (Cwlth) does not apply, negating the need for a sea dumping permit. > Remaining Capacity for INPEX's NT EPA endorsed disposal activities is calculated to be approximately 7 Mm3 within the nominated disposal area. Therefore likely unable to accommodate Mandorah disposal material	> Located within Northern Territory waters and consequently the Environment Protection (Sea Dumping) Act 1981 (Cwlth) does not apply, negating the need for a sea dumping permit. > Cumulative impact assessment required for additional spoil adding to Darwin Port's NT EPA endorsed disposal volumes	> Located within Northern Territory waters and consequently the Environment Protection (Sea Dumping) Act 1981 (Cwlth) does not apply, negating the need for a sea dumping permit. > Cumulative impact assessment required for additional spoil adding to Darwin Port's NT EPA endorsed disposal volumes

Appendix G Hydrographic and Aerial Survey Report

Appendix H Marine Magnetic Survey

Appendix I Benthic Community Habitat Ground Truthing Data

Appendix J Local Area Relationships

Appendix K Metocean Report

Appendix L Sediment Transport Report

DESIGN WITH COMMUNITY IN MIND

Communities are fundamental. Whether around the corner or across the globe, they provide a foundation, a sense of place and of belonging. That's why at Stantec, we always design with community in mind.

We care about the communities we serve—because they're our communities too. This allows us to assess what's needed and connect our expertise, to appreciate nuances and envision what's never been considered, to bring together diverse perspectives so we can collaborate toward a shared success.

We're designers, engineers, scientists, and project managers, innovating together at the intersection of community, creativity, and client relationships. Balancing these priorities results in projects that advance the quality of life in communities across the globe.

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