NCIS-5 - HMAS Coonawarra

Dredging and Dredged Material Management

Supplementary Environmental Report

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Supplementary Environmental Report

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Revision History

Revision	Date	Comment	Signatures			
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Rev 0	26/04/23	Issued for Use	J. McLean	D. Shooter	L. Crickmore	T. Arnold

Contents

List of figures

List of tables

List of abbreviations

2D	Two Dimensional
3D	Three Dimensional
AAPA	Aboriginal Areas Protection Authority
ADCPs	Acoustic Doppler Current Profilers
AIMS	Australian Institute of Marine Science
CATAMI	Collaborative and Annotation Tools for Analysis of Marine Imagery and Video
CFM	Continuous Flow-Cell Method
CM&C	Chief Minister and Cabinet
DDMP	Dredging and Disposal Management Plan
DDSPMP	Dredging and Dredge Spoil Placement Management Plan
DEPAC	Defence's Director of Environmental Planning, Assessment and Compliance
DEPWS	Department of Environment, Parks and Water Security
DIPL	Department of Infrastructure, Planning and Logistics
DITT	Department of Industry, Tourism and Trade
DLRM	Department of Land Resource Management
DO	Dissolved Oxygen
DTIF	Department of Territory Families, Housing and Communities
EIAs	Environmental Impact Assessments
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
KBR	Kellogg Brown & Root Pty Ltd
LAT	Lowest Astronomical Tide
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
MSB	Marine Supply Base
MSL	Mean Sea Level
NATA	National Association of Testing Authorities
NEMP	Nearshore Environmental Monitoring Plan
NISB	National Intertidal/Subtidal Benthic
NT EPA	Northern Territory Environment Protection Authority
NTG	Northern Territory Government
NTPFES	Northern Territory Police, Fire and Emergency Services

NTU	Nephelometric Turbidity Unit
PAR	Photosynthetically Active Radiation
PSD	Particle Size Distribution
SER	Supplementary Environmental Report
SSCs	Suspended Sediment Concentrations
TSCD	Transport and Civil Services Division
TSS	Total Suspended Sediment
WAMSI	Western Australian Marine Science Institution

1 Introduction

1.1 PROJECT BACKGROUND

The Commonwealth Department of Defence (Defence) (the Applicant), proposes to undertake dredging and dredged material disposal at HMAS *Coonawarra*, located approximately 2 km north-west of Darwin city centre. A Referral for this proposal was accepted by the Northern Territory Environment Protection Authority (NT EPA) on 4 April 2022 and placed on public display for 20 business days.

On 12 July 2022 the NT EPA issued a Notice of Decision and Statement of Reasons which specified that the required method of environmental impact assessment in accordance with section 55 of the *Environment Protection Act* and regulation 57(2)(b)(ii) of the Environment Protection Regulation is by Supplementary Environmental Report (SER). The Decision Notice identified the need for additional information to assess potential significant impacts on the marine environment.

1.2 NOTICE OF DIRECTION TO PROVIDE ADDITIONAL INFORMATION

A '*Notice of Direction to provide additional information in the SER'* was subsequently issued by the NT EPA on the 14 October 2022. Attachment 1 of the Notice of Direction outlines specific requests for information in relation to the following:

- Sea – Marine Ecosystems: Benthic habitats and communities
- Sea – Marine Environmental Quality: Hydrodynamic model.

This SER addresses the requests for additional information in the Notice of Direction. Table 1.1 below summarises the requests in Attachment 1 of the Notice of Direction and identifies the section/s in this report where each has been addressed. A copy of the Notice of Direction is also included as Appendix A.

Table 1.1 Additional information requested in Notice of Direction (NT EPA, 2022)

Comment	Additional Information Required	SER Reference
Sea – Marine Ecosystems		
The proposed dredging and dredge spoil disposal is likely to impact benthic habitats and communities within the predicted zone of influence, directly due to removal, and indirectly due to short-term water quality changes (suspended sediment concentrations and turbidity levels) and sediment deposition. The	Include the following additional information in the SER: **1.** Provide details of the proposed timing, methods and reporting to undertake a baseline marine field survey of benthic habitats and communities to: **a)** collect underwater video transect data at a sufficient density to produce comprehensive mapping (at an appropriate scale) of the extent of benthic habitats within the predicted zone of impact and zone of influence (see point 2 below).	Section 2.3 provides details on the benthic habitat assessment conducted for the project in January 2023. Section 2.3.2 and 2.3.3 provide details of the substrate and benthic habitat types observed within the zone of

Comment	Additional Information Required	SER Reference
proponent used a predictive benthic habitat mapping tool developed by the Department of Environment, Parks and Water Security in 2019 to determine the potential impacts of the action on physical and biological benthic habitats within a local and regional context, including seagrass, hard corals, macroalgae, filter feeder and bare seafloor habitats. Site specific mapping of benthic habitats and communities was not undertaken for the referral. Therefore, a comparison of modelled results against field based survey results within the predicted zone of influence has not been undertaken to validate (ground truth) the modelled predictions. The NT EPA considers that benthic habitat survey and mapping is required to increase the level of confidence in predicting the potential significant impacts of the proposed action. During nearshore disposal of dredge spoil (1-2 month duration), benthic communities within the zone of influence would be exposed to increased suspended sediment concentrations and reduced light availability and quality, potentially leading to stress and mortality. Therefore, there is a need to understand the TSS (mg/L) /turbidity (NTU) – light intensity relationship at the seafloor to assist with setting appropriate turbidity triggers for	**b)** identify and describe the type and spatial extent (with consideration of temporal/seasonal variation) of benthic substrates and biota within the zone of impact and zone of influence **c)** provide sufficient ground-truth data to assess the accuracy of the DEPWS predictive benthic habitat model through comparison against predictive mapping.	impact and influence. Section 2.7 provides a discussion on the accuracy of the predictive map in comparison to the field data collected in 2023.
	2. Confirm that benthic habitat survey and classification would be undertaken in accordance with the following guidance: **a)** National Environmental Science Program Field Manuals for Marine Sampling to Monitor Australian Waters **b)** National Intertidal/Subtidal Benthic (NISB) Habitat Classification Scheme **c)** Collaborative and Annotation Tools for Analysis of Marine Imagery and Video (CATAMI) classification scheme.	Section 2.3.1 describes the methodology employed to undertake the benthic habitat survey and classification conducted in January 2023. A copy of the benthic habitat assessment report is also included as Appendix C.
	3. Confirm that comprehensive benthic habitat mapping would be overlain with property boundaries, the nearshore discharge location, the predicted extent of the sediment plume dispersion and deposition effects, and depth contour lines for lowest astronomical tide (LAT), mean low water springs (MLWS), mean low water neaps (MLWN) and mean sea level (MSL).	Section 2.3.4 provides a benthic habitat map for the project, with tidal contours. Figure 3.26 shows predicted deposition effects on benthic habitats, while Figures 3.35 and 3.36 present the benthic habitat types within the zones of impact and influence.
	4. Provide detail about how the results of the benthic survey and mapping would be taken into account for each dredging action, using an adaptive management approach. Include detail about how potential impacts (related to sediment deposition, suspended sediment, turbidity and benthic light levels) on sensitive benthic communities and habitats (corals, seagrass, macro algae and filter feeders where presence is confirmed during field surveys) would be managed. Include detail about how benthic impacts from dredge spoil disposal would be monitored and measured, and the expected duration of recovery periods where impacts are predicted or observed (informed	Section 2.8 provides a discussion on the adaptive management approach to be adopted. Sensitive receptors within the zone of impact and influence are discussed in Section 2.4. Key impact mechanisms associated with the relevant sensitive receptors are

Comment	Additional Information Required	SER Reference
benthic communities and primary productivity.	by the revised hydrodynamic model – refer to item below).	described in Section 2.5. Details regarding the tolerance limits of sensitive receptors are provided in Section 2.6.
	5. Confirm that the draft Dredging and Disposal Management Plan to reflect any necessary changes arising from points 1-4 above.	Section 2.9 summarises the main updates incorporated in the DDMP, with a copy of the updated DDMP included as Appendix E.
Sea – Marine Environmental Quality		
The proponent developed a two-dimensional (depth averaged) hydrodynamic model in the 'Eulerian' Delft3D-FLOW modelling package, with suspended sediments modelled using the 'Lagrangian' 'random walk' particle tracking module, Delft3D-PART. The NT EPA understands that three dimensional (3D) modelling is considered best practice in most marine environments in order to predict dredging impacts to hydrodynamics, plume and sediment transport. The Western Australian Marine Science Institution (WAMSI) Dredge Science Node Guideline on dredge plume modelling for environmental impact assessment discusses 2D vs 3D hydrodynamic modelling to allow for accuracy and certainty in the assessment of impacts of changes in current strength to benthic communities; sediment transport along the seafloor, and plume density within the water column.	Additional information is required in the SER to improve confidence in the hydrodynamic model outputs, results, and impact predictions, and to assess the significance of potential impacts of suspended, deposited and remobilised sediments on the marine environment. **1.** Provide a detailed justification with information to support the use of a 2D hydrodynamic model for the prediction of dredging impacts from the proposal.	Sections 3.1 and 3.2 presents the supplementary modelling undertaken to increase the level of confidence in modelling predictions.
	2. Provide details and sources of the baseline data (including from field observations) that has been used in development, calibration and validation of the model to predict and validate the extent of the plume, including any plume validation data available from previous HMAS *Coonawarra* dredging monitoring programs.	A discussion of baseline water quality data is provided in Section 3.6. Plume validation using data from previous dredging campaigns is presented in Section 3.3. Other sources of model input data are described in Appendix D – Supplementary Dredging Modelling Report.
	Describe how the baseline and model input data used are consistent with the requirements of the WAMSI Dredge Science Node Guideline on dredge plume modelling for environmental impact assessment (specifically sections 3, 4 and 5 of the guideline).	Section 3.5 provides a discussion of the dredge model consistency with the WAMSI Dredge Science Node Guideline, with further details provided in Appendix D – Supplementary Dredging Modelling Report.

Comment	Additional Information Required	SER Reference
Further justification should be provided to support use of the 2D model (with random walk particle tracking) for the prediction of sediment plume, transport and deposition impacts from the proposed dredging. The justification should provide information to support the decision not to use a 3D model. The justification should describe how sediment transport within ambient settings and after sediment is deposited from dredge spoil or sediment plumes is addressed by the modelling. Further information should be provided to describe how the transport and fate of sediments (coarse and fine) has been quantified and modelled, and how sedimentation rates and implications for water quality (TSS and turbidity) and benthic communities and habitats has been assessed. Describe how the modelling allows for determination of the susceptibility of marine and benthic values and sensitivities to sedimentation and the suitability of the proposed water quality trigger levels that would be applied during dredging to avoid significant impacts. The models should be calibrated and verified by comparing modelled results against field based measurements.	Confirm that the timing of baseline data collection corresponds to the time of year that dredging is proposed to occur. As a guide, if dredging is proposed in the dry season/buildup, data should be provided for a minimum of 28 days. If in the wet season, data should be provided for 6-8 weeks (i.e. to capture at least two monsoonal events). Provide the baseline data as part of the information response to this Direction (either from existing or new site specific monitoring).	A discussion of the Baseline Water Quality Data Collection program is provided in Section 3.7.
	3. Describe how the following has been considered in development of the model and the prediction of impacts: **a)** the composition of TSS **b)** how TSS concentration data correlates to turbidity (NTU) level data at the proposed monitoring locations (including the two additional locations – refer to item below) **c)** the relationship between suspended sediment and light availability and quality at the seafloor	Section 3.8 describes the suspended sediment relationship with turbidity and light availability.
	4.	N/A
	5. Revise the monitoring program to include two additional sites as recommended by DEPWS; one along the western side of the Fannie Bay sand bank, as this lies in the major axis of most dredge plume modelling outputs; and at Bennet Shoal, which is likely to contain benthic primary producer habitats.	Section 3.7 and 3.11 outline the revised Baseline Water Quality Data Collection program and the monitoring program during dredging which include the refinements to monitoring locations and inclusion of the two additional sites as recommended by DEPWS.
	6. Review the proposed trigger values (TSS <20mg/L in dry season and <30mg/L in wet season) and the 1:1 TSS/turbidity (NTU) correlation, that would initiate a management response during nearshore spoil disposal and include triggers for time duration of exceedances for specific benthic communities including corals, seagrass, macro algae and filter feeders (where presence is confirmed during field survey). Interim triggers should be established from baseline TSS, turbidity and benthic light level data with consideration of the WAMSI Dredge Science Node research reports on ecological thresholds and environmental windows at	A discussion of the proposed trigger values and revised zones of impact and influence is presented in Section 3.9.

Comment	Additional Information Required	SER Reference
The revised modelling and setting of trigger values should be informed by the outcomes of the benthic habitats and communities survey and mapping (refer to item above).	https://www.wamsi.org.au/dredging-science-node/dsn-reports. As an example, in the case that only dry season site-specific data is available, this should be cross referenced with established guideline values (for the benthic communities present) in the WAMSI data, to establish interim guideline values for the wet season, which could be used until sufficient site-specific wet season monitoring data is available. In the case that existing site-specific seasonal baseline monitoring data is not currently available, the proponent should first obtain data for the season in which the initial dredging works are proposed to be undertaken.	
	7. Describe how sediment deposition modelling has been developed, including for fine and coarse material and report on the time duration, magnitude and extent of deposition, the deposited sediment thickness, and the fate of deposited sediments. Describe how the model has been designed, calibrated and validated to assess impacts related to sediment behaviour, transport pathways, fate, and deposition.	Sediment deposition modelling for fine and coarse material is discussed in Section 3.4, with further details provided in Appendix D – Supplementary Dredging Modelling Report.
	8. Demonstrate through survey, monitoring and modelling results that the proposed site for nearshore disposal is suitable for the avoidance of potential significant impacts to marine ecosystems.	The suitability of the nearshore disposal location is addressed in Section 3.10.
	9. Review and update the Draft Dredging and Disposal Management Plan to reflect any necessary changes arising from points 1-8 above.	Sections 2.9 and 3.12 note that the Draft Dredging and Disposal Management Plan (DDMP) has been reviewed and updated to reflect the supplementary information. A copy of the updated draft DDMP is included as Appendix E.

1.3 SUBMISSIONS ON REFERRAL INFORMATION

A number of submissions in relation to the published Referral information were also received during the public display period from the following government authorities:

- Aboriginal Areas Protection Authority
- Department of Environment, Parks and Water Security
- Department of Industry, Tourism and Trade

- Department of Infrastructure, Planning and Logistics
- Department of Territory Families, Housing and Communities
- Department of the Chief Minister and Cabinet
- Northern Territory Police, Fire and Emergency Services

No submissions from any non-agency stakeholders, businesses or members of the public were received. Many of the comments raised in the submission are also addressed in the *'Notice of Direction to provide additional information'* as outlined in Section 1.2. Each of the queries and comments have been addressed. This has not resulted in any change to the overall outcome of the assessment presented in the Referral. A summary of the submissions received is discussed further in Section 4 with detailed responses addressing each of the department's concerns included as Appendix B.

1.4 SUPPLEMENTARY ENVIRONMENTAL REPORT

This SER provides information responding in full to the additional information requests as outlined in Attachment 1 of the Notice of Direction, and all submissions received in relation to the published Referral information. The primary purpose of this SER is to increase the level of confidence in modelling predictions and understanding of benthic habitat and provide additional information to support the assessment of the proposed dredging and dredged material disposal activities.

Attachment 1 of the Notice of Direction has been used to provide a framework for the overall structure of this SER along with guidance provided in the NT EPA *Preparing a supplementary environmental report (SER) –Environmental Impact Assessment: Guidance for Proponents* document. Each comment raised has been worked through, with additional information as required presented in this document.

Table 1.2 provides an overview of the SER structure.

Table 1.2 SER Structure

SER Section	Description
Section 1 Introduction	Project background, status of environmental assessment process, and tabulated list of additional information as requested in Attachment 1 of the Notice of Direction with cross references to each relevant response provided in this report.
Section 2 SEA – Marine Ecosystems	Response to Notice of Direction to provide additional information. Additional assessment of existing benthic habitats and communities within and surrounding the project area, and potential impacts associated with the proposed activities.
Section 3 SEA – Marine Environmental Quality	Response to Notice of Direction to provide additional information. Supplementary hydrodynamic modelling, and additional baseline water quality assessment used to inform a review of potential impacts on marine and benthic habitat values.
Section 4 Response to Submissions on Referral Information	Summary of submissions received from each government authority.
Section 5 Conclusion	Overall conclusion regarding the assessment of impacts and management measures to be implemented during the proposed dredging and dredged material disposal activities at HMAS *Coonawarra*.

SER Section	Description
Section 6 References	Reference list of supporting documentation
Appendix A Notice of Direction to provide additional information in the SER	Copy of the Notice of Direction to provide additional information in the SER
Appendix B Response to Submissions on Referral Information	Presents responses to each Referral submission received.
Appendix C Benthic Habitat Mapping Report	Presents project specific benthic habitat survey data and mapping.
Appendix D Supplementary Dredging Modelling Report	Presents additional modelling assessment undertaken to assess dredging and disposal impacts.
Appendix E Updated Draft Dredging and Disposal Management Plan	The Draft DDMP has been updated to reflect the outcomes of the additional assessment undertaken and documents the reasonable and practicable steps to be taken to manage the potential environmental risks and impacts arising from the dredging and dredged material disposal activities.

2 Sea – Marine Ecosystems

2.1 INTRODUCTION

During the development of the published Referral documentation, a number of data sets were reviewed and assessed to identify marine and benthic habitats within the project area, which includes the dredge area, the dredge discharge pipeline, discharge location and area of Darwin Harbour which may be affected by sediment plumes associated with the dredged material discharge. This was undertaken to determine the potential for impacts associated with dredging and dredged material disposal on the benthic communities within the project area. One of these data sets was the 2019 predictive model of benthic habitats within Darwin and Boyne Harbours which was developed by the Department of Environment, Parks and Water Security in conjunction with the Australian Institute of Marine Science (AIMS), however that was not solely relied upon to assess potential impacts on benthic habitat communities.

In Attachment 1 of the Notice of Direction, it is noted that project specific benthic habitat survey and mapping is required to increase the level of confidence in predicting the potential for significant impacts on benthic habitat communities. While the published Referral did address the extent of potential impacts to benthic habitat based on a review of available data obtained from DEPWS, DENR, the results of field monitoring during the 2013 and 2006 HMAS *Coonawarra* dredge campaigns and the outcomes of sediment plume modelling, it is acknowledged that project specific survey data is beneficial in supporting the assessment of potential impacts.

Consequently additional assessment has since been undertaken to support not only the proposed current dredging campaign but also future campaigns, including a baseline survey of benthic habitats and communities, comparison of that field survey data with the latest version of the DEPWS predictive benthic habitat model and reanalysis of potential impacts within the predicted zone of impact and zone of influence.

2.2 RELEVANT MARINE BENTHIC HABITAT SURVEYS CONDUCTED IN DARWIN HARBOUR

To inform the project specific benthic habitat assessment, further review and reanalysis of available field survey data/mapping within the vicinity of the project and the surrounding waters of Darwin Harbour was undertaken.

Marine and benthic habitat data sets have been collected over the years by a number of organisations for project specific requirements or research purposes using varying methods as outlined in Table 2.1. It is noted that some of this habitat data was used by Galaiduk et al. (2019) to create a predictive habitat map (e.g. predicted areas where habitat types could occur based on modelled variables and habitat data) and that this model was subsequently updated (e.g. spatial coverage, modelled variables and additional habitat data) by Streten (2022).

Data and/or mapping associated with each of the field surveys and projects listed in Table 2.1 were obtained from a variety of sources including AIMS, INPEX, Department of Land Resource Management (DLRM) and the NT EPA. All available data relevant to the project and modelled areas of influence were reviewed to improve the understanding of benthic habitats likely to occur within the broader project area.

Table 2.1 Marine benthic habitat data sets relevant to the Project

Year	Data Type	Location	Collected by
2008	ROV and Dive survey	INPEX Ichthys	URS
2012 to 2013	Towed Video	Collated marine habitat data - East Arm, East Point, Darwin Harbour, Cox Peninsula and East Point to Mandorah and Middle Arm	GeoOceans (This dataset consists of data collected on 5 separate marine habitat surveys for 4 different project proponents)
2014	Drop camera	Fannie Bay	AIMS
2015	Drop camera	Woods Inlet, West, Middle and East Arms	AIMS
2016	Drop camera	Principally West and Middle Arms	AIMS for NTG
2017	Towed Video	Entrance to Darwin Harbour and the Shoal Bay region	AIMS for NTG
2020	Towed Video	South Shell Island, Old Man Rock and East Arm Wharf (Darwin Ship Lift Facility)	AIMS for AECOM on behalf of NTG
2020	Towed Video	Locations throughout Darwin Harbour including Woods Inlet, West and Middle Arms, and Wickham Point	AIMS for NTG

The spatial distribution of the data sets outlined in Table 2.1 is shown in Figure 2.1. In addition, results of seagrass monitoring undertaken for the Ichthys Project Nearshore Environmental Monitoring Plan (NEMP) – Seagrass Monitoring Program conducted between June 2012 and August 2014 between East Point and Lee Point were also reviewed in conjunction with these data sets.

As evidenced in Figure 2.1, a substantial amount of data has been collected over the years to understand the benthic habitat communities which occur within Darwin Harbour. Those field surveys of most relevance to the works proposed at HMAS *Coonawarra* are shown in Figure 2.2.

The ROV and diver sub-tidal surveys undertaken in 2008 captured video and still images that were processed by URS using quantitative and qualitative data analysis methods for the INPEX Ichthys Project. These surveys indicate that hard corals are located offshore and along the western side of the harbour, well beyond the HMAS *Coonawarra* project area.

The towed video data from 2012 to 2013 represents collated marine benthic habitat data collected on five separate towed camera surveys for four different project proponents (including three Northern Territory Government departments). The data was collected using towed camera methodologies to capture video and still images of the seabed. These images were processed using semi-quantitative analysis methods to classify the substrate composition, biota percent cover, object counts, and other habitat data. The same image analysis and data collection methods were used for all surveys and the data from all surveys were collated into combined datasets representing hard corals, macroalgae, seagrass, soft corals and sponges. This data indicates that sponges and other filter feeders were the organisms predominantly observed within the project area with occurrences of macroalgae recorded at East Point.

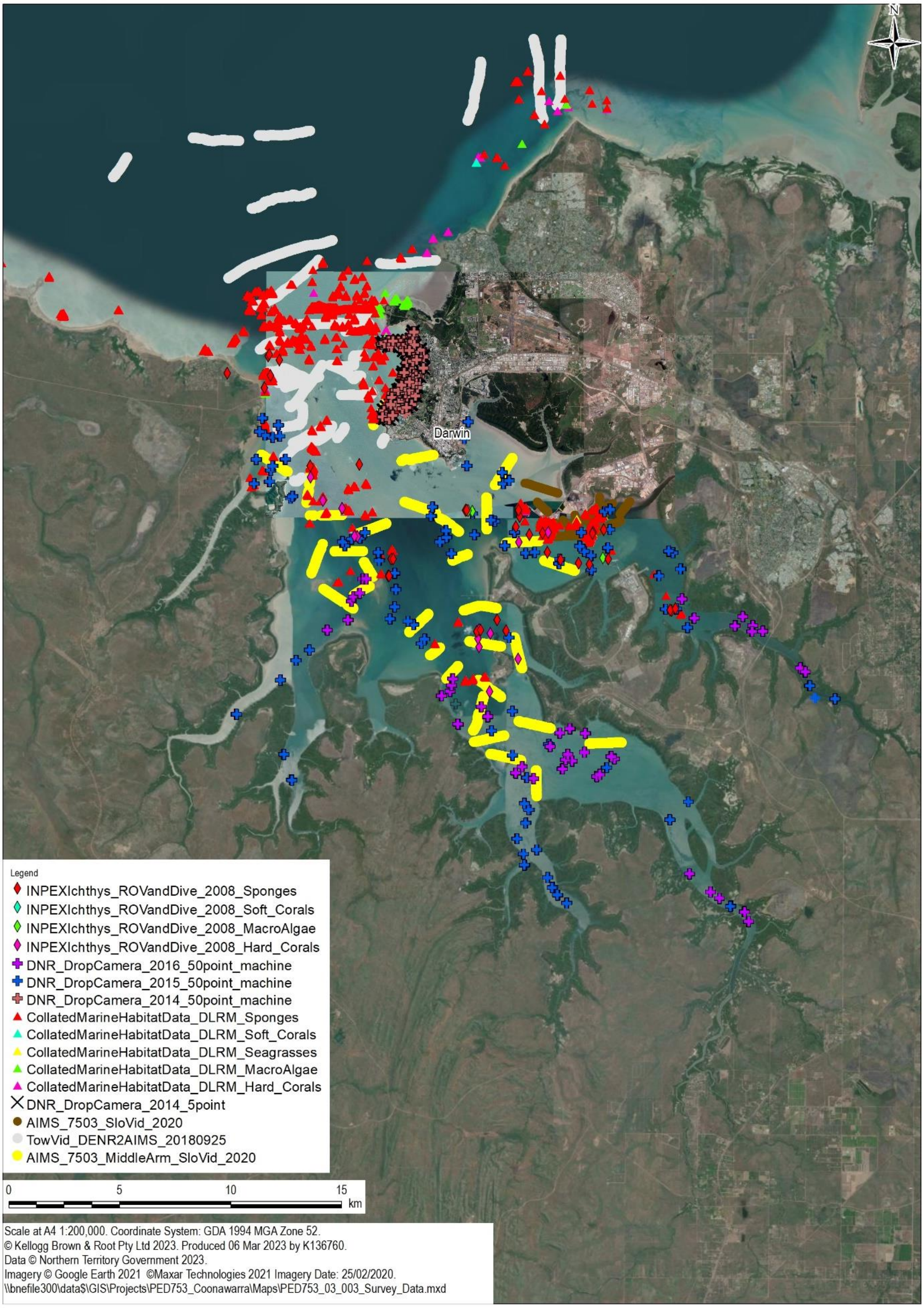

Figure 2.1 Broad spatial distribution of marine benthic habitat data sets

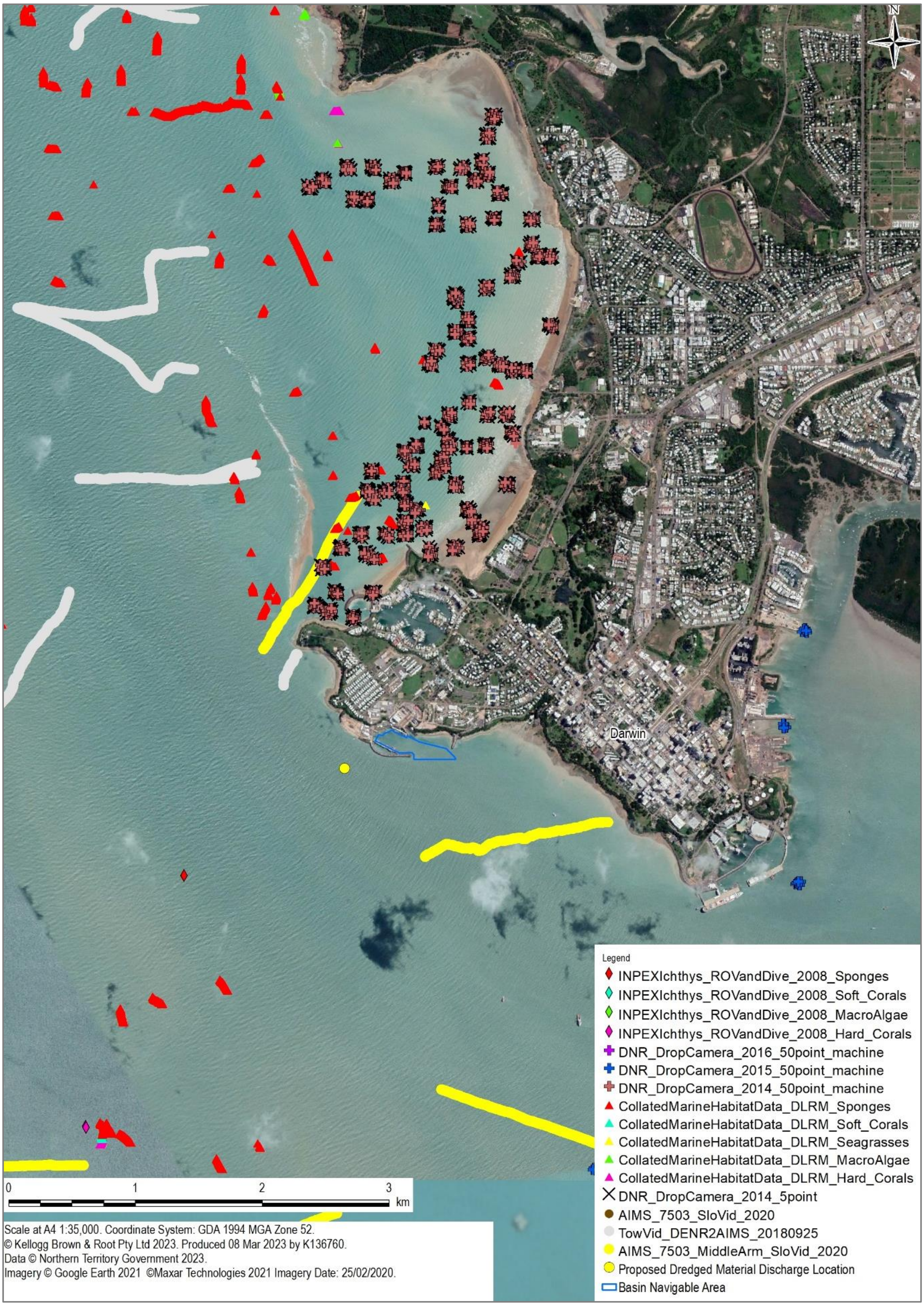

Figure 2.2 Spatial distribution of marine benthic habitat data sets relevant to proposed works

The 2015 and 2016 drop camera surveys focussed on those areas of the harbour located to the south of HMAS *Coonawarra* and were not particularly representative of the benthic habitat types within the project area. However, the 2014 drop camera survey assessed benthic communities within Fannie Bay. It was found that the majority of Fannie Bay was characterised by bare soft substrate with sparse occurrences of seagrass.

The most recent benthic habitat surveys undertaken using the towed video method in September to December 2017 and November/December 2020 provide a good indication of the habitat types which occur within the immediate vicinity of the project.

The 2020 towed video survey collected data along numerous transects within the harbour, with towed transects 1, 2 and 3 located within area of interest for the project (Figure 2.3). This transect data shows that the marine habitats immediately to the north extending from Emery Point into Fannie Bay and south of the project in front of the Darwin esplanade and beyond this between Stokes Hill Wharf and East Arm are dominated by bare substrate with patches of low percent cover filter feeders (<15%) including ascidians, hydroids, soft corals and sponges. No seagrass, hard coral, hydrocorals or bacterial mats were observed along any of the transects.

Figure 2.4 provides a summary of the benthic habitat data classifications and their percent cover recorded along each relevant 2020 towed video transect. The results of this field survey correlate well with the outcomes of the project specific 2023 field survey, as discussed further in Section 2.3, and confirms that limited benthic communities occur within the project area.

The 2017 towed video survey involved the collection and analysis of data along five towed video transects (1, 1001, 1531, 2001 and 1002) within the project area. The locations of these transects in relation to HMAS *Coonawarra* are shown in Figure 2.3.

Transect data adjacent to Emery Point (Transect 1) found that the seabed in this location is predominantly sand and silt with no other biota present.

Further north, along the western side of the offshore sand bank (north of Emery Point), the seabed was largely characterised by sand and silt, however patches of rock and gravel supporting a mix of benthic species including filter feeders, sponges and soft corals were also observed. These observations reflect the 2023 mapping undertaken for the same area which noted that the occurrence of hard material correlated with those areas where low density filter feeders were present.

The Fannie Bay area has also been surveyed numerous times over the past years due to its potential to support ephemeral seagrass habitat. Seagrass monitoring undertaken for INPEX identified large seagrass beds along the Darwin coastal region between Fannie Bay and Lee Point, and smaller isolated patches at Woods Inlet and off Charles Point along the Cox Peninsula (Cardno, 2015a). No seagrass beds were identified within Darwin Harbour itself during the monitoring program, although other environmental surveys have identified isolated sparse patches of seagrass at Weed Reef and Wickham Point (INPEX 2010). Seagrass within the Fannie Bay area is considered to be highly ephemeral with its presence and coverage varying depending on the conditions (GeoOceans, 2011; INPEX, 2010).

Figure 2.3 2020 and 2017 towed video transects relevant to the site

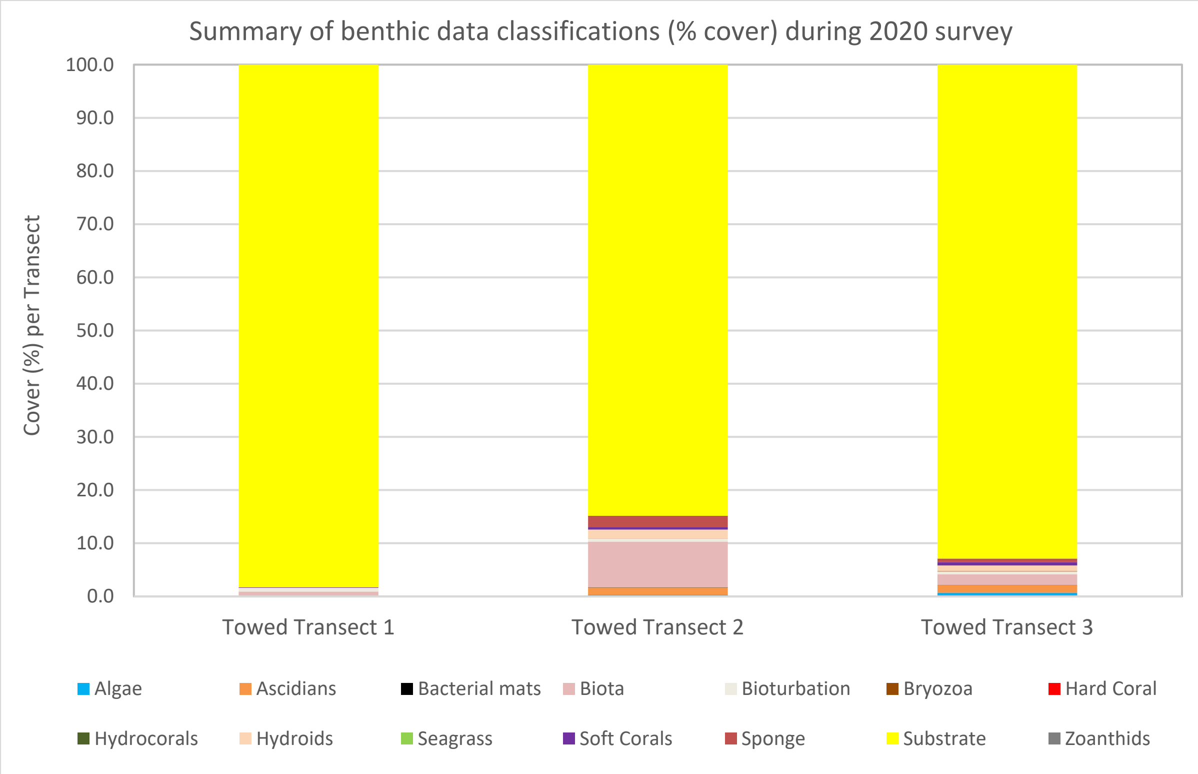

Figure 2.4 Percent cover of benthic habitat classifications recorded along each relevant 2020 towed video transect (Streten, 2022)

2.3 BENTHIC HABITAT ASSESSMENT

Project specific benthic habitat survey and mapping was undertaken by GeoOceans in January 2023 in accordance with the information requested in the Notice of Direction. This field survey was undertaken to identify key benthic habitats/characteristics within the project area, and to support the assessment of potential impact mechanisms relevant to the benthic communities present and the refinement of criteria appropriate for the communities present.

A copy of the HMAS *Coonawarra* Benthic Habitat Mapping Report is included as Appendix C, and details of the field survey methodology and results are presented in the following sections.

2.3.1 Methodology

Relevant existing benthic habitat data was reviewed and used as input to the development of a field survey scope for the assessment of benthic communities within the project area. The field survey was undertaken from 16 to 18 January 2023 and was conducted during neap tide conditions to target low current and less turbid conditions. Visibility during the survey was limited and varied between 30 cm and 1 m which was sufficient for the survey. Rainfall which occurred in the lead up to the field survey contributed to slightly higher suspended sediment levels in the harbour, with wind conditions which were predominantly from the northwest also contributing to additional turbidity within the shallow inshore areas.

The field survey and classification were undertaken in accordance with the requirements outlined in the Notice of Direction, including guidance in the Collaborative and Annotation Tools for Analysis of Marine Imagery and Video (CATAMI) classification scheme.

The benthic habitat survey focussed on the collection of underwater video transect data within the zone of impact and priority areas within the zone of influence, which incorporated a broad area informed by the results of previous field mapping campaigns and the modelled predictions in the published Referral. The survey effort also included Fannie Bay, although this area is not predicted to be within the zone of influence. Additional effort was made to assess those areas which have previously been known to support seagrass habitat by capturing supplementary stationary high resolution images. These high resolution still images were periodically taken throughout the Fannie Bay area to enhance the identification of any seagrass, including small leaf biomass, seagrass remnants or root systems which may be present.

A total of 50,479 points of habitat data were acquired across 73 towed camera transects. The transects ranged in length from 95 m to 139 m and covered a total distance of 7.5 km. Figure 2.5 shows the location of the towed video survey transects.

The video feed was analysed in real-time, using a customised software program. Field scientists recorded habitat point data live in real time based on the video feed and DSLR still imagery being displayed with any observed biota categorised based on the CATAMI classification system (CATAMI, 2013). Details about the substrate type were also recorded, including information such as percentage of soft and hard substrate, profile of the soft and hard substrate and an estimation of sediment grain size. All observations were recorded and geo-referenced using the software.

2.3.2 Substrate types

Four distinct substrate types were observed throughout the survey area including:

- Mixed hard and sand substrate
- High profile sand substrate (Dunes)
- Low profile sand substrate (Ripples)
- Flat sand/silt substrate

Fannie Bay was characterised by low profile sandy substrate with small ripples (<10cm), which were absent of biota. Some patches were flattened and absent of ripples, and from previous surveys (Geo Oceans, 2014) were observed to be the substrate types more likely to contain *Halophila* seagrass communities, however no live seagrass, seagrass remnants or root systems were observed during the field assessment.

To the west of the sand bar north of Emery Point, the substrate consisted of large dunes of sand greater than 5m in height. Typically biota was absent, however at times occurrences of rocky material with filter feeders or the remnants of filter feeders were observed between the high profile sand dunes.

The remainder of the survey area was characterised by two main substrate types including mixed hard and sand substrate, and flat sand/silt substrate. Sandy substrate with some rock boulders (>256mm) or small rock platforms protruding from the sand were observed commonly within the survey area. The coverage of rock material in these areas was low, however what was present was typically characterised by low density cover of filter feeders. The areas of flat sand and silt with occasional rock material were found to support very limited, if any, filter feeder species.

2.3.3 Benthic Habitat

Results of the benthic habitat mapping show that the majority of the survey area is characterised by bare substrate with sparse coverage of filter feeders, primarily sponges, observed in those areas where some hard substrate, such as rock and gravel, were present.

Seagrass, hard coral and macroalgae communities were not observed at any point during the survey.

Further discussion of the habitat types observed within the survey area, those that were absent, and the types of substrate encountered during the survey is provided in the following sections.

Figure 2.5 **2023 Benthic habitat survey sites – towed video (GeoOceans, 2023)**

Filter Feeders

Filter feeders were the only benthic habitat type observed throughout the survey area. The majority of observed filter feeders had a percent coverage of less than 10%, were patchy in nature and highly dependent on the availability of hard substrate. Figure 2.6 shows an overview of the range of percent cover of filter feeders recorded along each transect, with Figures 2.7 and 2.8 showing the northern and central and southern area results in more detail.

Over half of the points recorded within the survey area were observed to be bare substrate with no biota or minimal biota (<1%) (Figure 2.9). In addition to this, 40% of the observed points in the field recorded filter feeder densities of 10% or less. Consequently over 90% of the surveyed points represent either bare substrate or bare substrate with very sparse filter feeder species.

Occasional small patches of filter feeders greater than 20% cover were rare with less than 1% of all survey points recording filter feeder cover between 20% and 40%.

The highest observed density of filter feeders for any given individual data point was 40% which was only observed along one transect (site 48) spanning a length of approximately 1m, over a total transect length of approximately 95 m.

Sponges (Porifera) were the most dominant biota observed within the filter feeder cover.

Fannie Bay was characterised by bare sand substrate with no filter feeder species observed (Figure 2.10). Only a small area of branching erect sponges were observed adjacent to Myilly Point (Figure 2.11).

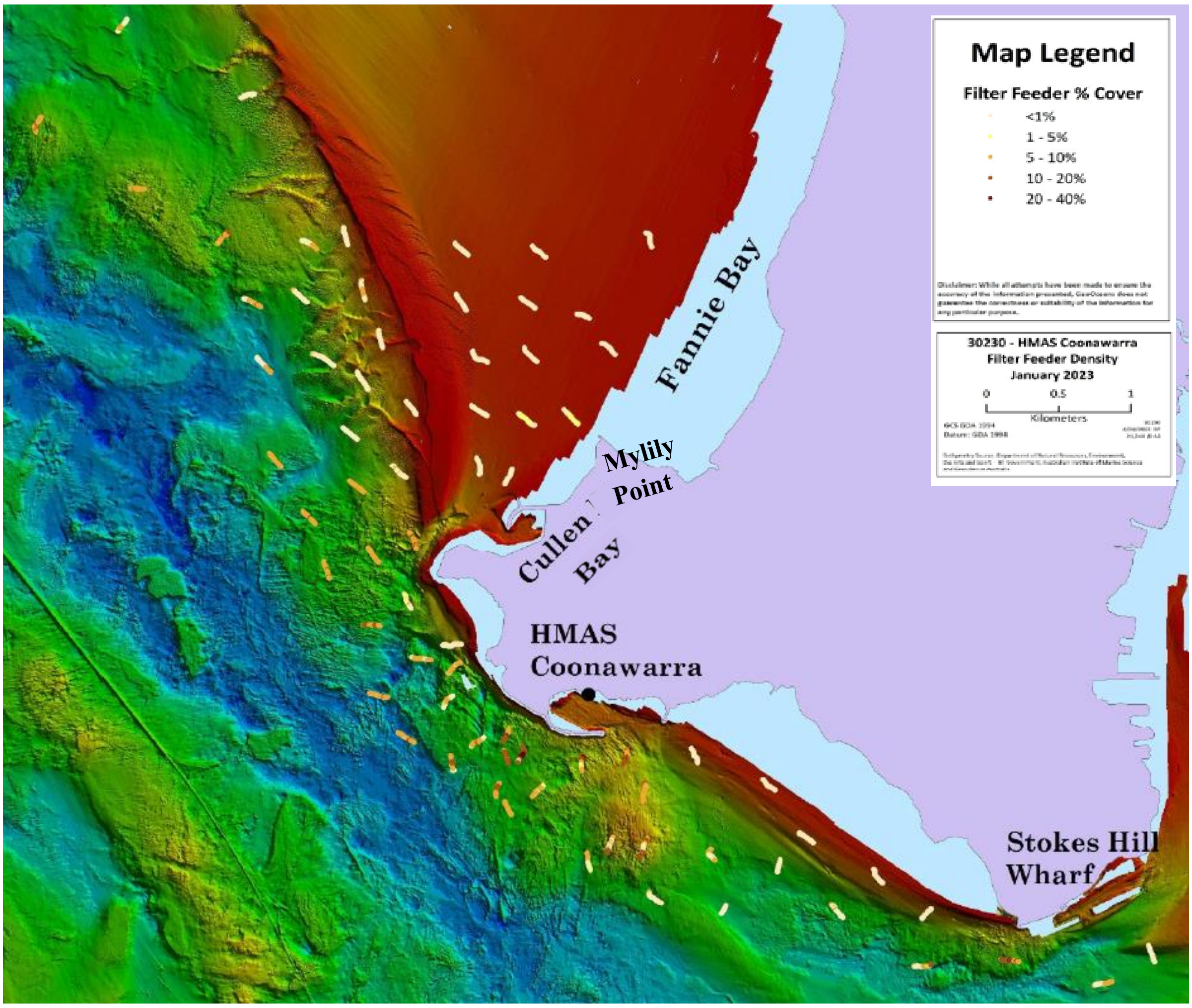

Figure 2.6 Benthic habitat map overview – Filter feeder density recorded along each transect (% cover filter feeder) (GeoOceans, 2023)

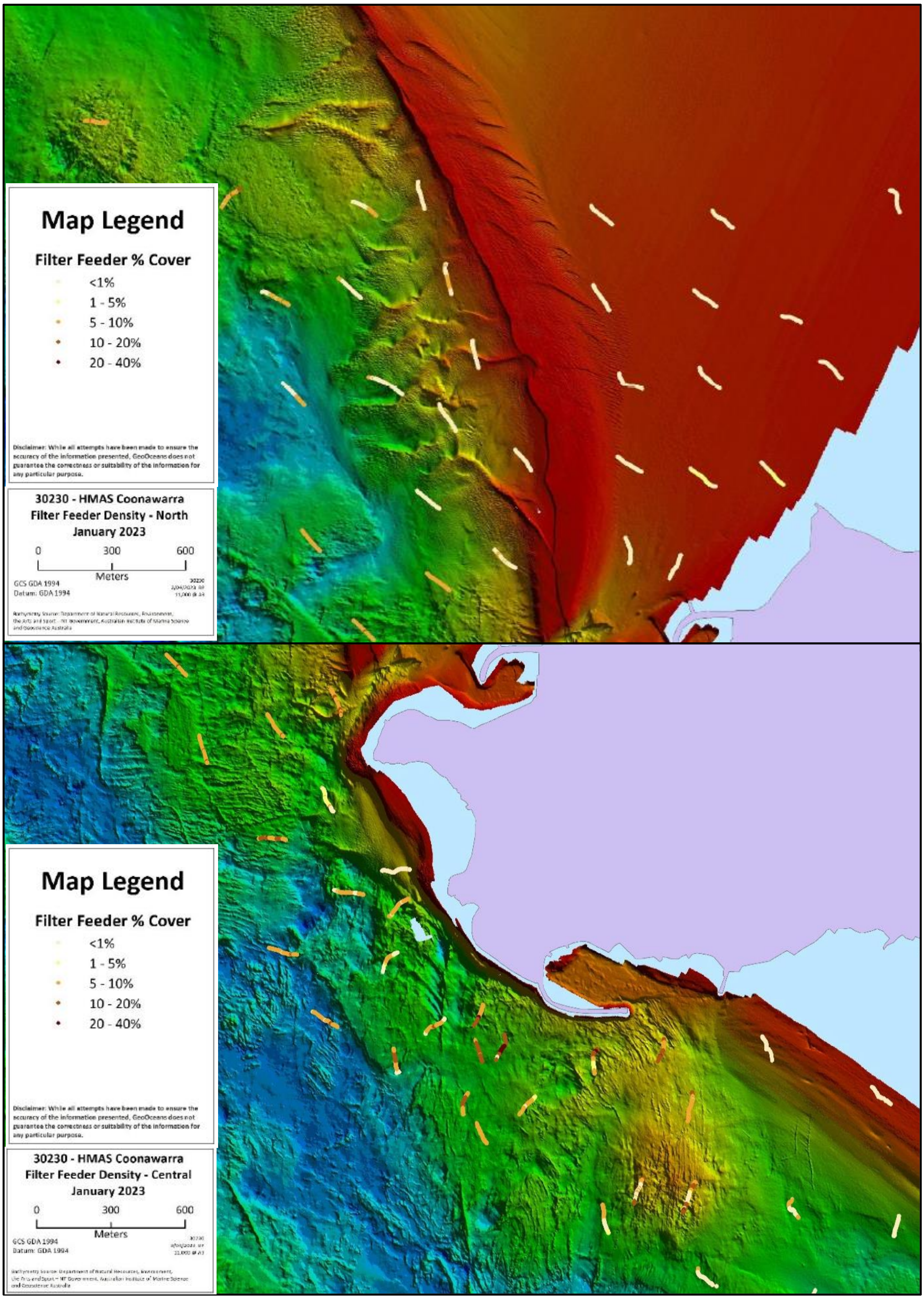

Figure 2.7 Benthic habitat map North and Central – Filter feeder density recorded along each transect (% cover filter feeder) (GeoOceans, 2023)

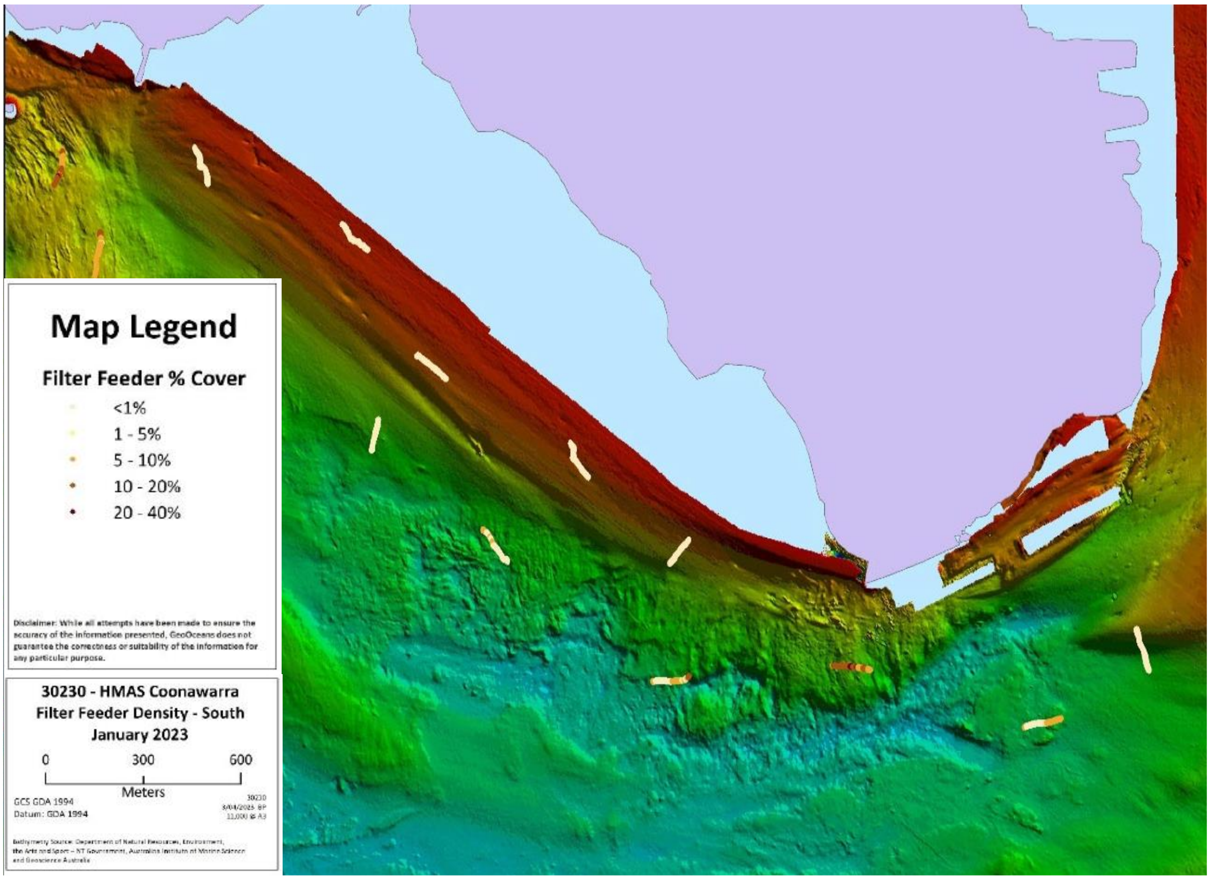

Figure 2.8 Benthic habitat map South – Filter feeder density recorded along each transect (% cover filter feeder) (GeoOceans, 2023)

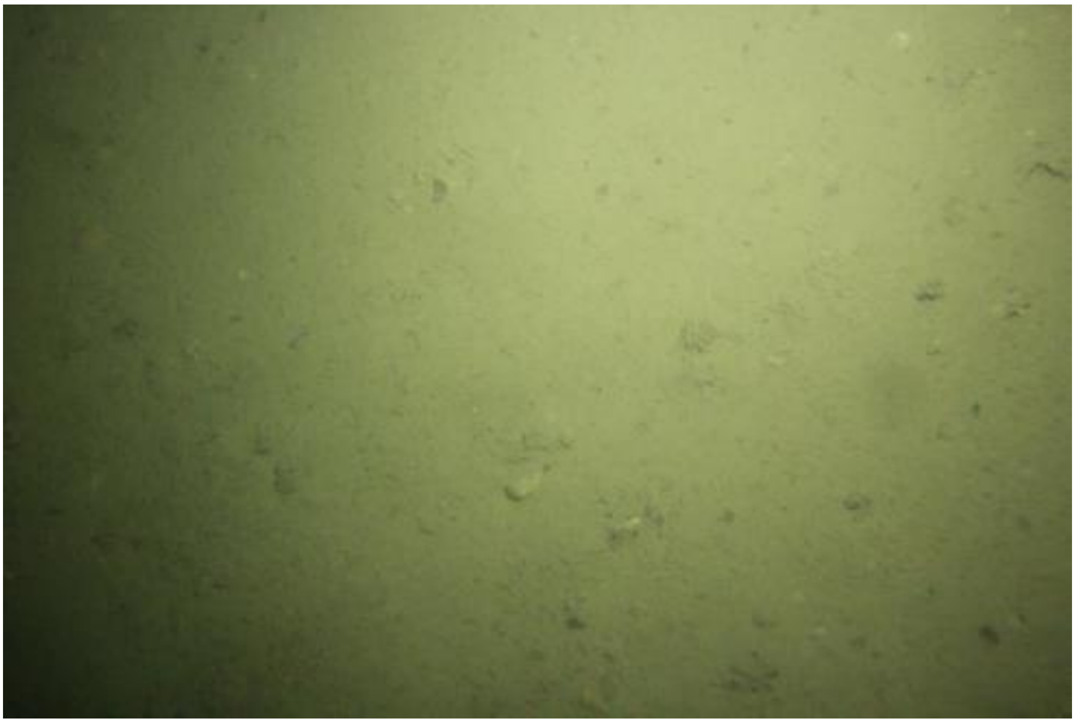

Figure 2.9 Example of bare sand/silt substrate representative of the majority of the survey area

Figure 2.10 Bare sand substrate observed throughout the majority of Fannie Bay

Figure 2.11 Example of sponge filter feeder observed within Fannie Bay

The area immediately to the west of the sand bank which runs north from Emery Point was characterised by large dunes of bare sand with some occurrences of rock and remnants of filter feeders observed between the high profile sand dunes (Figure 2.12).

Further west of the sand bank and throughout the remainder of the survey area filter feeder assemblages remained consistent with no notable variations in species composition. Species type and density showed some variation with distance from the shore and the sand bank. These observed changes largely correlated with depth but also appeared to align with the currents experienced within this area of the harbour.

Filter feeders within the nearshore areas of the survey area were dominated by sponges with a mixed assemblage of erect, massive and encrusting morphologies. These areas also supported patches of Bryozoans (Figure 2.13) , as well as less abundant soft coral species including branching and gorgonian fans and hydrozoans.

Further offshore sponges remained the dominant filter feeder species observed. Sponges of the laminar morphology were most prevalent followed by other erect forms including erect palmate, erect branching and some cup morphologies, along with low numbers of other filter feeders including bryozoans and ascidians (Figures 2.14). Cnidarian soft coral filter feeders such as gorgonian fans, sea whips and hydrozoans were also observed in the offshore area but were less prominent (Figure 2.15).

Bennett Shoal was investigated as part of the benthic habitat assessment as it was identified by DEPWS as an area that may support benthic primary producers. Similarly to the majority of the survey area, the only benthic habitat type observed at this shoal was low density sponge dominated filter feeders.

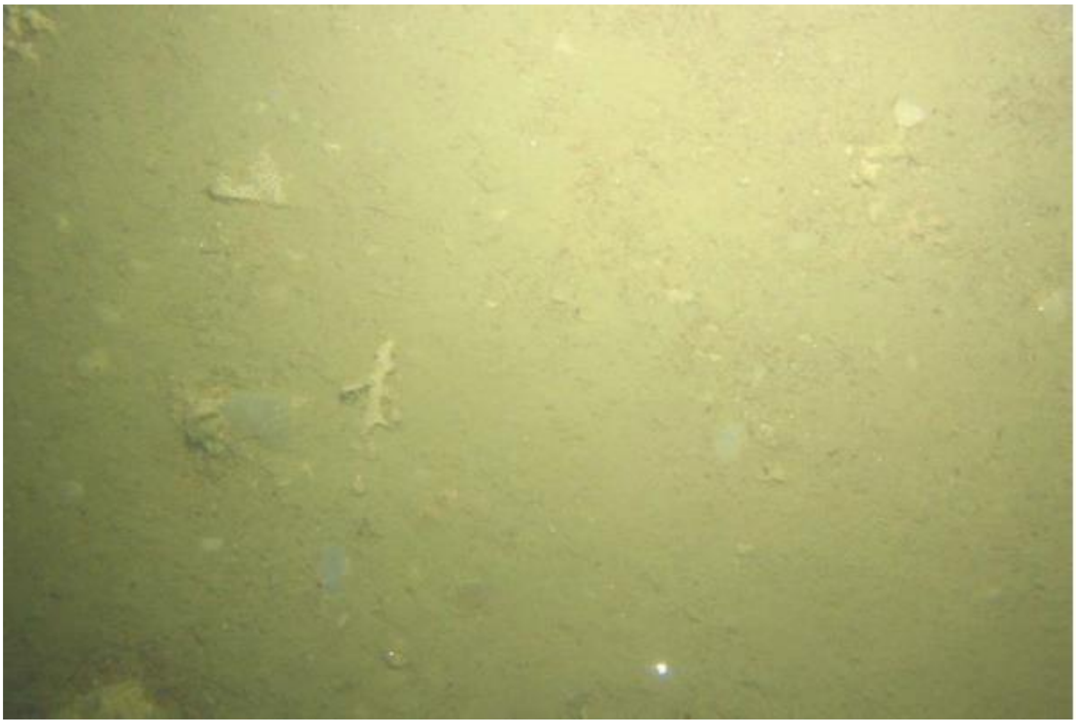

Figure 2.12 Bare substrate with remnants of filter feeders observed at the base of the high profile sand dunes

Figure 2.13 Example of low density filter feeder habitat containing lace Byrozoans

Figure 2.14 Example of low density filter feeder habitat containing sponges and Colonial Ascidian

Figure 2.15 Bare substrate with a single Hydrozoan

Transect data (Sites 51, 52 and 62) showed that the presence of filter feeder communities at Bennett Shoal largely coincided with the naturally high ridgelines and the presence of rock boulders/platforms which form the shoal. Filter feeder habitat was patchy and decreased between ridgelines as the substrate transitioned from rock to a mix of sand and gravel. Filter feeders observed at this location were dominated by a low density of sponges with covers of 15% or less. One small section of 30% filter feeder coverage was observed along a 2.5m section of transect at Site 52 (transect length approximately 125 m). Species composition was similar to that observed throughout the survey area. Along with the sponges there were patches of bryozoans, as well as less abundant soft coral species including gorgonian fans, and some hydrozoans.

The field survey also found that filter feeder abundance is somewhat higher at locations within proximity to the previous used nearshore dredged material discharge location (Sites 41, 42, 43 and 47). This disposal location was used during the last 2013 dredging campaign, and it is likely that a 'debris field' consisting of a small amount of gravelly material and fragments of other hard material settled out within close proximity to the discharge location (Figure 2.16). Smaller amounts of this hard material were also observed further down current of the discharge location (Figure 2.17).

The types of filter feeders observed throughout the survey area typically occur where hard substrates, such as rock and gravel, are present and therefore the higher incidence of filter feeders observed at this location is likely to be a result of the deposition of hard material from the previous dredging campaign which has ultimately provided opportunities for the recruitment and growth of filter feeders.

The existing conditions experienced in those areas where filter feeders are present are dominated by strong currents, high sediment loads and frequent increased turbidity levels. This suggests that the types of species present are not sensitive to the pressures of high sediment concentrations or strongly dependent on benthic light availability.

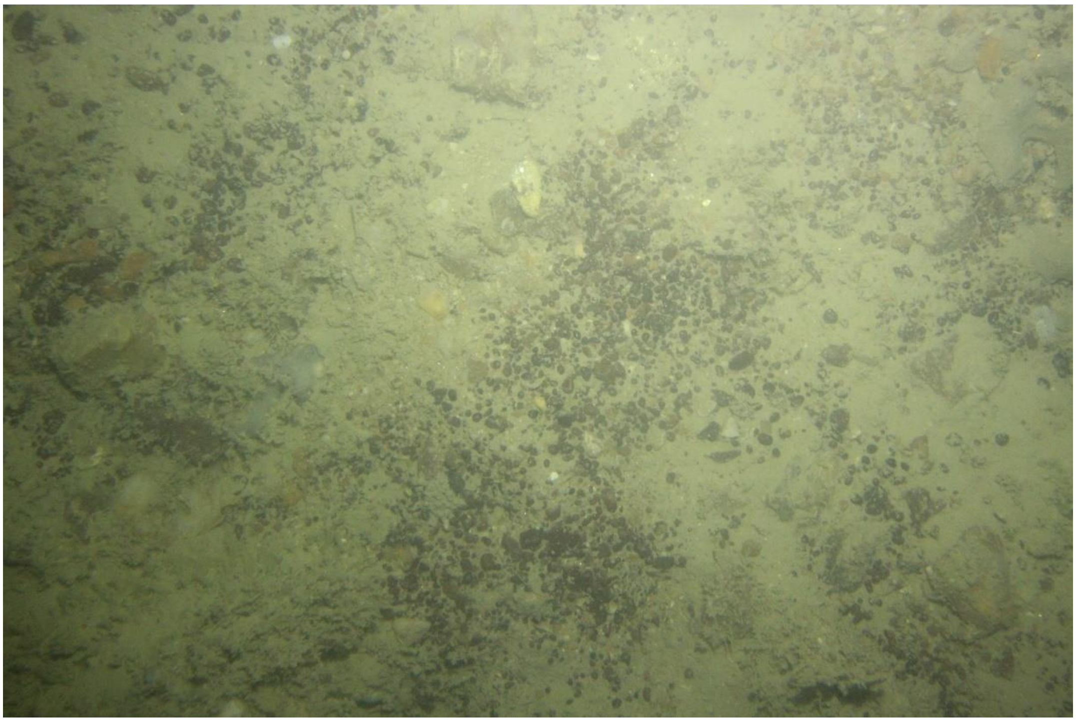

Figure 2.16 Gravel material observed at Site 41 near the discharge location

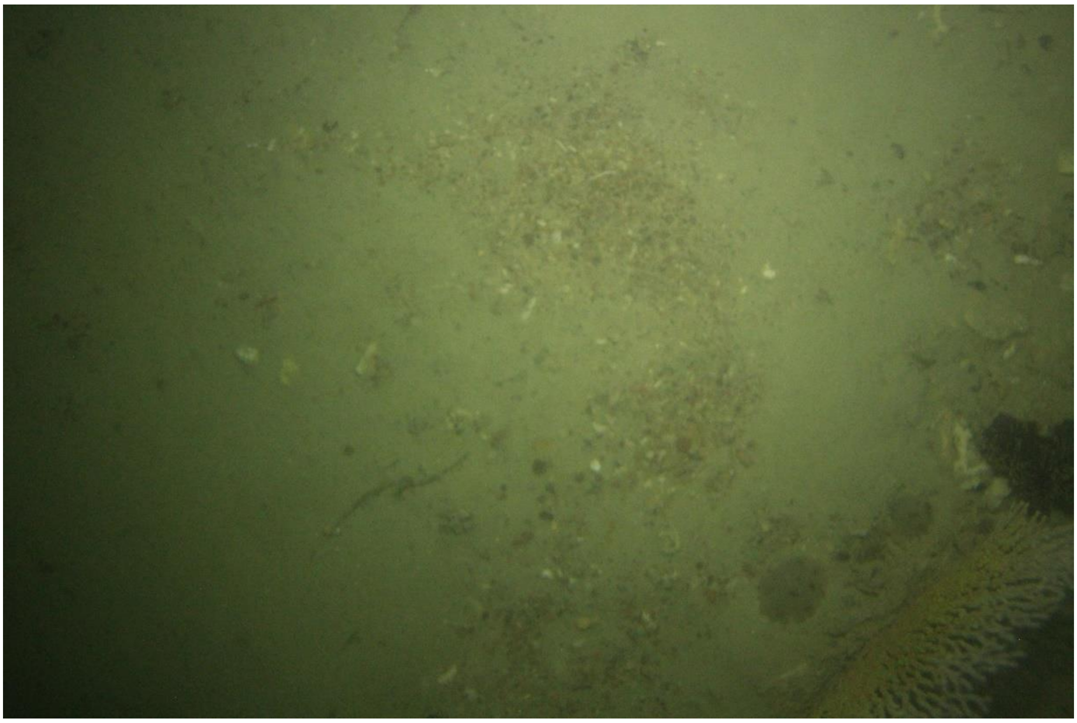

Figure 2.17 Gravel material observed at Site 38, within proximity to proposed discharge location

Figure 2.18 provides a summary of the mean percent cover of benthic habitat types recorded for each of the 2023 towed video transects. This data clearly demonstrates that the majority of the survey area is characterised by bare substrate with minimal biota.

As can be seen in Figure 2.18, very low density filter feeder coverage was commonly recorded. There were also parts of the survey area, where no biota was present, including Fannie Bay (Sites 20 to 29) which was largely characterised by bare sand.

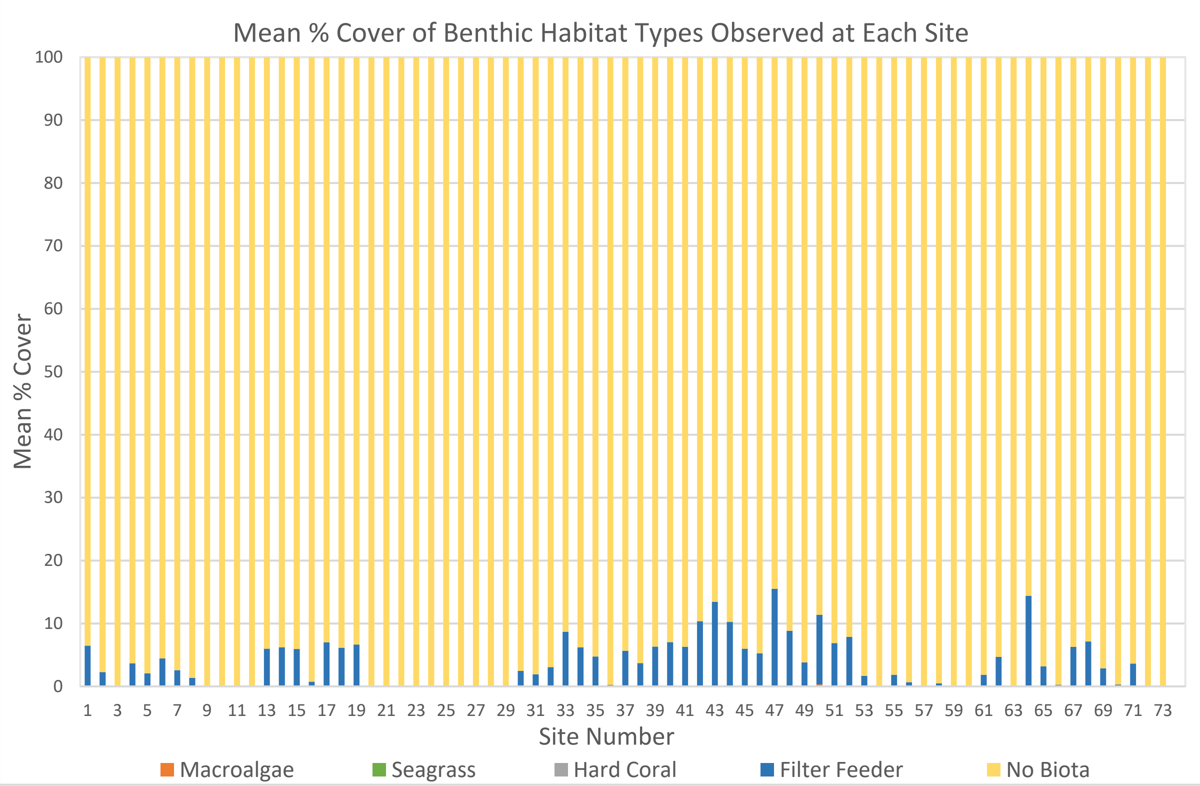

Figure 2.18 Mean percent cover of benthic habitat classifications for 2023 towed video transects (GeoOceans, 2023)

Figure 2.19 compares the mean percent cover of filter feeders with the presence of hard substrates observed along each transect. As was observed in the field, this graph indicates that the presence of filter feeders typically coincides with the availability of hard substrate.

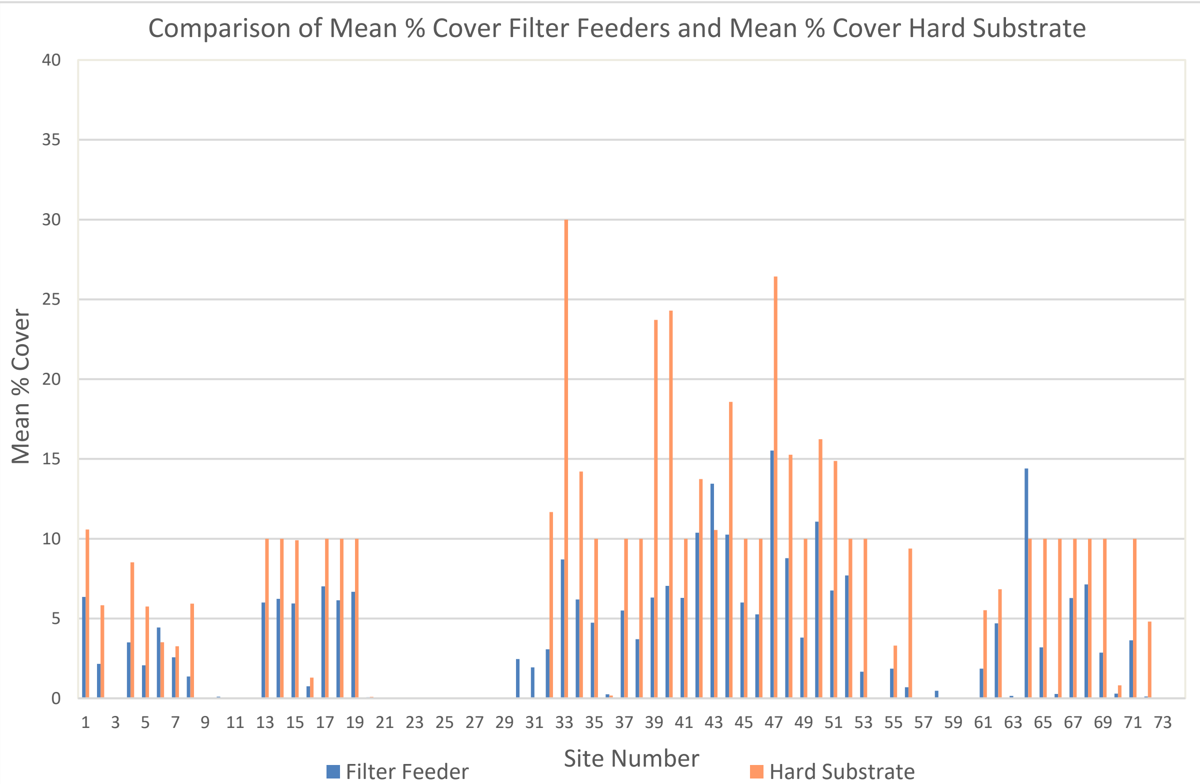

Figure 2.19 Comparison of mean % cover filter feeders and the presence of hard substrate

Macroalgae

Macroalgae was only observed in trace amounts throughout the survey area. No significant patches were observed, most likely due to the naturally turbid conditions experienced within Darwin Harbour and the lack of hard substrate in the shallow subtidal zone.

Hard coral

No hard coral was observed within the survey area. Previous field surveys conducted within Darwin Harbour have shown that hard coral habitat is often limited to the shallow subtidal and lower-littoral (intertidal) areas (Geo Oceans, 2012). However, suitable hard substrate within this shallow depth range is absent from the survey area.

Fannie Bay – Potential Seagrass Presence

No seagrass was observed during the survey period and there was no indication of seagrass remnants or root systems observed within the survey area.

Historically, Fannie Bay has been known to support *Halodule* and *Holophila* seagrass species in low densities (Geo Oceans 2014). Additional effort was made to locate any seagrass through the capture of high definition still photos within and surrounding areas where seagrass has previously been recorded however none was observed.

2.3.4 Benthic Habitat Mapping

A benthic habitat map for the project area showing relevant property boundaries and tidal contours is included as Figure 2.20. As previously discussed, Figure 2.20 clearly shows that the project area predominantly consists of bare substrate with sparse biota largely characterised by low density, low diversity sponges.

The majority of the survey area is characterised by bare substrate. Other mapped areas dominated by bare substrate were also observed to support sparse filter feeders, where the average density for an entire transect was between 2% and 10%. The coverage of filter feeders throughout these areas was very patchy and highly dependent on the availability of hard substrate.

Small, isolated areas characterised by bare substrate where the average filter feeder density for an entire transect ranged anywhere between 10% and 20% were also observed and mapped within the survey area. In practice though, the highest average filter feeder density recorded for an entire transect was only 16%.

2.4 SENSITIVE RECEPTORS

Outcomes of the 2023 benthic habitat survey and further review and reanalysis of other relevant benthic habitat data has provided a greater certainty of the type and extent of sensitive receptors within the proposed project area.

The only benthic habitat type that has the potential to be impacted during proposed dredged material disposal activities are the areas which support low percent cover sponge dominated filter feeders. Potential seagrass habitat which has been known, at times, to occur within Fannie Bay (although not observed during the 2023 survey) is also acknowledged as being a potential sensitive receptor due to its location and the possibility it may support seagrass in the future.

Further discussion of these sensitive receptors is provided in the following sections.

2.4.1 Filter Feeders

Based on the benthic habitat assessment conducted for the Project, and further analysis of other available benthic habitat data sets relevant to the project area, sponge dominated filter feeder communities are the only sensitive receptor within the predicted zones of impact and influence.

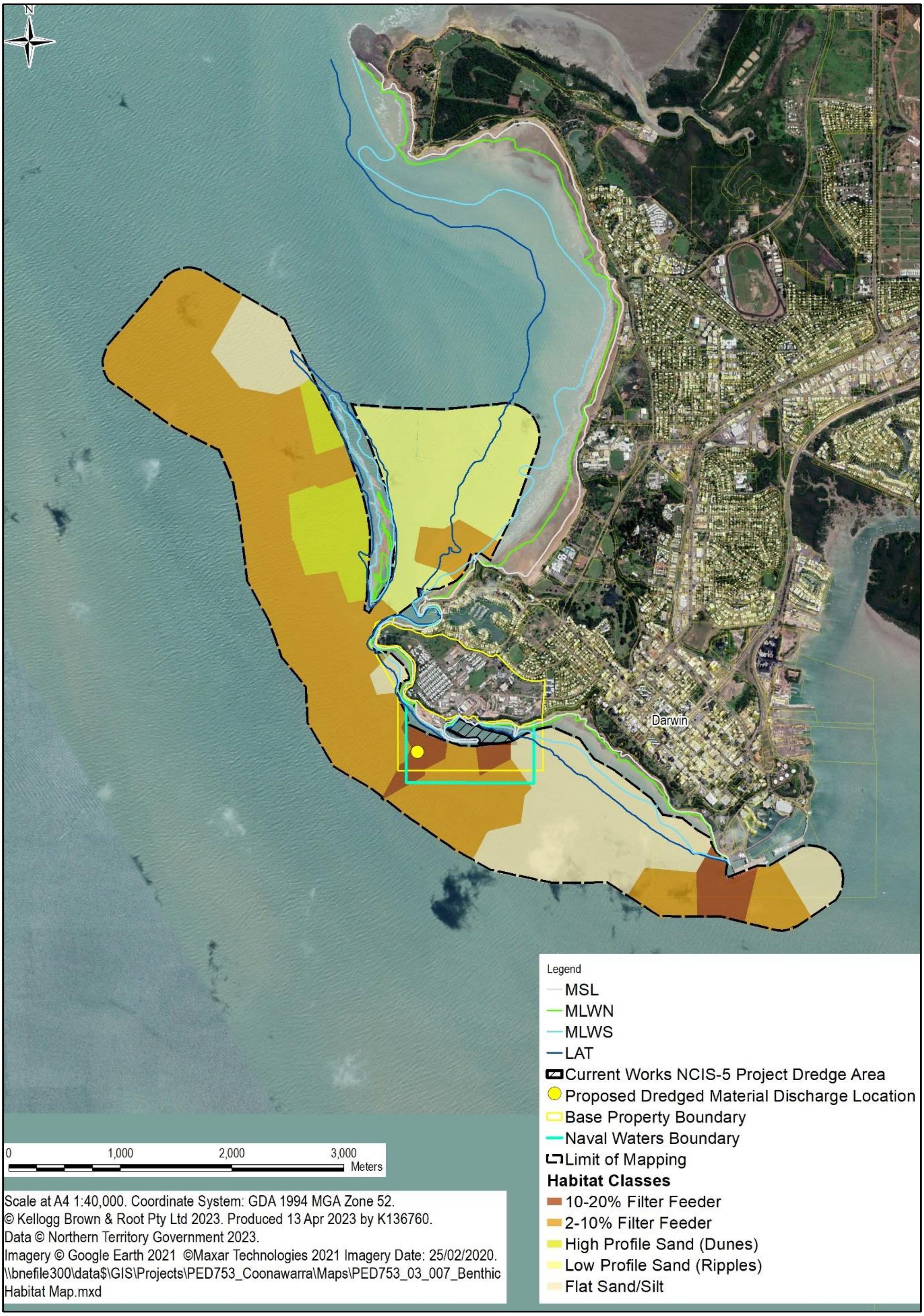

Figure 2.20 Benthic habitat map

The sponge dominated filter feeders observed within the survey area are of low percent cover (typically less than 10%), and have patchy distribution typically associated with the availability of hard substrate.

Filter feeder communities, such as those within the survey area, are widespread and well represented within the harbour, occurring in areas where hard substrate is available and coral-dominated communities are not established (Smit 2003, GeoOceans 2011). These habitats can occur at any depth in the lower intertidal and subtidal areas and are typically patchy by nature, often forming a transition zone between hard substrates and the subtidal mud-dominated substrates (Smit, 2003).

Whilst sponges were most prominent throughout the survey area, some soft corals were also observed. Soft coral diversity and spatial extent was however limited, as noted in previous studies which have shown that Darwin Harbour has a relatively low diversity of sea whips (approximately 30-40 species in 40 genera) and other soft corals (approximately 20-25 species in 11 genera). Their poor representation has previously been attributed to the turbidity of the water in the harbour and the combination of factors such as sedimentation, light availability, wave and flow exposure and steepness of reef that control the abundance of soft corals (Fabricius & Alderslade 2001).

Results of field surveys conducted during the previous 2013 dredging campaign (from camera and video records and diver observation), found that macroinvertebrates did not exhibit any signs of stress associated with poor water quality, such as excess mucous, bleaching or damage, or large scale mortality. Furthermore, benthic habitat monitoring during the Marine Supply Base (MSB) capital dredging campaign in 2012 and 2013 found no statistically significant changes in filter feeder communities across three surveys completed for the project (Macmahon 2013, DoI 2014).

The results of these surveys suggest that the filter feeder communities which are well represented throughout the harbour are not very sensitive to the physiological pressures associated with elevated suspended sediment concentrations and reduced benthic light availability associated with dredging activities or the natural environmental conditions experienced in Darwin Harbour.

Of interest is the survey data from the recent benthic habitat assessment conducted for the Project which indicated that filter feeder abundance is slightly higher within proximity of the previous nearshore dredged material discharge location. As noted in Section 2.3.3, it is likely that a ‘debris field’ consisting of a small amount of rocky and gravelly material settled out within close proximity to the discharge. The higher incidence of filter feeders observed in this location may be associated with the addition of hard substrate deposited during the previous dredging campaign which has provided opportunities for the recruitment and growth of filter feeders.

There is no indication from the results of the benthic habitat assessment and outcomes from previous surveys that the sponge morphologies present within the zone of influence are strongly dependent on benthic light availability. It is evident that the sponge dominated filter feeder communities present can tolerate the naturally strong currents and dynamic sediment transport processes which occur in this area of the harbour and are capable of recovering from disturbances that may have previously occurred during the last dredging campaign.

2.4.2 Fannie Bay – Potential Seagrass Presence

No seagrass communities occur within the predicted zone of impact or zone of influence. No live seagrass/seagrass remnants or root systems were observed within Fannie Bay during the 2023 benthic habitat survey.

Historically, Fannie Bay has been known to support low density ephemeral seagrass communities. Previous long term seagrass monitoring, completed for the Ichthys Project Nearshore Environmental Monitoring Plan (NEMP) showed that the *Halophila* beds in Fannie Bay are ephemeral, with peak seagrass coverage more likely to be present in June/July before a decline moving into the Monsoon season (Geo Oceans 2014b). Based on a review of available survey data seagrass is not always present in the dry season. If and when it is present it tends to coincide with the dry season however there have been years when no seagrass has been observed within the Fannie Bay area.

The results of seagrass monitoring conducted during the previous HMAS *Coonawarra* dredging campaign also showed that seagrass in this area tends to be ephemeral with its presence and spatial coverage varying depending on conditions. Seagrass monitoring was completed before and after dredging during the end of the dry season in September and again in October 2013 within those areas of Fannie Bay where it had previously been reported. However no seagrass was observed using either video transects or diver deployed methods, and it was concluded that the lack of seagrass was likely to be reflective of natural temporal changes in seagrass communities.

Although there is currently no evidence of seagrass occurring within Fannie Bay, the results of previous field surveys and their ephemeral nature show there is the potential for seagrass to occur within this area. The zone of influence associated with the proposed dredging and dredged material discharge is not predicted to extend into Fannie Bay and is therefore unlikely to be a mechanism for seagrass to be adversely affected even if it is present in the future. Despite this, a precautionary approach to baseline data collection and to monitoring during dredging will be undertaken to confirm the reliability of sediment plume predictions. Further details regarding the proposed monitoring regime are outlined in Sections 3.7 and 3.11 and are also provided in Appendix E (Dredging and Disposal Management Plan (DDMP)).

2.4.3 Mangroves

As discussed further in Sections 3.2 and 3.4, there is the potential for the effects of dredging and sediment discharge to extend towards some shallow disturbed intertidal areas of the harbour through sediment dispersion. Therefore further review of those mangroves which occur within the broader project area has been undertaken.

Within Darwin Harbour, mangrove communities are important to the ecological health of the region. Mangroves in the Darwin Harbour area constitute approximately 44% of the mangrove communities in the Darwin Coastal Bioregion and about 5% of the total mangrove area of the Northern Territory (Brocklehurst and Edmeades, 1996).

Two to three small patches of mangroves exist around the shoreline of the HMAS *Coonawarra* basin, however these are growing on the fringes of the rock walls and are disconnected from other mangrove areas. Seven mangrove species were identified along the intertidal area, with the most common being *Avicennia marina* (Grey Mangrove).

The nearest area of mangroves outside the basin is located approximately 500 m to the east of HMAS *Coonawarra* near Doctor's Gully. From this location, scattered occurrences of individual mature mangroves interspersed with patches of juvenile mangroves occur along the rocky intertidal area following the Darwin esplanade shoreline for approximately 1.4 km.

Beyond this area, the closest significant mangrove communities to HMAS *Coonawarra* are located approximately 5 km to the north at East Point and approximately 6 km to the east at the Charles Darwin National Park.

2.5 IMPACT MECHANISMS

Impact mechanisms relevant to the identified sensitive receptors include the following primary cause effect pathways:

- increased sediment deposition that could result in smothering
- reduced filtering and feeding by elevated suspended sediment concentrations (SSCs)
- reduced light availability for photosynthesis (by light scattering in the water column)

Dredged material disposal activities will result in pulses of increased turbidity, suspended sediment levels and associated reduction in light availability. Natural periods of increased turbidity also occur, particularly during spring tide conditions, and there are also periods of lower turbidity during neap tide conditions. These occur in the absence of rainfall runoff as the result of repeated current resuspension of fine sediments and wave/current turbulence resuspension in shallow nearshore areas. Because of the intermittent nature of the dredging discharge, benthic habitats will not be exposed to continuous periods of increased turbidity and lower light. Fine sediment particles that may temporarily settle on sponges and other filter feeders in the affected area will be resuspended and further dispersed by tidal currents.

Further discussion of these impact mechanisms on the sensitive receptors within the project area is provided in the following sections.

2.5.1 Filter Feeders

Sediment deposition

There are two main impact mechanisms associated with sediment deposition include:

- Coarse sediment deposition – The distribution and thickness of coarse sediment on the bed, close to the proposed discharge location.
- Fine material deposition – The distribution of fine sediments across the predicted zone of influence.

The deposition of larger heavier sediment particles (e.g. gravel, rock fragments, sand or clay balls) in the immediate vicinity of the discharge location will impact benthic infauna and filter feeder abundance, species diversity and productivity. Benthic habitats within this area are reported to consist of a combination of fine sediments with a variety of burrowing organisms along with gravel and rock material which supports low density sponge dominated filter feeders. While some of these species will initially be impacted by the deposition of larger sediments, once discharge is complete, infauna species will recolonise the area relatively quickly (Filho *et al.*, 2006).

Outcomes of the most recent benthic habitat assessment also suggests that the deposition of a small amount of heavier sediment at the discharge location during the 2013 dredging campaign is likely to have facilitated the recruitment and growth of filter feeder species at this location. Therefore, it is likely that upon cessation of the discharge activities, the presence of deposited hard material may again facilitate the regrowth of filter feeders.

Fine sediment deposition associated with the dredged material disposal activities has the potential to result in the smothering of recruits and adult sponges, especially encrusting, massive, cups and plate-like morphologies (Pineda *et al.* 2017). Modelling predicts that the extent and thickness of fine sediment deposition to be very low throughout the project area. Some of the fine sediment from the dredged material disposal activities will eventually settle on the seabed, however, due to the strong currents and tidal movements will be dispersed over a large area to the extent that settled sediment would be within the normal range of sediment deposition and redistribution processes experienced in the harbour.

The sponge dominated filter feeder species present are accustomed to the natural environmental conditions experienced in Darwin Harbour. Based on the outcomes of modelling smothering or burial during dredging is unlikely and therefore will not substantially change or adversely impact the composition of filter feeder communities throughout the broader project area.

Suspended sediment concentration

During dredging and disposal activities benthic habitats may be affected by elevated suspended sediment concentrations (SSCs). The only benthic habitat type that has the potential to be impacted are low density, low percent cover sponge dominated filter feeders. Studies on sponges have shown that long term exposure to high SSCs can lead to clogging of their aquiferous systems and may potentially compromise heterotrophic feeding (Pineda et al. 2017). Some sponges exhibit short term responses to high turbidity such as temporarily closing or reducing the size of their openings and through reduced pumping activity.

Light attenuation

Suspended sediment levels within the water column associated with dredged material disposal has the potential to reduce light penetration and therefore the availability of light for photosynthesis (Erftemeijer *et al.* 2012). This has the potential to impact benthic primary producers (Luter et al. 2021), with the level of impact dependent upon the life history of the receptor affected and the intensity, duration and frequency of adverse events relative to the natural background conditions to which the receptors are adapted.

Benthic infauna are not sensitive to light or sediment effects and therefore are unlikely to be adversely affected by this aspect of the proposed dredging and dredged material disposal activities.

Filter feeders observed within the project area are dominated by sponges. The impacts of light reduction are likely to vary between sponge species, and depends on the flexibility of their feeding strategy. Whilst some of the nutrition of some phototrophic sponges can be adversely affected by light reduction, other species may have the ability to increase heterotrophic feeding rates to compensate for the decrease in photosynthetic yields. To determine how marine sponges respond to light attenuation, five species were experimentally exposed to a range of light treatments (WAMSI, 2019). This laboratory study found that phototrophic sponges displayed species specific responses to light reduction when subjected to low light levels for a continuous period of 28 days. Some of the phototrophic species exhibited signs of stress, with reduced fluorescence yields and chlorophyll concentrations, but recovered completely after 14 days under natural light conditions. The study also found that heterotrophic sponge species were not affected at all by light reduction (WAMSI, 2019).

The nearest area of benthic habitat sensitive to changes in light availability would be in Fannie Bay at times when seagrass is present. This area is located outside the predicted zone of influence and seagrass is currently not present, as discussed further in Section 2.5.2.

2.5.2 Fannie Bay – Potential Seagrass Presence

Dredging and dredged material disposal activities will not directly impact any area of seagrass.

Based on supplementary modelling results and monitoring data which measured the extent and intensity of sediment plumes during previous dredge campaigns, it is unlikely that suspended sediment plumes will extend into the shallow nearshore areas of Fannie Bay which could support ephemeral seagrass.

Modelling of the fate of fine sediments also indicates that there will be the distribution of a thin layer of fines (less than 3 mm) attributed to the dredging which will settle in the low energy environment of Cullen Bay, however, is not expected to extend into Fannie Bay. Therefore the risk of sediment-related effects and light attenuation on seagrass communities within Fannie Bay are not predicted.

Despite this, a precautionary approach will be adopted. Baseline water quality data, including TSS and PAR, will be collected and analysed. Water quality monitoring will also be undertaken during dredging to confirm the reliability of sediment plume predictions. Further details regarding the proposed monitoring regime are outlined in Sections 3.7 and 3.11 and are also provided in Appendix E (Dredging and Disposal Management Plan (DDMP)).

2.5.3 Mangroves

Dredging and discharge related activities have a low potential to indirectly affect mangroves through increased deposition of fine sediment. Modelling shows that coarse-grained sediments quickly settle out of suspension, falling to the seabed within a short distance of the release point and therefore will not adversely impact any mangroves.

The deposition of fine sediment would have some influence on the mangroves which occur along the rocky intertidal area following the Darwin esplanade shoreline. However, this would only involve a very thin layer of fine sediment deposition in areas which supported sparse mangroves.

Studies have shown that excess deposition of sediment greater than 50 mm (INPEX, 2010) may cause stress to mangroves due to smothering and burial of aerial root systems, with impacts ranging from reduced vigour to mortality, depending on the species and sediment characteristics (Cardno, 2015b).

2.5.4 Key impact mechanisms

Based on the above assessment, and to inform and develop an adaptive management approach to dredging, potential impact mechanisms are principally associated with direct sediment load, including:

- the effects of suspended sediment concentrations on the low density, low diversity sponge dominated filter feeders which occur within the zones of impact and zone of influence, and;
- the impact of heavy material sediment deposition within the immediate vicinity of the discharge location (zone of high impact).

2.6 TOLERANCE LIMITS FOR SENSITIVE RECEPTORS

2.6.1 Filter Feeders

Filter feeder communities are an element of the local ecosystem and are present within the predicted zones of impact and influence albeit at low densities. Benthic filter feeders are a diverse group and can include bivalves, hard and soft corals, sea squirts and sponges.

Studies have shown that filter feeder communities can dominate the seafloor particularly in more turbid waters where sunlight penetration is low and in deeper waters towards the lower limit of the photic zone and beyond (Abdul et al. 2019). Sponges are one of the most prominent components of filter feeder communities, due to their high abundance and diversity, their ability to filter and pump large volumes of water, and are functionally important as habitats for other sedentary and mobile marine taxa. For these reasons, sponges are considered to be a key indicator of filter feeder health and ecosystem function and are therefore useful for assessing and managing potential dredging related effects on filter feeder communities within the zones of impact and influence.

Studies undertaken as part of the Western Marine Science Institution (WAMSI) Dredging Science Node (WAMSI, 2019) report that sponges are well adapted to sediment and are resilient to high suspended sediment loads for extended periods of time. Given the dynamic and turbid nature of the broader project area and Darwin Harbour in general, it is expected that those benthic communities within the predicted zones of impact and influence would be well adapted to such conditions.

Although literature shows that sponges are influenced in a variety of ways, most studies suggest that sponges consistent with those observed within the project area are able to tolerate, and in some cases thrive in environments subject to dynamic sediment processes. Sponges known to tolerate sediment stress include endopsammic species (living partially buried within sediments), fast growing species with morphological plasticity, erect growth forms and growth forms that have exhalant openings. Whilst the sensitivity of sponges to sedimentation is known to vary between taxa with different morphologies, individuals possessing encrusting, massive, cups and plate-like morphologies have shown to be more sensitive to sedimentation than erect and upright forms which were regularly observed during the 2023 benthic habitat survey (Abdul Wahab et al., 2017, Pineda et al. 2017b).

It is acknowledged that wide variations in tolerances occur between species, and between morphologies within species. While laboratory research has been undertaken into the effects of suspended sediment levels on filter-feeders (e.g. Duckworth, Giofre & Jones 2017, Pineda et al 2017), the results are only indicative of select species under laboratory conditions and are considered to be of limited applicability in field conditions, especially conditions as dynamic as those experienced within Darwin Harbour.

However, based on the literature available, suspended sediment concentrations of ≤10 mg/L for less than 28 days (continuous) has been shown to be tolerated by most sponges. Studies have also shown that some sponges are capable of surviving exposure to elevated suspended sediment concentrations for extended periods (>23 mg/L for 28 days), with some reductions observed to their feeding behaviour with associated depletion of energy reserves.

For the types of sponge morphologies observed within the project area, literature suggests that they are capable of surviving under low to moderate dredging impact scenarios (i.e. ≤30 mg/L, ≥ 0.5 mol photons/m^2/d for up to 28 days), and that they have the ability to tolerate high suspended sediment concentrations of greater than 70 mg/L over a continuous 28 day period.

Changes in turbidity, sedimentation and light over a two year large scale capital dredging program at Onslow, northwestern Australia, were quantified to assess their effects on filter feeder communities, in particular sponges. During the dredging program there were pronounced acute and chronic changes in water quality over large areas and in some locations (where there was no requirement to manage water quality) turbidity levels approximately doubled and light levels halved over the dredging campaign. Despite these changes, and the influence of other climatic factors such as a marine heatwave, tropical cyclones and several flooding events, there were no marked effects on sponge abundance, morphology and mode of nutrition. This apparent stability shows a degree of resilience of sponge communities to water quality disturbances during a managed dredging program and also indicates an established sponge community adapted to living in environments characterised by high sediment loads and regular cyclone exposure (Wahab et al., 2017). It should be noted that the environmental setting in which this dredge campaign was undertaken differs greatly to that of Darwin Harbour, particularly with regard to species diversity and baseline water quality conditions, but nonetheless provides a good indication of sponge communities' ability to tolerate high sediment loads.

Recolonisation (recovery) of filter feeder communities will be influenced by the resulting water quality and any alterations to the substrate that may have occurred as a result of dredging and dredged material discharge. Basic re-colonisation is generally quicker than return to a situation that resembles pre-impact conditions (McCauley et al. 1977). Studies have shown that sponges are largely tolerant of short term dredging related pressures (Pineda, 2017). Under laboratory conditions, sponge morphologies subjected to a range of suspended sediment concentrations, consistent with those present within the project area, were observed to recover 14 days after experimental exposures in control conditions.

No highly productive or well developed filter feeder habitat was observed during the recent benthic habitat survey within the zones of impact or influence. Based on a review of available literature and the results of studies undertaken in the field, it is expected that the low density, low diversity filter feeder species present would be well adapted to the dynamic sediment transport processes which occur within the project area. Based on modelling results and the fact that dredging operations will not be continuous, (i.e. daylight hours only, six days a week with normal stoppages), it is also likely that the filter feeder communities present would be able to tolerate high suspended sediment concentrations up to 70 mg/L.

It is acknowledged that quantitative data on tolerance thresholds for filter feeders is limited. Therefore, as a precautionary approach to account for the potential presence of more susceptible filter feeder species, a criteria of 10 mg/L will be adopted to represent the Zone of Influence and 23 mg/L will be adopted to define Zone of Low to Medium impact, during both dry and wet season.

These criteria can be reviewed and refined based on the further baseline data which will be collected prior to the proposed dredging campaign.

Refinements to the zones of influence and impact and their corresponding criteria are discussed further in Section 3.9.

2.6.2 Fannie Bay – Potential Seagrass Presence

As previously discussed in Section 2.4, no seagrass communities occur within the predicted zones of impact or zone of influence. The results of previous field surveys within Fannie Bay and the ephemeral nature of seagrass does however suggest that there is the potential for seagrass to occur, at times, within this area of the harbour, albeit outside the predicted Zone of Influence.

Studies have shown that seagrass species have the ability to respond rapidly to sediment burial, both physiologically and morphologically. Many seagrass species are adapted to highly dynamic sedimentary environments, responding in ways that promote plant vigour during moderate burial events.

Based on a review of recently published WAMSI Dredging Science Node outcomes, and other relevant literature (Cabaçao et al. 2008; Duarte et al. 1997; Ooi et al. 2011; Vermaat et al. 1997), an appropriate sedimentation deposition tolerance limit for seagrass is considered 40 mm. Given the ongoing resuspension of sediment as a result of the tide and high velocity currents experienced within the project area, modelling indicates that sedimentation depths of 40 mm of fine sediment will not occur at any location, with the highest level of fine sediment deposition predicted to occur within Fannie Bay being <1 mm.

Additional data with regard to understanding PAR and benthic light availability in Fannie Bay is being collected as part of the baseline data collection program and will also be monitored during dredging. This data will be analysed for the possible need for it in the future. However in the meantime, the approach will be to monitor whether dredge plumes are consistent with the modelled predictions to confirm that Fannie Bay is actually beyond the zone of influence.

Based on the modelling outcomes, the predicted zones of impact and influence do not extend into Fannie Bay and given that sediment deposition is predicted to be negligible within the Fannie Bay area, the risk to potential seagrass habitat is considered to be low.

2.6.3 Mangroves

Modelling results indicate that isolated patches of mangroves will be influenced by the deposition of fine sediments. Scattered mangroves which line the rocky intertidal foreshore along the Darwin esplanade are predicted to receive less than 2 mm of fine sediment deposition, which is an order of magnitude less than the 50 mm tolerance limit of these species.

Given the low levels of fine sediment deposition and considering that no excess sedimentation was observed during previous dredging campaigns, the risk to mangroves from the proposed dredging and disposal activities is low.

2.7 COMPARISON OF BENTHIC HABITAT SURVEY WITH PREDICTIVE BENTHIC HABITAT MODELLING

As noted in the Referral, predictive modelling of the benthic habitats within, and in the vicinity of, the Project area was encompassed within the modelling of Darwin Harbour habitat classes undertaken by AIMS in 2019 (Galaiduk et al 2019). This extensive program considered bathymetric, physical seabed and biological data collected during project specific and historical field sampling campaigns to produce spatial predictive habitat models (Galaiduk et al 2019). The 2019 predictive model was reviewed during preparation of the Referral. The modelling and associated predictive habitat maps were primarily limited to subtidal areas due to lack of bathymetric data for intertidal areas. The model also did not take into consideration water column characteristics such as turbidity, or factors such as sediment accumulation rates, any of which may preclude the establishment of certain biological communities (such as hard corals and seagrass) in areas that may otherwise be modelled as potentially suitable habitat.

While the 2019 model data was an input to prediction of benthic biodiversity, it was not solely relied upon in the Referral assessment as there was other available field surveys and results from previous dredging campaigns. The Referral also noted that model improvements were proposed to better predict less common benthic classes (e.g. hard coral and seagrass) in the shallow subtidal and intertidal areas (Galaiduk et al. 2019).

To address this, Streten (2022) incorporated data from a topographical LiDAR survey undertaken in Darwin Harbour intertidal areas during spring low tide in November 2022. Physical oceanographic variables were also trialled to try to improve the predictive benthic model's precision and accuracy, coupled with additional benthic habitat data.

Data associated with the updated model predictions was obtained from the DLRM and AIMS. These modelled results were compared with the findings of the benthic habitat field survey. To the west of the offshore sand bank and throughout the broader project area (within the predicted zone of influence), the predicted extent of filter feeders and sponges does, to an extent, align with the outcomes of the 2023 benthic habitat survey, particularly with regard to the low density, low diversity sponge dominated filter feeder communities observed at Bennett Shoal and to the west of the sand bank. However, the predictive model does not identify the area directly adjacent to the basin and within proximity to the proposed discharge location as supporting any benthic communities. While it is acknowledged that these areas are predominantly characterised by bare substrate with minimal biota, the benthic habitat survey did observe patches of low percent cover filter feeders which were dependent on the availability of hard substrate.

The extent of filter feeders represented in the updated model is over predicted in Fannie Bay when compared with recent field survey which shows that the shallow nearshore environment of the bay is largely characterised by bare sandy substrate with the occasional occurrence of individual sponges.

The updated model suggests that seagrass occurs to the south of the Project in close proximity to Doctors Gully, and immediately to the north between the project area and Emery Point. It also maps seagrass area between Cullen Bay and Fannie Bay. Previous studies have however reported that seagrass habitat does not occur further south than in Fannie Bay. Seagrass communities within the Fannie Bay area and further north are considered to be highly ephemeral, typically occurring within the lower intertidal zone between 0 to +1m LAT, with presence and coverage varying depending on the conditions (GeoOceans, 2011; INPEX, 2010).

This is evident from the results of the project specific benthic habitat survey during which no seagrass was observed, and there was no indication of seagrass remnants or root systems within the survey area.

The seagrass monitoring conducted during the previous HMAS *Coonawarra* dredging campaign and other published sources also show that seagrass in this area of Darwin Harbour tends to be ephemeral with its presence dependent on conditions. Seagrass monitoring was completed prior to dredging during the end of the dry season in September and again in October 2013 within those areas of Fannie Bay where it had previously been reported. However no seagrass was observed using either video transects or diver methods, with the lack of seagrass in the area considered likely to be due to normal temporal changes in seagrass presence.

Additionally, review of the revised predictive habitat map presented in Streten (2022) and other field surveys conducted in Darwin Harbour, found that it does not consider the seagrass habitat mapping data undertaken as part of the Ichthys Project Nearshore Environmental Monitoring Plan (NEMP) – Seagrass Monitoring Program. As such, mapped seagrass communities between Fannie Bay and Lee Point appear to be inconsistent with those represented in the revised predictive habitat map.

The model also indicates the presence of hard corals adjacent to both the western and eastern side of the offshore sand bank. However the field survey conducted in 2023 found that this area is characterised by bare sandy substrate with minimal biota. The AIMS 2020 towed video transect survey conducted within the same area also did not observe any hard coral species, but rather bare substrate with patches of low percent cover filter feeders.

Further review of the presence of hard coral habitat was conducted for the proposed Ichthys LNG Maintenance Dredging Program 2023 – 2027. This found that the habitat modelling used to inform the revised predictive habitat map does not predict any hard coral communities at Northeast Wickham Point or Channel Island, which have known coral communities. This is likely because the habitat model outputs *"represent the potential fundamental ecological niche for the habitats analysed based on environmental suitability derived from the model covariates, however, do not represent the realised ecological niche (i.e. whether a habitat will or will not be found at any location at any point in time)"* (Streten 2022).

As previously noted, the predictive model represents the potential ecological niche rather than the realised niche. Outcomes of the benthic habitat mapping undertaken for the Project are consistent with the information presented in the published Referral and are further supported by the outcomes of recent and historical benthic habitat field survey conducted for the Project. Consequently the benthic habitat mapping conducted for the project is the appropriate source of data and mapping of the type and spatial extent of benthic substrates and biota within the predicted zone of impact and zone of influence and can be relied upon to ensure appropriate impact assessment.

2.8 ADAPTIVE MANAGEMENT APPROACH

The key elements for implementing an adaptive management approach for the proposed dredging campaign and for the planning and refinement of assessments for future dredge campaigns include the following:

- Baseline water quality data collection (refer to Section 3.7)
  - Review/confirm water quality conditions and relationships (i.e. NTU v TSS, TSS v PAR) which are inputs to this assessment
  - Utilise baseline data in future planning
- Sediment plume characterisation/behaviour measurements carried out during dredging (refer to Section 3.11)
  - Collection and use of data in the refinement of modelled predictions for future dredging campaigns
  - Use of data to provide warning and allow adjustments to be made for this or future campaigns if sediment plume behaviour is found to be different to the modelled predictions
- Water quality monitoring during dredging (Refer to Section 3.11)

- Monitoring data in Fannie Bay will provide early warning if sediment plumes behaviour is different from predictions
- Data collected from the water quality monitoring loggers will be used in future planning

The primary impact mechanisms for focus in an adaptive management approach will be suspended sediment concentrations (particularly far field) and coarse sediment deposition within the immediate vicinity of the discharge location.

The only habitat type present within the zone of impact and zone of influence is a low density depauperate community of sponge dominated filter feeders. The nature of the filter feeder species present shows a level of resilience to the dynamic current and sediment transport processes experienced within this section of the harbour. Based on the results of the recent benthic habitat assessment it is also evident that these species are capable of recovering from disturbances with the deposition of heavy material within the vicinity of the discharge location during the last dredging campaign in 2013 now showing signs of recruitment and growth of filter feeders.

The adaptive management approach proposed will therefore focus on confirming the adequacy of sediment plume predictions by monitoring and collecting water quality data to improve modelled predictions for future dredging campaigns.

The exception to this is Fannie Bay, which has the potential to support seagrass in the future. A precautionary approach will be adopted to manage the potential for seagrass habitat within Fannie Bay to be affected.

As outlined in Section 3.7, additional field data is proposed to be collected during the baseline water quality monitoring program to further refine the relationship between TSS (mg/L) and turbidity (NTU) and the light intensity relationship at the seafloor by measuring photosynthetically active radiation (PAR). The collection of this data and refinement of these relationships will be used to support the management of current and future dredging and discharge related activities.

A water quality monitoring station will be established in the entrance to Fannie Bay prior to and during dredging to monitor dredging effects. Although modelling results do not predict that impacts associated with suspended sediment plumes will affect shallow nearshore areas of Fannie Bay, water quality data will be recorded for the duration of dredging and used as measured evidence to compare with the modelled outcomes.

Further details associated with the proposed baseline water quality monitoring program is provided in Section 3.7 with a revised water quality monitoring program to be implemented during dredging provided in Section 3.11.

2.9 UPDATED DRAFT DREDGING AND DISPOSAL MANAGEMENT PLAN

The draft Dredging and Disposal Management Plan (DDMP) has been updated based on the outcomes of recent field survey and an improved understanding of those sensitive receptors within the predicted zone of impact and zone of influence.

Refinements have principally been made to the proposed plume prediction validation monitoring and routine water quality monitoring programs.

A copy of the updated DDMP is included as Appendix E.

3 Sea - Marine Environmental Quality

3.1 INTRODUCTION

To address the comments outlined in Table 1 of the Notice of Direction, supplementary modelling has been undertaken to expand on the previous modelled outcomes reported in the Referral.

The objective of the supplementary modelling was to conduct an assessment of the predicted impacts of dredging to address the requirements of the SER process and the Notice of Direction.

The model update expands upon the previous studies undertaken, capturing the following:

- Review of additional available datasets from monitoring of previous dredge campaigns
- Development of a 3-dimensional (3D) model as a refinement to previous 2-dimensional (2D) modelling
- Review of the modelling approach in light of the guidance provided in the WAMSI Dredge Science Node '*Guideline on dredge plume modelling for environmental impact assessment'*
- Expanded modelling of sediment deposition and fate
- Review of dredge program based on further contractor advice

Each of the comments raised in Table 1 of the Notice of Direction have been addressed in the following sections, with detailed discussions of the modelling methodology, refinements and additional information used in assessing the impacts of proposed dredging activities provided in the Supplementary Dredging Modelling Report included as Appendix D.

3.2 HYDRODYNAMIC MODELLING

The conceptual understanding of the hydrodynamic and sediment transport processes within the project area have been revisited along with the guidance provided in the WAMSI Dredge Science Node '*Guideline on dredge plume modelling for environmental impact assessment'*.

The performance of the dredge modelling has been improved through the integration of field data collected during the 2006 and 2013 dredging campaigns. Uniquely, these previous dredge campaigns are comparable to the dredge activities currently proposed for HMAS *Coonawarra*. Data from these campaigns has been used to confirm the conceptual model and enhance the level of confidence in the understanding of the main sediment processes at the site.

The proposed dredging and disposal activities occur within an area of the harbour which is dominated by strong tidal currents and has a well mixed water column. Measured data shows that current, density and sediment concentrations are typically consistent through the water column. Based on this understanding and the guidance outlined in the WAMSI guideline which is applicable to the proposed dredging campaign and project setting, the use of a 2D model (as reported in the Referral) is considered to remain appropriate. Nonetheless, a 3D model has been developed to improve the level of confidence in the modelled predictions and address the comments raised in Table 1 of the Notice of Direction.

The following sections provide a summary of the supplementary hydrodynamic modelling undertaken.

3.2.1 Hydrodynamics

Validation of the 3D modelled hydrodynamics (water level, current speed and direction) involved the comparison of model results to measured timeseries and depth profile data, and was undertaken to supplement earlier validations of the 2D model as presented in the Referral.

The main objectives of the validation were to confirm that the 3D model behaviours were representative of the actual situation, and to confirm that key model inputs validated in the previous model revision remained relevant.

As noted in the Referral, a site-specific data collection campaign was undertaken to confirm the hydrodynamics at the site with bed-mounted Acoustic Doppler Current Profilers (ADCPs). The ADCPs also captured hydrodynamics through the water column to enable a review of the 3D behaviours at the site.

The modelled and measured hydrodynamics show good agreement for both current magnitudes and directions. It also shows a well-mixed vertical distribution of current speed and magnitude through the water column, with no pronounced 3D variability.

Overall, both the 2D and 3D models were found to adequately represent the hydrodynamics at the site.

3.2.2 Suspended sediment

Supplementary 3D modelling of sediment plume predictions was carried out to supplement the predictions presented in the Referral. This supplementary modelling focussed on dredging via CSD with nearshore discharge given the broader extent of the sediment plume and deposition resulting primarily from the discharge activity (i.e. the findings from modelling of multiple scenarios in the Referral show that this is the conservative case).

The release of dredged sediment at the proposed discharge location will result in changes to water quality due to the generation of a suspended sediment plume. The sediment plumes generated at this location will follow the dominant tidal current regime with suspended sediment concentrations greatest close to the point of discharge.

Figures 3.1 to 3.4 present “snapshots” of the suspended sediment concentrations predicted above background during different tidal phases. Due to the large tidal range, plume behaviour varies significantly between the different tidal phases as shown in Figures 3.1 to 3.4. These instantaneous “snapshots” show the extent of the plume running to the north during the ebb tide and south during the spring tide, aligned with the hydrodynamics, a behaviour that is consistent with past measurements and previous modelling.

The use of sediment plume monitoring data from the previous 2006 and 2013 dredging campaigns to validate the 3D model results is discussed further in Section 3.3.

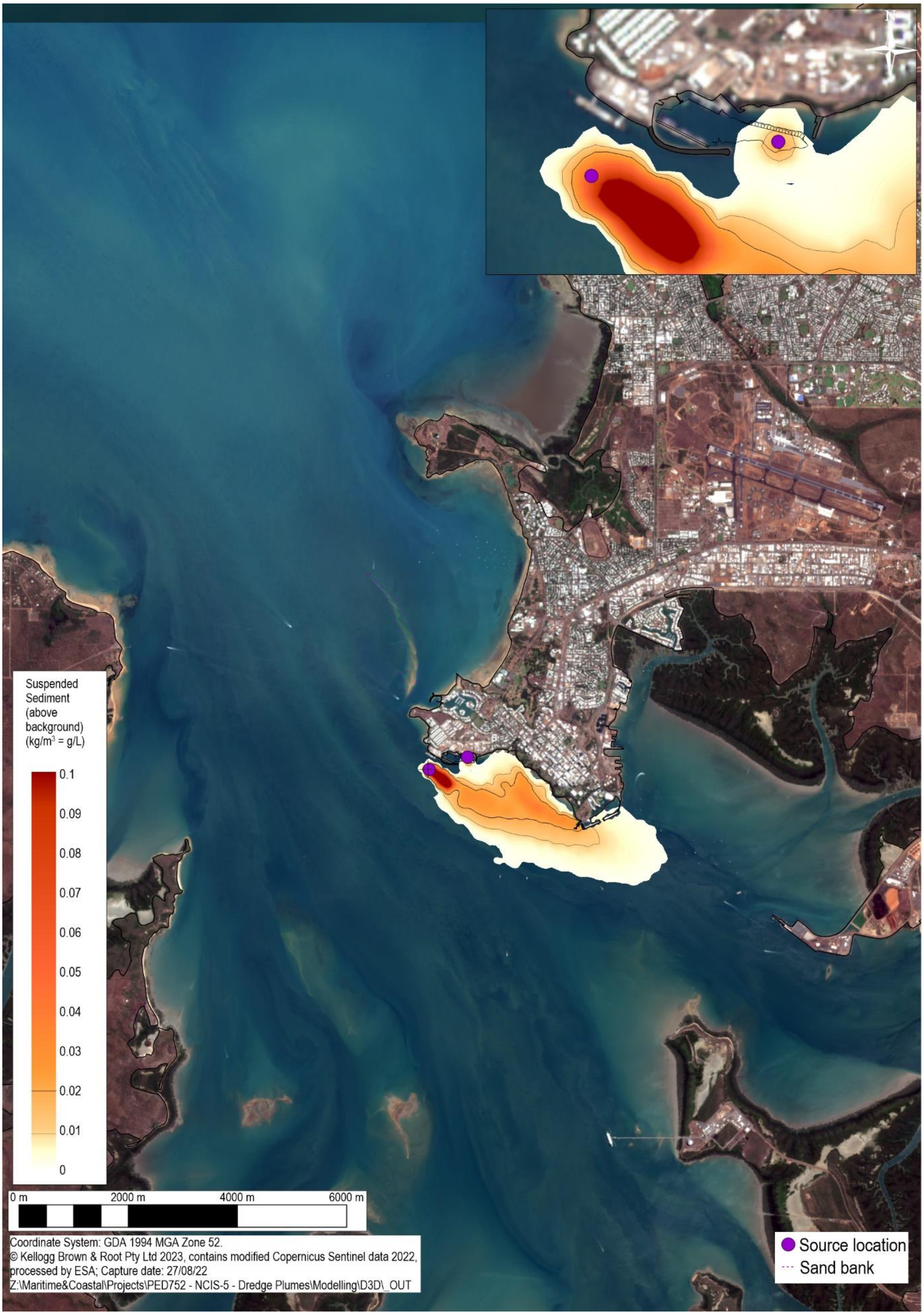

Figure 3.1 **Instantaneous suspended sediment concentrations above background - at 12/11/2017 14:00 – Flood tide, neap condition – CSD dredging with nearshore discharge**

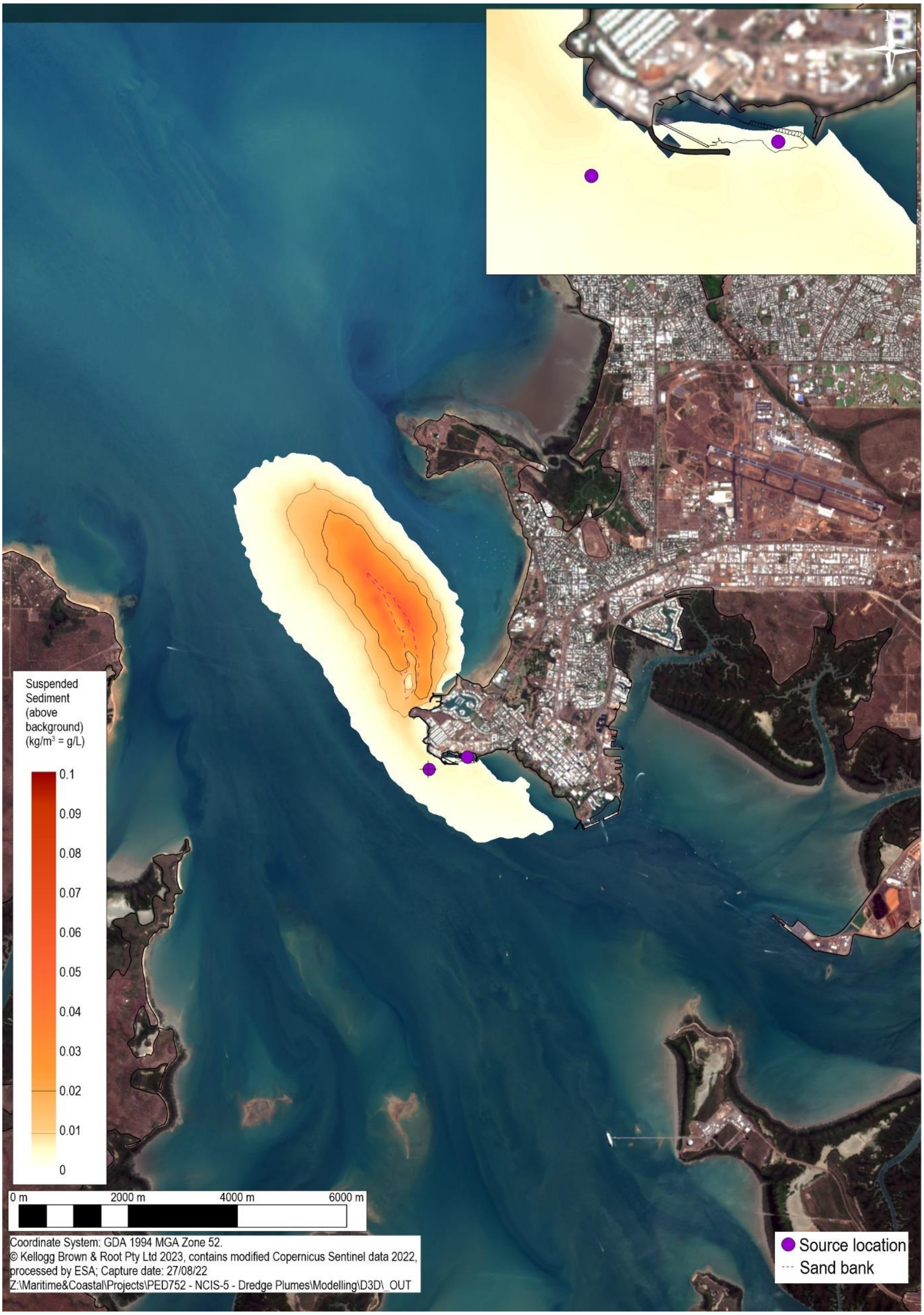

Figure 3.2 **Instantaneous suspended sediment concentrations above background - at 12/11/2017 21:00 – Ebb tide, neap condition – CSD dredging with nearshore discharge**

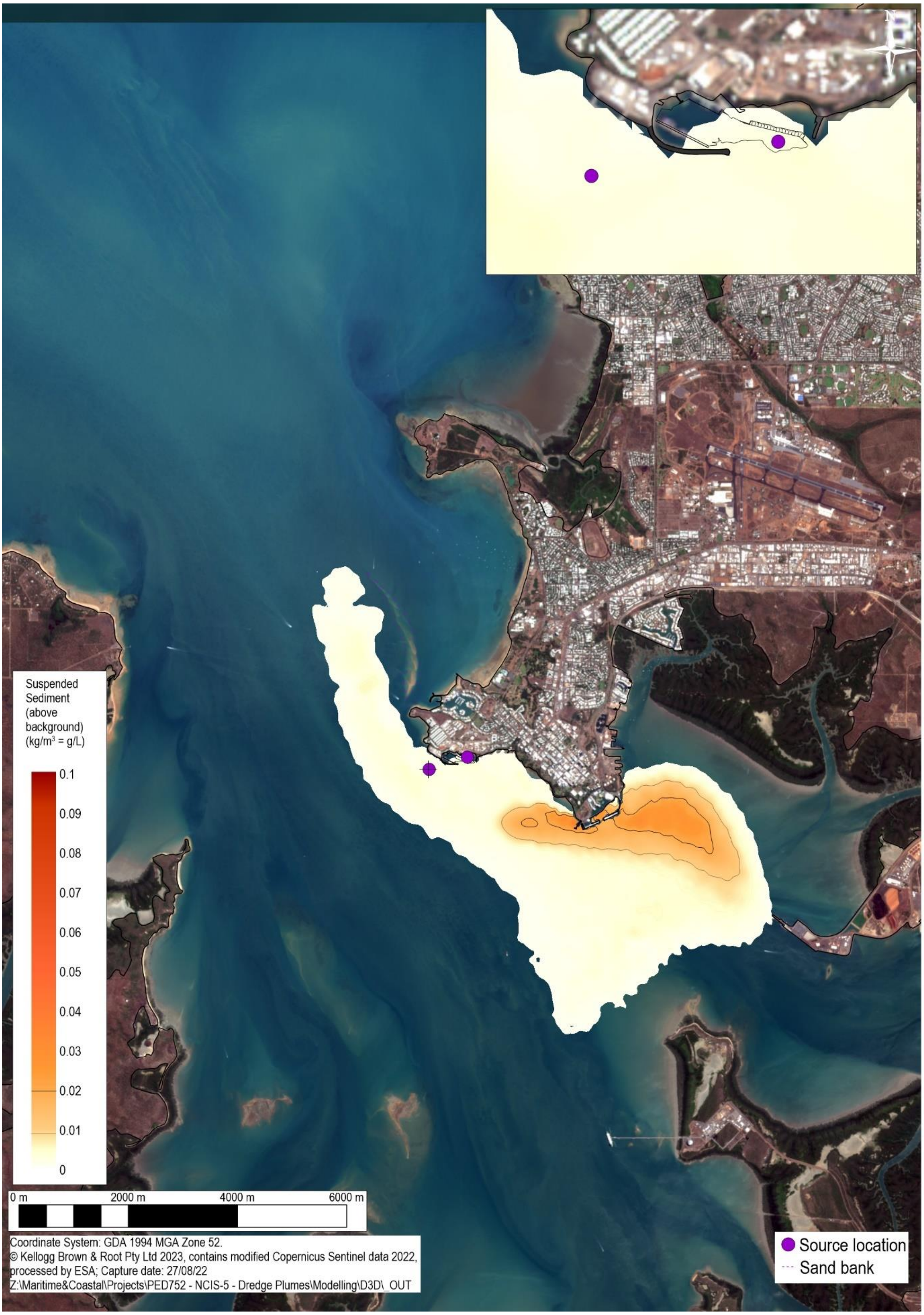

Figure 3.3 **Instantaneous suspended sediment concentrations above background - at 18/11/2017 19:00 – Flood tide, spring condition – CSD dredging with nearshore discharge**

Figure 3.4 **Instantaneous suspended sediment concentrations above background - at 18/11/2017 13:00 – Ebb tide, spring condition – CSD dredging with nearshore discharge**

As outlined in the Referral, the 90th percentile result was chosen for the purposes of impact assessment as it is representative of infrequently occurring (only 10%) suspended sediment concentrations at the higher end of the simulated range.

The 3D modelled 90th percentile suspended sediment concentration for the dry season is shown in Figure 3.5. During the dry season, the plume extent is shown to extend approximately 9 km from the site to the north, and approximately 5 km from the site to the south. To assess the temporal variation of the sediment plumes, times series results from the full simulated period for the CSD and nearshore discharge has been extracted at six representative reporting locations shown on Figure 3.6. The dry season timeseries outputs shown in Figures 3.7 to 3.12 represent the tide only scenario including a representative dry season background (3 mg/L).

The wet season modelled 90th percentile suspended sediment concentration is similar in its extent and behaviour, with a minor increase in turbidity due to slightly higher baseline water conditions experienced during the monsoon season (Figure 3.13). The wet season timeseries outputs shown in Figures 3.14 to 3.19 represent the tide only scenario including a representative wet season background (5 mg/L).

The asymmetric extent of the dry and wet season plumes running to the north during the ebb tide and south during the spring tide, aligns with the hydrodynamics, a behaviour that is consistent with past measurements and previous modelling results.

Modelled results for each reporting location for both dry and wet season are generally consistent with the results presented in the published Referral document.

As previously noted in the Referral, reporting locations TS01 and TS02 to the north of the discharge location are directly influenced by the predicted sediment plumes. The model predictions at TS01, show short term elevated suspended sediment concentrations of up to 90 mg/L with the highest concentrations all predicted within the neap tidal phase where tidal movement is at its lowest (Figure 3.7). As expected, the concentrations predicated at the TS02 site are less than at TS01 as a result of increasing plume dispersion with distance from the discharge location.

Sediment concentrations at both TS01 and TS02 are predicted to be less than 20 mg/L for approximately 90% of the time. Due to tidal reversal, and the daily shutdown period of the dredge, recovery to baseline is shown to occur within almost every 24 hour period regardless of the concentrations experienced during that day. At TS01, where the highest concentrations are predicted, the elevated suspended sediment is only predicted to be above 10 mg/L for 12 hrs before returning to near baseline conditions. The duration of ‘high peak’ periods are typically short and range between 2 to 4 hours. As can be seen in Figures 3.7 and 3.8, due to the distance of the reporting locations from the discharge location and various tidal movements there is a lag between discharge of dredge material and the sediment plumes reaching the reporting locations. This means that the timing of the daily recovery period varies with many instances of low turbidity occurring during daylight hours.

The supplementary modelling results again reiterate that elevated sediment plume concentrations are not predicted to encroach into Fannie Bay, where potential seagrass habitat has been reported. The very low suspended sediment time series results for reporting locations TS03 and TS04 within Fannie Bay support this (Figures 3.9 and 3.10).

The results from TS03 show that the dredging and discharge related activities have very little effect on suspended sediment concentrations at this location, with less than approximately 7 mg/L (dry season) predicted throughout the dredging campaign with recovery to baseline occurring every 24 hours (in a number of instances during daylight hours). The highest concentrations again occur within the neap tidal phases where mixing and water movement is at its lowest. Location TS04 which is located in the northern section of Fannie Bay is outside the 90th percentile predicted plume area with no elevated turbidity levels as a result of dredging predicted (Figure 3.10).

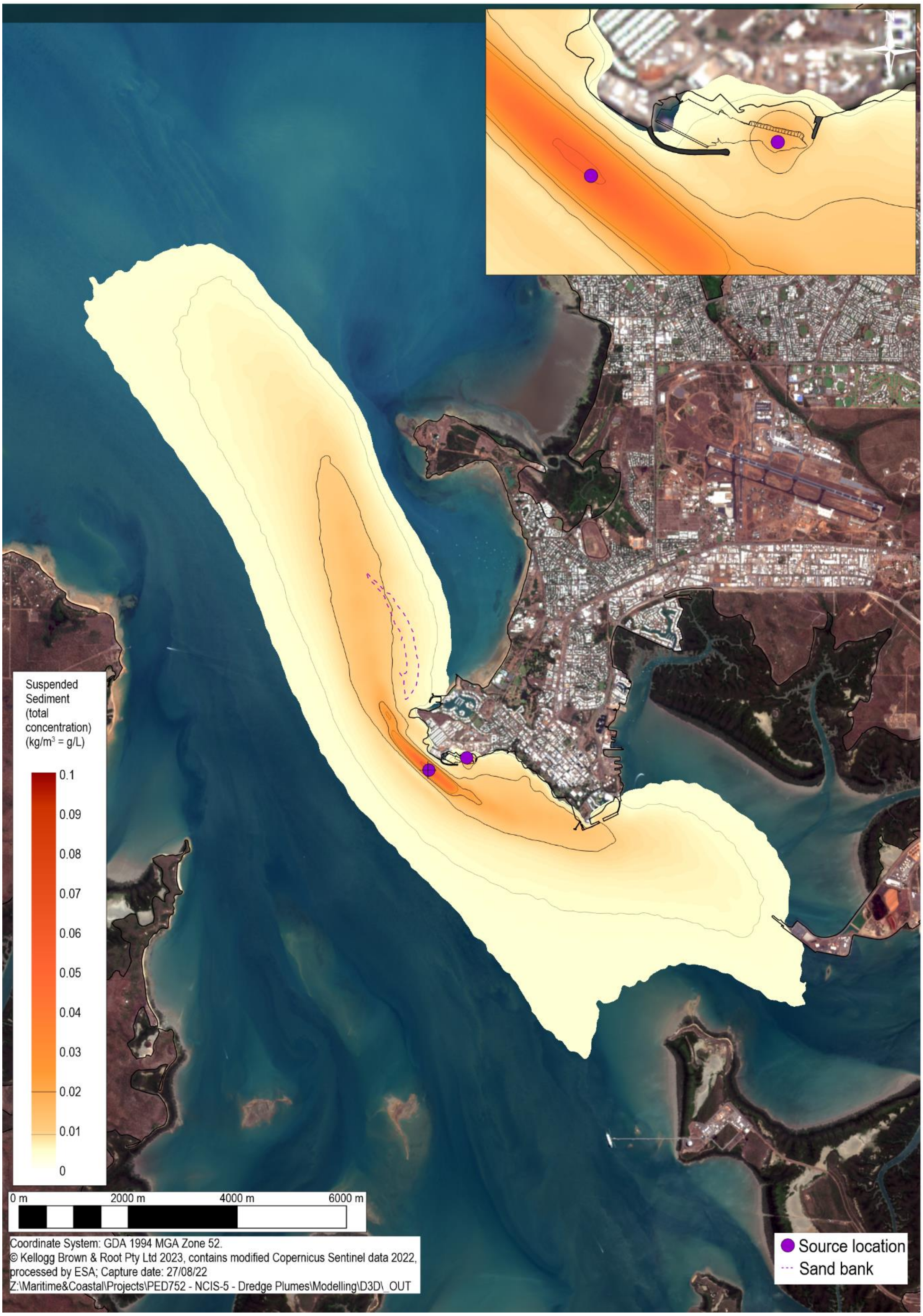

Figure 3.5 **90th Percentile suspended sediment concentrations from CSD with nearshore discharge – Dry season (includes 3 mg/L background concentration)**

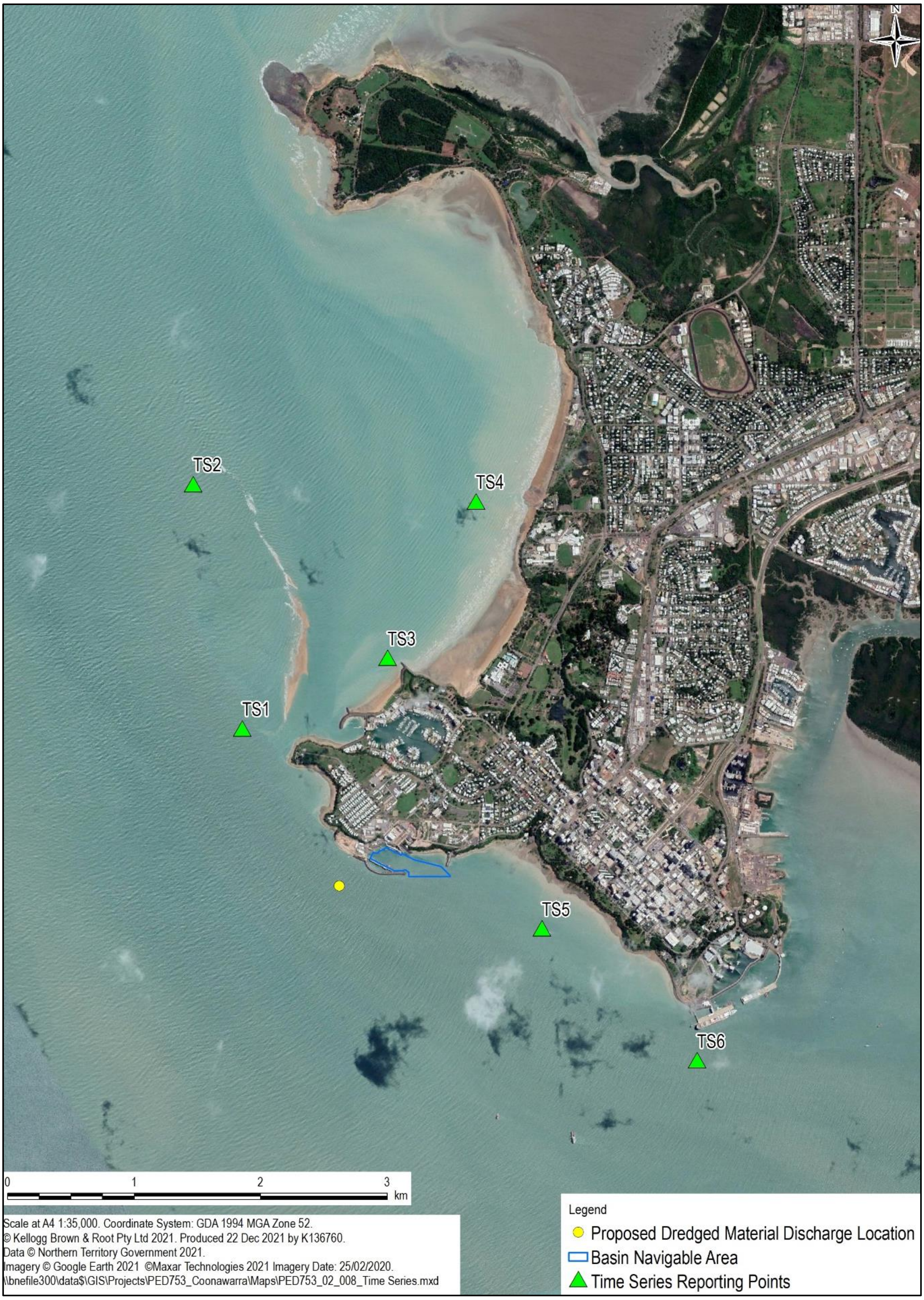

Figure 3.6 Time series modelled data reporting locations

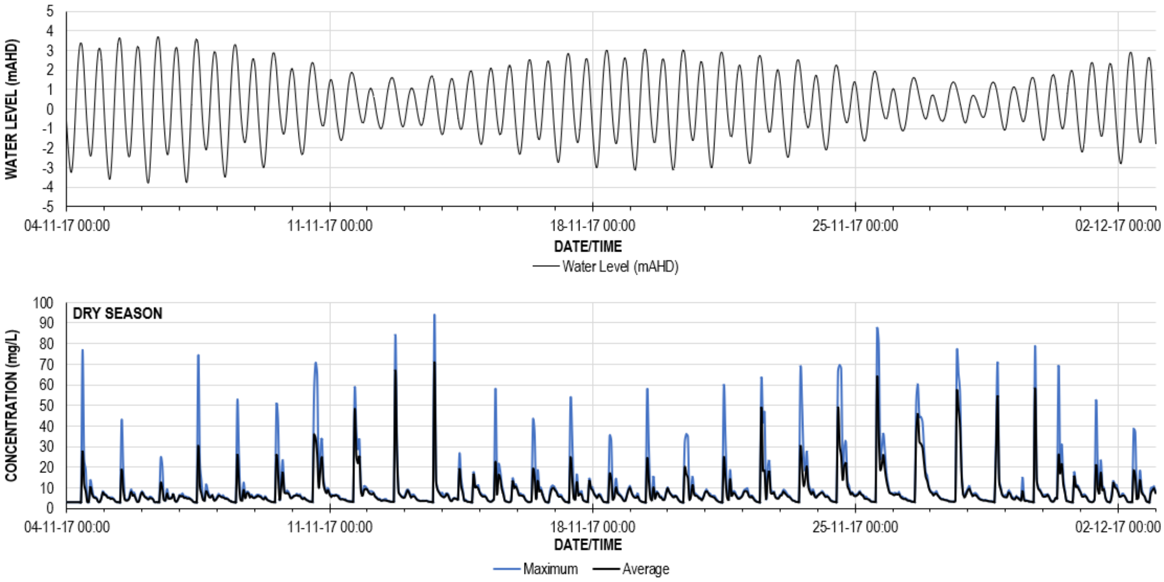

Figure 3.7 Dry season CSD dredging with nearshore discharge – suspended sediment concentrations including background (3mg/L) Timeseries output location TS01

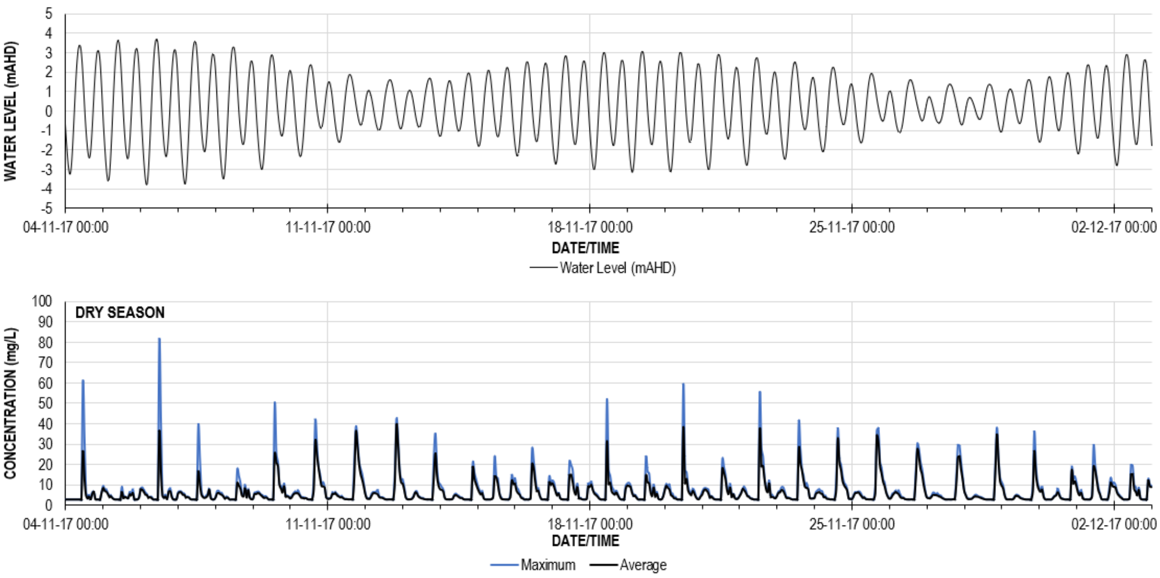

Figure 3.8 Dry season CSD dredging with nearshore discharge – suspended sediment concentrations including background (3mg/L) Timeseries output location TS02

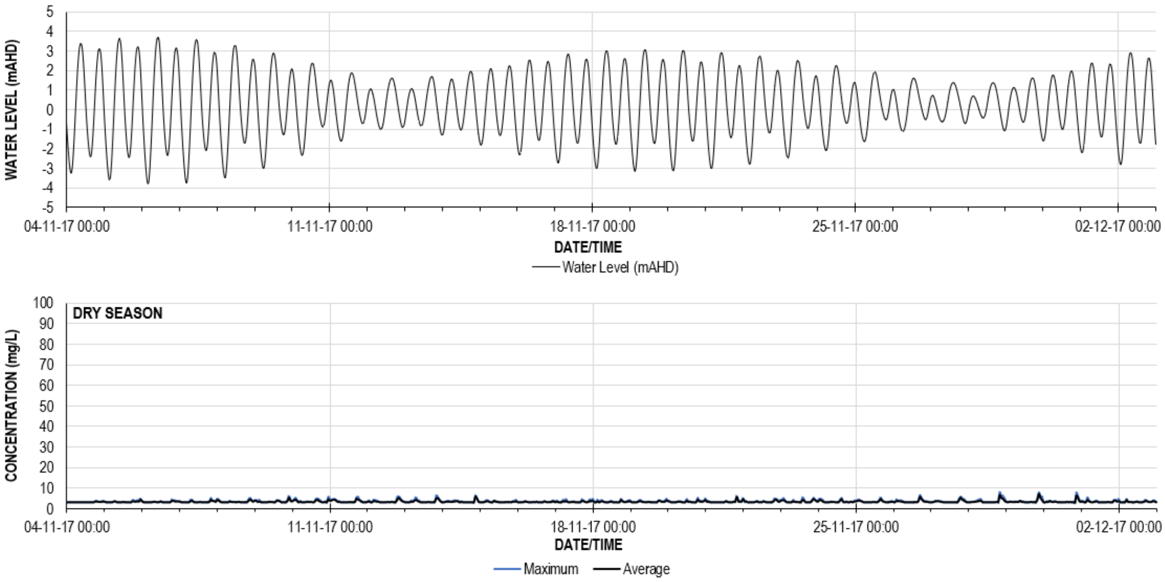

Figure 3.9 **Dry season CSD dredging with nearshore discharge – suspended sediment concentrations including background (3mg/L) Timeseries output location TS03**

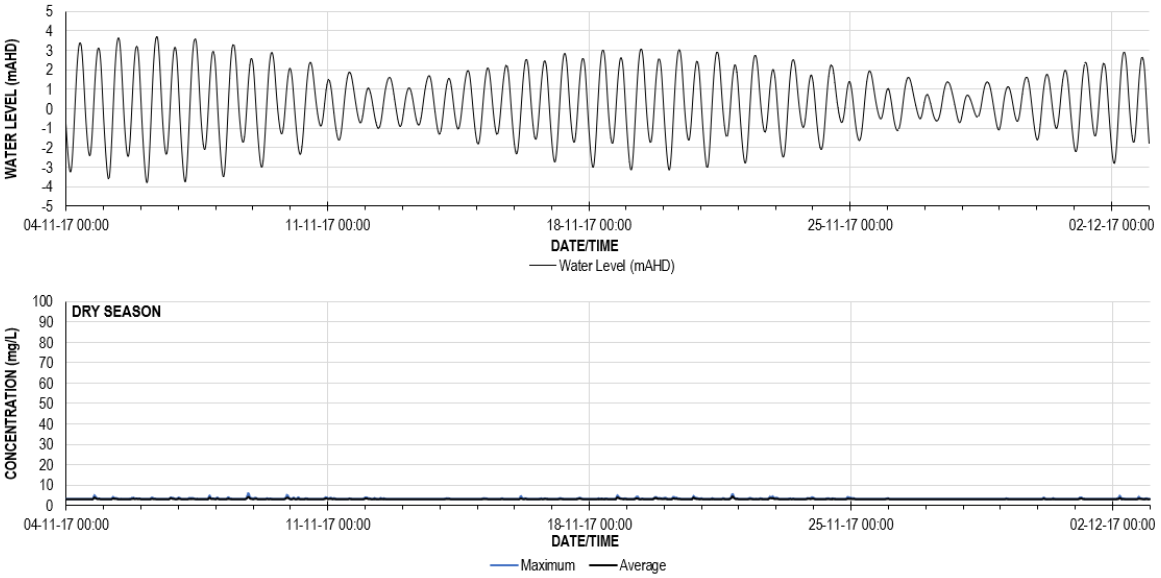

Figure 3.10 **Dry season CSD dredging with nearshore discharge – suspended sediment concentrations including background (3mg/L) Timeseries output location TS04**

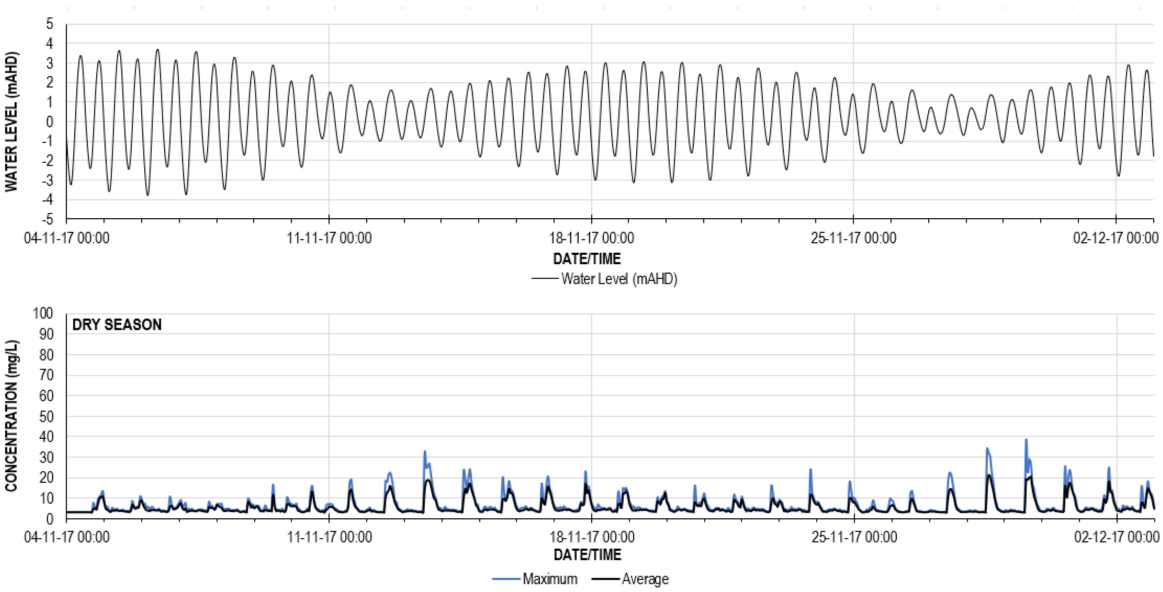

Figure 3.11 Dry season CSD dredging with nearshore discharge – suspended sediment concentrations including background (3mg/L) Timeseries output location TS05

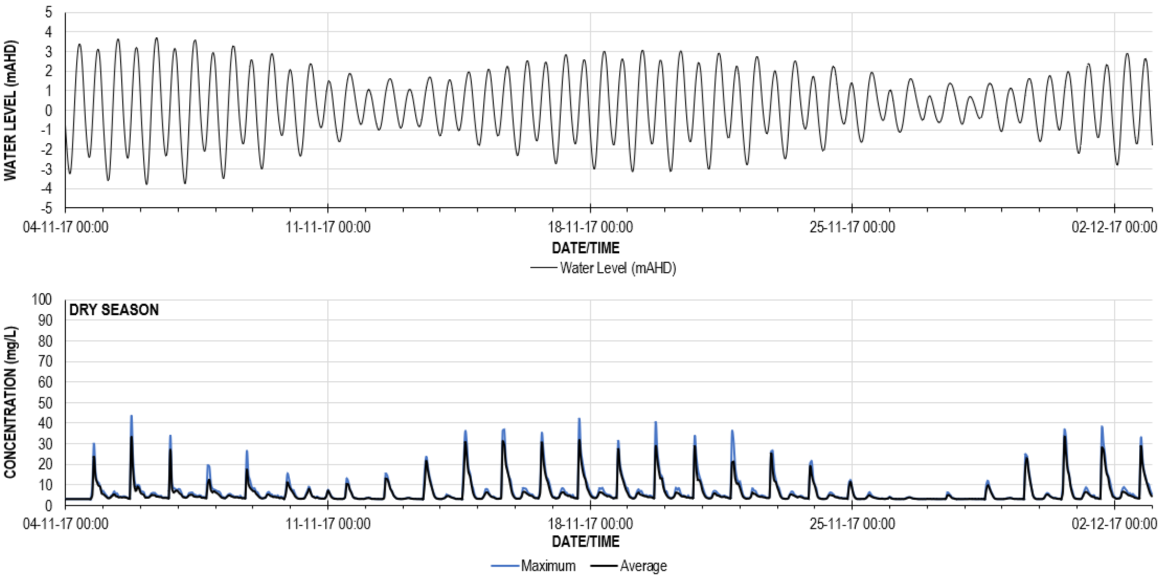

Figure 3.12 Dry season CSD dredging with nearshore discharge – suspended sediment concentrations including background (3mg/L) Timeseries output location TS06

Figure 3.13 **90th Percentile suspended sediment concentrations from CSD with nearshore discharge – Wet season (includes 5 mg/L background concentration)**

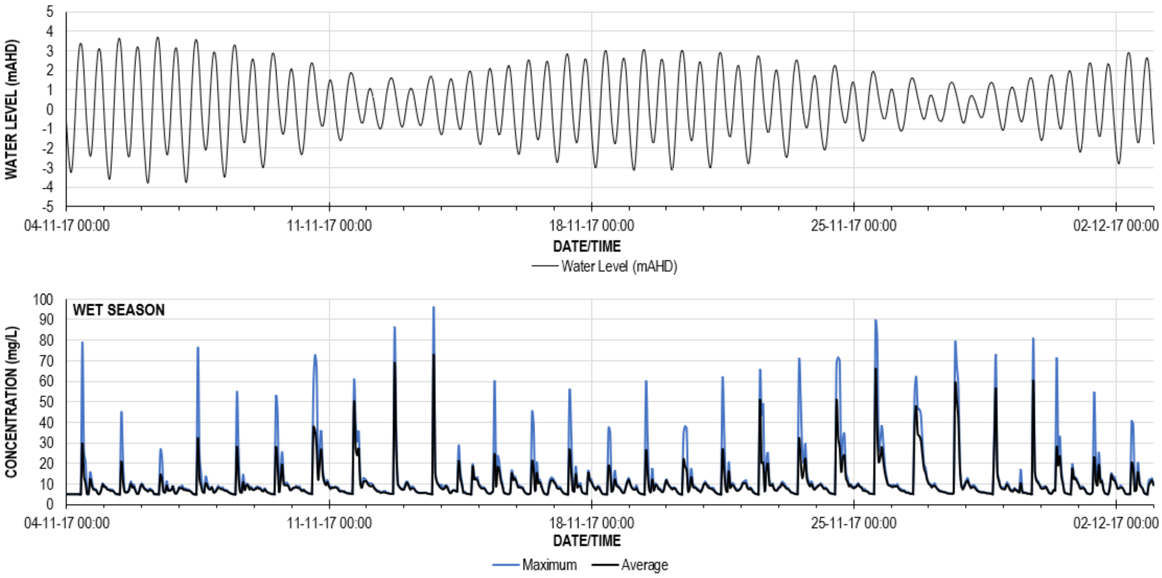

Figure 3.14 Wet season CSD dredging with nearshore discharge – suspended sediment concentrations including background (5mg/L) Timeseries output location TS01

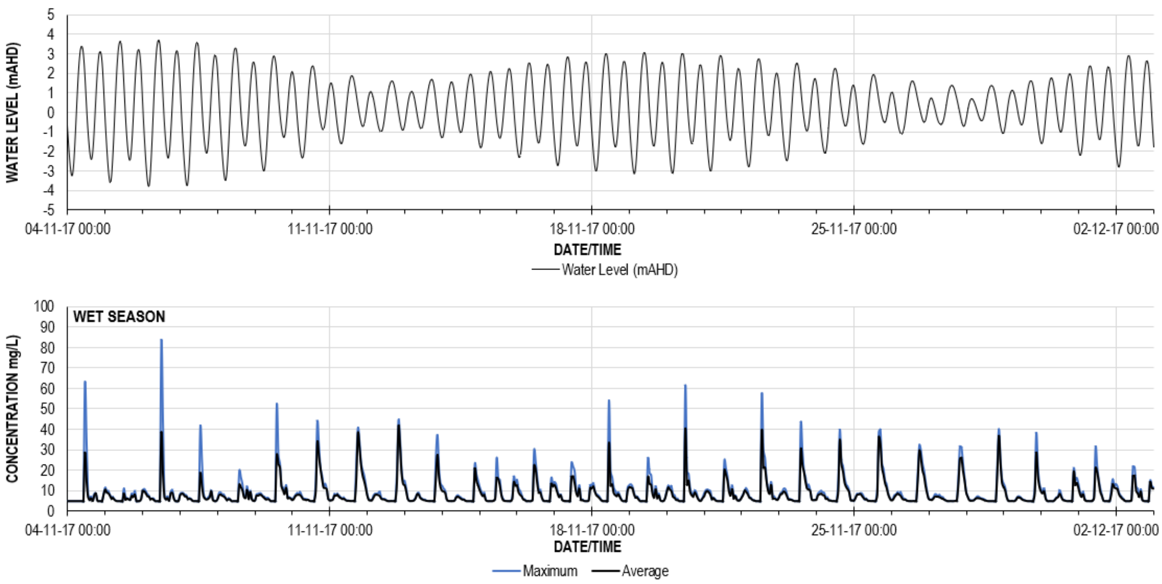

Figure 3.15 Wet season CSD dredging with nearshore discharge – suspended sediment concentrations including background (5mg/L) Timeseries output location TS02

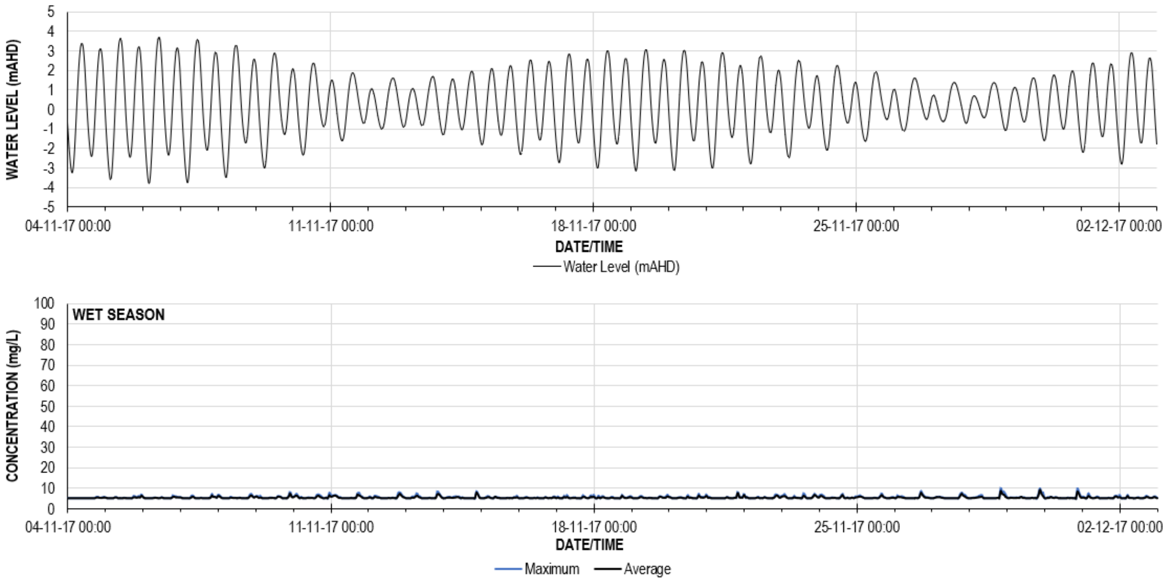

Figure 3.16 Wet season CSD dredging with nearshore discharge – suspended sediment concentrations including background (5mg/L) Timeseries output location TS03

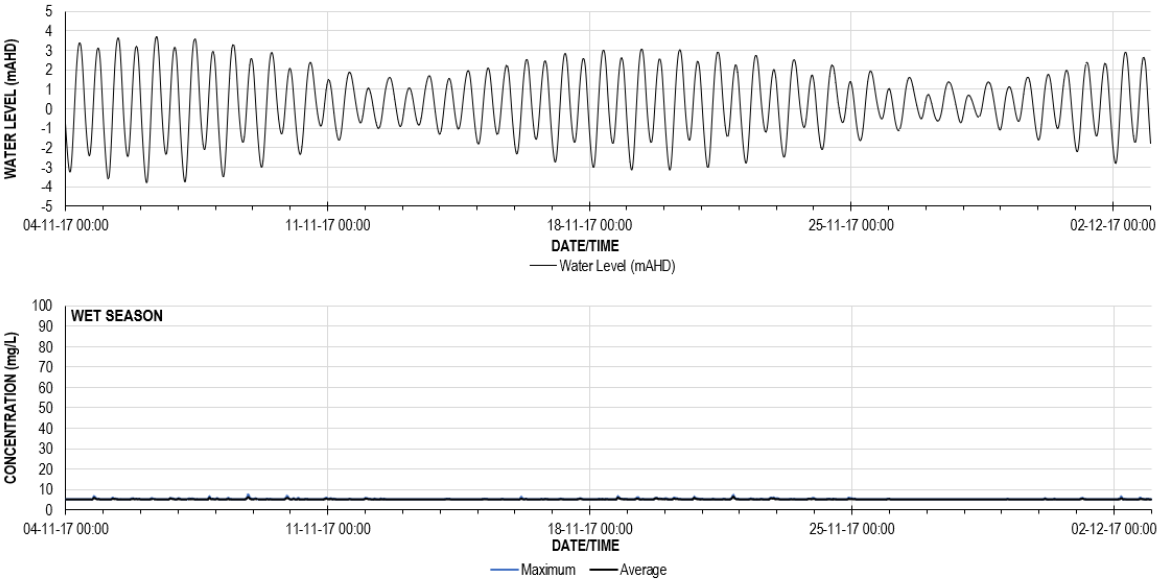

Figure 3.17 Wet season CSD dredging with nearshore discharge – suspended sediment concentrations including background (5mg/L) Timeseries output location TS04

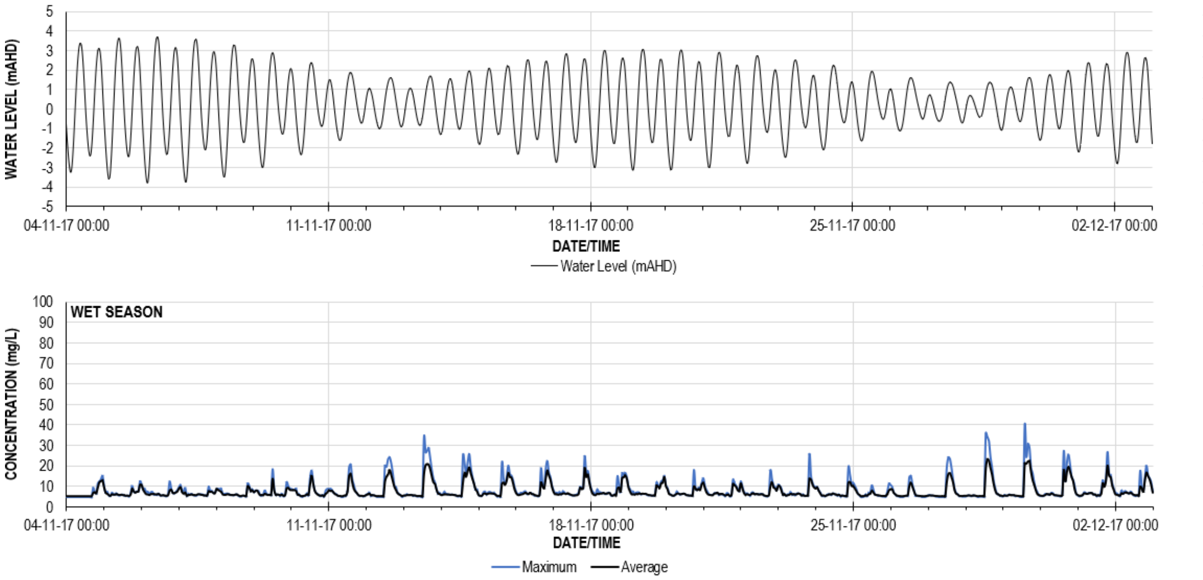

Figure 3.18 Wet season CSD dredging with nearshore discharge – suspended sediment concentrations including background (5mg/L) Timeseries output location TS05

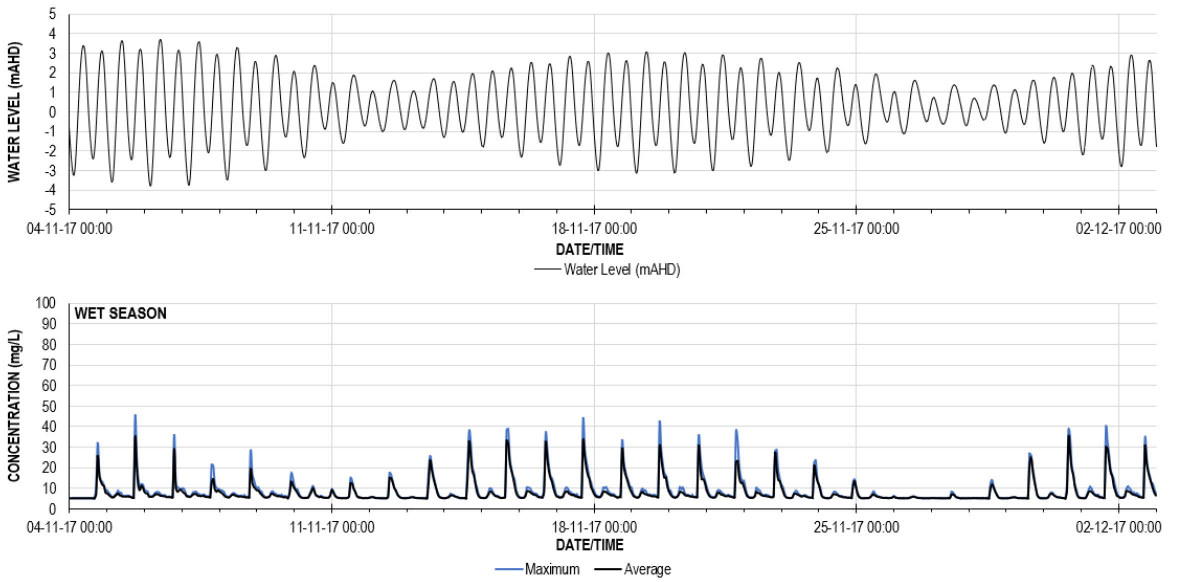

Figure 3.19 Wet season CSD dredging with nearshore discharge – suspended sediment concentrations including background (5mg/L) Timeseries output location TS06

Time series reporting locations TS05 and TS06 are located within the predicted plume to the south of the discharge location. As with the reporting locations to the north, both TS05 and TS06 show elevated suspended sediment concentrations (Figures 3.18 and 3.19). Turbidity concentrations between 10 mg/L and 20 mg/L commonly occur at TS5 with the highest concentrations at this location ranging between 30 mg/L and 40 mg/L. Concentrations at TS6 are slightly higher than those reported at TS05 and more commonly range between 20 mg/L and 40 mg/L. Peak concentrations at TS05 are predicted to occur within the neap tidal phase where tidal movement is at its lowest, while predicted concentrations at TS06 tend to follow the tidal cycle and are more pronounced during spring tides.

The difference in predictions between TS05 and TS06 is a result of the more complex current patterns in this area (e.g. a local gyre forms on the flood tide). As TS05 is located slightly further inshore than TS6 it experiences different current and tidal movements.

Additional timeseries outputs for the proposed monitoring locations WQ1, WQ3 and WQ4, as discussed in Section 3.7 (Figure 3.32), were also reviewed to understand sediment concentrations within the vicinity of Bennett Shoal, to the west of the offshore sand bank and in the entrance to Fannie Bay. The dry season timeseries outputs shown in Figures 3.20 to 3.22 represent the tide only scenario plus dry season background (3 mg/L).

The time series results for WQ1 are consistent with those predicted for TS03. Very low suspended sediment concentrations are predicted to occur (predominantly less than approximately 5 mg/L) because the plume is not anticipated to encroach into Fannie Bay (Figure 3.20).

WQ4 is within close proximity to TS01 and shows similar elevated suspended sediment concentrations with peaks of up to 90 mg/L, although the magnitude of concentrations predicted is somewhat less pronounced than those reported at TS01 (Figure 3.21). The highest concentrations are more closely related to the neap tidal phase where tidal movement is at its lowest than those predicted for TS01.

WQ3 is associated with Bennett Shoal (Figure 3.22). Time series data at this locations shows elevated suspended sediment concentrations which typically occur during neap tide. Concentrations typically range between 10 mg/L and 20 mg/L with individual short term peak concentrations ranging between 60 mg/L and 160 mg/L.

The suspended sediment concentration predictions for all reporting locations are shown to be within the range of values known to occur naturally within the harbour. The timeseries data for both dry and wet season shows that elevated suspended sediment concentration associated with dredging typically last 12 hours before returning to baseline conditions and no gradual increase in the underlying ‘baseline’ concentrations is observed at any site. During this period the duration of ‘high peak’ periods are generally short and range between 2 to 4 hours. This indicates that once dredging ceases the system will quickly return to its pre dredging condition. As described above, due to the distance of the reporting locations from the discharge location and tidal movements, the timing of the daily recovery period varies with many instances of low turbidity occurring during daylight hours.

Consistent with the findings outlined in the published Referral, only a small area within the predicted plume may experience suspended sediment concentrations consistently above 20 mg/L with concentration spikes above this value all aligning with a specific tidal phase (i.e. the neap tide). The neap tide phase is when tidal movement and mixing is at its lowest however this phase tends to last only 3 to 4 days before an extended period of up to 9 days of more favourable mixing conditions and lower suspended sediment concentrations.

This modelled data assumes that dredging will occur 12 hours per day 7 days a week however in practice the dredge will not operate on Sundays and there will be frequent stoppages for maintenance, and to minimise disruptions to ongoing naval operations. These stoppages will result in additional recovery time and reduce the magnitude and duration of the daily plumes.

Overall 3D modelling of the spatial behaviour and concentration of the predicted sediment plumes during flood and ebb tides are generally consistent with the results of the previous 2D model.

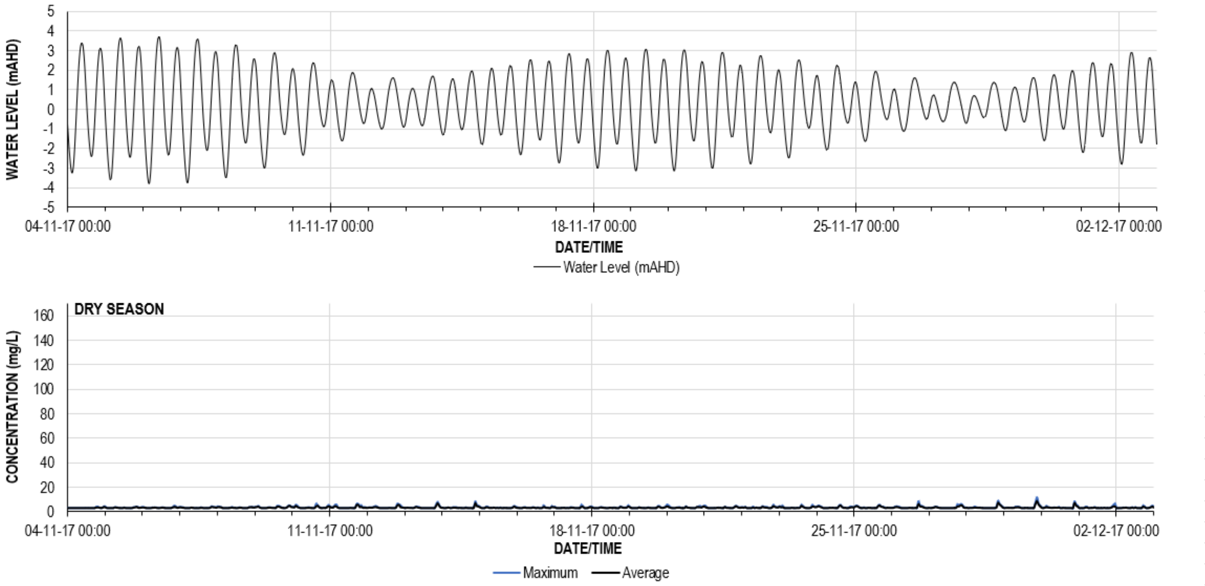

Figure 3.20 **Dry season CSD dredging with nearshore discharge – suspended sediment concentrations including background (3mg/L) Timeseries output location WQ1**

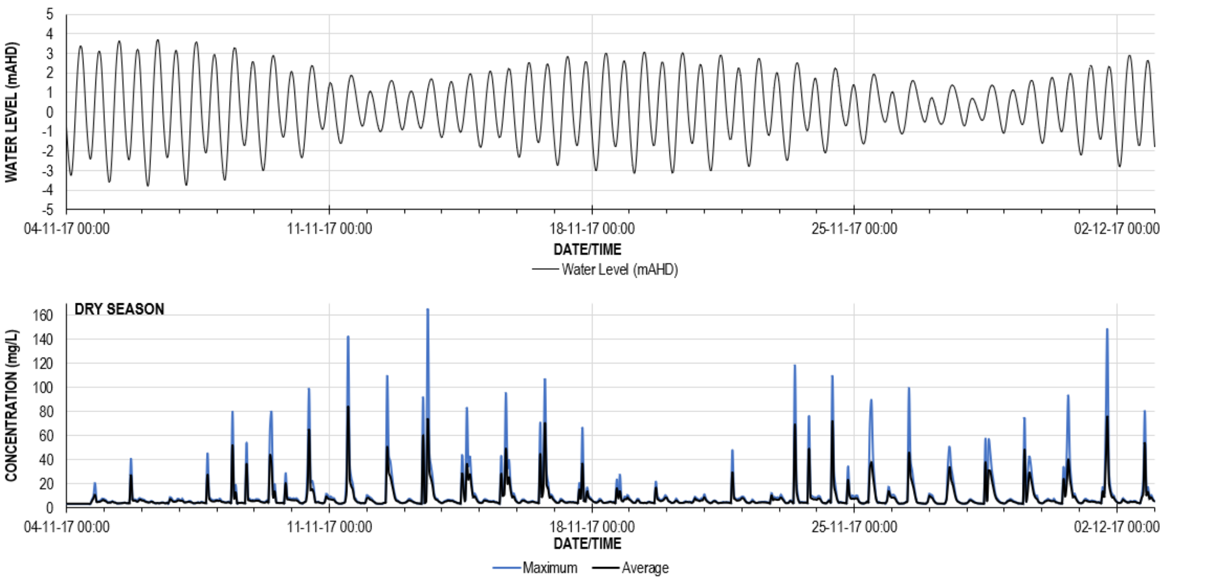

Figure 3.21 **Dry season CSD dredging with nearshore discharge – suspended sediment concentrations including background (3mg/L) Timeseries output location WQ3**

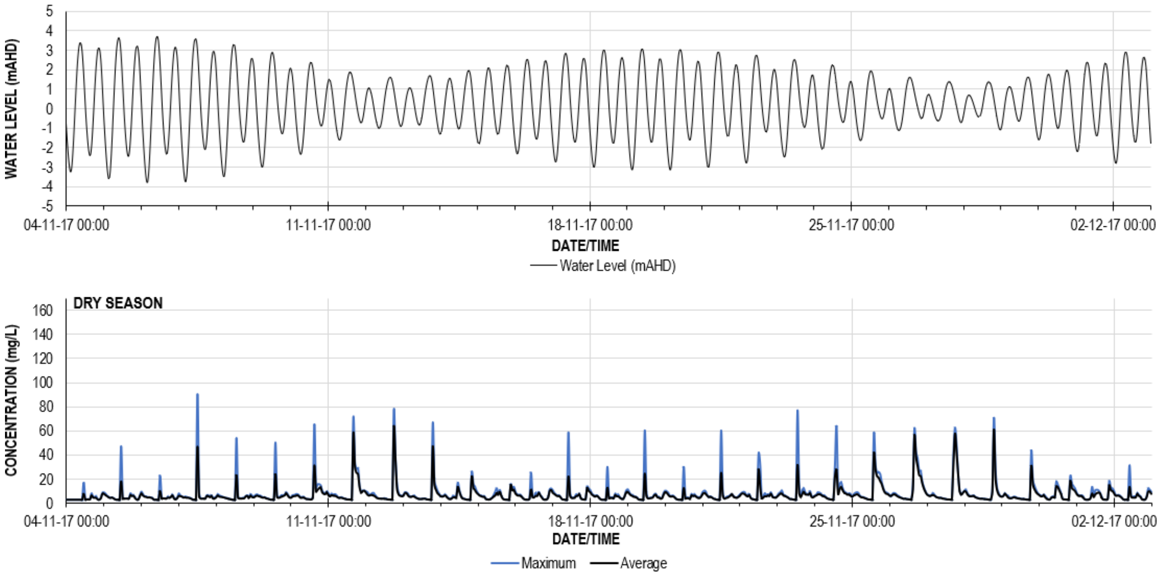

Figure 3.22 **Dry season CSD dredging with nearshore discharge – suspended sediment concentrations including background (3mg/L) Timeseries output location WQ4**

3.2.3 Comparison of 2D and 3D modelling

A comparison of the previous 2D modelled outcomes with the refined results from the 3D model is included in Appendix D – Supplementary Dredging Modelling Report.

The performance of the supplementary dredge modelling has also been validated by comparison with representative field data from monitoring of the 2006 and 2013 dredging campaigns. These previous campaigns are comparable to the current and future works proposed at HMAS *Coonawarra*.

The model was refined during the SER process to represent 3D effects as an improvement to previous modelling. This further modelling work shows no significant changes from the previous reported 2D modelling. Both the 2D and 3D models are able to represent the fundamental plume behaviours.

The 2D model can reasonably represent impact areas, however the 3D model refinements now provide an improved ‘tool’ for undertaking future assessments.

3.3 PLUME VALIDATION – PREVIOUS DREDGING CAMPAIGNS

An overview of water quality data from the monitoring of the 2006 and 2013 dredging campaigns was provided in the Referral, however further raw data was obtained during the SER process which further comparison with modelled predictions to be undertaken.

A large volume of field data was reviewed and sorted to identify what could be compared with modelled cases, based on the tide, dredge operations, location, and supplementary model predictions.

The data included water quality depth profiles targeting sediment plumes generated during dredging. There were also depth profiles located beyond the extent of sediment plumes, as well as time series water quality logger data.

In addition satellite imagery captures were also assessed as part of the validation process.

A discussion of the datasets utilised for model validation, including previous dredging data and satellite data capture, is presented in Section 4 of the Supplementary Dredging Modelling Report included as Appendix D. Outcomes of the validation process are summarised in the following sections.

3.3.1 Sediment plume validation

During the 2006 and 2013 dredging campaigns, monitoring of turbidity as depth profiles was routinely undertaken targeting the observed dredge plume and areas around the plume.

A data collation and analysis process has been undertaken to identify specific depth profile datasets for comparison with 3D model outputs. The number and position of the depth profile locations varied from day-to-day, and not all profiles measured in the field detected the presence of a plume. In addition, it was also evident that on some occasions the field team collected data when dredge discharge was either not occurring (i.e. was interrupted), or the concentration of solids in the discharge was very low (neither the discharge pipe or the dredge status could be seen by the field team from the monitoring area). Comparison with the identified representative data showed that the modelling represents realistic sediment plume extents and vertical total suspended solid behaviours.

Generally the modelled plume was found to exhibit similar behaviours to the field measurements. Plume profile measurements indicate a relatively well-mixed condition, however the model slightly overpredicts the 3-dimensionality of the plume. The concentrations reported by the model are slightly conservative which is appropriate for the assessment of dredging and dredged material disposal related effects.

In addition to the depth profile measurements, monitoring during the 2013 dredging campaign also involved the installation of three bed-mounted unattended water quality loggers at the same locations utilised for the collection of baseline water quality data prior to the commencement of dredging. The time series data captured at these locations was representative of near bed conditions.

All data loggers were bed-mounted and recorded turbidity peaks that were often higher than the concentrations recorded in the water column by the depth profiles. The data logger series is therefore not entirely representative of fine suspended sediment concentrations in the overlying water column as they are also recording the resuspension and resettling of heavier sediment close to the bed (bed load) which is a somewhat separate process and not directly comparable to the modelled far field fine suspended sediment results.

This logger data does also capture the 'spike' related to the daily dredging and discharging periods. The model also shows the signal of the dredge plume at similar timing and duration showing that the model is able to represent general plume behaviour on both ebb and flood tides. During neap tide periods, when 'bed load' is lower, there is better agreement between the model and measured peaks, providing confidence that the model is appropriately capturing the up-current and down-current distributions of the plume over time.

Comparison between observations during previous dredging campaigns and the supplementary modelling improve confidence in the model performance. Although there are some inherent limitations in the field data measurements, the overall results of the validation process demonstrate that the model reliably predicts the fundamental behaviour and characteristics of the sediment plume consistent with what has been measured in the field.

3.3.2 Satellite data capture

Available satellite imagery for the period of time which coincided with the 2006 and 2013 dredging campaigns has also been reviewed. Limited satellite data captures were found to occur during those time periods, with only 'Landsat' imagery with relatively low resolution found to be available.

However, representative ebb tide and flood tide images captured during the 2013 and 2006 dredging campaigns, respectively, were sourced, reviewed and compared with modelled results for equivalent tide and dredging combination (Figures 3.23 and 3.24).

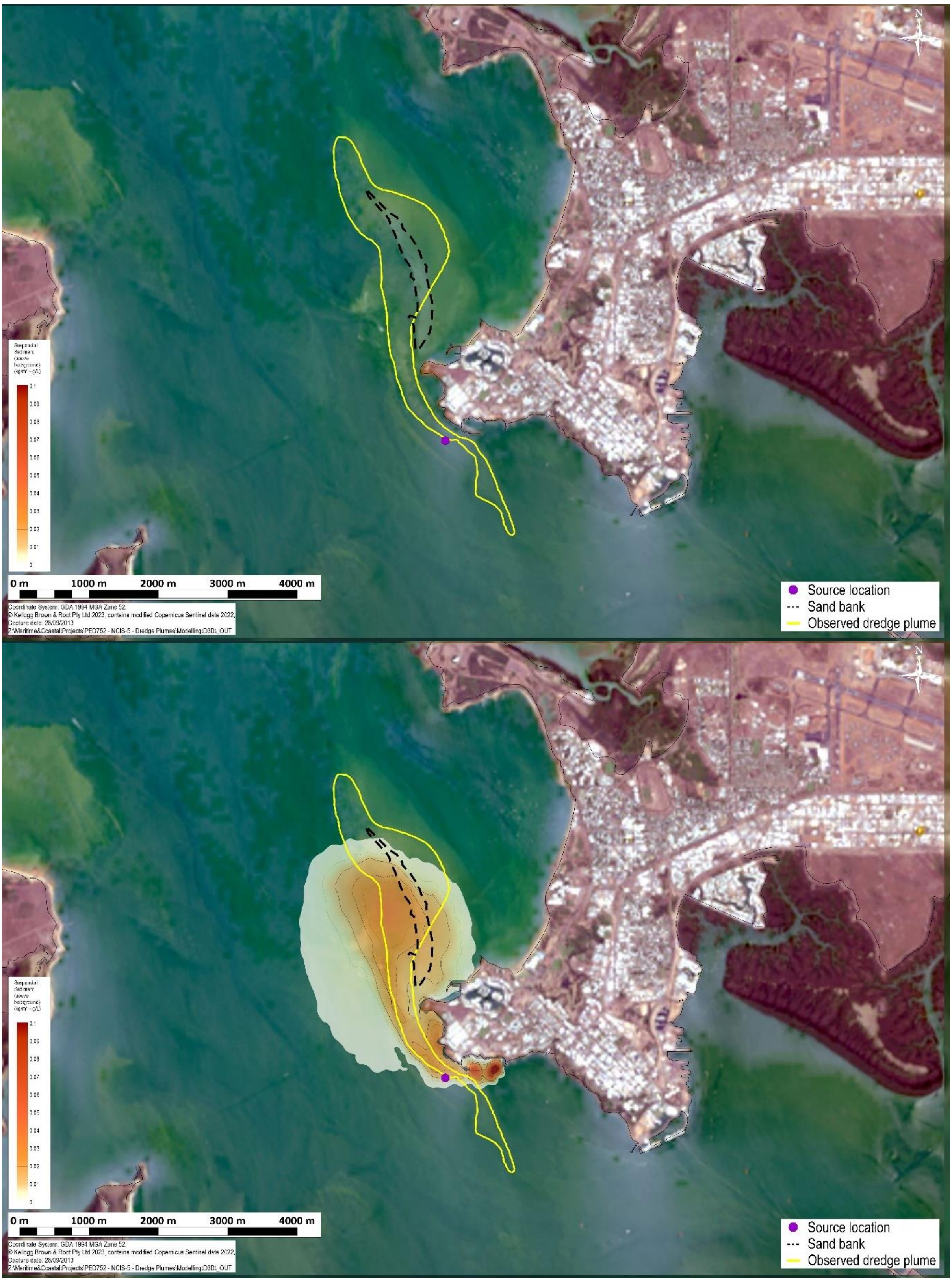

Figure 3.23 Satellite imagery data capture during 2013 dredging campaign – Observed ebb tide dredge plume (top) compared with modelled dredge plume (bottom) (26 September 2013)

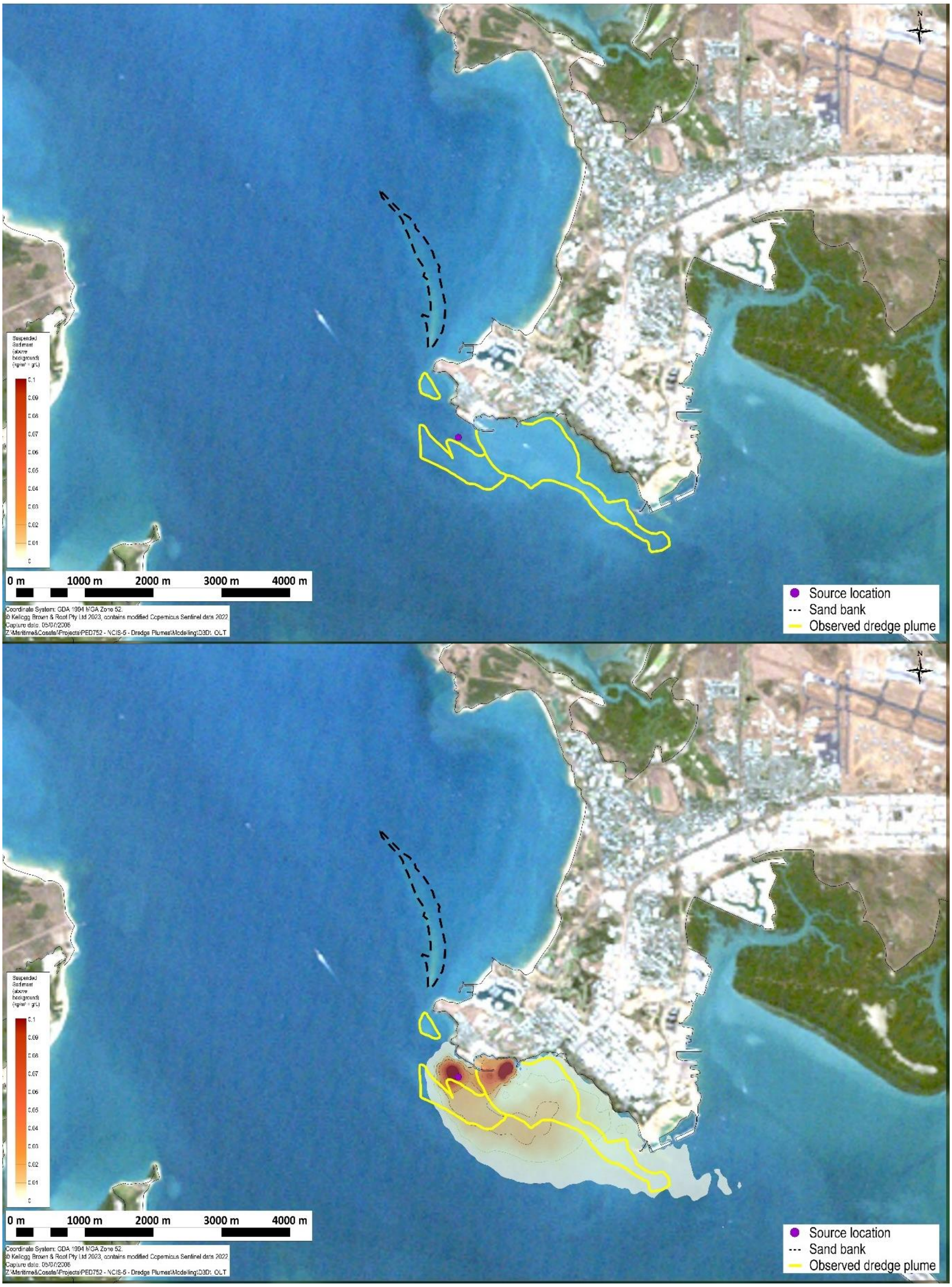

Figure 3.24 **Satellite imagery data capture during 2006 dredging campaign – Observed flood tide dredge plume (top) compared with modelled dredge plume (bottom) (5 July 2006)**

The imagery for both campaigns shows a relatively good match with the modelled extent of plumes and supports the usefulness of satellite imagery as a source of data for monitoring dredging and disposal activities, noting that there is now better resolution and more frequent imagery available.

3.4 SEDIMENT DEPOSITION MODELLING

The deposition of fine and coarse material was modelled and reported on in the Referral. However, the sediment deposition and sediment transport model has since been expanded to further define the duration, magnitude and extent of sediment deposition, sediment thickness and the fate of deposited sediments associated with the proposed dredging and disposal activities.

The following sections provide a summary of the modelled outcomes for fine and coarse material deposition following the completion of dredging. The areas of fine and coarse material deposition and thickness is presented in Figure 3.25.

Further discussion regarding the deposition and sediment fate modelling undertaken for both fine and coarse material is included in Appendix D – Supplementary Dredging Modelling Report (Section 6).

3.4.1 Coarse sediment deposition

The majority of sediment to be dredged will consist of fine material which remains in suspension for an extended period (the main focus of the impact assessment), however there will also be a component of coarser heavy particles which settle very quickly. The deposition of this coarse material (which would include gravel, rock fragments, pieces of cohesive clay, and coarse and medium grained sands) was modelled to predict the extent of direct deposition in the immediate vicinity of the discharge location. The modelling work confirmed that coarse-grained sediments quickly settle out of suspension, falling to the seabed within a short distance of the release point.

The deposition area and thickness are presented in Figure 3.25, which captures the extent of sediment deposition for coarse gravel, and coarse and medium grained sands. This extent of coarse sediment deposition would be similar to what has occurred previously during past dredging campaigns.

The initial deposition of coarse material in the immediate vicinity of the discharge location will temporarily impact benthic habitat with some reduction of abundance, species diversity and productivity likely. Based on the results of the benthic habitat assessment, and as shown in Figure 3.26, bare substrate which supports sparse sponge dominated filter feeders is the only sensitive receptor within the predicted zone of high impact, which as defined in Section 3.9, constitutes the direct footprint of the modelled zone of heavy material deposition within the vicinity of the dredge and discharge locations.

The benthic habitat assessment also noted that the type and condition of benthic communities at the proposed discharge location remains similar to that of the surrounding project area, even after the completion of multiple dredging campaigns. It is likely that upon cessation of the discharge activities, the presence of some additional harder substrate material within what is deposited will provide opportunities for the regrowth of filter feeders.

3.4.2 Fine sediment fate

For fine sediment (the majority of what will be discharged), the model predicts the net thickness (in millimetres) of fine sediment deposited onto the seabed at the completion of the dredge campaign. The model was run over a one month period, representing a full dredging and dredge material discharge period (albeit conservatively). The simulated net thickness of sediment is a function of the estimated density of the material and the transport, deposition and erosion processes simulated by the model.

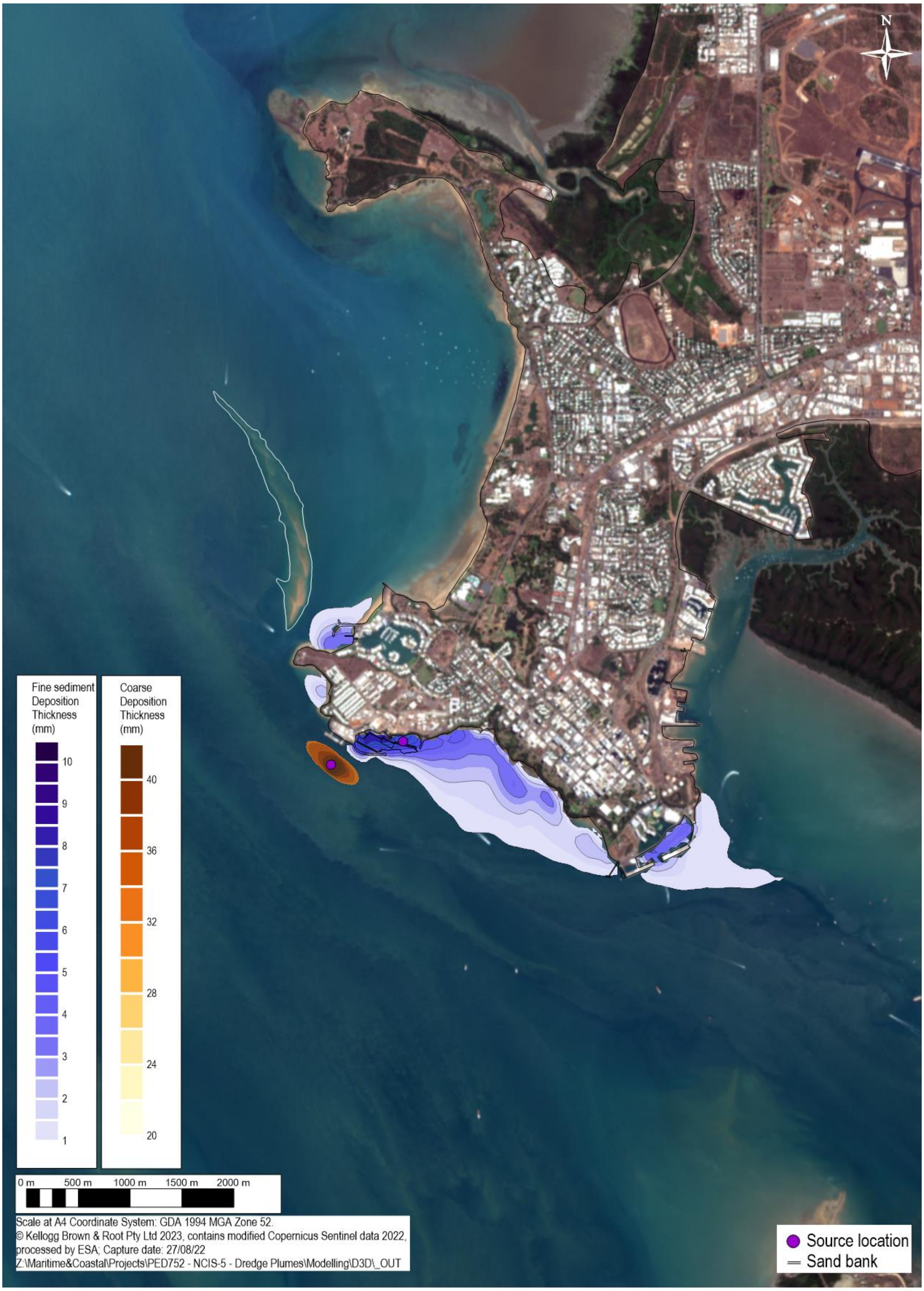

Figure 3.25 Fine and coarse sediment deposition thickness (mm) following the completion of dredging

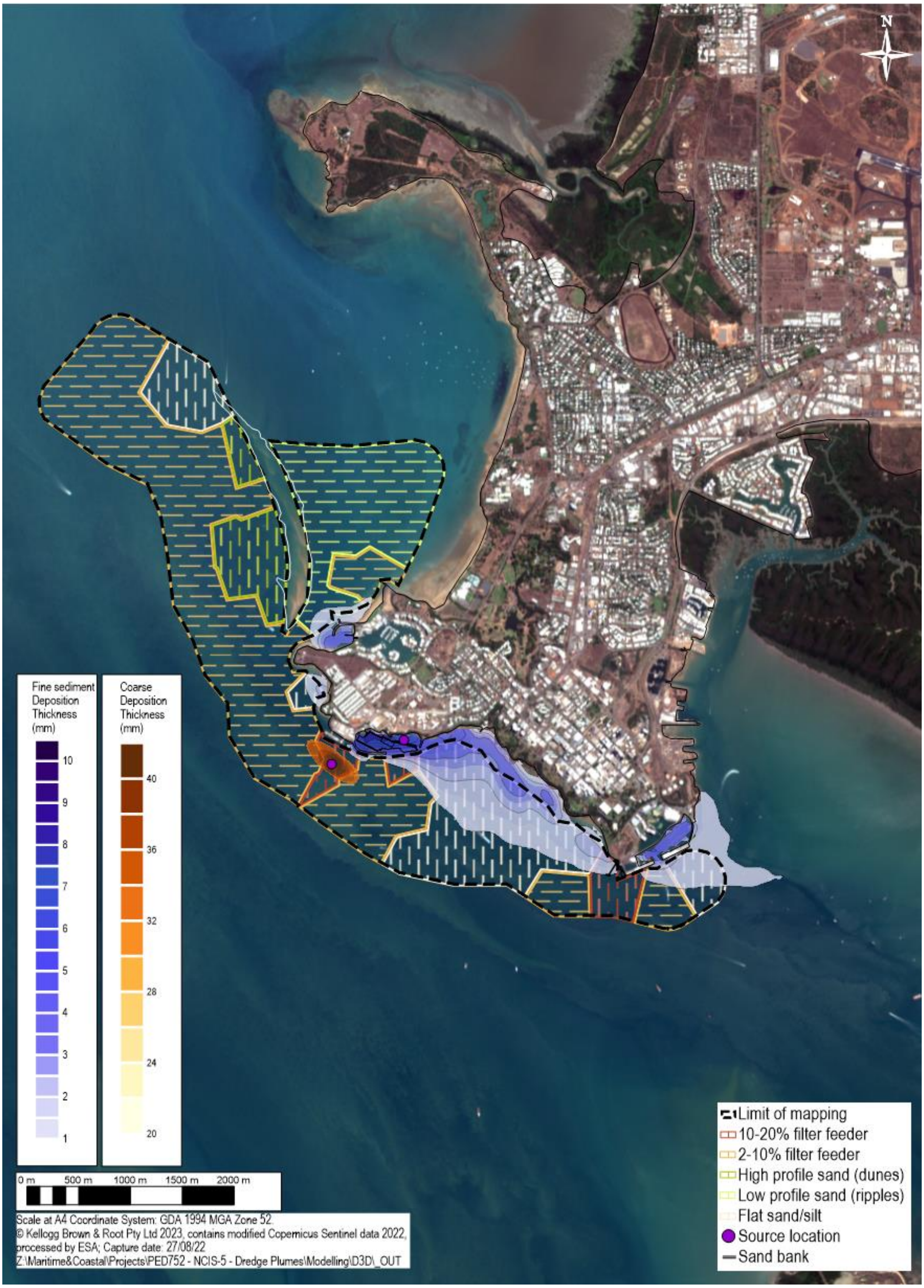

Figure 3.26 **Comparison of benthic habitats and sediment deposition thickness (mm) following the completion of dredging**

Figure 3.25 shows the predicted fine sediment deposition. The extent and thickness of fine sediment deposition is very low throughout the project area. The highest sedimentation predicted is within the HMAS *Coonawarra* basin, where the dredging is to be undertaken. The modelled thickness of fine material deposition within this portion of the dredge area is approximately 10 mm. Beyond the basin area, fine material deposition is lower with a nearshore area likely to receive up to approximately 5mm (and up to 8mm in a smaller area closer to the basin), with the remainder of the area to experience less than this.

These modelling outcomes confirm the initial predictions as presented in the Referral, which noted that it is unlikely that released fine sediments will remain close to the discharge location, given that the bed stresses in this area of the harbour are very high.

Some short-term temporary settling of fine material may occur within the extents of the plume, during low current periods (e.g. at turn of the tide), however, this would be resuspended and dispersed when currents increase. The erosion and sediment transport processes within the main plume area are consistently high, typically exceeding critical erosion stresses by orders of magnitude on a daily basis.

Fine materials fall out of suspension and remain on the bed where bed stresses are very low, particularly along the margins of the intertidal area around small foreshore areas, mangrove fringes and in enclosed basins. Modelling of the fate of material supports this finding (Figure 3.26), indicating settling in the low energy environment of Cullen Bay and in artificially deepened areas at Fort Hill (less than 3 mm). The deposition of fine marine sediments across these nearshore areas would be indiscernible from the distribution of natural sediments that continually circulate via the same resuspension and deposition processes.

The distribution of fine sediment deposition within the harbour has been compared with the benthic habitat mapping for the project area in Figure 3.26. The majority of fine sediment deposition will occur in areas which are characterised by bare substrate with sparse filter feeders. Modelling results also indicate that deposition of up to 2 mm of fine sediments in the vicinity of small patches of mangroves which occur along the rocky intertidal area following the Darwin esplanade shoreline. This is an order of magnitude less than the level of sediment deposition which may cause stress to mangroves (50 mm), as discussed in Section 2.6.3.

3.5 MODEL CONSISTENCY WITH WAMSI GUIDELINE

The WAMSI Dredge Science Node '*Guideline on dredge plume modelling for environmental impact assessment'* focusses on the prediction of impacts to benthic communities and habitats from the effects of sediment introduced to the water column as a result of dredging and dredged material disposal activities. The WAMSI guideline is considered to be a source of "best-practice" guidance for dredge plume modelling for Environmental Impact Assessments (EIAs) in Western Australia and was referenced by the NT EPA in Attachment 1 of the Notice of Direction.

The guideline focusses mainly on the assessment of large scale capital dredging projects and recognises that simplified approaches may suffice for other types of dredging campaigns (e.g. smaller scale, shorter duration, simpler conceptual processes).

The modelling effort to date has taken into consideration aspects of the guidelines which are applicable to the project situation given the scale and nature of the proposed works and the conceptual understanding of the physical and environmental processes at the site. The supplementary modelling undertaken focuses on the prediction of far-field (passive) impacts of dredge plumes and has been used to further support the assessment of impacts on those benthic habitats within the predicted zones of impact and influence.

Additional information has been presented in the SER to improve confidence in the hydrodynamic and plume dispersion model results, and thus impact predictions. Of relevance are the development of the 3D model, and examination of further historic dredging data sourced during the SER process.

Further discussion regarding the application of the WAMSI Guideline, the baseline and model input datasets used in the modelling process, including bathymetry data, physical environment datasets, benthic habitat data and suspended sediment observations is provided in the Supplementary Dredging Modelling Report included as Appendix D.

3.6 BASELINE WATER QUALITY MONITORING DATA

A substantial amount of water quality data was reviewed and analysed to support the impact assessment process and coastal processes modelling outlined in the Referral. Although this provided an understanding of the typical baseline conditions experienced within the vicinity of HMAS *Coonawarra*, additional data from DEPWS has now been obtained which spans a longer period of time and the data has been reanalysed along with baseline data captured by 'pre-start' monitoring for the previous 2006 and 2013 dredging campaigns.

The INPEX long term water quality data collected between 2010 and 2011, along with water quality data collected for INPEX within Fannie Bay between 9 November and 9 December 2012, remain relevant to the proposed works as discussed in Section 7.6 of the Referral. These data sets provide a good basis for understanding baseline water quality conditions experienced within the broader harbour area as well as the nearshore shallow water environment of Fannie Bay which is of direct relevance to the proposed works given its proximity to HMAS *Coonawarra*.

In addition to the discussion of baseline water quality provided in Section 7.6 of the Referral, further assessment and reanalysis of data associated with the following water quality monitoring programs has been undertaken to demonstrate the natural water quality variability principally associated with the sediment transport processes experienced within this section of the harbour:

- DEPWS estuarine monitoring program associated with eight monitoring locations spanning between 2012 to 2020
- DEPWS Flow-cell monitoring data from 2017 to 2021
- Nearshore water quality data collected prior to 2006 dredging campaign
- Time series water quality logger data collected prior to the 2013 dredging campaign
- Water quality depth profile data collected prior to the 2013 dredging campaign

Further discussion and analysis of these additional baseline water quality monitoring data sets relevant to HMAS *Coonawarra* is provided in the following sections.

3.6.1 DEPWS Estuarine Water Quality Monitoring

As outlined in the published Referral documentation, the water quality of Darwin Harbour is regularly monitored and compared with relevant standards for the protection of environmental, recreational and cultural values. The Department of Environment, Parks and Water Security (DEPWS) annually collates water quality data for Darwin Harbour from a range of monitoring programs including data collected by DEPWS, other government agencies and the private sector. The monitoring program managed by DEPWS covers ambient environmental monitoring of the harbour and its waterways with the results of the water quality monitoring program reported in the annual Darwin Harbour Region Report Cards.

Since publication of the Referral, the 2021 Middle Harbour Report Card (DEPWS, 2021) has become available. Summary data for offshore locations in this part of the harbour indicates, similarly to that of 2020, that turbidity levels are typically low, with periods of elevated turbidity between 2.5 NTU and 12.5 NTU occurring at times, which is slightly higher than the previous year.

To better understand water quality conditions within proximity to the HMAS *Coonawarra* project area, available water quality data associated with the relevant estuarine monitoring sites up to the end of 2018 was originally obtained from DEPWS. To support this assessment, more recent data was requested from the department. Water quality data up to the end of 2020 was obtained and the monitoring sites addressed in the published Referral were reanalysed along with four additional monitoring locations within the harbour (Figure 3.27).

Where available, water quality parameters including dissolved oxygen (DO), pH, salinity, nutrients turbidity, and wet/dry season variations in turbidity were also reviewed for each monitoring location and are summarised in Tables 3.1 to 3.8.

Reanalysis of the available data supports the findings presented in the Referral, with average turbidity values generally in the order of 3 NTU during the dry season and 5 NTU during the wet season. This limited data set also shows that variations in turbidity are commonly observed, with turbidity levels ranging between approximately 1 NTU and 29 NTU. Slightly higher turbidity levels are observed at these sites during the wet season, however it is evident that this monitoring program is somewhat biased to the dry season and neap tidal conditions and is not designed to detect short-term, spatially specific water quality changes (Makarynska, 2019).

As noted in the Referral, the greatest fluctuations in turbidity levels for these estuarine monitoring sites are observed at site G8155136 which is located approximately 2 km west of HMAS *Coonawarra*. At this location turbidity levels are typically in the order of 3 NTU to 6 NTU with periodic seasonal fluctuations ranging between 17 NTU and 29 NTU during the dry and wet season, respectively. It is however acknowledged that each of the estuarine monitoring locations are situated further offshore where the resuspension of fine sediments due to wind and wave mechanisms is not as prevalent, which is what more commonly occurs in the nearshore setting of the project. These locations are also more commonly monitored during neap tide conditions, which does not capture the naturally higher turbidity levels which typically occur during spring tides.

Table 3.1 Water quality summary data for Estuarine Monitoring Location G8150391

Data	DO (mg/L)	pH (Field)	Salinity (ppt)	Turbidity (NTU)	Wet Season (NTU)	Dry Season (NTU)
Min	5.1	7.2	31.2	0.8	1.3	0.8
20th %ile	5.5	7.8	33.9	1.7	1.8	1.7
Median	5.8	7.9	35.6	2.3	2.6	2.2
80th %ile	6.4	8.1	36.8	3.3	3.8	2.8
Max	7.0	8.5	37.8	9.4	6.9	9.4
No. of measurements	24	24	25	88	36	52
Duration	June 2012 - May 2020	June 2012 - May 2020	June 2012 - May 2020	June 2012 - May 2020	Oct 2012 - Oct 2018	Jun 2012 - May 2020

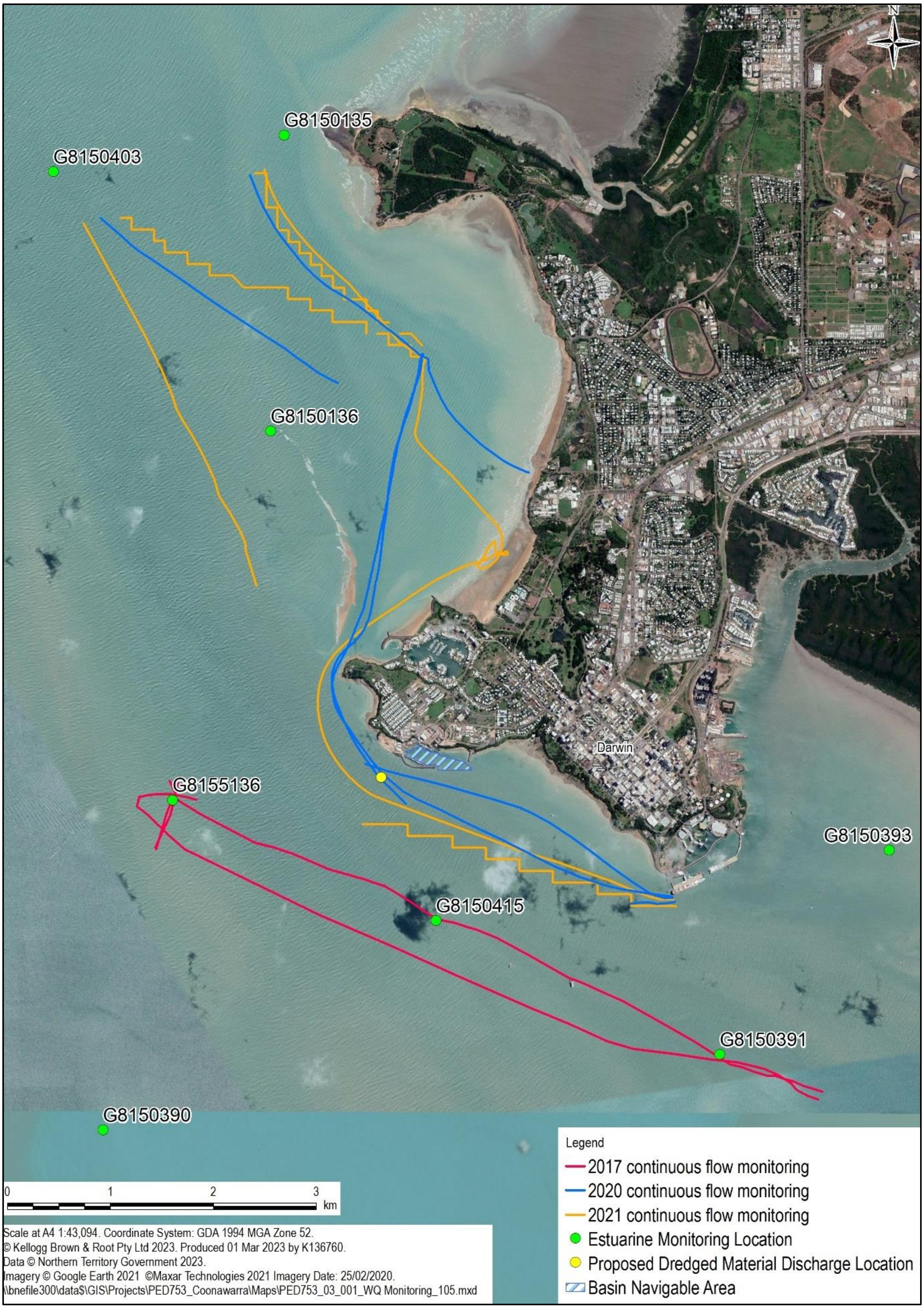

Figure 3.27 DEPWS Estuarine Water Quality Monitoring and Continuous Flow Monitoring Locations

Table 3.2 Water quality summary data for Estuarine Monitoring Location G8150415

Data	DO (mg/L)	pH (Field)	Salinity (ppt)	Turbidity (NTU)	Wet Season (NTU)	Dry Season (NTU)
Min	5.8	8.2	37.7	0.3	1.6	0.3
20th %ile	5.9	8.2	37.8	1.7	1.9	1.3
Median	6.1	8.2	37.9	2.3	3.0	1.7
80th %ile	6.2	8.2	38.1	3.4	3.9	2.2
Max	6.3	8.2	38.2	5.5	5.5	3.4
No. of measurements	2	2	2	37	22	15
Duration	May-20	May-20	May-20	July 2017 - May 2020	Nov 2017 - Oct 2018	July 2017 - May 2020

Table 3.3 Water quality summary data for Estuarine Monitoring Location G8155136

Data	DO (mg/L)	pH (Field)	Salinity (ppt)	Turbidity (NTU)	Wet Season (NTU)	Dry Season (NTU)
Min	4.7	7.2	21.5	0.4	0.8	0.4
20th %ile	5.2	8.4	32.8	1.8	2.1	1.5
Median	5.6	8.5	34.5	3.2	3.4	2.9
80th %ile	5.8	8.6	35.5	5.7	6.2	5.0
Max	7.1	8.8	39.1	29.0	29.0	17.0
No. of measurements	285	396	392	157	86	71
Duration	Feb 1987 - May 2020	Dec 1986 - May 2020	Dec 1986 - May 2020	Oct 1990 - May 2020	Oct 1990 - Apr 2018	May 1991 - May 2020

Table 3.4 Water quality summary data for Estuarine Monitoring Location G8150136

Data	DO (mg/L)	pH (Field)	Salinity (ppt)	Turbidity (NTU)	Wet Season (NTU)	Dry Season (NTU)
Min	5.2	7.7	28.0	0.9	1.4	0.9
20th %ile	5.9	7.9	33.8	1.5	1.5	1.5
Median	6.2	8.1	34.8	1.9	1.6	2.0
80th %ile	7.1	8.3	37.2	2.3	1.9	2.7
Max	9.5	8.4	39.2	5.3	2.1	5.3
No. of measurements	14	14	14	16	3	13
Duration	Aug 2010 - May 2020	Aug 2010 - May 2020	Aug 2010 - May 2020	Aug 2010 - May 2020	Mar 2011 - Mar 2016	Aug 2010 - May 2020

Table 3.5 Water quality summary data for Estuarine Monitoring Location G8150403

Data	DO (mg/L)	pH (Field)	Salinity (ppt)	Turbidity (NTU)	Wet Season (NTU)	Dry Season (NTU)
Min	5.4	7.3	26.1	0.3	1.1	0.3
20th %ile	5.8	7.7	34.2	1.2	1.2	1.2
Median	6.3	7.9	35.5	1.9	2.1	1.9
80th %ile	6.9	8.1	36.2	3.3	2.9	3.4
Max	7.7	8.3	38.4	10.2	5.2	10.2
No. of measurements	18	18	18	45.0	19	26
Duration	Jul 2014 - May 2020	Jul 2012 - May 2020	Jan 2013 - May 2020	Jun 2012 - May 2020	Oct 2012 - Oct 2018	Jun 2012 - May 2020

Table 3.6 Water quality summary data for Estuarine Monitoring Location G8150135

Data	DO (mg/L)	pH (Field)	Salinity (ppt)	Turbidity (NTU)	Wet Season (NTU)	Dry Season (NTU)
Min	5.2	7.6	25.4	0.5	0.9	0.5
20th %ile	5.6	8.0	33.9	0.8	1.2	0.8
Median	6.5	8.2	35.1	2.0	1.5	2.5
80th %ile	7.1	8.3	37.3	3.4	1.8	3.5
Max	9.5	8.8	39.2	4.5	1.9	4.5
No. of measurements	14	14	14	17	3	14
Duration	Aug 2010 - May 2020	Aug 2018 - May 2020	Aug 2010 - May 2020	Aug 2018 - May 2020	Mar 2011 - Mar 2016	Aug 2010 - May 2020

Table 3.7 Water quality summary data for Estuarine Monitoring Location G8150393

Data	DO (mg/L)	pH (Field)	Salinity (ppt)	Turbidity (NTU)	Wet Season (NTU)	Dry Season (NTU)
Min	5.2	7.4	31.2	0.8	2.1	0.8
20th %ile	5.8	7.8	33.2	1.9	2.1	1.7
Median	6.2	8.0	34.9	2.5	2.2	2.7
80th %ile	6.6	8.2	36.5	3.8	2.7	4.9
Max	7.2	8.5	37.9	7.7	3.5	7.7
No. of measurements	17.0	17.0	17.0	19.0	5.0	14.0
Duration	Jun 2012 - May 2020	Jun 2012 - May 2020	Jun 2012 - May 2020	Jun 2012 - May 2020	Feb 2015 - Apr 2016	Jun 2012 - May 2020

Table 3.8 Water quality summary data for Estuarine Monitoring Location G8150390

Data	DO (mg/L)	pH (Field)	Salinity (ppt)	Turbidity (NTU)	Wet Season (NTU)	Dry Season (NTU)
Min	5.5	7.5	33.0	0.2	0.8	0.2
20th %ile	5.8	7.7	33.8	1.4	1.5	1.3
Median	6.0	8.0	35.5	2.2	2.7	1.9
80th %ile	6.6	8.2	37.0	3.3	4.0	2.8
Max	7.2	8.5	38.1	10.1	7.0	10.1
No. of measurements	14	15	15	51	15	36
Duration	Jun 2012 - May 2020	Jun 2012 - May 2020	Jun 2012 - May 2020	Jun 2012 - May 2020	Dec 2013 - Oct 2018	Jun 2012 - May 2020

3.6.2 DEPWS Flow-cell Monitoring Data

Water quality data is also collected by the Aquatic Group of the DEPWS. To assess the water quality of Darwin Harbour against the Darwin Harbour water quality objectives, surface water quality (pH, dissolved oxygen, salinity, temperature and turbidity) is measured at high frequency intervals along transects, using a continuous flow-cell method (CFM).

The CFM collects spatially extensive continuous data by driving water through the flow-cell of a water quality sonde. This occurs on a vessel while it is moving and captures water quality parameters at intervals as low as 1 second.

CFM data for Darwin Harbour was obtained from the DEPWS between 2017 and 2021. This data was reviewed, with CFM data for Middle Harbour being of most relevance to the project as shown in Figure 3.27. Analysis of the data shows that turbidity levels did not vary greatly along each transect, given that it is only representative of surface waters and a limited duration. Data for each year was analysed with median turbidity levels of 2.3 NTU, 1.3 NTU and 2.5 NTU representative of the 2017, 2020 and 2021 transects, respectively. The CFM data was however found to be biased to certain periods during the dry season on neap tides to minimise variability associated with tidal influence and is largely restricted to the surface waters within main channels. It therefore does not capture the full range of natural water quality variations experienced within the harbour, particularly nearshore fluctuations associated with strong tides and wind/wave sediment resuspension and dispersion mechanisms.

3.6.3 Other water quality baseline data sources

The published Referral discussed the relevance and applicability of baseline water quality monitoring data collected within Fannie Bay in 2013 as part of the INPEX Project.

It further discussed the outcomes of a study undertaken during the 2012-2013 and 2013-2014 wet season which identified that turbidity levels varied across the harbour and depending on the location and tidal phase. During this monitoring program values of above 40 NTU were regularly recorded during windy periods associated with the monsoon (which frequent this region) in the vicinity of the HMAS *Coonawarra* project area (Andutta et al., 2019). This study found that high turbidity values recorded in near shore areas correlate closely with increased wind and wave height due to the resuspension of fine sediments in these systems.

The outcomes of these monitoring programs continue to be of most relevance as they capture the full variability of water quality conditions experienced within the Project area, with high turbidity values recorded in the near shore areas which correlate closely with increased wind and wave height due to the resuspension of fine sediments in these systems.

3.6.4 Baseline Water Quality Data from Previous Dredging Campaigns

Baseline water quality monitoring data was captured prior to the commencement of dredging for both the 2006 and 2013 dredging campaigns. The data is representative of the natural variability in water quality conditions experienced within the nearshore setting of the project area.

Further discussion of baseline water quality conditions monitored prior to the 2006 and 2013 dredging campaigns is provided in the following sections.

Baseline Water Quality Monitoring Data – Prior to 2006 Dredging Campaign

Baseline monitoring conducted prior to the commencement of the 2006 dredging campaign showed periods of naturally high turbidity within the shallow nearshore environment of the project area. Monitoring of turbidity was carried out on a daily basis for nine days prior to dredging at a number of ambient water quality monitoring locations in the project area. Other parameters including pH, temperature, conductivity and percent (%) oxygen saturation were also recorded.

Monitoring locations of most relevance include the nearshore sites at Mindil Beach and Cullen Bay Beach to the north, and Doctors Gully to the south (Figure 3.28).

Average turbidity levels recorded at each location prior to dredging are presented in Table 3.9. Averages were based on replicate measurements which involved multiple readings taken at the same location at the same time.

At the Cullen Bay Beach location turbidity ranged between 2 NTU to 36 NTU, while during the same period turbidity at Doctors Gully ranged between 13 NTU and 363 NTU and similarly at Mindil Beach turbidity varied from 4 NTU to 225 NTU.

This data shows substantial variability in turbidity across both time and location, with turbidity peaks of varying magnitudes evident at all sites. Fluctuations in turbidity were most pronounced at Doctors Gully, albeit substantial variations in turbidity was evident across all three nearshore sites.

On the day prior to the commencement of dredging turbidity levels recorded at the discharge location were up to 45 NTU (Table 3.10), with turbidity levels recorded at the Doctors Gully shallow nearshore monitoring site, approximately 1.5 km east of HMAS *Coonawarra,* of up to 127 NTU.

Weather records show that no rainfall occurred during the month of June, which indicates that these shallow nearshore locations experience naturally high turbidity variability, which (in the absence of rainfall) is strongly influenced by wind and wave fine sediment resuspension.

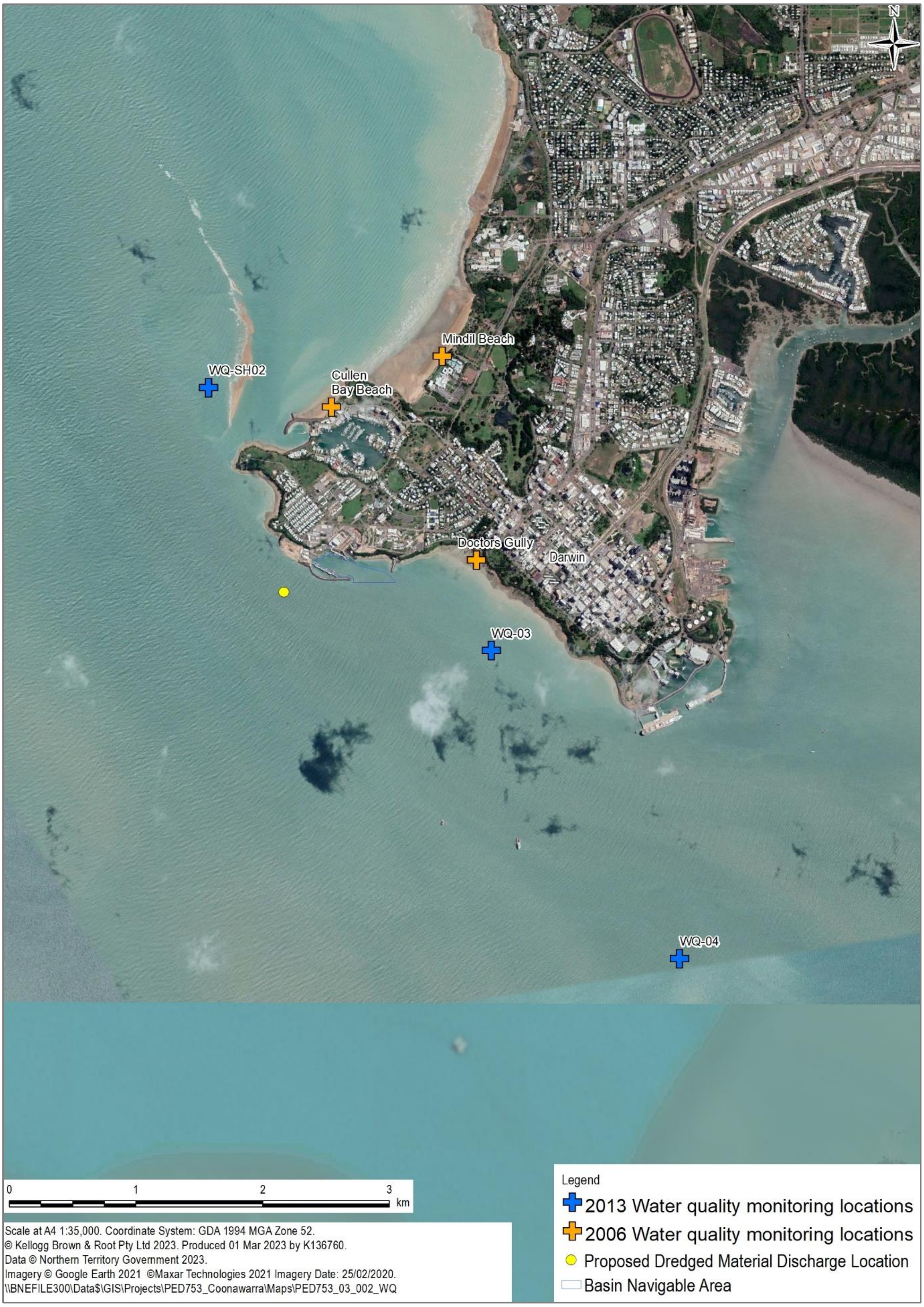

Figure 3.28 Baseline water quality monitoring locations during previous dredging campaigns

Table 3.9 Average turbidity levels recorded during baseline water quality monitoring prior to 2006 dredging campaign

Date	Mindil Beach – Average Turbidity (NTU)	Cullen Bay Beach – Average Turbidity (NTU)	Doctors Gully – Average Turbidity (NTU)
15/06/2006 (PM)	99	28	100
16/06/2006 (PM)	80	31	210
19/06/2006 (PM)	38	24	363
20/06/2006 (AM)	16	2	182
21/06/2006 (PM)	5	3	13
22/06/2006 (AM)	143	4	118
22/06/2006 (PM)	4	3	50
23/06/2006 (AM)	6	9	30
23/06/2006 (PM)	72	36	17
26/06/2006 (AM)	35	29	39
28/06/2006 (PM)	225	31	127
SUMMARY DATA (NTU)			
Min	4	2	13
20th %ile	6	3	30
Median	38	24	100
80th %ile	99	31	182
Max	225	36	363
No. of monitoring events	11	11	11

Table 3.10 Turbidity levels recorded at the discharge point the day prior to the commencement of dredging (28 June 2006)

Depth from surface	Turbidity (NTU)
Surface	45
10 m	7
20 m	9

Baseline Water Quality Monitoring Data – Prior to 2013 Dredging Campaign

Prior to the commencement of the 2013 dredging campaign, unattended water quality monitoring loggers were deployed at a number of locations within proximity to HMAS *Coonawarra* (Figure 3.28). The instruments were mounted on bed frames with sensor approximately 1 m off the bed. The instruments were deployed to collect time series turbidity data every 30 minutes during the deployment period. All loggers were deployed in depths ranging from 10m to 18m.

The time series data captured baseline turbidity conditions from 10 to 15 September 2013 and was representative of near bed conditions during the transition from a spring to neap tide. Figure 3.29 shows the time series data recorded prior to the commencement of dredging.

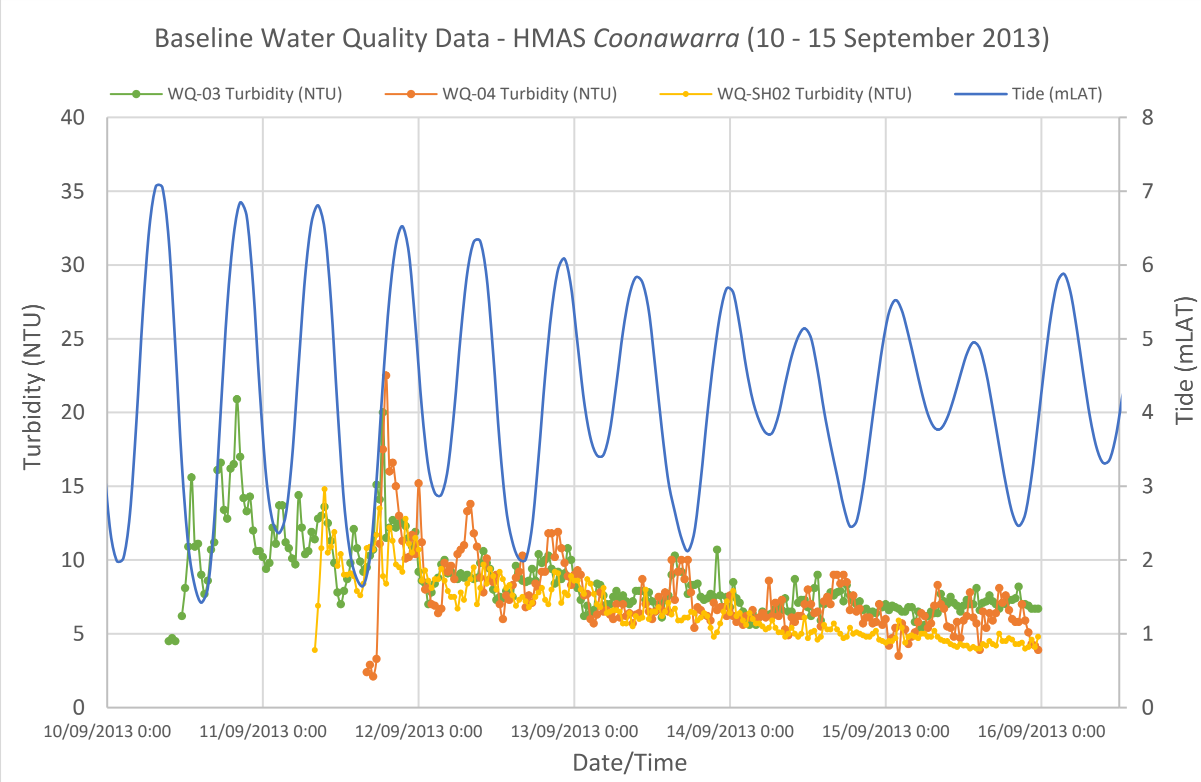

Figure 3.29 Timeseries baseline water quality data recorded between 10 – 15 September 2013

As shown in Figure 3.29, each of the three monitoring locations exhibited similar variations in turbidity, over time and in magnitude, and there is a general correlation with the magnitude of the tide. A summary of turbidity values recorded at each location is provided in Table 3.11.

Median turbidity levels for all three locations were approximately 7 NTU. However fluctuations greater than 10 NTU were regularly observed at all three locations and typically coincided with mid-tide (i.e. strongest tidal currents). Naturally high turbidity peaks of 20 NTU or greater were also observed on occasion at sites WQ-03 and WQ-04.

Table 3.11 Timeseries baseline water quality monitoring summary prior to 2013 dredging campaign

Turbidity (NTU)	Water Quality Monitoring Location		
	WQ-03	WQ-04	WQ-SH02
Min	4.5	2.1	3.9
20th %ile	6.8	5.8	4.8
Median	7.9	6.8	6.25
80th %ile	10.6	9.0	8.6
Max	20.9	22.5	14.8
No. of Measurements	268	208	224
Duration	10 - 15 Sep 2013	11 - 15 Sep 2013	11 - 15 Sep 2013

During this baseline monitoring period, no rainfall was recorded in the Darwin Harbour catchment, with the exception of 0.2mm on 10 September 2013, nor was there any substantial rainfall in the months leading up to the deployment of the instruments. With the lack of catchment inputs to the system, the natural variations in turbidity are the result of the large tidal range, strong tidal currents and wind wave shallow water resuspension within this area of the harbour.

The baseline monitoring period captures the end of a spring tide and extends into the early stages of a neap tidal cycle. Slightly higher turbidity levels recorded towards the beginning of the monitoring period indicates that the larger tides and currents experienced during this time are the principal mechanisms driving sediment movement and resuspension in the water column. Similarly, these processes are still evident during the neap tide however are not as strong and therefore the effect of the tide and velocity of currents is not as pronounced but nearshore/shallow resuspension is still evident, and this is dispersed around our area of interest.

3.6.5 Summary of Baseline Water Quality Conditions

Review of this baseline data confirms the conceptual understanding of sediment related water quality at the site, which is located within a dynamic tidal system with strong tidal currents and sediment transport processes attributable to the large tidal range and pronounced monsoonal climate. Water column turbidity is principally linked to tidal current velocity with fine sediment resuspended by currents and distributed throughout the harbour as natural sediment 'plumes'. Reanalysis of the available data sets supports the findings presented in the Referral, with long term average turbidity values typically in the order of 3 NTU during the dry season and approximately 5 NTU during the wet season, but with frequent short term peaks of much higher than that and very high turbidities experienced in shallow turbulent nearshore areas.

Satellite data also provides a useful understanding of baseline conditions experienced at the site over the different tidal cycles. Figures 3.30 and 3.31 show satellite imagery captures of the project area from August and September 2022, which are representative of the dry season with no rainfall occurring at the time of the captures or from the three months preceding them. These images clearly show the dynamic sediment transport processes which occur on a daily basis within the harbour during both spring and neap tides. The repeated resuspension and temporary settling is also evident in the near-bed time series baseline water quality logger data captured prior to the 2013 dredging campaign.

Figure 3.30 provides a snapshot of the substantial movement and redistribution of sediment throughout the entire harbour which occurs during spring ebb tides. This image shows that even in the absence of rainfall, currents and turbulence cause elevated suspended sediment concentrations in the water column, the effects of which are typically more pronounced during spring ebb tides.

Water quality conditions associated with a neap flood tide are shown in Figure 3.31. This image shows that although less prominent, the effects of the tide and currents still influences sediment movement and resuspension in the water column. Most notably it demonstrates the natural resuspension of sediments within the shallow nearshore environment, which is influenced by wind wave turbulence, and generates turbidity which is then distributed by the currents.

3.7 ADDITIONAL BASELINE WATER QUALITY DATA COLLECTION

As outlined in the Referral and above, a substantial amount of relevant water quality data has been reviewed and has since been reanalysed. While a good understanding of baseline conditions including the natural variations experienced in this area of the harbour has been established, it is acknowledged that it would be beneficial to collect site specific nearshore time series water quality data and associated depth profiles to improve upon the understanding of natural processes and variations experienced at the site and to support the management of future dredging campaigns.

The current dredging campaign is scheduled to occur in the dry season, and a baseline water quality monitoring program has been scheduled to obtain representative turbidity (NTU), total suspended sediment (TSS) and PAR data, which will be both temporally relevant and available prior to the commencement of dredging.

Figure 3.30 Substantial sediment transport processes which occur during spring ebb tides (Satellite imagery capture: 27 August 2022)

Figure 3.31 Sediment transport processes occurring during neap flood tide, and shallow water resuspension within the nearshore environment (Satellite imagery capture: 12 September 2022)

This will include the deployment of bed frame mounted monitoring instruments to capture this water quality data over a one month period at three locations as shown in Figure 3.32. The timing and duration of monitoring is intended to capture data over two spring and neap tide cycles.

The monitoring locations previously proposed in the published Referral have been reviewed and amended based on the updated predicted sediment plumes and the type and extent of benthic habitats known to occur within the project area. The locations recommended by DEPWS in Table 1 of the Notice of Direction are also incorporated.

Monitoring location WQ1 has been slightly repositioned within the entrance to Fannie Bay as this will provide data representative of the shallow nearshore areas of the bay which are influenced by wind/wave resuspension (and at times known to support potential seagrass habitat). In addition, during dredging, this water quality monitoring location will provide an early warning of any dredge related sediment plume that may enter the Fannie Bay area (noting that historical monitoring data and updated modelling do not predict this will occur).

The other two monitoring locations will be positioned within the harbour to the north and south of HMAS *Coonawarra*. Data from these locations will reflect water quality conditions largely influenced by the tide and the broader redistribution of sediment throughout the harbour. Monitoring location, WQ3, has been repositioned near Bennett Shoal as was recommended by DEPWS. It will capture flood tide effects.

A new monitoring location, WQ4, has been added west of the offshore sand bank, again as recommended by DEPWS. It will capture ebb tide conditions.

The instrumentation to be deployed at Fannie Bay will also include a tethered surface buoy with a water quality monitoring instrument to capture turbidity and PAR at approximately 0.5 m from the surface (this can be telemetry enabled during dredging).

Monitoring parameters will be logged at 15 minute intervals at all locations to create a time series data record for each location over the 30 day deployment period.

During deployment and retrieval of the instrumentation, conductivity, temperature and turbidity (NTU) profiles will be measured at each location and elsewhere within the predicted zone of influence. These measurements will be taken at the time of instrument deployment and retrieval which will likely be timed to occur at/near the turn of the tide and also at approximately half tide on the same day when tidal current velocities are greater.

Similarly, during deployment and retrieval a series of water samples across the range of turbidity conditions observed will be collected and analysed across each of the locations for field measured turbidity and laboratory determined Total Suspended Solids (TSS). The collection and analysis of these samples will assist in further establishing the relationship between NTU and TSS.

Data from this additional baseline monitoring will be assessed to confirm the current understanding of baseline conditions and identify whether any adjustments may be needed to the monitoring planned during the current dredging campaign. It will also be used to support the assessment and management of future dredging campaigns at HMAS *Coonawarra*.

3.8 TURBIDITY AND SUSPENDED SOLIDS RELATIONSHIP

3.8.1 Turbidity and TSS

The characteristics of the sediment to be dredged are fully reported in the published Referral (Section 7.4). The fine material to be dredged (the recently accumulate upper layers which represent most of the volume to be discharged) consist of the same fine sediments which are circulating in suspension within Darwin harbour.

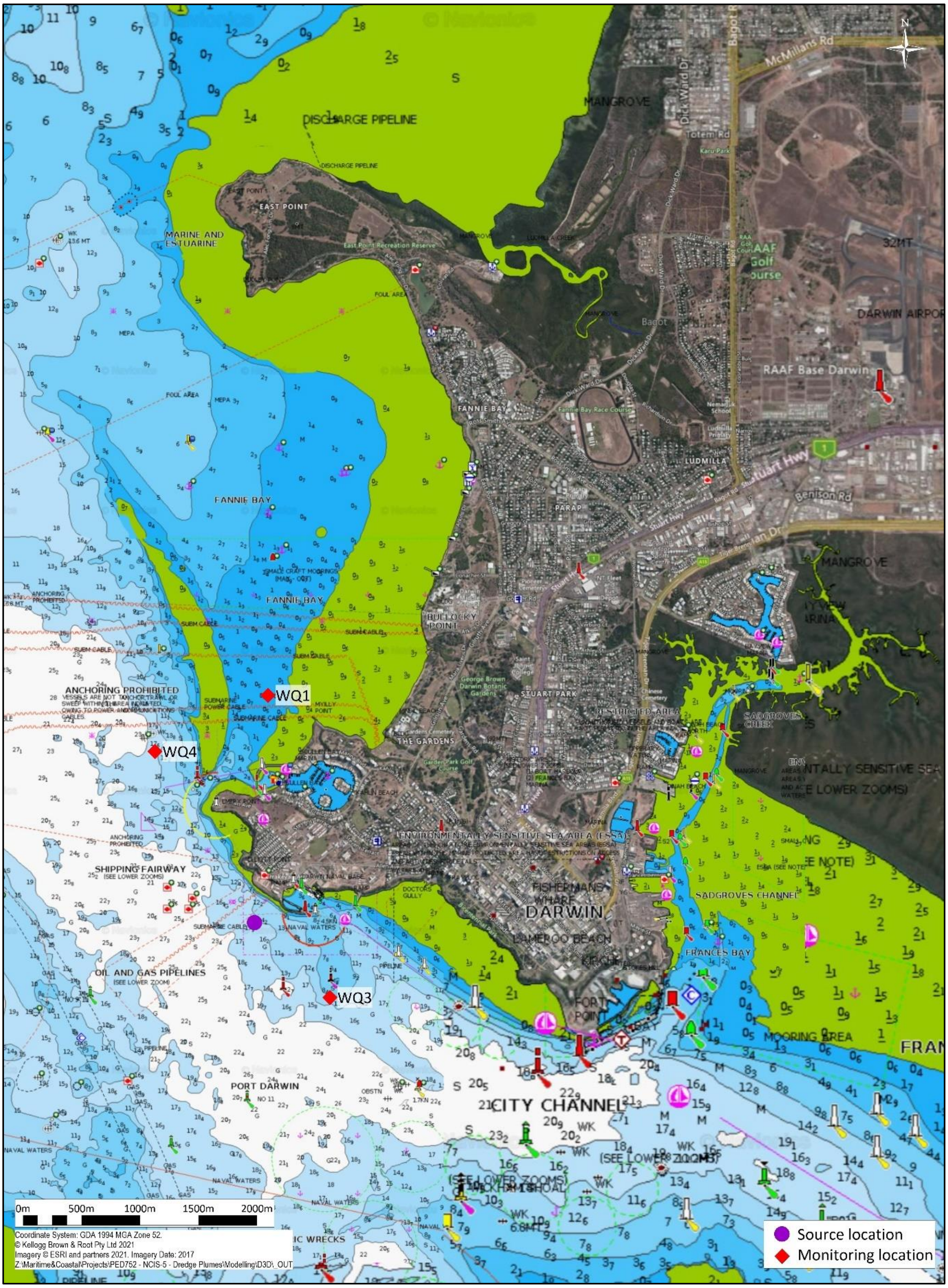

Figure 3.32 **Proposed water quality monitoring locations**

From the sediment investigations undertaken at the site, the characteristics of these fine sediments is well understood. Further discussion of these sediment characteristics is provided in the Supplementary Dredging Modelling Report included as Appendix D (Section 2.3).

The model predicts suspended sediment plume concentrations as total suspended solids concentration (TSS) in mg/L but this cannot be monitored directly in the environment as it is a laboratory determined parameter. Turbidity (NTU) is therefore used for field measurements. The relationship between these two parameters needs to be established with site specific and 'dredged material specific data'. Currently for assessment purposes, a relationship of 1:1 between NTU and suspended solids concentration has been adopted based on the harbour-wide NTU/TSS relationship of 1:1 which was derived during the INPEX capital dredging program undertaken in 2013 (Cardno, 2013). This relationship has again been applied to the 2023 – 2027 Ichthys LNG Maintenance Dredging Program (INPEX, 2022).

As described in Section 3.7, project specific and site specific data will be collected during the scheduled baseline monitoring to further establish the relationship between TSS and NTU. This will provide temporally relevant data prior to the commencement of dredging which will be used to review the modelled predications and determine whether adjustment to field monitoring criteria is necessary. In addition, further site specific data will be collected during the current dredging campaign to support the assessment and management of future dredging campaigns at HMAS *Coonawarra*.

3.8.2 TSS and PAR

Published literature and previous water quality monitoring programs which have collected PAR data to support dredging campaigns within Darwin Harbour have been reviewed to examine the relationship between suspended sediment and light availability. For example, benthic light levels at the seabed in Darwin Harbour were investigated as part of the Ichthys NEMP. It was found that the intensity of underwater light, measured as PAR, decreases exponentially with increasing depth in the water column.

Low benthic light levels are known to occur at any time of the year within Darwin Harbour, typically due to the coincidence of high tides and elevated turbidity. Extended periods of naturally low light levels and 'blackout' conditions (i.e. no benthic light) are most prevalent during episodic events in the wet season; however, these occur variably (Cardno, 2015c).

As outlined in Section 3.7 and 3.11, PAR data will be collected prior to the commencement of dredging and during the current dredging campaign. This site specific data will be reviewed to further understand the relationship between benthic light availability and those established benthic communities within the zone of influence and will be used to inform future dredging campaigns. Given the lack of strongly light sensitive benthic communities within the broader project area the relationship between suspended sediment and light availability at the seafloor is considered less critical to the assessment of dredging and discharge related activities at the site but nonetheless further data collection will be undertaken to provide additional understanding of this and inform future campaigns.

3.9 PROPOSED CRITERIA, ZONE OF IMPACT/INFLUENCE AND TRIGGER VALUES

The proposed suspended sediment concentration trigger values outlined in the published Referral have been reviewed based on the outcomes of the benthic habitat assessment, further examination of available baseline water quality data, and review of available literature on the tolerance limits of those benthic habitats present within the zone of influence.

Given that quantitative data on tolerance thresholds for filter feeder species is limited, criteria which reflects a conservative approach and the impact mechanisms identified has been adopted.

It is proposed that suspended sediment concentration trigger levels of 10 mg/L and 23 mg/L be adopted to represent the Zone of Influence and Zone of Low to Medium Impact, respectively. These trigger values would be applied to both the dry and wet season and will be reviewed once baseline data has been obtained (i.e. at this stage these trigger values are effect based).

As outlined in Section 2.6.1, these values are considered to be conservative given that they are derived from observations of 28 days continuous exposure to elevated suspended sediment concentrations. During the proposed dredging, elevated concentrations of suspended sediment will not be constant given the strong bidirectional currents experienced within the project area and that dredging and discharge operations will not be continuous.

In addition, modelling indicates that elevated suspended sediment concentrations typically last 12 hrs before returning to baseline conditions, which is substantially less than the 28 days of continuous exposure which the trigger levels are based on. The duration of 'high peak' periods are shorter and range between 2 to 4 hours. Modelling also shows no gradual increase in the underlying 'baseline' concentrations which indicates that once dredging is complete the system will quickly return to its pre dredging condition.

The definitions for each zone of impact and zone of influence have been updated and are described below.

Zone of High Impact

This zone constitutes the area of the coarse heavy material deposition which is predicted to occur within the immediate vicinity of the dredge (within the basin) and discharge location and accounts for smothering/blanketing from coarse sediments discharged during dredging.

Based on the outcomes of the recent benthic habitat survey, the filter feeders present within the vicinity of the discharge location are evidence of recovery from similar effects during the previous dredging campaign.

Zone of Low to Medium Impact

Within this zone, some impact to benthic habitats and benthic biota may occur as a result of indirect impacts from increased suspended sediment which occur at times occur within this zone. While impacts within this zone are predicted to occur, there is a good likelihood that disturbed areas will recover after completion of the dredging and disposal operations.

It is expected that there will be no long-term modification of the sponge dominated filter feeder communities in this zone. The outer edge of the Zone of Low to Moderate Impact is delineated by the 90th percentile 23 mg/L contour plot for suspended sediment concentration, as defined by dredge plume modelling. This delineates the areas within which the 90th percentile concentration is predicted to be above the trigger value of 23 mg/L suspended sediment concentration.

Zone of Influence

This zone includes the areas in which, at some time during the dredging works, benthic communities may experience (detectable) changes in sediment-related environmental quality. However, the intensity, duration and frequency of these changes is such that any stress or impact to benthic habitats is likely to be reversable and no mortality of benthic biota is expected to occur.

The outer boundary of this zone is delineated by the 90th percentile 10 mg/L contour plot for suspended sediment concentration as defined by dredge plume modelling. This reflects the area where, for 90% of the time, suspended sediment concentrations from dredging and discharge related activities will be above the tolerance limit of 10 mg/L for filters feeders but below 23 mg/L.

Figures 3.33 and 3.34 present the predicted zones of impact and influence during the dry and wet seasons respectively. Figures 3.35 and 3.36 represents those benthic habitat communities within the zones of impact and influence.

The updated modelling results and the resulting zones of impact and influence, show high suspended sediment concentrations from dredging and discharge related activities will occur periodically within the areas up-current and down-current of the dredge and discharge location.

No benthic communities which are dependent on benthic light availability have been identified within the zones of impact and influence. The nearest area which could at times be sensitive to changes in benthic light availability, is the potential seagrass habitat located to the north of the project (outside of the predicted zone of influence) within Fannie Bay. As shown in Figures 3.35 and 3.36 the predicted zones of impact and influence do not reach this area.

Modelling shows that while elevated suspended sediment concentrations are predicted to occur throughout the dredging campaign, the duration of the ‘high peak’ periods is generally short and ranges between 2 to 4 hours. Based on the modelling predictions and the results of previous dredging campaigns at HMAS *Coonawarra,* once dredging is complete the system will quickly return (within 3 to 4 days) to its pre dredging water quality condition (i.e. near baseline marine water quality conditions).

Based on modelling results, the fact that dredging operations will not be continuous, (i.e. typically daylight hours, six days a week with multiple stoppages) and that suspended sediment concentrations consistent with the modelled predictions occur as part of the natural variation within the areas of the harbour where filter feeders are present, it is unlikely that permanent impacts would occur.

Recolonisation (recovery) of filter feeder communities in the initial deposition area near the discharge will be influenced by alterations to the substrate that may occur as a result of dredged material discharge.

As shown by the benthic habitat assessment, the presence of filter feeders within the vicinity of the discharge location is evidence of recovery from similar effects during the previous dredging campaigns. It is also likely that upon cessation of the discharge activities, the presence of harder substrate materials within what is deposited will provide opportunities for the regrowth of filter feeders.

With respect to suspended sediment related stresses beyond this area, studies have shown that sponges with morphologies consistent with those in the project area are capable of recovery from exposure to the predicted range of suspended solids conditions within weeks of the cessation of elevated concentrations (WAMSI, 2019).

3.10 SUITABILITY OF NEARSHORE DISHCHARGE LOCATION

The dredged sediment release point is approximately 300m south-west of the western breakwater, which is the discharge location previously used for basin dredging.

Within the vicinity of the dredged material discharge location, bed level is approximately -15 mLAT and the currents are strong on both the incoming and outgoing tides. Modelling shows that the proposed discharge location is not within a depositional area given that the currents experienced at the site are of high velocity with sediment transport processes typically following the strong ebb and flood currents.

Given the dynamic tidal regime at the proposed discharge location and the predominantly fine particle size of the dredged sediment, modelling indicates that sediment deposition within the vicinity of the discharge location would be limited to the small proportion of coarse/heavy particles which settle very quickly to the bed.

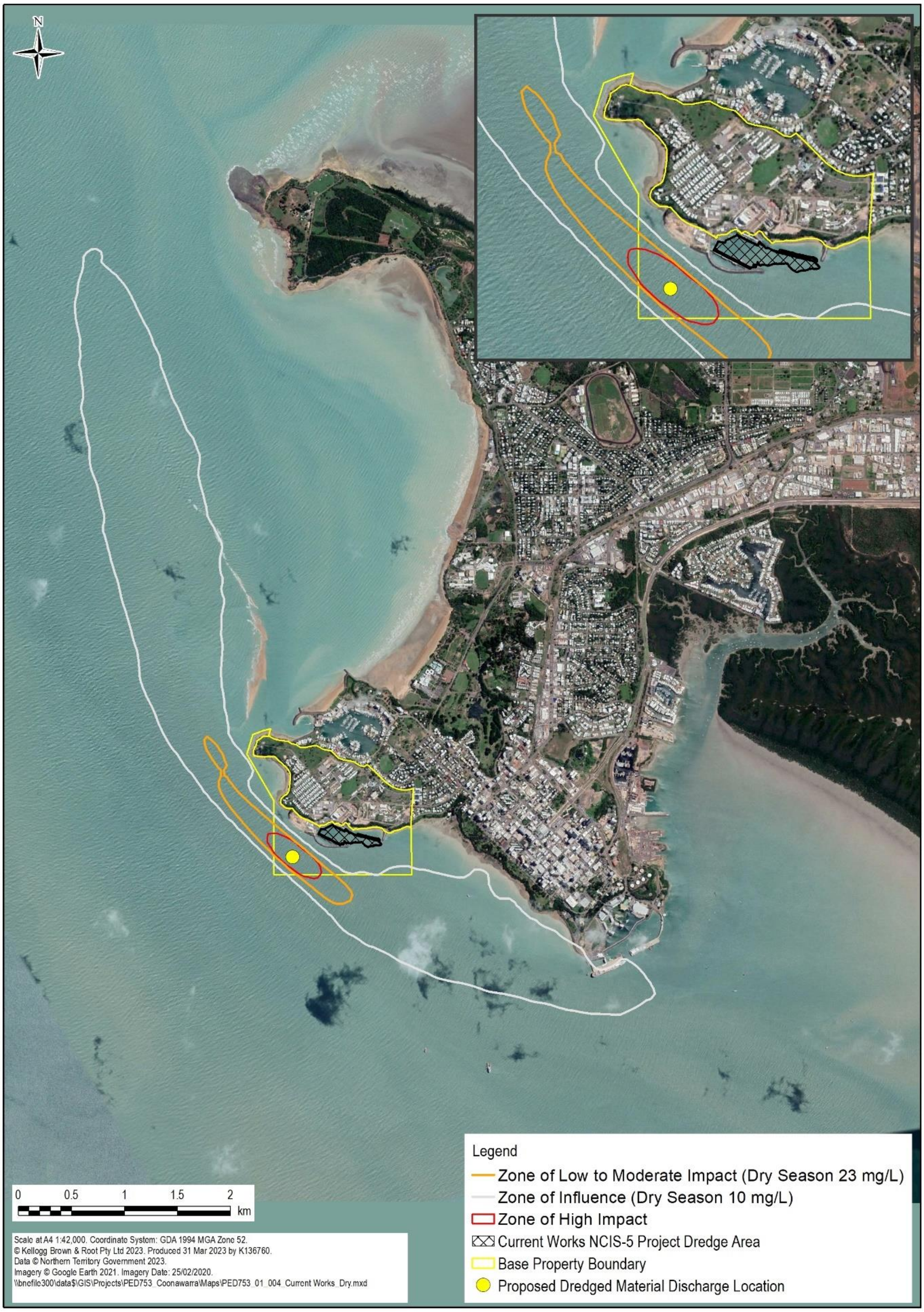

Figure 3.33 **90th percentile current NCIS-5 project suspended sediment concentration – Zones of impact and influence (Includes 3 mg/L background – Dry Season)**

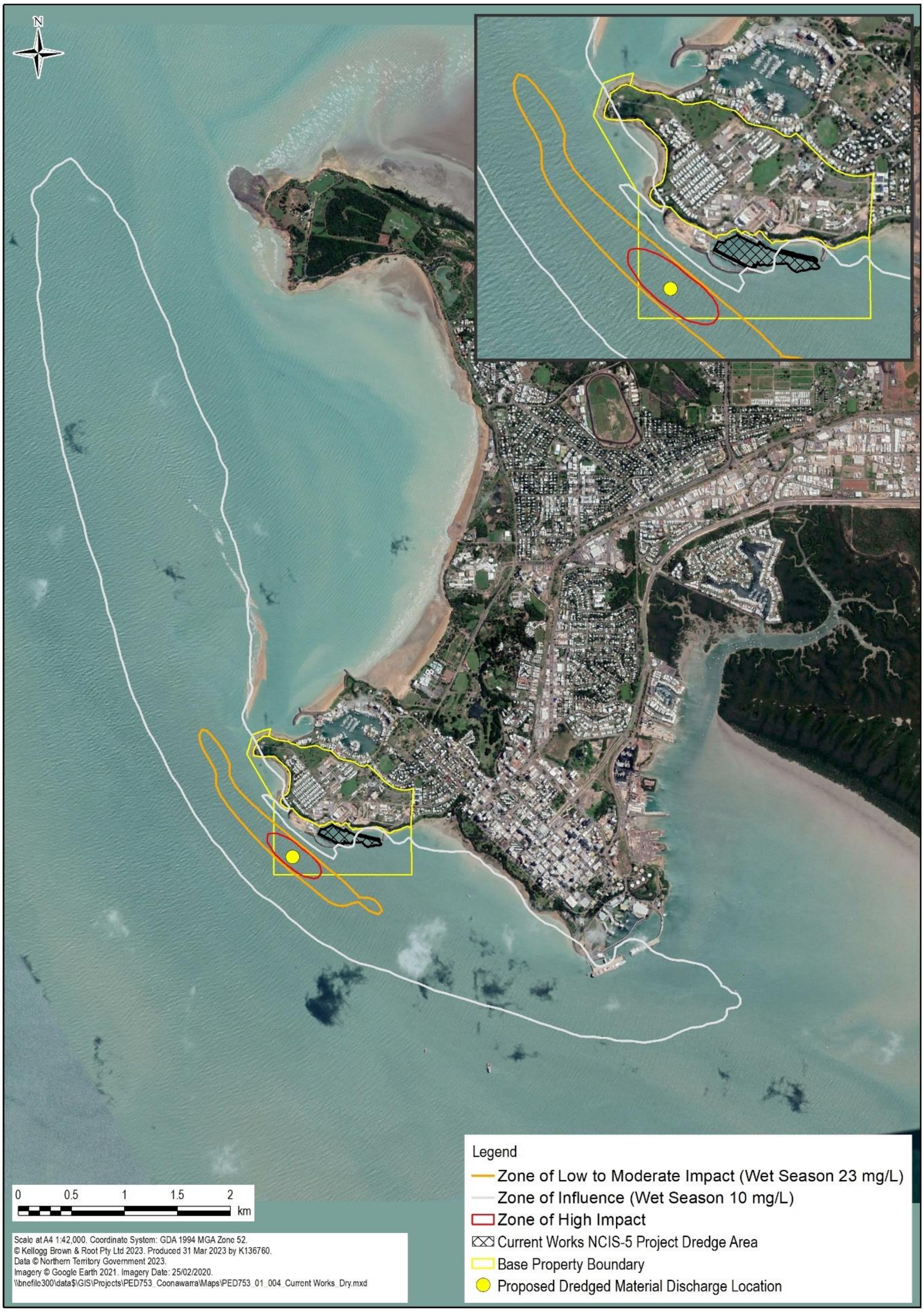

Figure 3.34 **90th percentile current NCIS-5 project suspended sediment concentration – Zones of impact and influence (Includes 5 mg/L background – Wet Season)**

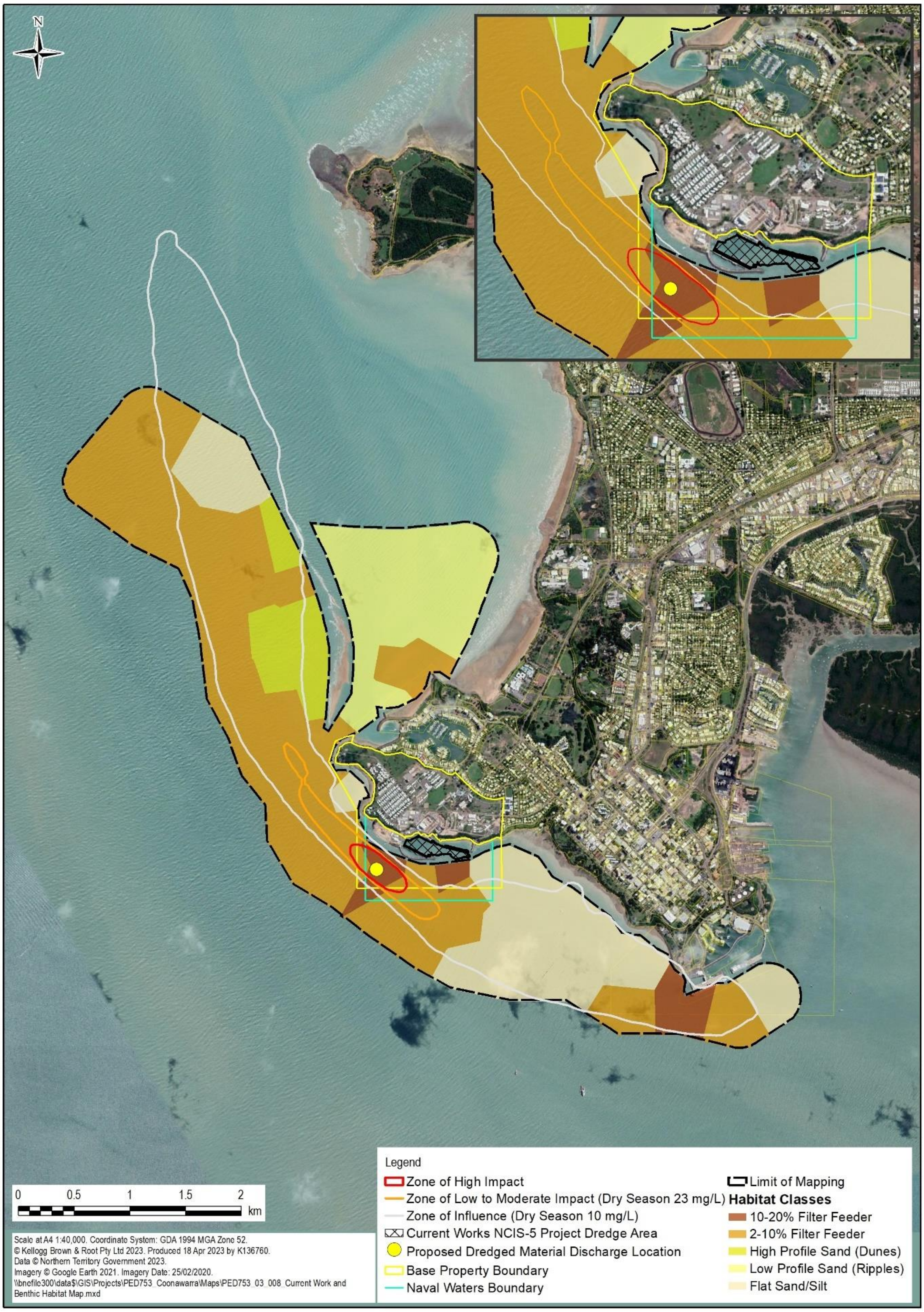

Figure 3.35 **Benthic habitats within the 90th percentile suspended sediment concentration zones of impact and influence (Includes 3 mg/L background – Dry Season)**

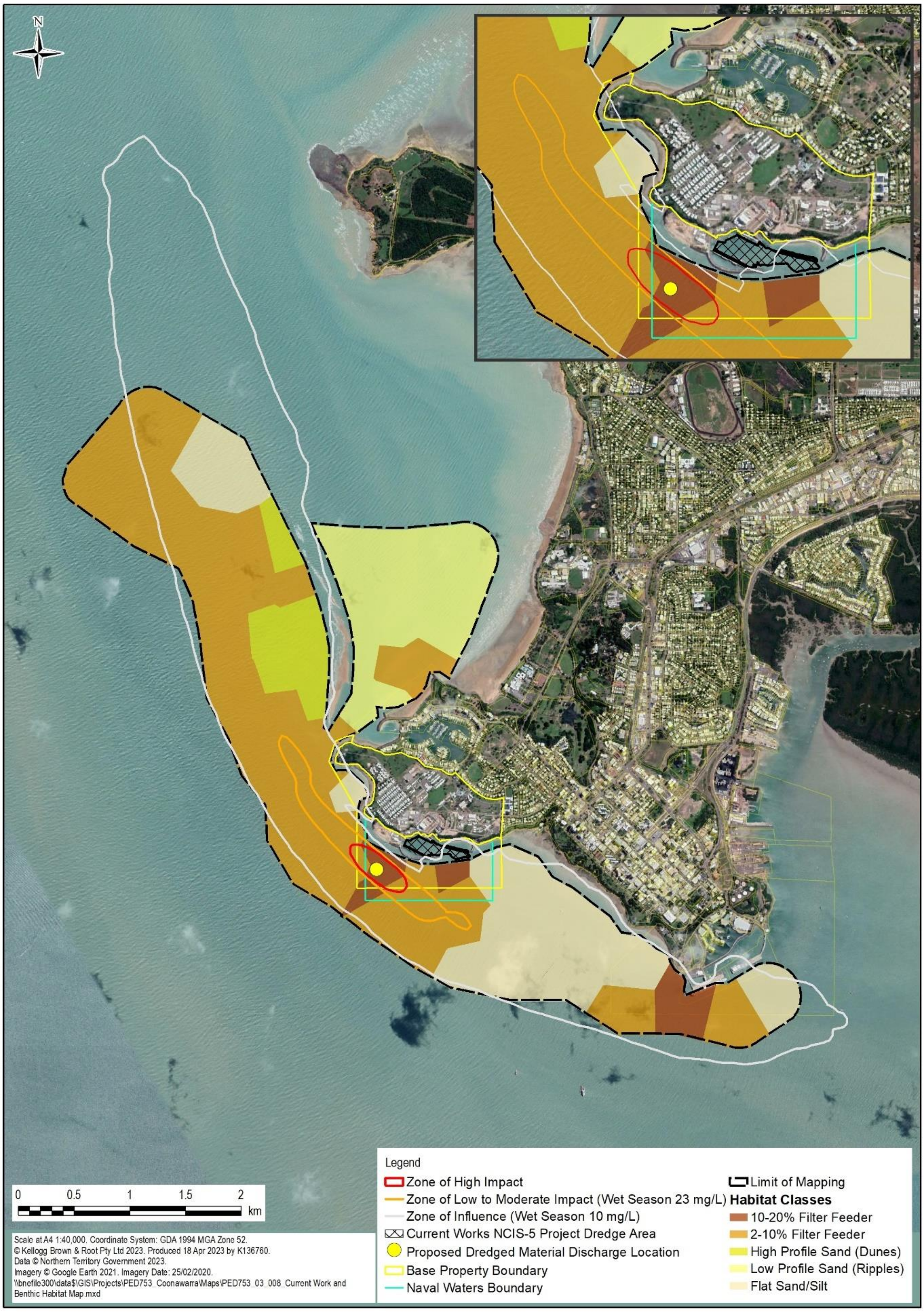

Figure 3.36 **Benthic habitats within the 90th percentile suspended sediment concentration zones of impact and influence (Includes 5 mg/L background – Wet Season)**

Based on the results of the benthic habitat assessment, and further review and re-analysis of other available benthic habitat data sets, bare substrate which supports sparse sponge dominated filter feeders is the only sensitive receptor within the predicted zones of impact and influence. Given the dynamic and turbid nature of the broader project area and Darwin Harbour in general, it is expected that these filter feeder communities would be well adapted to such conditions.

The chosen disposal location (and resulting plume) area support similar unremarkable benthic habitat to that of the surrounding harbour area. The disposal location is not located near any notable sensitive receptors, it is positioned within a relatively uniform section of the harbour with no particular constraints indicating a better location. The environmental values of the disposal location and surrounding area to be impacted are well represented throughout Darwin Harbour.

3.11 REVISED MONITORING PROGRAM

The proposed dredging monitoring program has been reviewed and refined based on the outcomes of the supplementary assessment. Amendments to the program have been made in line with the impact mechanisms identified, the values (uses) which exist, the benthic habitats present within the zones of impact and influence and outcomes from monitoring during previous dredging campaigns.

The principal focus of the program is to confirm that the extent and nature of suspended sediment plumes generated during dredging and discharge (and therefore impacts) are within the modelled predictions. In addition, an early warning telemetry based system is proposed to be established at the entrance to Fannie Bay to identify any dredge related elevated suspended sediment effects that may enter the Fannie Bay area. This is a precautionary monitoring approach given that impacts are not predicted to extend into Fannie Bay and currently there is no evidence of seagrass being present in the bay.

Aspects of the program which have been refined include:

- Updates to the monitoring locations, with the inclusion of sites on the western side of the offshore sand bank and at Bennett Shoal
- Adjusted location for the early warning of sediment approaching potential seagrass habitat previously within Fannie Bay
- Refinement of the methodologies and frequencies of monitoring to be applied during dredging

The proposed monitoring program will also be revisited once baseline data is collected. Outcomes of the baseline monitoring program will be assessed to confirm the current understanding of baseline conditions and whether any adjustments may be needed to the monitoring approaches planned to be implemented during the current dredging campaign. This data will also be used to support the assessment and management of future dredging campaigns at HMAS *Coonawarra* (e.g. refine modelling).

As noted in the published Referral and DDMP, due to the substantial difference in the extent of marine water quality impacts predicted for the two dredge methodologies (i.e. CSD with nearshore discharge vs backhoe dredging with land-based disposal), monitoring programs for each dredge type have been developed.

Sections 3.11.1 and 3.11.2 present a summary of the proposed water quality monitoring programs to be implemented during the proposed dredging and discharge related activities. Detailed descriptions of the monitoring programs are provided in the updated DDMP which is included as Appendix E.

3.11.1 Cutter Suction Dredging and Nearshore Discharge

Objective

The objectives of this monitoring program are to:

- monitor the extent / characteristics of sediment plumes generated during dredging and sediment discharge activities and confirm that they are within what was predicted
- confirm no sediment plume effects attributable to the dredging and discharge related activities enter Fannie Bay
- obtain data on sediment plume behaviours and characteristics which can be used to refine assessment (e.g. modelling) for future dredging campaigns.

Monitoring locations

The water quality monitoring locations as previously proposed in the published Referral have been reviewed and amended based on the type and extent of benthic habitats known to occur within the project area, the extent of predicted sediment plumes generated during dredging and as recommended by DEPWS in Table 1 of the Notice of Direction.

The proposed monitoring locations are the same as those proposed to be monitored during the baseline water quality monitoring program (Locations WQ1, WQ3 and WQ4) as well as a control site as shown in Figure 3.37.

Site WQ1 has been slightly repositioned within Fannie Bay. This monitoring location is proposed to be located outside the predicted zones of impact and influence and has been positioned to provide an early warning of the potential for sediment plumes to approach the area where potential seagrass habitat has previously been reported within Fannie Bay.

The published Referral included monitoring location WQ2 which was positioned further north in Fannie Bay within the ephemeral seagrass habitat of the bay. However given that the predicted zone of influence does not extend into Fannie Bay, WQ2 is no longer needed, particularly given the purpose of WQ1.

The other two monitoring locations will be positioned within the harbour to the north and south of HMAS *Coonawarra*. Data from these locations will capture the effect of sediment plumes generate during dredging on the ebb and flood tide. Monitoring location, WQ3, has been repositioned near Bennett Shoal to capture the effect of sediment plumes on the flood tide, and was also recommended by DEPWS.

A new monitoring location, WQ4, will be located to the west of the offshore sand bank as this will capture data on the plume during ebb tides. This site was also recommended by DEPWS.

In addition, multiple locations will also be monitored during plume characterisation investigations.

As outlined in the Referral, a control site located to the north of Fannie Bay will also be monitored to assist in determining if elevated sediment concentrations which may be detected at WQ1 are associated with the dredging activities or other mechanisms within the harbour unrelated to the dredging works. If monitoring at the control site is warranted, the exact location will be determined in the field to ensure it is representative of background conditions.

Trigger levels

A key trigger will be detecting evidence that key plume behaviour or extent is notably different from what is predicted (e.g. from plume investigations or satellite image analysis).

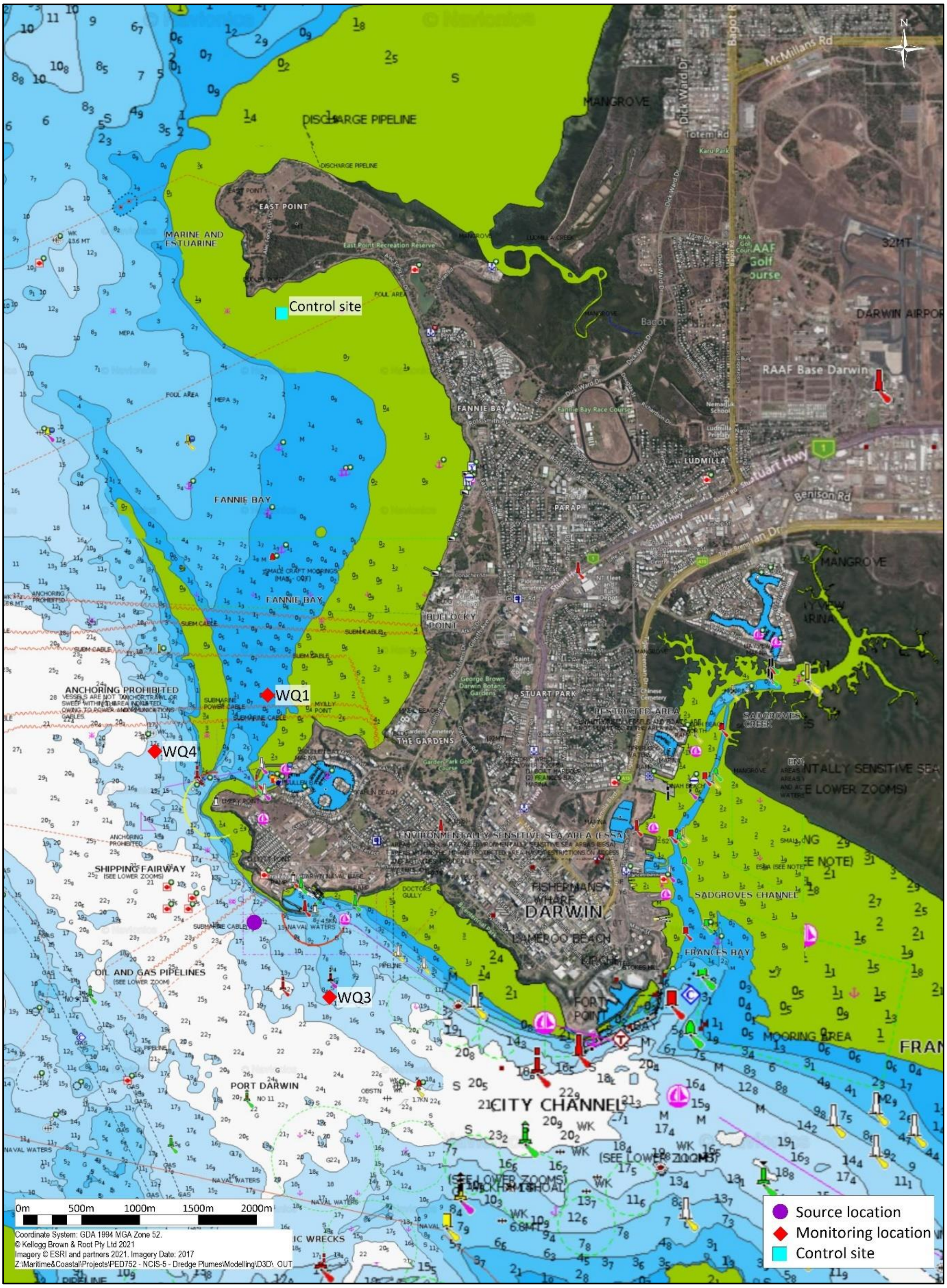

Figure 3.37 Monitoring Locations during dredging

Water quality monitoring data will be collected at locations WQ3 and WQ4 during dredging. These locations are not response based locations (they are within areas where impacts are predicted), rather data from each site will be used to improve the assessment and understanding of sediment plumes generated during dredging and discharge related activities for future campaigns.

Telemetry based water quality monitoring will be undertaken at WQ1. Data at this location will provide an early warning of dredged related suspended sediments entering Fannie Bay. An impact based trigger is not needed at this location, instead an early warning plume detection level of 30 NTU (based on the 6 hourly average turbidity) will be used to detect whether sediment plume effects from dredging approach Fannie Bay.

Method

Pre-Commencement

Pre-commencement monitoring will be undertaken on the two days prior to the beginning of CSD dredging and will include daily infield water quality monitoring, telemetry system deployment and seagrass spot checks.

A telemetry enabled monitoring buoy will be set up at site WQ1 (subject to obtaining the approvals required for buoy installation). At locations WQ1, WQ3 and WQ4 bottom frames with water quality monitoring loggers will be deployed. Instruments will be set up to monitor turbidity, PAR, conductivity and temperature throughout the dredging program. Monitoring frequency will be every 15 or 30 minutes.

During this period spot checks to determine the presence of seagrass within Fannie Bay will also be undertaken via direct inspection/drop camera and grab sampling.

Plume prediction validation

The plume prediction validation period will occur for the first five days of dredging via CSD and will include:

- Targeted plume extent observations and characterisation (e.g. depth profiles, transects);
- Satellite imagery analysis;
- Daily infield checks at each of the monitoring locations in Figure 3.37;
- Telemetry system monitoring;
- Collection and laboratory analysis of suspended sediment samples to confirm the relationship with turbidity (e.g. within the plume); and
- Visual monitoring of the dredging and discharge operations.

Plume monitoring:

During this period the visible extent of the dredge plume will be investigated. Vertical profiling and transects will be measured within the dredge plume to characterise the plume. The extent of the plume will be marked using a GPS with a focus on the area up to 2 km from the source.

The validation monitoring will include the use of published satellite data which will be interpreted and linked to field measurements twice during this period.

The location of the plume profiles and transects will vary between monitoring periods as the plume shifts.

Plume characterisation and satellite data analysis will be compared to the modelled predictions.

Daily infield monitoring:

Throughout this period, daily infield monitoring will also occur at each of the water quality monitoring locations as shown on Figure 3.37 and will consist of:

- Water quality depth profiles;
- Parameters to measured will include depth, temperature, conductivity, and turbidity;
- Water samples will be collected and analysed by a laboratory from a series of locations where turbidity is measured at the same time and location, sufficient to capture a range of suspended sediment concentrations.

Daily visual monitoring (to be undertaken by the Contractor):

The Contractor will be responsible for undertaking daily visual monitoring during dredging and discharge related activities, and will involve the following tasks:

- Visual monitoring of nearfield sediment plumes from the dredge conducted from a safe, elevated position;
- Visual inspection and GPS check to ensure the dredge material discharge point is in the correct location and depth;
- Visual inspection to ensure dredge material discharge pipeline is not leaking; and
- Visual inspection of nearfield discharge plume (e.g. within 100 m of source)

As part of the visual monitoring, the extent, direction (bearing) and distance of any visible plumes extending from the dredge activity and disposal location is to be recorded by sketching it on a proforma, along with details of the dredge location, tidal phase, wind and weather conditions.

Routine monitoring

Routing monitoring will commence after the plume predication validation phase of monitoring and will incorporate telemetry monitoring, fortnightly satellite data captures, monthly infield turbidity monitoring (as described above) and daily routine visual monitoring (by the contractor as described above).

At WQ1 telemetry instrument data download, maintenance, calibration and redeployment will occur during each of the monthly water quality checks.

Management Response

The proposed management response to any identified early warning trigger at WQ1 is presented in detail within the updated Draft DDMP (Appendix E) and will include:

- Investigation / confirmation of the source of the plume (i.e. is it associated with the dredge or discharge activities);
- Confirmation that dredge and discharge activities are in accordance with the DDMP;
- From review of data and of the above, determine if further field assessment is required.

3.11.2 Backhoe dredging with offsite disposal

Objective

The objective of this monitoring program is to obtain water quality information during the initial first 2 days of dredging to confirm the results of the model predictions whereby no impacts will extend beyond the basin.

Monitoring locations

Given the limited predicted plume extent during backhoe dredging, no buoy mounted water quality monitoring locations are proposed.

Trigger levels

As sediment plumes will be mostly contained within the basin no trigger levels are proposed.

Method

Plume prediction validation

The plume prediction validation period will occur for the first two days of dredging via Backhoe and will include:

- Specific plume monitoring;
- Satellite imagery analysis; and
- Visual monitoring of the dredging and barging operations.

During this period the visible extent of the dredge plume will be monitored. Vertical profiling will take place along approximately two transects through the visible extent of the dredge plume or sufficient transects to define the plume. The extent of the plume will be marked using a GPS with a focus of up to 500 m from the source. The validation monitoring will include the use of published satellite data which will be interpreted and linked to field measurements once during this period.

Daily visual monitoring will be undertaken by the Contractor and will include visual monitoring of nearfield sediment plumes from the dredge conducted from a safe, elevated position.

The extent, direction (bearing) and distance of any visible plume extending from the dredge activity is to be recorded by sketching it on a proforma, along with details of the dredge location, tidal phase, wind and weather conditions.

Routine monitoring

Routine monitoring will commence after the plume predication validation phase and will incorporate daily visual monitoring of sediment plumes by the contractor from the dredge conducted from a safe, elevated position.

3.12 UPDATED DRAFT DREDGING AND DISPOSAL MANAGEMENT PLAN

The draft Dredging and Disposal Management Plan (DDMP) has been updated based on the outcomes of the supplementary 3D modelling, refinements of the proposed trigger values, zones of impact and influence and to reflect those amendments made to the monitoring program proposed to be implemented during dredging.

A copy of the updated DDMP is included as Appendix E.

4 Response to Submissions on Referral Information

4.1 OVERVIEW

A total of seven submissions on Referral information from government authorities were received during the public display period. These submissions identified potential impacts on:

- water quality
- benthic habitat and communities
- marine fauna; and
- an underwater cultural heritage site within proximity to the proposed dredging and disposal activities.

Those comments provided in the Notice of Direction to provide additional information in the SER covered a lot of the queries raised in these submissions.

A summary of the key issues raised by each government authority is provided in Section 4.2. Each query and comment raised by the government authorities have been assessed with detailed responses provided in Appendix B.

4.2 REFERRAL SUBMISSIONS

4.2.1 Aboriginal Areas Protection Authority

The Aboriginal Areas Protection Authority (AAPA) noted that it was unlikely that cultural values relating to sacred sites in the proposed area would be significantly impacted.

The Authority confirmed that the proposed dredge area and discharge location are at least 450m from the nearest sacred site. The proposed monitoring locations were also reviewed and similarly the Authority confirmed that each location is at least 400m from any record of a sacred site.

4.2.2 Department of the Chief Minister and Cabinet

The Department of the Chief Minister and Cabinet (CM&C) noted that the proposed works will not have any major economic or social impacts to the community.

Comments received from the Department suggested that further information regarding workforce composition, local employment opportunities and potential impacts of the workforce on the local economy would be of benefit, as well as details of any consultation undertaken with the Aquascene fish feeding tourist attraction and other businesses which may be affected by sediment plumes.

The Department also noted that the published Referral did not consider vehicle traffic. It is acknowledged that further information regarding vehicle traffic associated with the dredging and discharge related activities would be beneficial and has therefore been addressed further in Appendix B.

The CM&C suggested that an AAPA Certificate for the site be obtained. This is discussed further in Appendix B.

4.2.3 Department of Environment, Parks and Water Security

The Flora and Fauna Division of DEPWS acknowledged that it is likely that impacts will be localised, and any impacts to the ecological values of the Harbour more broadly will be minor. However the department did identify a number of information gaps with regard to the modelling of sediment deposition and potential impacts of turbidity and sedimentation.

A summary of the key issues raised by the Flora and Fauna Division is provided below:

- Terrestrial ecosystems - The department noted that while vegetation types within the proposed works area have been identified further information should be provided on the predicted impacts on these communities, particularly with regard to potential impacts on the vulnerable Common Brushtail Possum. However it was noted that it is unlikely that this species would be significantly impacted. It should be noted that impacts on terrestrial ecosystems are not the subject of the Referral, but have been assessed by Defence's Director of Environmental Planning, Assessment and Compliance (DEPAC) in accordance with the requirements of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).
- Coastal Processes - The department noted that plume modelling and sediment transport modelling be revisited, and that 3D modelling techniques be considered.
- Marine and migratory fauna - The department acknowledges and accepts the Referral's conclusion that with proposed mitigation measures, risks to migratory species is considered to be low. It also notes that the risk to turtle and dugong habitat through sediment transport and sedimentation is likely to be low from a regional context, however there is the potential for local impacts which may alter the use of the area by individual megafauna. The Department also recommended that impacts of light pollution on threatened and migratory fauna be addressed by ensuring that any lighting design follow the national light pollution guidelines.
- Benthic habitats – It was noted that more information regarding the distribution of benthic communities in the modelled zone of influence be provided, to assess the risks associated with elevated total suspended solids and reduced light quality due to the proposed works. A benthic habitat assessment was undertaken in January 2023 to address this.
- Marine environmental quality – This noted supported for the TSS triggers proposed in the Referral and recommended that further time series water quality data be collected.

The Water Resources Division acknowledged that the proposed dredging and dredged material disposal activities are not anticipated to impact groundwater or surface water systems near the site and therefore have no issues with the proposed works.

4.2.4 Department of Industry, Tourism and Trade

The Mineral Titles, Petroleum Titles and Fisheries divisions of the Department of Industry, Tourism and Trade (DITT) concluded that the proposed works will have no impacts from their perspective, provided the NT EPA are not concerned with the proposed works area and have set trigger levels.

The DITT does also suggest engagement with stakeholders within the tourism industry.

4.2.5 Department of Infrastructure, Planning and Logistics

The Transport and Civil Services Division (TSCD) of the Department of Infrastructure, Planning and Logistics (DIPL) recommended that further information be provided with regard to marine transport requirements during dredging, potential impacts to bathymetry at the dredged material discharge location and communication with port users during the dredging campaign.

As noted by the TSCD, it is acknowledged that further details associated with the transportation of hard material to the Port at East Arm would be beneficial in understanding the proposed activities and the likelihood of impacts.

4.2.6 Department of Territory Families, Housing and Communities

The Department of Territory Families, Housing and Communities (DTIF) confirmed that the proposed dredging works are unlikely to impact any heritage places.

However it is acknowledged that the published Referral did not address the location of the declared heritage place known as the WWII Degaussing Range which is located within the restricted waters of the Larrakeyah Naval Base. Although the DTIF note that the proposed dredging works are unlikely to impact this heritage place, its locality is important to note, particularly with regard to future eastern wharf dredging.

4.2.7 Northern Territory Police, Fire and Emergency Services

The Northern Territory Police, Fire and Emergency Services (NTPFES) did not identify any issues with the proposed works but did note that the department has limited capacity to respond to waterway incidents without the support of private contractors.

Further discussion of this is provided in Appendix B.

5 Conclusion

This SER has been developed to address the Notice of Direction to provide additional information as issued by the NT EPA to supplement the NCIS-5 - HMAS *Coonawarra* Dredging and Dredged Material Management Referral (KBR, 2022).

To support the published Referral and to address those comments raised in the Notice of Direction and from the government authority submissions received, the following additional assessment was undertaken:

- Obtained and reviewed additional benthic habitat data from DEPWS, AIMS and the NT EPA to further understand the marine benthic habitat types likely to occur within the broader project area
- Obtained and analysed additional water quality data from DEPWS to better define baseline conditions experienced within the vicinity of HMAS *Coonawarra*
- Obtained and analysed additional data from the monitoring of previous dredging campaigns which was made available during the SER process and which enabled direct validations of suspended sediment levels
- Undertook a project specific marine benthic habitat survey in January 2023 to confirm the extent and type of benthic communities within the modelled zones of impact and zone of influence. This confirmed that the project area is characterised by bare substrate and sparse filter feeder communities.
- Designed, commissioned, and scheduled a project specific baseline water quality monitoring program for prior to the commencement of dredging
- Completed supplementary modelling including the development of 3D model, and sediment deposition modelling, to increase the level of confidence in modelled predictions
- Reanalysed potential impacts, tolerances and trigger levels
- Updated the DDMP to reflect the findings of the above and to ensure that an adaptive management regime can be implemented during dredging and future dredging campaigns

The additional assessment and modelling undertaken for the SER has not identified any major changes to the outcomes of the published Referral assessment.

The results of the benthic habitat assessment have narrowed the potential impacts and impact mechanisms and show that there is a low potential for impact on benthic habitats within the predicted zones of impact and influence.

Supplementary modelling represents 3-dimensional effects as an improvement to previous modelling. There is now an improved confidence that both the 2D and 3D models are able to represent plume behaviours. The addition of the 3D model provides an improved ‘tool’ for undertaking assessment, with impact predictions considered to be slightly conservative based on measured data from previous dredge campaigns.

As described in this SER, collection of further baseline data is scheduled, including water quality (NTU, TSS and PAR) along with plume characterisation data to confirm the outcomes of this assessment and for use to support future dredging campaigns.

The benthic communities in the project area consist of bare substrate and patches of sparse filter feeder communities. Based on a review of available literature and the results of studies undertaken in the field, these low density, low diversity filter feeders would be well adapted to the dynamic current and sediment transport processes which occur within the project area.

Based on modelling results, the fact that dredging operations will not be continuous and that suspended sediment concentrations consistent with the modelled predictions occur frequently as part of the natural variation of the harbour where these sparse filter feeders are present, it is unlikely that permanent impacts would occur.

The predicted zones of impact and influence do not extend into Fannie Bay and the risk to potential seagrass habitat is considered to be low.

The presence of filter feeders within the vicinity of the discharge location is evidence of recovery from the previous dredging campaign and similar recovery in this area would be expected after the upcoming campaign. In areas beyond the initial coarse material deposition, the periodic elevated suspended sediment concentrations are likely to result in some stresses to the filter feeders present. Studies have also shown that sponges with morphologies consistent with those present within the project area are capable of recovery from the effects of elevated suspended solids within weeks of the cessation of elevated concentrations (WAMSI, 2019).

Based on the outcomes of further assessment as presented in this SER, implementation of the updated project specific DDMP and evidence from previous dredging campaigns conducted at HMAS *Coonawarra*, the residual risk to the environment remains low and the impacts predicted are unlikely to be significant.

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Appendix A

Notice of Direction to provide additional information in SER ntepa Northern Territory Environment Protection Authority

DIRECTION TO PROVIDE ADDITIONAL INFORMATION IN THE SUPPLEMENTARY ENVIRONMENTAL REPORT (SER)

This direction is given under regulations 119(2) and 121(2) of the Environment Protection Regulations 2020

Name of proposed action	HMAS Coonawarra - Dredging and Dredged Material Management
Proponent	Australian Government Department of Defence
NT EPA reference	EP2022/012
Description of proposed action	Capital dredging works comprising: • campaign one - up to 101,000 m^3 of dredge material • campaign two – up to 116,000 m^3 of dredge material, to occur 2 to 3 years after the first campaign • nearshore discharge of dredged material near HMAS Coonawarra in Darwin Harbour and land based disposal at Darwin Port. Ongoing maintenance dredging at HMAS Coonawarra in the order of 10,000 to 15,000 m^3 once every 5 to 7 years and nearshore discharge of dredged materials near HMAS Coonawarra in Darwin Harbour.
Nature of proposed action	Coastal and marine
Method of environmental impact assessment type	Assessment by Supplementary Environmental Report (SER)
Direction	The proponent is directed to: • address all the submissions (received in relation to the referral information) in the SER • provide additional information in the SER as detailed in **Attachment 1.**
Submission period for SER	The SER must be submitted to the NT EPA within 12 months of the date of this Direction.

Form	The SER must generally conform with the Web Content Accessibility Guidelines (WCAG) 2.0 Level AA and material relevant to creating accessible documents on the NT Government website.
	In particular, the SER must:
	• be provided as:
	  o accessible PDF files that do not exceed 20 MB
	  o a printed copy to be displayed at the locations listed below
	• be divided into two parts:
	  o a main report (with summary available as separate document)
	  o appendices to the main report

	• have a navigable table of contents • present information in format that is easy to follow • use hyperlinks to assist with navigation through the document.

Manner	The SER must be:
	• provided electronically to the NT EPA for publishing on the NT EPA webpage public register
	• published electronically on the proponent's webpage and maintained for the duration of the proposal
	• provided in printed hard copy for display at the following locations during the public consultation submission period:
	  o NT EPA, Level 1, Arnhemica House, 16 Parap Road, Parap
	  o Northern Territory Library, Parliament House, Darwin
	  o Environment Centre NT, Unit 3, 98 Woods Street, Darwin
	  o Northern Land Council, 45 Mitchell Street, Darwin.

Person authorised to give direction	Dr Paul Vogel AM – Chairperson, Northern Territory Environment Protection Authority. Delegate of the NT EPA under section 36 of the *Northern Territory Environment Protection Authority Act 2012*.
Signature	
Date of direction	14 October 2022

Attachment 1 – Table of additional information to be included in Supplementary Environmental Report

Environmental Factors	Comment	Additional Information Required
SEA		
Marine ecosystems	<u>Benthic habitats and communities</u> The proposed dredging and dredge spoil disposal[1] is likely to impact benthic habitats and communities within the predicted zone of influence, directly due to removal, and indirectly due to short-term water quality changes (suspended sediment concentrations and turbidity levels) and sediment deposition. The proponent used a predictive benthic habitat mapping tool developed by the Department of Environment, Parks and Water Security in 2019 to determine the potential impacts of the action on physical and biological benthic habitats within a local and regional context, including seagrass, hard corals, macroalgae, filter feeder and bare seafloor habitats. Site specific mapping of benthic habitats and communities was not undertaken for the referral. Therefore, a comparison of modelled results against field based survey results within the predicted zone of influence has not been undertake to validate (ground truth) the modelled predictions. The NT EPA considers that benthic habitat survey and mapping is require to increase the level of confidence in predicting the potential significant impacts of the proposed action. During nearshore disposal of dredge spoil (1-2 month duration), benthic communities within the zone of influence would be exposed to increased suspended sediment concentrations and reduced light availability and quality, potentially leading to stress and mortality. Therefore, there is a need to understand the TSS	<u>Benthic habitats and communities</u> Include the following additional information in the SER: 1. Provide details of the proposed timing, methods and reporting to undertake a baseline marine field survey of benthic habitats and communities to: a. collect underwater video transect data at a sufficient density to produce comprehensive mapping (at an appropriate scale) of the extent of benthic habitats within the predicted zone of impact and zone of influence (see point 2 below). b. identify and describe the type and spatial extent (with consideration of temporal/seasonal variation) of benthic substrates and biota within the zone of impact and zone of influence c. provide sufficient ground-truth data to assess the accuracy of the DEPWS predictive benthic habitat model through comparison against predictive mapping. 2. Confirm that benthic habitat survey and classification would be undertaken in accordance with the following guidance: a. <u>National Environmental Science Program Field Manuals for Marine Sampling to Monitor Australian Waters</u> b. <u>National Intertidal/Subtidal Benthic (NISB) Habitat Classification Scheme</u> c. <u>Collaborative and Annotation Tools for Analysis of Marine Imagery and Video (CATAMI) classification scheme</u>. 3. Confirm that comprehensive benthic habitat mapping would be overlain with property boundaries, the nearshore discharge location, the predicted extent of the sediment plume dispersion and deposition effects, and depth contour lines for lowest astronomical tide (LAT), mean low water springs (MLWS), mean low water neaps (MLWN) and mean sea level (MSL). 4. Provide detail about how the results of the benthic survey and mapping would be taken into account for each dredging action, using an adaptive management approach. Include detail about how potential impacts (related to sediment deposition, suspended sediment,

[1] The proposed action is on Commonwealth land which is not subject to Northern Territory law under section 52(2) of the Australian Constitution. The proposed action was referred to the Northern Territory Environment Protection Authority (NT EPA) under the *Environment Protection Act 2019* (EP Act) due to the potential for significant environmental impact within areas of NT jurisdiction. The NT EPA's assessment process and the additional information direction is only relevant for potentially affected areas that are within NT jurisdiction.

<table>
<tr><th>Environmental Factors</th><th>Comment</th><th>Additional Information Required</th></tr>
<tr><td></td><td>(mg/L) /turbidity (NTU) – light intensity relationship at the seafloor to assist with setting appropriate turbidity triggers for benthic communities and primary productivity.</td><td>turbidity and benthic light levels) on sensitive benthic communities and habitats (corals, seagrass, macro algae and filter feeders where presence is confirmed during field surveys) would be managed. Include detail about how benthic impacts from dredge spoil disposal would be monitored and measured, and the expected duration of recovery periods where impacts are predicted or observed (informed by the revised hydrodynamic model – refer to item below).
5. Confirm that the draft Dredging and Disposal Management Plan to reflect any necessary changes arising from points 1-4 above.</td></tr>
<tr><td>Marine environmental quality</td><td><u>Hydrodynamic model</u>
The proponent developed a two-dimensional (depth-averaged) hydrodynamic model in the ‘Eulerian’ Delft3D-FLOW modelling package, with suspended sediments modelled using the ‘Lagrangian’ ‘random walk’ particle tracking module, Delft3D-PART.
The NT EPA understands that three dimensional (3D) modelling is considered best practice in most marine environments in order to predict dredging impacts to hydrodynamics, plume and sediment transport. The Western Australian Marine Science Institution (WAMSI) Dredge Science Node Guideline on dredge plume modelling for environmental impact assessment discusses 2D vs 3D hydrodynamic modelling to allow for accuracy and certainty in the assessment of impacts of changes in current strength to benthic communities; sediment transport along the seafloor, and plume density within the water column.

Further justification should be provided to support use of the 2D model (with random walk particle tracking) for the prediction of sediment plume, transport and deposition impacts from the proposed dredging. The justification should provide information to support the decision not to use a 3D model. The justification should describe how sediment transport within ambient settings and after sediment is deposited from dredge spoil or sediment plumes is addressed by the modelling.</td><td><u>Hydrodynamic model</u>
Additional information is required in the SER to improve confidence in the hydrodynamic model outputs, results, and impact predictions, and to assess the significance of potential impacts of suspended, deposited and remobilised sediments on the marine environment.
1. Provide a detailed justification with information to support the use of a 2D hydrodynamic model for the prediction of dredging impacts from the proposal.
2. Provide details and sources of the baseline data (including from field observations) that has been used in development, calibration and validation of the model to predict and validate the extent of the plume, including any plume validation data available from previous HMAS Coonawarra dredging monitoring programs. Describe how the baseline and model input data used are consistent with the requirements of the WAMSI Dredge Science Node Guideline on dredge plume modelling for environmental impact assessment (specifically sections 3, 4 and 5 of the guideline).
Confirm that the timing of baseline data collection corresponds to the time of year that dredging is proposed to occur. As a guide, if dredging is proposed in the dry season/build-up, data should be provided for a minimum of 28 days. If in the wet season, data should be provided for 6-8 weeks (i.e. to capture at least two monsoonal events). Provide the baseline data as part of the information response to this Direction (either from existing or new site specific monitoring).
3. Describe how the following has been considered in development of the model and the prediction of impacts:
a. the composition of TSS
b. how TSS concentration data correlates to turbidity (NTU) level data at the proposed monitoring locations (including the two additional locations – refer to item below)
c. the relationship between suspended sediment and light availability and quality at the seafloor.</td></tr>
</table>

Environmental Factors	Comment	Additional Information Required
	Further information should be provided to describe how the transport and fate of sediments (coarse and fine) has been quantified and modelled, and how sedimentation rates and implications for water quality (TSS and turbidity) and benthic communities and habitats has been assessed. Describe how the modelling allows for determination of the susceptibility of marine and benthic values and sensitivities to sedimentation and the suitability of the proposed water quality trigger levels that would be applied during dredging to avoid significant impacts. The models should be calibrated and verified by comparing modelled results against field based measurements. The revised modelling and setting of trigger values should be informed by the outcomes of the benthic habitats and communities survey and mapping (refer to item above).	4. 5. Revise the monitoring program to include two additional sites as recommended by DEPWS; one along the western side of the Fannie Bay sand bank, as this lies in the major axis of most dredge plume modelling outputs; and at Bennet Shoal, which is likely to contain benthic primary producer habitats. 6. Review the proposed trigger values (TSS <20mg/L in dry season and <30mg/L in wet season) and the 1:1 TSS/turbidity (NTU) correlation, that would initiate a management response during nearshore spoil disposal and include triggers for time duration of exceedances for specific benthic communities including corals, seagrass, macro algae and filter feeders (where presence is confirmed during field survey). Interim triggers should be established from baseline TSS, turbidity and benthic light level data with consideration of the WAMSI Dredge Science Node research reports on ecological thresholds and environmental windows at https://www.wamsi.org.au/dredging-science-node/dsn-reports. As an example, in the case that only dry season site-specific data is available, this should be cross referenced with established guideline values (for the benthic communities present) in the WAMSI data, to establish interim guideline values for the wet season, which could be used until sufficient site-specific wet season monitoring data is available. In the case that existing site-specific seasonal baseline monitoring data is not currently available, the proponent should first obtain data for the season in which the initial dredging works are proposed to be undertaken. 7. Describe how sediment deposition modelling has been developed, including for fine and coarse material and report on the time duration, magnitude and extent of deposition, the deposited sediment thickness, and the fate of deposited sediments. Describe how the model has been designed, calibrated and validated to assess impacts related to sediment behaviour, transport pathways, fate, and deposition. 8. Demonstrate through survey, monitoring and modelling results that the proposed site for nearshore disposal is suitable for the avoidance of potential significant impacts to marine ecosystems. 9. Review and update the Draft Dredging and Disposal Management Plan to reflect any necessary changes arising from points 1-8 above.

Appendix B

Response to Submissions on Referral Information

Contents

List of figures

List of abbreviations

KBR	Kellogg Brown & Root Pty Ltd
AAPA	Aboriginal Areas Protection Authority
DEPWS	Department of Environment, Parks and Water Security
DITT	Department of Industry, Tourism and Trade
DIPL	Department of Infrastructure, Planning and Logistics
DTFHC	Department of Territory Families, Housing and Communities
DCMC	Department of the Chief Minister and Cabinet
NTPFES	Northern Territory Police, Fire and Emergency Services
ICN	Industry Capability Network
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
3D	Three Dimensional
2D	Two Dimensional
NT	Northern Territory
EP Act	*Environment Protection Act 2019*
DEPAC	Director of Environmental Planning, Assessment and Compliance
ZoI	Zone of Influence
TSS	Total Suspended Sediment
NTU	Nephelometric Turbidity Unit
PAR	Photosynthetically Active Radiation
SER	Supplementary Environment Report
PSD	Particle Size Distribution
AFANT	Amateur Fishermen's Association of the Northern Territory
NTGFIA	Northern Territory Guided Fishing Industry Association

1 Introduction

A total of seven submissions in relation to the Referral information were received during the public display period. These submissions were made by the following government authorities:

- Aboriginal Areas Protection Authority (AAPA)
- Department of Environment, Parks and Water Security (DEPWS)
- Department of Industry, Tourism and Trade (DITT)
- Department of Infrastructure, Planning and Logistics (DIPL)
- Department of Territory Families, Housing and Communities (DTFHC)
- Department of the Chief Minister and Cabinet (DCMC)
- Northern Territory Police, Fire and Emergency Services

No submissions from the public or other stakeholders were received. Many of the comments raised in the above submissions are also addressed in the *'Notice of Direction to provide additional information'*.

Potential impacts on water quality, benthic habitat and communities, marine fauna, and an underwater cultural heritage site within the vicinity of the proposed dredging and disposal activities were the main aspects raised in the submissions.

The comments or queries raised by the submitters have been addressed and the responses presented in Section 2 of this document.

The additional assessment undertaken to address the various comments has not identified any new issues or major changes to the outcomes in the published Referral assessment.

2 Response to Submissions on Referral Information

2.1 ABORIGINAL AREAS PROTECTION AUTHORITY

This section provides responses to the comments received from the Aboriginal Areas Protection Authority (AAPA). The comments are presented in italics, with the response provided below each one.

Comment

Culture and Heritage – Sacred Sites

Section 7.11.1 of the Referral report acknowledges the 'Gundul sacred site' located in the Larrakeyah Barracks Precinct at Emery Point and states that the site is not within the project area and will not be disturbed by the proposed activities addressed in the referral.

Figures 4.1 and 4.2 in the Referral report show the proposed dredge areas and proposed dredged material discharge location. The Authority confirms that the dredge areas and discharge location are at least 450m distant from the nearest sacred site (Kulndal; site 5073-2).

The Authority has also reviewed the proposed locations for monitoring activities associated with the proposal. Section 10.4.2 states the proposed monitoring locations are shown in Figure 7.1, but these in fact appear to be shown in Figure 7.12. Section 10.4.2 also states that monitoring will occur at sites shown in Figure 10.30. The Authority has manually compared the monitoring locations shown in Figures 7.12 and 10.30 with the Authority's records of sacred sites. The Authority does not have records of any sacred sites within about 400m of each of the proposed monitoring locations indicated on these maps.

The legal mechanism for protecting sacred sites from potential impacts from proposed developments is to obtain and comply with an Authority Certificate issued by the Authority in accordance with the Northern Territory Aboriginal Sacred Sites Act 1989. The Authority notes that the Department of Defence has previously obtained Authority Certificates for related works in this area but the Authority has not done an assessment to determine if all proposed works are covered by those certificates.

Response

The advice provided here in relation to sacred sites is noted. Department of Defence (Defence) has established frameworks in place to address and manage the potential for encountering sites of heritage value, including sacred sites and they are bound by Commonwealth legislation which covers these issues.

This includes the identification and management of risks to heritage during the planning, development and operation of Defence facilities which may include places with natural and biodiversity values, places important to Indigenous people, places significant for Defence history and places that are important to Australia's history and cultural life.

Defence undertakes ongoing liaison with the Traditional Owner representatives in relation to the management and protection of the sacred site identified in the Larrakeyah Barracks area. In relation to the proposed dredging and disposal works, Defence's intention is to continue to use these established legislative and management frameworks.

Further to the comment relating to proposed monitoring locations, it is noted that these have been adjusted slightly to reflect the results of the latest sediment plume modelling. The adjusted monitoring locations are shown on Figure 2.1.

Comment

Culture and Heritage

The Authority considers that it is unlikely that this proposal would have a significant impact on cultural values associated with sacred sites in the area.

Response

This advice is noted. Nevertheless, precautionary measures will be put in place to ensure that during dredging contractors and their personnel are informed of the cultural heritage values in the area, and Defence's established 'unexpected finds' protocol is in place.

2.2 DEPARTMENT OF CHIEF MINISTER AND CABINET

This section provides responses to the comments received from the Department of Chief Minister and Cabinet. The comments are presented in italics, with the response provided below each one.

Comment

Community and economy – Workforce

The proponent states a contractor will be appointed to carry out the proposed works.

Workforce composition, local employment opportunities and impacts of the workforce on the local economy, services, and accommodation should be considered in the Referral.

CM&C suggests the proponent consult ICNT regarding engaging local contractors where possible.

Response

A contractor will be appointed to carry out the proposed dredging and discharge related activities at HMAS *Coonawarra*. Dredging operations involve relatively specialised works, with limited availability of suitable contractors and machinery. The dredging and dredged material disposal activities will not involve a large workforce, with only a small number of people with the required skills needed to manage and operate the relevant machinery and vessels.

Defence's tender process and criteria used in the evaluation of contractors deals with and encourages the engagement of local contractors. The process recognises that local organisations and contractors can be sought via a variety of engagement platforms including the Industry Capability Network (ICN). Local employment opportunities, engagement of local suppliers and subcontractors, are evaluated as part of the tender assessment process. Upon award of the contract, a plan outlining local engagement to deliver the project, will be prepared, reviewed and implemented prior to the commencement of works.

The workforce associated with the dredging component of the works is unlikely to result in any adverse impacts to the local economy, services and accommodation, particularly in the Darwin precinct which is well placed to support infrastructure projects of a much larger scale than the dredging proposed.

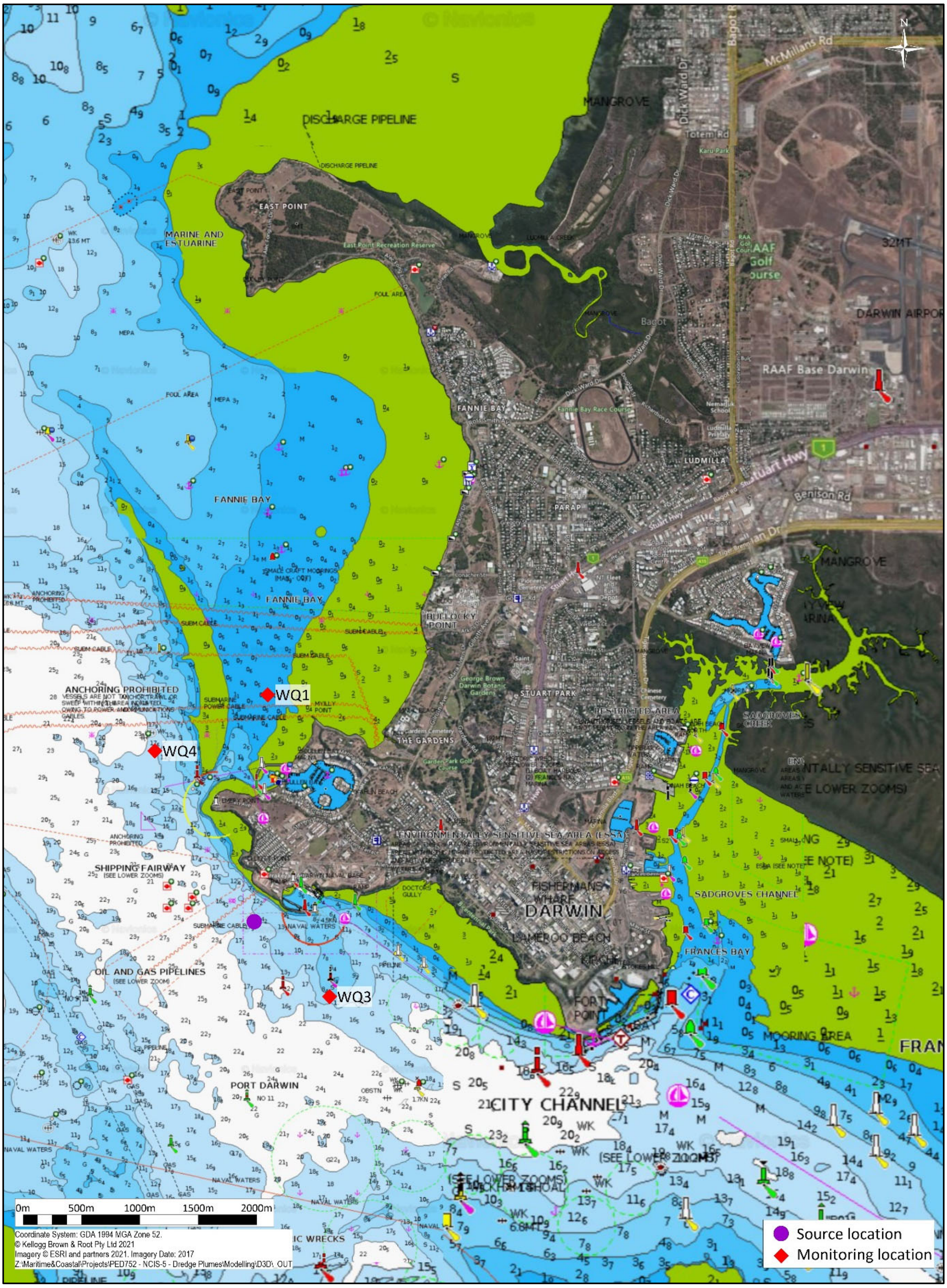

Figure 2.1 Proposed water quality monitoring locations

Comment

Community and economy – Economic impacts and Consultation

The Referral Report acknowledges Aquascene fish feeding tourist attraction, located approximately 600 metres from the project area, may be affected by sediment plumes and underwater noise.

The Referral would benefit from including details and outcomes of consultation with Aquascene, and any other business that may be affected by sediment plumes or noise.

Response

Aquascene was established in 1981 and is a tourist operation involving fish feeding at high tide. Dredging of the original harbour basin at HMAS *Coonawarra* occurred between 1980 and 1982, with six other dredging campaigns conducted between 1993 and 2015. All dredging operations conducted to date at HMAS *Coonawarra* have occurred since the establishment of Aquascene in 1981. No issues associated with dredging related suspended sediment plumes affecting this activity have been identified from previous campaigns. Based on modelling results and monitoring of previous dredging, it is not expected that the generation of suspended sediment plumes will adversely affect operations at Aquascene.

Dredging related noise generating activities will include CSD operation, attendant work boats, the backhoe dredge and barge movement. Noise from the continuous operation of the CSD is not likely to be loud enough to cause nuisance at Aquascene or other nearby noise sensitive locations based on experience from previous dredge campaigns, the fact that the operation of the CSD and support vessels will generate noise similar to existing shipping and vessel movements conducted within the broader project area, and will be limited to normal work hours. Backhoe dredging of hard material and the subsequent filling of barges is expected to be a louder process but also unlikely to result in noise nuisance.

Sediment plumes and noise emissions generated during dredging activities will be temporary and intermittent and will be managed through the implementation of the Dredging and Disposal Management Plan (DDMP).

Prior to and during the dredging campaign, mechanisms will be put in place to allow stakeholders or members of the public to raise any issues or complaints with the Defence project team, and (during construction) with the Contractor. The Contractor will be required to track and manage any complaints that may be received during the works. Details of this process are outlined in the DDMP (Appendix E) including the requirement to implement corrective actions in response to valid complaints.

It is also noted that as part of the approval process, the Referral and all supporting documentation were placed on public display and no submissions were received from any non-agency stakeholders, businesses or the public.

Comment

Community and economy – Traffic

The Referral Report includes detailed consideration of vessel traffic, however, consideration of other traffic is not included. The Referral would benefit from including consideration of road traffic.

Response

Road traffic associated with the proposed dredging and dredged material disposal activities will be limited to a small number of construction related vehicles.

Road access to HMAS *Coonawarra* is via the Larrakeyah Barracks. Road traffic within the Barracks is primarily associated with base operation and defence personnel and families who reside within the barracks. Access to the base is through the residential area to the east of the site via Packard Street.

The proposed works will result in a minor increase in construction related vehicles on the local road network and traffic within the Larrakeyah Barracks. Vehicular traffic will largely be associated with the movement of a small number of construction personnel and materials to and from the site and would consist of light vehicles, maintenance vehicles and supply vehicles to support works prior to, during and at the completion of dredging. There will be a laydown and compound area allocated at East Arm and this would allow the delivery of some dredging related equipment/supplies to that location which would direct those away from the road network near Larrakeyah. If any heavy construction related vehicles are required to access the site (e.g. for the delivery of pipeline segments), then these will be managed accordingly to ensure morning and afternoon peak traffic times are avoided.

The Contractor will be required to develop and implement a Construction Traffic Management Plan whereby all construction vehicles associated with the dredging operations will be required to adhere to appropriate road rules. A number of upgrade projects have recently been undertaken at HMAS *Coonawarra*, and consequently there is a well-established process in place for managing and accommodating construction related road traffic at the site.

Comment

Culture and heritage

CM&C suggests the proponent obtain an AAPA certificate for the project site.

Response

As outlined in the AAPA submission and as previously noted in Section 2.2, the AAPA advises that cultural values relating to sacred sites are unlikely to be impacted by the proposed works.

The advice to obtain an AAPA certificate is noted, however in this circumstance Defence, as a Commonwealth entity, have existing legislation and processes in place to address and manage the potential for encountering sites of heritage value, including sacred sites.

Defence also routinely undertakes liaison with the Traditional Owner representatives in relation to activities carried out at the Larrakeyah Barracks with the potential to affect identified sacred sites, and this will continue.

2.3 DEPARTMENT OF ENVIRONMENT, PARKS AND WATER SECURITY

This section provides responses to the comments received from the Department of Environment, Parks and Water Security. The comments are presented in italics, with the response provided below each one.

Comment

Land – Terrestrial Ecosystems

The coastal escarpment adjacent to the proposal is mapped as monsoon vine thicket with some mangrove vegetation likely to occur along the coastal foreshore. These vegetation types are considered to be significant and/or sensitive vegetation in the Northern Territory and may provide habitat for threatened species. The referral identifies that these vegetation types are present but provides no information on whether there will be impacts associated with the proposal. Given the proximity of works to these vegetation types, it is recommended that the proponent provide further information on the predicted impacts to these communities.

Response

The proposed dredging and discharge related activities at HMAS *Coonawarra* will occur within the marine environment and will have minimal interaction with terrestrial habitats, as noted in Section 8 of the Referral. There is no mechanism for the dredging and dredged material disposal activities to impact the area of monsoon vine thicket which runs along the top of the coastal escarpment.

Comment

Land – Terrestrial Ecosystems

The monsoon vine thicket along the coastal escarpment is highly likely to support the vulnerable (Environment Protection and Biodiversity Conservation Act 1999) Common Brushtail Possum (north-west). The referral does not include any consideration of the potential impacts or risks to this species or its habitat.

The Flora and Fauna Division has reviewed the available records which confirms that the species is common in urban and semi-urban environments in the Darwin region. Current knowledge of the species' ecology suggests that suitable and occupied habitat is extensive along the Darwin Esplanade and coastal escarpment. This habitat extends beyond the Coonawarra Naval Base and it is unlikely this species will be significantly impacted by the proposed works.

Response

Advice regarding the likely presence of the Common Brushtail Possum (north-west) in the area (listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999)* is noted.

As described in the Referral, the proposed dredging and discharge related activities will occur within the marine environment and will have no impact on terrestrial habitats. There is no mechanism for the dredging and dredged material disposal activities to impact the Common Brushtail Possum (north-west) or its habitat.

Comment

Coastal Processes – Currents, hydrodynamic and wave models

The proponent has used Delft3D as their modelling tool, and the hydrodynamic model is based on a 2D depth average. The WA Dredge Science node recommends that 3D modelling is necessary to understand the impacts to hydrodynamics, plume and sediment transport modelling.

The Flora and Fauna Division recommends that the proponent revisits plume modelling and sediment transport modelling and considers using 3D modelling techniques in conjunction with the long-term monitoring data (referred to in Marine Environmental Quality). The models should be calibrated and verified.

Response

To address this and similar comments outlined in Table 1 of the Notice of Direction, supplementary data analysis and modelling has been undertaken to expand on the previous modelled outcomes reported in the Referral. This includes the development of a 3D model. Further investigation of the dispersion and fate of dredged material and the potential settlement behaviour of suspended sediment in Darwin Harbour has also been undertaken to provide greater confidence in the predictions of far-field plume dispersion and to assess the significance of potential impacts of suspended, deposited and remobilised sediments on those sensitive receptors within the project area.

Supplementary modelling was undertaken to address the following:

- 3-dimensional (3D) modelling as a refinement to previous 2-dimensional (2D) modelling

- Review of additional available datasets for model validation
- Expanded modelling of sediment deposition and fate

The Supplementary Dredging Modelling Report is included as Appendix D.

Comment

Coastal Processes – Sediment deposition dredge spoil

The referral has not included models of sediment deposition, nor does it model the potential for sediment to be remobilised after deposition. Further, it is expected that coarser material will remain in the vicinity of the disposal site and will not be readily transported by currents. It is unclear if the fate of this coarse material has also been considered by the proponent when assessing the extent and severity of impacts from the proposed disposal.

The Flora and Fauna Division recommends that sediment deposition and sediment transport modelling is undertaken for fine and coarse material. The sediment transport model should be calibrated and validated. The referral should at least report on the extent, deposited sediment thickness, time duration and fate of deposited sediments.

Response

Supplementary modelling has been carried out to address this comment, and similar points in the Notice of Direction. This can found in Section 3.7 of the SER, and a detailed discussion is provided in the Supplementary Dredging Modelling Report included as Appendix D. A summary of the modelled outcomes is presented below.

The modelling confirmed that coarse-grained sediments (and other heavy particles such as rock fragments and gravel) quickly settle out of suspension, falling to the seabed within a short distance of the release point. Coarse sediment deposition up to approximately 40 mm thick is predicted to occur over a 500m extent in the immediate vicinity of the discharge point, similar to the estimation presented in the Referral.

Outcomes of the fine sediment fate modelling confirm the initial predictions presented in the Referral, which noted that fine dredge sediments will not remain close to the discharge location, given that the bed stresses in this area of the harbour are very high.

The further modelling of fine sediment undertaken shows that the thickest layer of sedimentation simulated to occur is within the HMAS *Coonawarra* basin, where the dredging is to be undertaken. The maximum modelled thickness of fine material deposition within this portion of the dredge area is approximately 10 mm. Beyond the basin area, fine material deposition is lower with some small areas likely to receive up to 5mm, with the remainder of the area likely to experience a deposition of fine sediment within a range less than this.

Temporary settling of fine material may occur within the extents of the plume. However, strong current erosion and sediment transport processes will quickly resuspend and move this sediment.

The deposition of fine marine sediments within these nearshore areas would be indistinguishable from the distribution of natural sediments that continually circulate via the same resuspension and deposition processes.

Comment

Marine Ecosystems – Marine and migratory fauna

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 the breakwall*
- *indirect impacts from decline in water and sediment quality with potential loss of ecosystem function,*
- *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.

Response

The advice provided here is noted. Further to this, supplementary assessment has been completed, including further review and re-analysis of available benthic habitat data sets and project specific benthic habitat survey and mapping. This showed that predominantly bare substrates supporting low density, low diversity sponge dominated filter feeder communities are the only sensitive receptor within the predicted zones of impact and influence. These do not provide important habitat or foraging areas for turtles or dugong.

It is acknowledged that ephemeral seagrass habitat may occur at times within Fannie Bay (although it was not present at the time of survey) which may provide some habitat values for these species. Impacts associated with the proposed dredging and dredged material disposal operations are not predicted to extend into Fannie Bay and the area which may support seagrass habitat is beyond the predicted zone of influence.

During dredging, it is acknowledged that the movements of individual marine megafauna which may occasionally visit the area may be temporarily altered as a result of the dredging and discharge related activities. However the proposed operations are not predicted to impact any suitable foraging areas or any areas considered to be highly utilised by these species.

Through the implementation of the DDMP, which describes proposed mitigation measures, potential risks to marine fauna will be low.

Comment

Marine Ecosystems – Marine and migratory fauna

The infrastructure build associated with the proposal will create light pollution and may impact on threatened and migratory fauna.

The Flora and Fauna Division recommends that lighting design follows national light pollution guidelines.

Response

With regard to the proposed dredging operations, activities will occur during daylight hours (6:30 am to 6:30 pm) six days a week excluding Sundays and public holidays, apart from normal stoppages for repositioning equipment and maintenance. There will be lights on the dredge vessels however these will likely remain within the basin area at night. Lighting will be limited to navigational lights and security lights which are unlikely to have any substantial impact on threatened or migratory fauna (i.e. not expecting 'working' flood flights or similar). Barge transit may occur at night, but lighting would be consistent with normal shipping activities which occur within the harbour.

It is likely that laydown areas at the base and possibly East Arm will be required to support the dredging and disposal operations. Any lighting required at these locations will however be similar to what is already present and will primarily be for security purposes rather than 'working' lighting.

No 'working' lighting is associated with the proposed dredging and discharge related activities and therefore there is no mechanism for the proposed dredging and discharge related activities to create light pollution.

Comment

Marine Ecosystems – Marine and migratory fauna

A range of marine megafauna utilise the waters within the wider area of Darwin Harbour including turtles, dugong, dolphins and sawfish. To the south of the site, the East Arm (over 4 km south) and Middle Arm (over 2 km south-south-west) of Darwin Harbour are considered to be important foraging areas for the Indo-Pacific Humpback dolphin, and to a lesser extent both the Indo-Pacific bottlenose and the Australian snubfin dolphins.

The proponent has noted that the foreshore is lined with mangroves and mudflats. These habitats may support migratory and threatened bird species. The referral provides no assessment of the potential impacts or risks to these species or their habitats. While there has been no assessment provided, the Division notes that the mangroves and mudflats within the proposal area are unlikely to provide important foraging, staging or roosting habitat for these species. The Flora and Fauna Division is satisfied that the risk to these species from the proposal is low.

Response

Advice regarding potentially important foraging areas for the Indo-Pacific Humpback dolphin, Indo-Pacific bottlenose and the Australian snubfin dolphins, as well as those mangrove and mudflat habitats which may support migratory and threatened bird species is noted.

Section 7.7.2 of the Referral discussed these species and important foraging areas associated with the East Arm and Middle Arm of Darwin Harbour. Due to the modified nature of the HMAS *Coonawarra* basin, the basin area does not provide important habitat for dolphins. While there have been occasional instances of dolphins observed inside the basin, this is infrequent and as itinerant visits while they move between more favourable foraging areas. The potential for the proposed dredging and discharge related activities to adversely impact dolphins was assessed in the Referral, with potential impacts associated with vessel movements and underwater noise identified as potential impact mechanisms which would be managed via the implementation of the DDMP.

An assessment of potential impacts to migratory and threatened shorebirds was also undertaken and included in the Referral as outlined in Section 7.7.2 and Section 8. Based on a review of site characteristics, sediment plume modelling results, an understanding of the dredge operations and outcomes of a shorebird survey conducted in March 2017, it was determined that there is no potential for the proposed dredging and discharge related activities to significantly impact intertidal ecosystems or have any significant adverse impact on shorebirds.

Section 7.2.2 of the Referral noted that within HMAS *Coonawarra*, the only foraging habitat that may be utilised by shorebirds is limited to the narrow intertidal area and breakwater located in the eastern portion of the site. While migratory species may occasionally be present within this area, the site does not provide important foraging or roosting sites for migratory birds. The assessment determined that there is no significant utilisation of the project area by shorebirds and no high tide roost sites exist within the base and along the intertidal areas adjacent to HMAS *Coonawarra*.

Comment

Marine Ecosystems – Benthic habitats

The proponent has provided information on the benthic habitats that are likely to be present within the proposal area.

This information is based on monitoring from the 2006 and 2013 dredge campaigns as well as the 2019 DEPWS predictive habitat model. Staff from the Division have considered the zone of influence using the most recent information (Streten et al 20212).

The Flora and Fauna Division agrees with the referral's conclusion that the Coonawarra Naval basin is a highly modified environment and that the risks to benthic flora and fauna within the basin is low. However, there are remaining uncertainties on the risks to the zone of influence (ZoI) outside of the Coonawarra Naval basin.

The Division has benthic habitat data for the western side of the Fannie Bay modelled as sand bar, however the remaining zone of influence remains unmapped. Without this information it is not possible to determine the value of these habitats or assess the potential impact on these ecosystems from elevated suspended solids and reduced light quality/availability.

As the zone of influence is relatively large and occurs over an extended period (2-3 months) there is uncertainty over the benthic communities present in this zone and the potential for those communities to be significantly impacted. To resolve this uncertainty, the Division recommends that further information is sought on the distribution of benthic communities in the modelled zone of influence. This information would inform a more comprehensive assessment of the values within the zone of influence as well as the assessment of the risks from elevated total suspended solids and reduced light availability/quality due to the proposal.

Response

Attachment 1 of the Notice of Direction also noted that project specific benthic habitat survey and mapping is required to increase the level of confidence in predicting the potential for significant impacts on benthic habitat communities.

Consequently additional assessment has been undertaken to support not only the proposed current dredging campaign but also future campaigns, including a project specific field survey and mapping of benthic habitats and communities, comparison of the field survey data with the latest version of the DEPWS predictive benthic habitat model and reanalysis of potential impacts within the predicted zone of impact and zone of influence.

Details of the field survey methodology and results are provided in Section 2.3 of the SER, with those sensitive receptors relevant to the proposed zones of impact and zone of influence discussed in Section 2.4 of the SER.

A copy of the HMAS *Coonawarra* Marine Habitat Mapping Report is included as Appendix C, with a summary of the survey results presented below.

Results of the benthic habitat mapping show that the majority of the survey area is predominately characterised by bare substrate with sparse coverage of filter feeders, primarily sponges, observed in those areas where hard substrate, such as rock and gravel, were present.

Seagrass, hard coral and macroalgae communities were not observed at any point during the survey.

Outcomes of the field survey and further review and reanalysis of other relevant benthic habitat data has provided a greater level of certainty with regard to the type and extent of sensitive receptors within the proposed zones of impact and zone of influence.

The only benthic habitat type that has the potential to be impacted during proposed dredged material disposal activities are low percent cover sponge dominated filter feeders. These filter feeders are resilient to high sediment load, high current and low light conditions and are considered to be widespread and well represented within the harbour. The field survey did not identify any strongly light dependent communities.

Potential seagrass habitat which has been known, at times, to occur within Fannie Bay (albeit was not observed during the 2023 survey) is also acknowledged as a potential sensitive receptor but it is beyond the zone of influence for the proposed dredging and dredged material disposal activities.

An assessment of potential impacts on those sensitive receptors within the project area are discussed in Section 2.5 of the SER and are principally related to direct sediment load within the water column. A discussion of the tolerance limits for each sensitive receptor is provided in Section 2.6 of the SER.

Comment

Marine Ecosystems – Benthic primary Producer habitats

Plume generation, reduced light conditions, sedimentation and liberation of contaminants pose greater risk to sensitive benthic habitats. Results from plume modelling indicate that areas on either side of the Fannie Bay sand bank and subtidal areas between Coonawarra basin and Fort Hill wharf will have elevated suspended sediments as a result of dredge spoil disposal.

The referral considers this a low risk to sensitive habitats as water quality will return baseline conditions within 12-24 hours. However, sediment deposition rates have not been estimated, nor has the proponent modelled the resuspension of deposited dredge spoil material. Thus there is insufficient information to assess the impact from sedimentation on sensitive receptors.

Sediment deposition is not the only environmental parameter that is influenced by sediment plumes. Light availability at the seafloor, which is a physical environmental parameter that drives a number of ecosystem processes, is another parameter to consider.

Flora and Fauna Division is concerned about the exposure duration of TSS and the consequences for light availability/quality at the seafloor, especially for a 2-3 month dredging campaign. As benthic primary producers rely on light, and with dredging occurring during day time hours, there will be no recuperation period for light dependant organisms.

To inform the risk assessment there is a need to understand the TSS / turbidity - light intensity relationship at the seafloor, which when coupled with the plume modelling will allow a more comprehensive risk assessment. It will also assist with setting appropriate turbidity triggers for benthic communities and primary productivity. The Flora and Fauna Division recommends that, in conjunction long-term WQ monitoring, the proponent undertake monitoring of light availability and quality and turbidity at the seafloor at the proposed monitoring sites.

The Flora and Fauna Division also recommends that two additional sites are included into the monitoring program, one along the western side of the Fannie Bay sand bank, as this lies in the major axis of most dredge plume modelling outputs; and at Bennett Shoal, which is likely to contain benthic primary producer habitats. The proponent should also inform their approach using the research undertaken by WAMSI under the NESP Dredging node.

To link the WQ parameters and health of benthic communities, monitoring of benthic primary producer habitats should be undertaken at the proposed monitoring sites (including the two sites proposed by Flora and Fauna Division).

Response

The queries raised in this comment were also incorporated in Table 1 of the Notice of Direction and therefore have been addressed in the SER.

A benthic habitat survey was undertaken in January 2023 to identify key benthic habitats/characteristics within the broader project area, and to support the assessment of potential impact mechanisms relevant to the benthic communities present and the refinement of criteria which may apply to each community.

Details of the assessment carried out are noted in the response above and included in Section 2.3 of the SER, with a copy of the Benthic Habitat Assessment Report included as Appendix C.

Further assessment, including additional modelling of sediment deposition and sediment transport has been undertaken to further define the duration, magnitude and extent of sediment deposition (both coarse and fine), and the fate of sediments associated with the proposed dredging and disposal activities.

Impacts of fine and coarse material deposition on sensitive receptors is discussed in Section 2.5 of the SER. A summary of the modelled outcomes for fine and coarse material deposition is provided in Section 3.7 of the SER with further discussion regarding deposition and sediment fate modelling provided in Appendix D – Supplementary Dredging Modelling Report (Section 6).

Discussion of the relationship between TSS and NTU, as well as the relationship between suspended sediment and light availability at the seafloor has been dealt with in Section 3.8 of the SER. A baseline water quality monitoring program has been commissioned to capture TSS, NTU and PAR data (Refer to Section 3.6 of the SER). Based on the supplementary modelling results, monitoring locations have been revised and now include locations on the western side of the Fannie Bay sand bank and near Bennett Shoal, as recommended by the department. During dredging, these same locations will be monitored to capture TSS, NTU and PAR data.

Site specific data collected during the baseline monitoring program and during the dredging campaign will be used to further establish the relationship between TSS and NTU. Although light dependent benthic habitats were not identified within the zone of influence, the PAR data collected will also be reviewed to further understand the relationship between benthic light availability and suspended sediment effects and will be used to inform future dredging campaigns.

Comment

Marine Environmental Quality – Background TSS Triggers

The Flora and Fauna Division cautions the use of DEPWS monitoring data as this is collected for surveillance or ambient purposes which is skewed for dry season and neap tidal conditions. Its applicability for predicting conditions during spring tide and/or wet season is also constrained. The results of monitoring during previous Coonawarra basin dredge maintenance programs may well be appropriate. If this data is used, the Division recommends that details of the monitoring parameters (locations, duration, seasonality, baseline or impact sites) are also provided.

Response

It is acknowledged that data from the DEPWS harbour estuarine and flow-cell monitoring programs have limited application and tend to be biased to the dry season and neap tidal conditions.

As noted, further analysis of water quality monitoring data collected prior to and during both the 2006 and 2013 dredging campaigns has been undertaken (also noted in the Notice of Direction). Although the water quality data from the 2006 and 2013 dredging campaigns was used in the assessment in the Referral, further raw data was obtained during the SER development which enabled additional assessment of baseline conditions.

The large volume of field data was reviewed and analysed so it could be matched to the correct tide, dredge operations, location, and the supplementary model predictions.

The data included water quality depth profiles within sediment plumes generated during dredging and beyond the extent of sediment plumes, as well as time series water quality logger data prior to and during dredging.

Further discussion of baseline water quality monitoring data and plume characterisation data from previous dredging campaigns conducted at HMAS *Coonawarra* is provided in Sections 3.3 and 3.4 of the SER.

Comment

Marine Environmental Quality – Background TSS Triggers

The Flora and Fauna Division is satisfied with the proposed triggers levels and recommends that the proponent collects time-series data for TSS and turbidity over tides and seasons (Wet, Dry and transitional periods) for the zone of influence from dredging activities. This information would provide useful information for characterising water quality condition at a local scale, particularly for turbidity, TSS and light.

Flora and Fauna Division recommends that turbidity, TSS and light data is at least collected continuously during the NCIS- 5 dredging campaign and continues until the works for the development of the eastern area of the basin is completed.

This long-term data set would allow statistically robust analysis of turbidity and TSS at an appropriate scale and allow for appropriate trigger levels to be set for the Eastern Project dredging campaign.

Response

The request to undertake water quality monitoring to collect relevant turbidity (NTU), total suspended sediment (TSS) and PAR data is also noted in Table 1 of the Notice of Direction and has been addressed in the SER.

The benefits of collecting nearshore time series water quality data to improve the understanding of natural water quality processes and variations at the site and to support the management of future dredging campaigns is acknowledged in Section 3.6 of the SER.

The current dredging campaign is proposed to occur in the dry season, and therefore as outlined in Section 3.6 of the SER, a baseline water quality monitoring program is currently scheduled to obtain representative dry season turbidity (NTU), total suspended sediment (TSS) and PAR data, so that it is seasonally relevant and available prior to the commencement of dredging.

Water quality loggers capable of recording time-series NTU and PAR data will be deployed at three locations. One monitoring location will be located near Bennett Shoal, another in the entrance to Fannie Bay with the third location to be positioned to the west of the Fannie Bay sand bank. During the deployment and retrieval of the monitoring loggers, a series of water samples across the range of turbidity conditions observed will be collected and analysed for field measured turbidity and laboratory determined TSS to further establish the site specific relationship between NTU and TSS.

Outcomes of the monitoring program will be assessed to confirm the current understanding of baseline conditions and whether any adjustments may be needed to the monitoring approaches implemented during the current dredging campaign. The data will be used to support the management of future dredging campaigns at HMAS *Coonawarra*.

Further discussion of the baseline water quality monitoring program, and details of the monitoring programs to be implemented during dredging are outlined in Sections 3.6 and 3.11 of the SER.

2.4 TRANSPORT AND CIVIL SERVICES DIVISION OF THE DEPARTMENT OF INFRASTRUCTURE, PLANNING AND LOGISTICS

This section provides responses to comments received from the Transport and Civil Services Division of the Department of Infrastructure, Planning and Logistics. Each of the comments are presented in italics, and the response follows.

Comment

The referral does not provide sufficient information about the following activities to determine significance of the impact:

1. *vessel/barge movements during dredging*
2. *cutter suction dredge to nearshore discharge location*
3. *backhoe dredging for disposal at an onshore facility (i.e. hard material disposal), expected volumes 6,000m³/43,000m³ per campaign:*
    a. *barging to East Arm*
    b. *disposal of material at alternate facility*

To inform significance of impacts from the above actions, the following information is required:

1. *detail marine transport requirements including communication plan, management of vessel barge movements including route(s); frequency; and use of shipping channels*
2. *detail:*

- if there will be significant change to bathymetry due to disposal of waste at this location to impact use of waterways by other port users including for anchoring/fishing
- how port users will be alerted of the location of the pipeline
- how port users will be alerted of the location of the pipeline moving within 50m of the declared coordinates in real time
- impact of using near shore marine disposal in the previous dredging operations.

3. detail:
    a. number of return barge trips, hours of operation and route to transport hard material to East Arm. This information should be discussed per campaign.
    b. if alternate onshore facility required, commit to liaising with TSCD to assess impact of transportation to alternate location. Required information will include alternate location, transport mode/s, route/s; frequency; hours of operation and use of public roads.

Response

1. Marine Transport Requirements

For the current dredging campaign, the Contractor will be responsible for the development and implementation of both a land and marine based traffic management plan prior to the commencement of any works at HMAS *Coonawarra*. In developing this plan, the contractor will liaise with the Darwin Harbour Master and the HMAS *Coonawarra* Port to confirm their requirements.

The management plan will include a communication plan, details of vessel movements including arrival and departure procedures, transportation routes and measures for works being undertaken on water at the East Arm Wharf facilities. The Contractor will ensure all activities and vessel movements are appropriately communicated and coordinated with the Harbour Master as well as the HMAS *Coonawarra* Port Services Manager, before, during and upon completion of the dredging campaign.

Vessel movements beyond the basin will primarily involve barges which will be used to transport sediment removed by the backhoe dredge to East Arm for unloading. The barges would transit via shipping channels (e.g. within or just outside depending on advice from the Harbour Master), specifically City Channel and East Arm Channel to East Arm Wharf, all of which are frequented by other vessel traffic. Barges suitable for dredged sediment transport travel slowly (up to approximately 4 to 6 knots) both laden and unladen. These barge movements would be limited to the period of backhoe dredging and the number of trips will be low, at less than two or three barge trips per day.

For future dredging campaigns, a formal process for managing this aspect of the works will be followed and agreed in detail with the successful contractor prior to commencement of works at the site. The management of vessel movements and marine transport requirements will be done in accordance with requirements specified by the HMAS *Coonawarra* Port Services Manager and Regional Harbour Master.

2. Port Users

Changes to bathymetry

Material to be dredged via CSD will be discharged via pipeline to the previously used nearshore discharge location which is approximately 300 m south-west of the western breakwater. Within the vicinity of the dredged material discharge location, bed level is approximately –15 mLAT. At this location currents are strong on both the incoming and outgoing tides. Deposition of both coarse and fine material have now been further assessed.

Given the strong tidal currents at the proposed discharge location and the predominantly fine particle size of the dredged sediment, there will be minimal deposition of fine sediment in the vicinity of the discharge location.

Although the majority of the discharged dredged sediment will be fine, it will contain some heavy material (e.g. sand, gravel, fragments of rock or cohesive clay) which settles quickly and will accumulate in the immediate vicinity of the discharge location. This would also have been the case during previous dredge campaigns (some evidence of this was seen in the benthic habitat survey). Coarse sediment deposition up to approximately 40 mm thick is predicted to occur over a 500m extent in the immediate vicinity of the discharge point, similar to the estimation presented in the Referral. This level of sedimentation is insufficient to significantly change the bathymetry of the seabed or to form a ‘shoal’.

The coarse material deposition which will occur within the vicinity of the discharge location is therefore unlikely to result in any adverse effects to other port users including anchoring/fishing.

Discharge pipeline and notification to port users

Dredged material will initially be pumped via a 100 to 150 m section of flexible floating pipe, located inside the basin, which will allow for the necessary movements of the cutter suction dredge.

This section will then be connected to a pipe section which passes over the existing breakwater and then submerged out to the discharge location. Ballast blocks will be used to secure the discharge location in place, and floats deployed to mark the location of the discharge point. These arrangements will be confirmed with the Harbour Master and the pipeline will be monitored and repositioned as required.

Prior to placement of pipeline, the Contractor will liaise with the Regional Harbour Master to ensure a Notice to Mariners is in place to notify port users of the timing and location of the pipeline and dredging operations. The Notice to Mariners will include the location of the pipeline and discharge location including a sufficient buffer area encompassing these components to ensure any interactions with Port users are avoided. If necessary, public or commercial vessel access to the dredged material discharge location could be limited as it is within the base property boundary and naval waters area to ensure the safety of all port users. The specific requirements will be confirmed with the Harbour Master and the Port Services Manager.

The position of the pipe outlet will be monitored using GPS during discharge to ensure the release point remains within 50 m of the discharge location. The Contractor will be responsible for daily monitoring and if required repositioning the location of the pipeline and the discharge point throughout the duration of the dredging campaign.

Impact of using near shore discharge in previous dredging

There is no evidence of any substantial changes to the bathymetry of the seabed or the formation of a 'shoal' in the vicinity of the discharge location as a result of previous dredging and dredged material disposal campaigns. Underwater video survey conducted within the vicinity of the discharge location has also not identified any dramatic changes to the seabed.

The proposed discharge location is not within a depositional area given that the currents experienced at the site are of high velocity with sediment transport processes typically following the strong ebb and flood currents. Due to the strong currents and tidal movements, material discharged at this location is dispersed over a large area to the extent that settled sediment is generally within the normal range of sediment deposition and redistribution processes experienced in the harbour.

The benthic habitat assessment also noted that the type and condition of benthic communities at the proposed discharge location remains similar to that of the surrounding project area, even after the completion of multiple dredging campaigns. Observations during the benthic habitat survey indicate the deposition of a small amount of heavier sediment (e.g. some gravel and rock pieces) near the discharge location from the 2013 dredging campaign. This appears to have provided suitable substrate for the recruitment and growth of filter feeder species at this location. It is likely that upon cessation of the discharge activities, deposited heavier material may again facilitate the growth of filter feeders.

3. Onshore disposal

The timing of backhoe dredging to remove isolated patches of hard material is likely to be after the completion of dredging by CSD. Barges will be used to transport sediment removed by the backhoe dredge to East Arm for unloading. All material unloaded onshore at East Arm will then be transported via truck to the land based storage facility.

Barges will transit via an approved route along designated shipping channels. The number of barge movements required would be dependent on the size of barge selected. Preferably a barge with sufficient capacity to handle the equivalent of, or greater than, a full day of dredge production would be utilised during dredging. This would enable barge transit to the Port for unloading to occur outside dredging hours and for the barge to return for the next day. In practice, it is likely that only a small number of barge trips will be needed, however an allowance has been made for up to two to three per day in the case that smaller barges are utilised or if there is any other reason for a barge trip to the Port.

Similarly to the approach proposed for the current dredging campaign, all backhoe material dredged as part of the future eastern wharf dredging campaign would be transported by barge via an approved route along designated shipping channels to a location where it can be unloaded on-shore for re-use and/or land-based storage (e.g. at East Arm or similar facility). As per the current dredging campaign, the number of barge movements required would be dependent on the size of barge selected. A barge with sufficient capacity to handle the equivalent of, or greater than, a full day of dredge production would preferably be utilised during dredging. Based on this it is likely that only a small number of barge trips will be needed, however an allowance has been made for up to two to three per day in the case that smaller barges are utilised.

As discussed in the Referral, the East Arm disposal site controlled by Darwin Port is the only established on-land pond based dredged sediment facility in Darwin. Currently, this is the location proposed for the disposal of hard dredged material.

If an alternate onshore facility is required for either the current or future eastern wharf dredging campaign, relevant assessments will be carried out and liaison with the Transport and Civil Services Division will be undertaken to ensure impacts associated with any on land transportation are appropriately assessed and managed. Information regarding the alternate location, transport modes, routes, frequency, hours or operation and use of public roads would be provided to the department to assess the extent of potential impacts on the transportation network.

2.5 DEPARTMENT OF INDUSTRY, TOURISM AND TRADE

This section provides responses to comments received from the Department of Industry, Tourism and Trade. The comments are presented in italics, with the response provided below each one.

Comment

Mineral Titles Division

Advised that there are no issues from their perspective with this referral

Response

This advice is noted.

Comment

Petroleum Titles Division

Advised that the area set aside for dredging is covered by a Petroleum Reserved Block (RB51, under s9 of the Petroleum Act 1984). The reserved block prevents the application for or grant of an exploration permit or licence under the Petroleum Act 1984. In addition, a reserved block under s6 of Geothermal Energy Act 2009 (GRO1) partially overlaps the area. The reserved block prevents the application or grant of an exploration permit or licence under the Geothermal Energy Act 2009. Overall, the dredging proposal has no impact from an Energy Titles perspective.

Response

The advice is noted.

Exploration permits or licences under the *Petroleum Act 1984* and *Geothermal Energy Act 2009* are not being sought as part of the proposed dredging and dredged material disposal activities.

Comment

***Marine Environmental Quality* - Fisheries Division**

Ensuring robust management of the dredge plume is the main concern from Fisheries' perspective. Presumably EPA are comfortable with the location of monitoring sites and trigger levels set.

Response

Monitoring locations and relevant trigger levels were proposed in the published Referral documentation. As part of this SER process, new data has been reviewed and refinements made to the proposed monitoring locations and trigger levels. Further detail is provided in Section 3.6

(Project Specific Baseline Water Quality Monitoring), Section 3.9 (Proposed Trigger Values and Zones of Impact/Influence) and 3.11 (Revised Monitoring Program) of the SER document.

A Draft Dredging and Disposal Management Plan (DDMP) has also been prepared which provides a framework to manage and monitor dredging and dredged material disposal activities at HMAS *Coonawarra*. The DDMP specifies the monitoring programs to be implemented during dredging, including monitoring locations and relevant monitoring criteria. A copy of the Draft DDMP is provided in Appendix E.

Beyond this SER, further data will be collected, and monitoring undertaken to confirm the behaviour and extent of sediment plumes to inform the future management of dredging and dredged material disposal activities at HMAS *Coonawarra*.

Comment

Marine Environmental Quality - Stakeholder Engagement

The proponent references impacts to water quality, including "This may have some effect on the recreational uses of the water including viewing, and water sports which are all popular activities within some parts of the project area." The proponent also refers to the fish feeding tourism business neighbouring the project area.

The proponents list of Stakeholders does not yet include any tourism operators. Given the potential impacts to water quality during dredging it is recommended that the proponent engage with the Regional Tourism Organisation – Tourism Top End, recreational/guided fishers and tourism operators in the area including: Amateur Fishermen's Association of the Northern Territory (AFANT), Northern Territory Guided Fishing Industry Association (NTGFIA), Aquascene Doctors Gully (fish feeding) and 00Seven Jetski Adventures.

Response

The proposed dredging and disposal activities are key components of a Commonwealth Defence project. Defence has established procedures and protocols in place to manage and respond to stakeholder concerns. To date, Defence has undertaken consultation with project stakeholders, agencies, the Port of Darwin and potential contractors and continue to consult with identified stakeholders through the assessment process as well as during the pre-construction phase. Once a contractor has been awarded the project, they will also have a responsibility to manage and engage with relevant stakeholders for the duration of the works.

Prior to and during the dredging campaign, mechanisms will be put in place to enable stakeholders and members of the public to raise any issues or concerns with either the Defence project team or the Contractor. The Contractor will be required to track and manage any complaints that may be received during the works. Details of this process are outlined in the DDMP (Appendix E) including the requirement to implement corrective actions in response to complaints.

It is also noted that as part of the approval process, the Referral and all supporting documentation were placed on public display and no submissions were received from non-agency stakeholders or the public.

Dredging of the original harbour basin at HMAS *Coonawarra* occurred between 1980 and 1982, with six other dredging campaigns conducted between 1993 and 2015. There is no record of substantial stakeholder concerns or complaints associated with previous dredging operations.

2.6 HERITAGE BRANCH OF THE DEPARTMENT OF TERRITORY FAMILIES, HOUSING AND COMMUNITIES

This section provides responses to the comments received from the Heritage Branch of the Department of Territory Families, Housing and Communities. The comments are presented in italics, with the response provided below each one.

Comment

Culture and heritage

In the Referral report and appendices A, D and F, Section 7.11.2 Nonindigenous Heritage (page 71) states that there are no declared heritage places situated within HMAS Coonawarra and that the works are unlikely to affect heritage values. That is inaccurate, as there is a declared heritage place known as the WWII Degaussing Range within the restricted waters of the Larrakeyah Naval Base. It is located approximately 300m SE from the edge of the furthest point of the proposed NCIS-5 Project Dredge Area (see attached map extract). It is true that the proposed dredging works are unlikely to impact on the heritage place, but it is worth noting its position, particularly in relation to the proposed future eastern wharf dredging.

Response

It is acknowledged that a declared Heritage Place is located approximately 300 m south-east from the proposed dredge area (Figure 2.2). Further review of the Northern Territory Governments Heritage Register identifies the place as the World War II Degaussing Range which was declared and gazetted on 3 July 2013.

According to the Heritage Register, the Degaussing Range, built in Darwin Harbour in 1945, was an early Admiralty version of an innovative naval defence technology used to measure the magnetic signature of ships to assess their vulnerability to enemy magnetic mines. The Degaussing Range consisted of a series of 12 sensor coils embedded in the seabed which were connected by cables to a control room located within an operations hut built on the cliff face at the Larrakeyah Naval Base.

Today, the physical remains located at this Heritage Place are reported to consist of the 12 steel rings approximately 1.7m in diameter on the ocean floor, insulated cable and two large concrete support blocks.

The proposed dredging and dredged material disposal activities will not directly impact this Heritage Place. The release of dredged sediment at the proposed discharge location will result in changes to marine water quality due to the generation of suspended sediment plumes, and it is predicted that sediment plumes generated at this location will typically follow the tidal regime with suspended sediment concentrations greatest at the point of discharge. Fine sediment particles (the majority of the discharge) will disperse over a large area while heavier particles (e.g., gravels, clumps of clay) will settle on the seabed in the vicinity of the discharge location. Based on modelling results sediment deposition at the Heritage Place will be negligible given the tides and currents experienced in this area of the Harbour. It is unlikely that temporary local increases to turbidity and suspended sediment levels within the water column will adversely affect the heritage values of the WW II Degaussing Range.

Figure 2.2 Location of World War II Degaussing Range (Heritage Council Northern Territory, 2022)

2.7 NORTHERN TERRITORY POLICE, FIRE AND EMERGENCY SERVICES

This section provides responses to the comments received from the Northern Territory Police, Fire and Emergency Services. The comments are presented in italics, with the response provided below each one.

Comment

In relation to the waterway dredging, the Northern Territory Fire and Rescue Service has little to no capacity to respond to waterway incidents without the support of private contractors.

Response

This advice is noted.

The dredging contractor will have strict protocols in place to manage the day to day dredging and dredged material disposal operations.

The contractor will be required to plan for and manage any incidents that may arise during the works and, if necessary, there is support available from the Navy. The base has the capacity for operations in the basin and will be managed accordingly.

3 Conclusion

Each of the queries and comments raised by the various government authorities has been addressed with no change to the overall outcome of the assessment of dredging and discharge related activities on the environment, as presented in the Referral.

Given the outcomes of the further assessment reported in this document and the SER, implementation of the updated project specific DDMP, and evidence from previous dredging campaigns conducted at HMAS *Coonawarra*, the residual risk of the dredging and discharge related activities on the environment remains low.

4 References

Streten, C. (editor)., 2022, Revised predictive benthic habitat map for Darwin Harbour. Report prepared for Department of Environment, Parks and Water Security. Australian Institute of Marine Science, Darwin, 119 pp. including appendices.

Appendix C

Benthic Habitat Mapping Report

HMAS Coonawarra Marine Habitat Mapping January 2023

for KBR

Document Ref:	VER-30230-REP-001
Revision:	1
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Controlled Document

Revision History

Rev	Date	Comment	Author	Reviewed	Approved
A	14/02/23	Internal review	B. Piek	S. Brekke	
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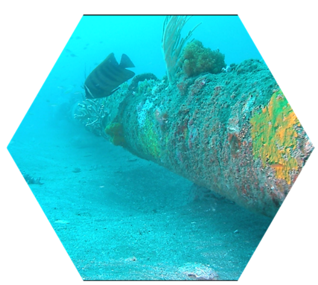
1	3/4/23	Revisions	B. Piek	C. Oyarzun	C. Oyarzun

Contents

1 Summary

KBR contracted Geo Oceans to supply remotely deployed underwater camera equipment and personnel to execute a habitat survey in the near shore waters around HMAS Coonawarra Naval Base in Darwin. The survey was undertaken between 16th -18th January 2023 during the Monsoon season. A total of 50,479 points of habitat data were acquired across 73 towed camera transects. The transects ranged in length from 95m to 139m and covered a total distance of 7.5km. Throughout the survey area a dominance of Filter Feeder communities was observed. The majority of the filter feeder community had a percentage coverage of less than 10%. Seagrass and hard coral were not observed at any point during the survey.



2 Introduction

KBR contracted Geo Oceans to supply remotely deployed underwater camera equipment and personnel to execute a habitat survey in the near shore waters around HMAS Coonawarra Naval Base in Darwin. Geo Oceans specialise in the provision of professional services using underwater robotics for inspection and marine science surveys.

KBR has undertaken modelling of the potential dredge sediment plume area of impact. This was provided to Geo Oceans in order to design a sampling plan that would effectively classify and map the habitat types within the area.

3 Methods

3.1 Survey Logistics

The survey was undertaken between 16th -18th January 2023. Due to logistical and timing requirements this survey was undertaken in the Monsoon season. The additional rainfall during this season resulted in additional turbidity. The survey was conducted over the neap tides to allow for the best chance at low current and lower turbidity. Despite these precautions the visibility was still poor, varying from approximately 30cm to 1m. The wind was predominantly from the northwest during this period which resulted in additional turbidity on shallower inshore sections.

The towed camera operations were conducted on the *Warrigal,* a 15m jetboat with a Davit installed. The water depth in the areas surveyed ranged from approximately -26 m to +0.5m Lowest Astronomical Tide (LAT).

Figure 1 Towed camera deployment, setup aboard the Warrigal

3.2 Survey Design

A detailed analysis of previous data and maps was undertaken to validate the available environmental data in the survey area. Prior to the survey, Geo Oceans plotted the location of 60 towed camera transect locations in ArcGIS software, which would form the basis for the towed camera survey. Additional transects were added in response to on-site habitat assessment and KBR areas of interest.

3.3 Towed Camera Operations

The towed camera system consisted of topside electronic technology and survey software and in-water towed camera equipment. The topside technology allowed the on-site (real-time) assessment of data and the assimilation and recording of data sets (i.e., video, still images, GPS and on-site habitat assessment).

Prior to camera deployment, the transect number and locations were confirmed and recorded within the survey system. The still, video and GPS inputs were confirmed as operational, and the towed camera frame was lowered to the seafloor. The camera frame was lowered until visual confirmation was achieved that the camera was at the appropriate height for data collection. This was typically 0.5m off the seafloor. The vessel navigated from the transect start point while towing the towed camera system at a speed of approximately 0.6 knots for at least 100m. While historically the video camera on the tow camera is capable at detecting the types of seagrass typically found in Darwin Harbour, as an added confirmation at the start of every transect the vessel maintained position while a set of good quality DSLR still images was taken. The aim being to further confirm any absence of seagrass as well as to detect any seagrass remnants, small leaf biomass or root systems, particularly in areas where seagrass has been previously observed.

3.3.1 Topside Control Unit

The topside component of the towed camera system combines GO Visions™ habitat assessment software, ArcGIS software, GPS, a Topside Control Unit (TCU), dual monitors, hard drives and a laptop interface (Figure 2).

The system is controlled through the laptop interface and coordinated through the TCU. Video footage, still images and GPS positioning data is collected through the TCU and assessed by the operator within the GO Visions™ software on the laptop interface. The GO Visions™ software is used to encode GPS data to the video footage and still images. On-site habitat assessments are undertaken simultaneously by the operator. All data inputs are then collectively recorded through the GO Visions™ software and logged in an MS Access database file.

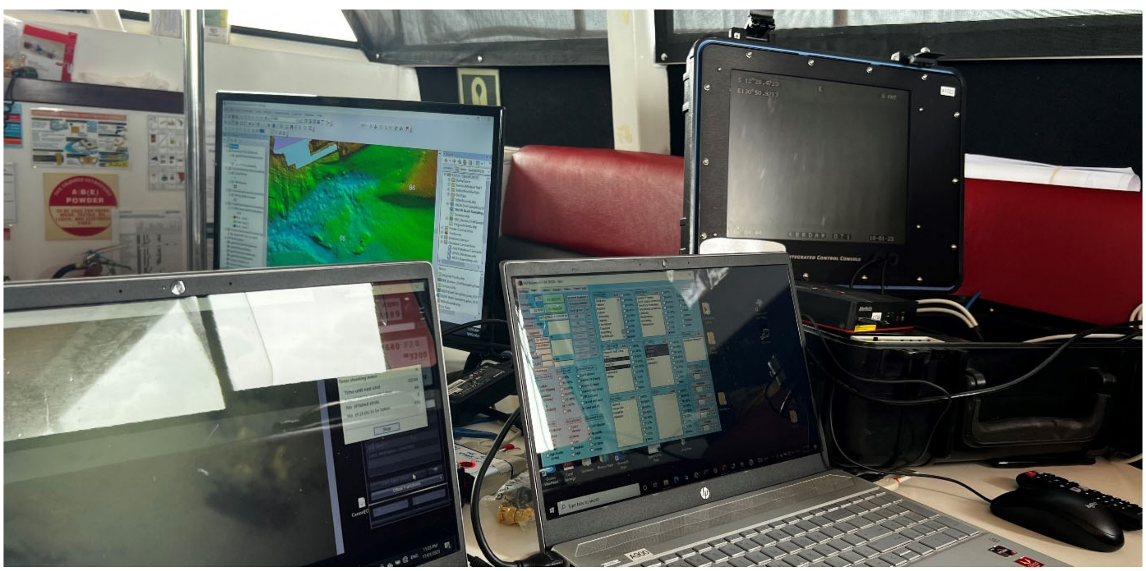


Figure 2 Towed Camera video analysis setup aboard the Warrigal.

3.3.2 Towed Camera

The towed camera frame housed a low light (0.1 lux) video camera and DSLR still image camera. The towed camera frame has a hydrodynamic design to minimise the subsequent drag forces from the water. This reduces camera lag behind the vessel and the error associated with spatial positioning between the GPS receiver on the vessel and the subsea camera frame.

The video camera was mounted on a 45° forward facing angle. The digital SLR camera (DSLR) was housed inside a subsea pod and mounted to the towed camera frame on a 90° downward angle (facing the seafloor).

The Digital Single Lens Reflex (DSLR) stills camera was controlled by and displayed on the laptop interface. The DSLR was set to automatically trigger exposures at 5 second intervals.

Lighting was provided by a pair of 1200 Lumen torches. One facing downward to provide light for the DSLR and one facing forward to provide light for the forward-facing SD camera.

3.3.3 Spatial Positioning

The GPS position (latitude and longitude) coordinates were acquired using a Hemisphere DGPS with an accuracy of less than 5m (95% confidence). The GPS antennae was positioned as close as possible to the towed camera's surface tow point. To reduce the towed camera frame's drag, the vessel was operated at slow speeds (less than 0.6kn) to minimise the camera's spatial position error relative to the GPS antennae.

3.4 Data Analysis

The video feed was analysed in real-time, using Geo Oceans' customised software program (GO Visions™). Field scientists recorded habitat point data live in real time based on the video feed and DSLR still imagery being displayed. Biota was categorised into five different subtidal 'Community Classes' as defined in the habitat classification scheme (Appendix A). This was based on the CATAMI system (CATAMI, 2013). The "Filter Feeder – Soft Coral" and "Filter Feeder – Other" Community Classes were combined into a single Filter feeder group. Substrate was also recorded and included information such as percentage of hard and soft substrate, profile of the soft and hard substrate and an estimation of sediment size.

Observations were recorded and geo-referenced using GO Visions™ software.

3.5 Data Checking

Data were error checked in a Microsoft Access database for blank fields and erroneous GPS coordinates and habitat classifications. The data were converted into a GIS shapefile (as point data) and displayed in ArcGIS. Habitat data were symbolised to show the dominant community types (i.e., Coral, Seagrass, Filter Feeders and Macroalgae). The point data were reviewed for habitat classifications that were inconsistent with surrounding point data and satellite imagery.

3.6 Map Production

The habitat data was processed into maps using two methods. A preliminary map using the raw data was created by showing the Raw Point data in ArcGIS using the percentage cover of the dominant habitat type to provide details within each transect (Figures 3-6).

The habitat data was then classified based on the dominant biota for each transect. The mean percentage cover for each transect was determined for the dominant biota type and this value was used to further refine the data set. The filter feeder category was broken into two categories, that was transects with an average density of between 2 and 10% and transects with an average density of between 10 and 20%. Where there was no dominant biota the percentage of hard substrate versus soft sediment was considered. Where soft sediment was dominant the category was further broken up according to sediment profile into the following categories: 'High Profile Sand (Dunes)', 'Low Profile Sand (Ripples)' and 'Flat Sand/Silt' substrate. Habitat polygons were interpolated from the habitat classes represented by each transect, using Thiessen polygons, which for any point within the polygon use the value of the nearest transect. The boundary was digitized from tangents to 300m buffers around all transect midpoints.

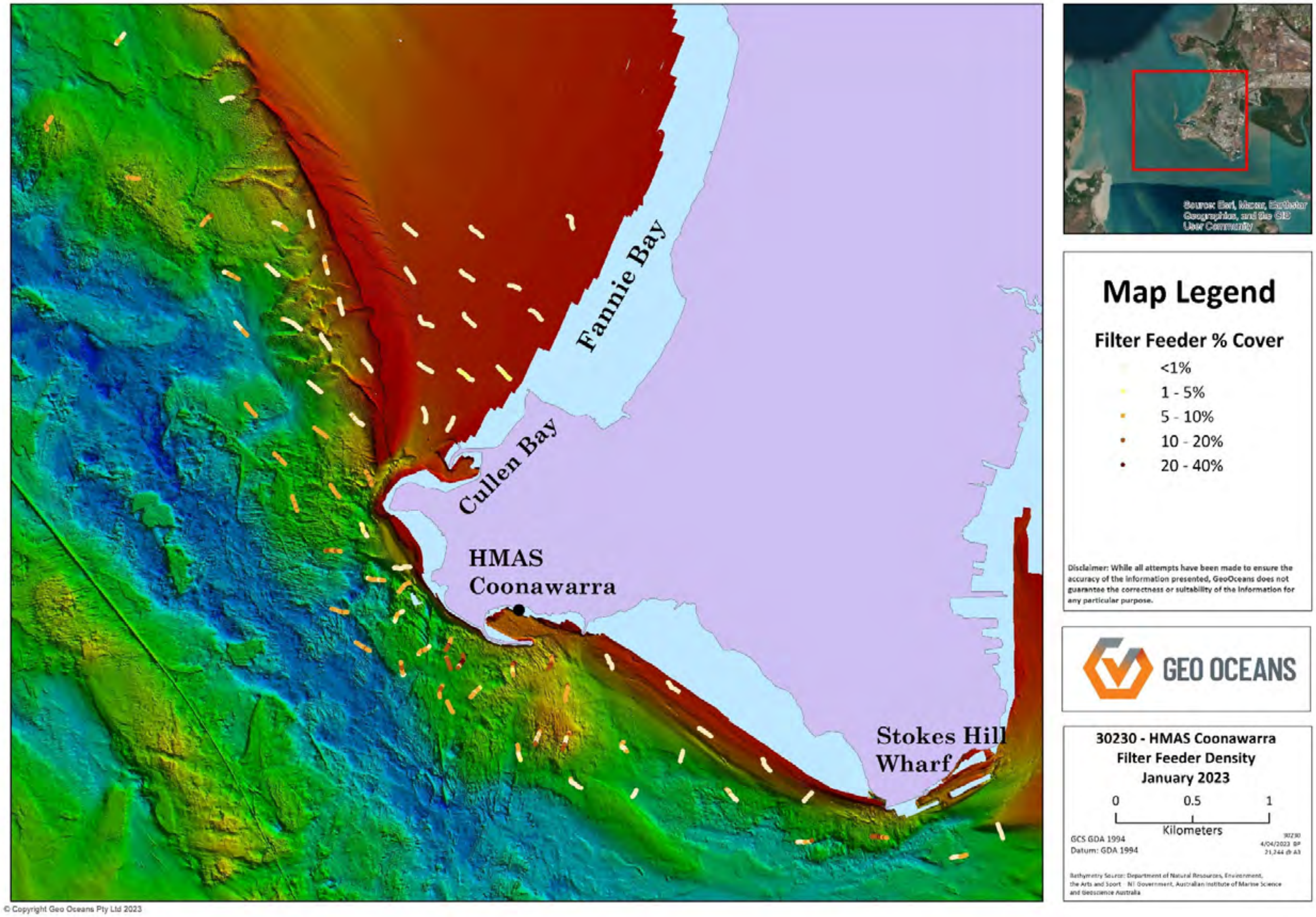


Figure 3. Map showing filter feeder density for each transect – Overview

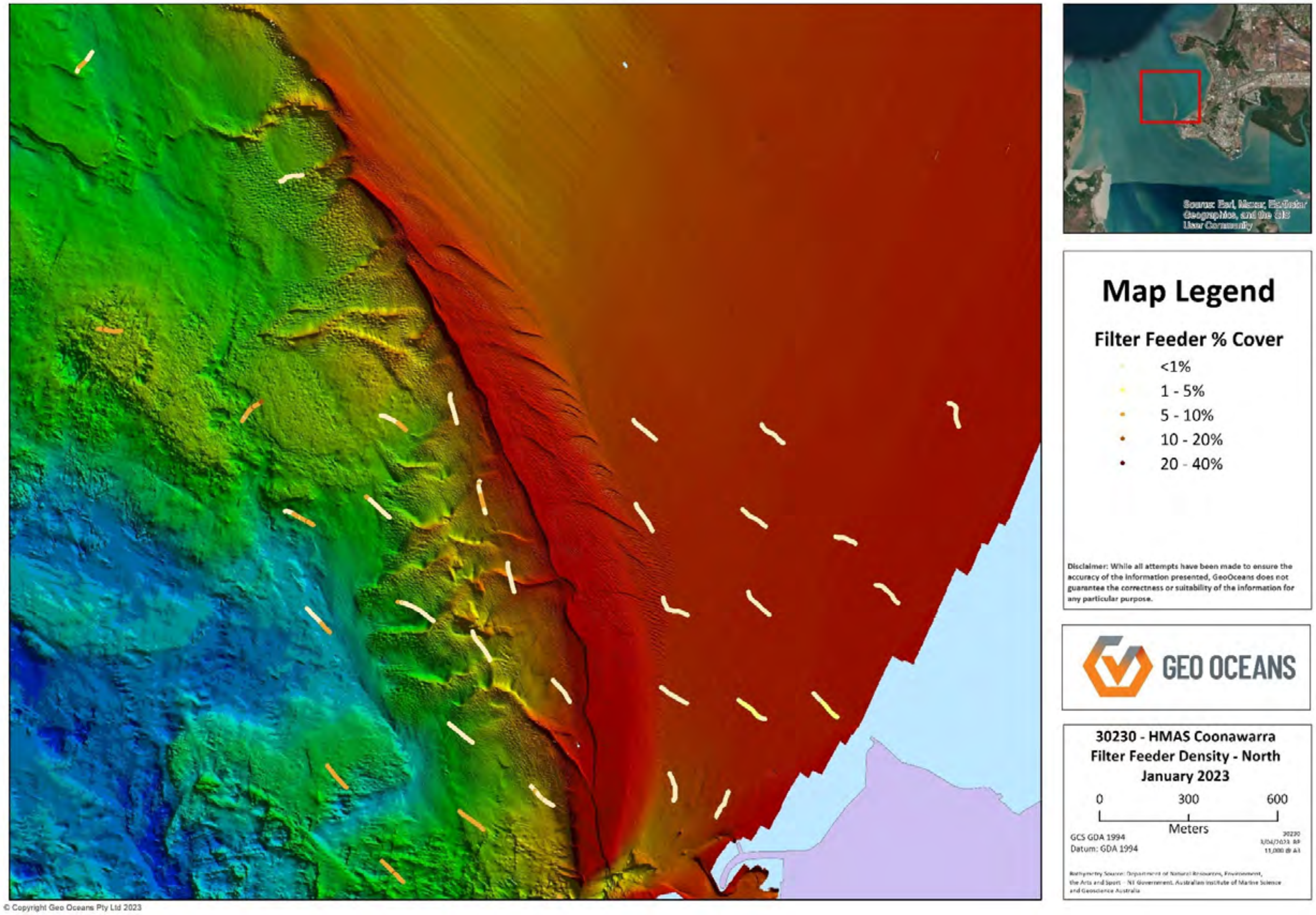


Figure 4. Map showing filter feeder density for each transect – Northern Area

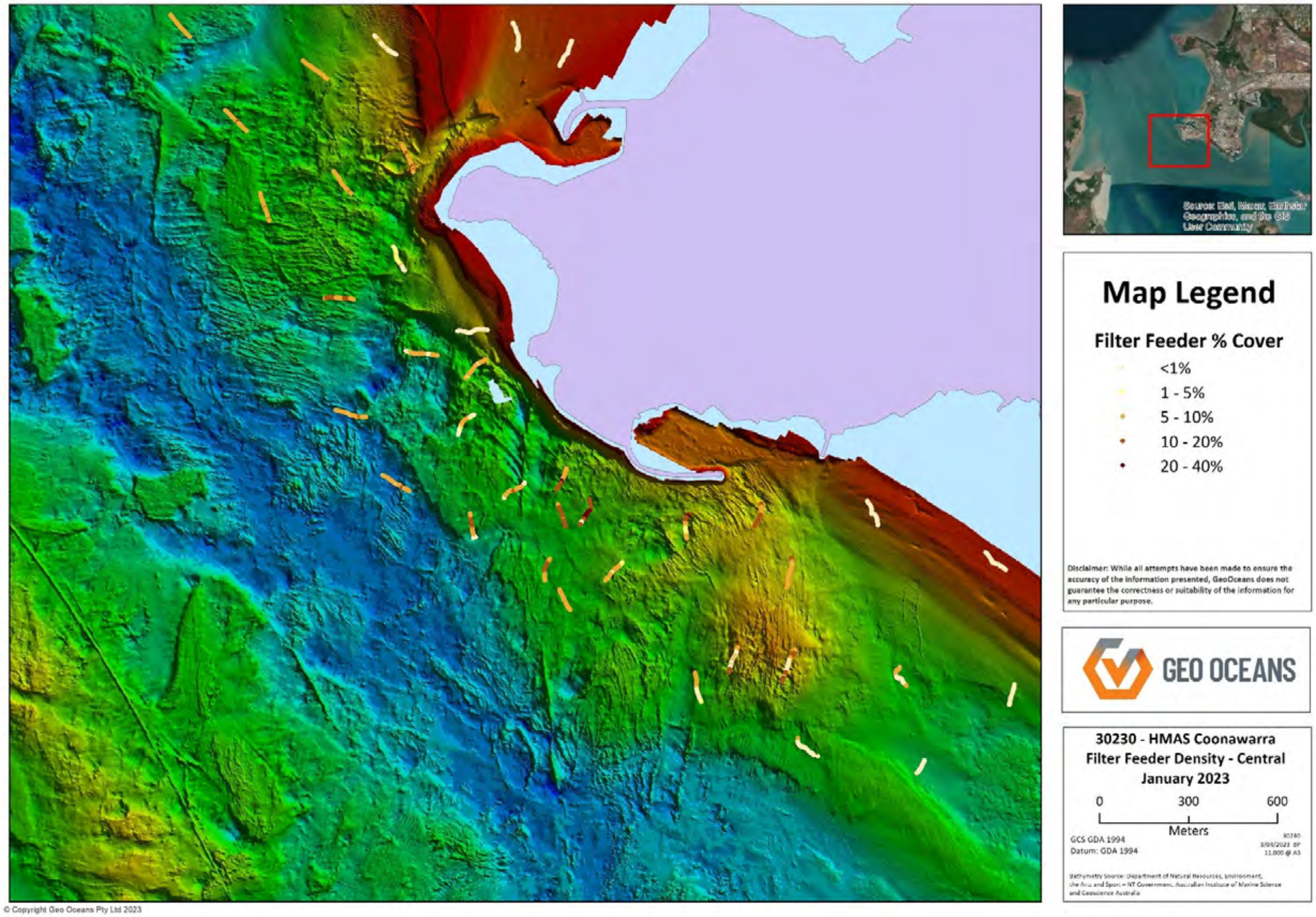


Figure 5. Map showing filter feeder density for each transect – Central Area

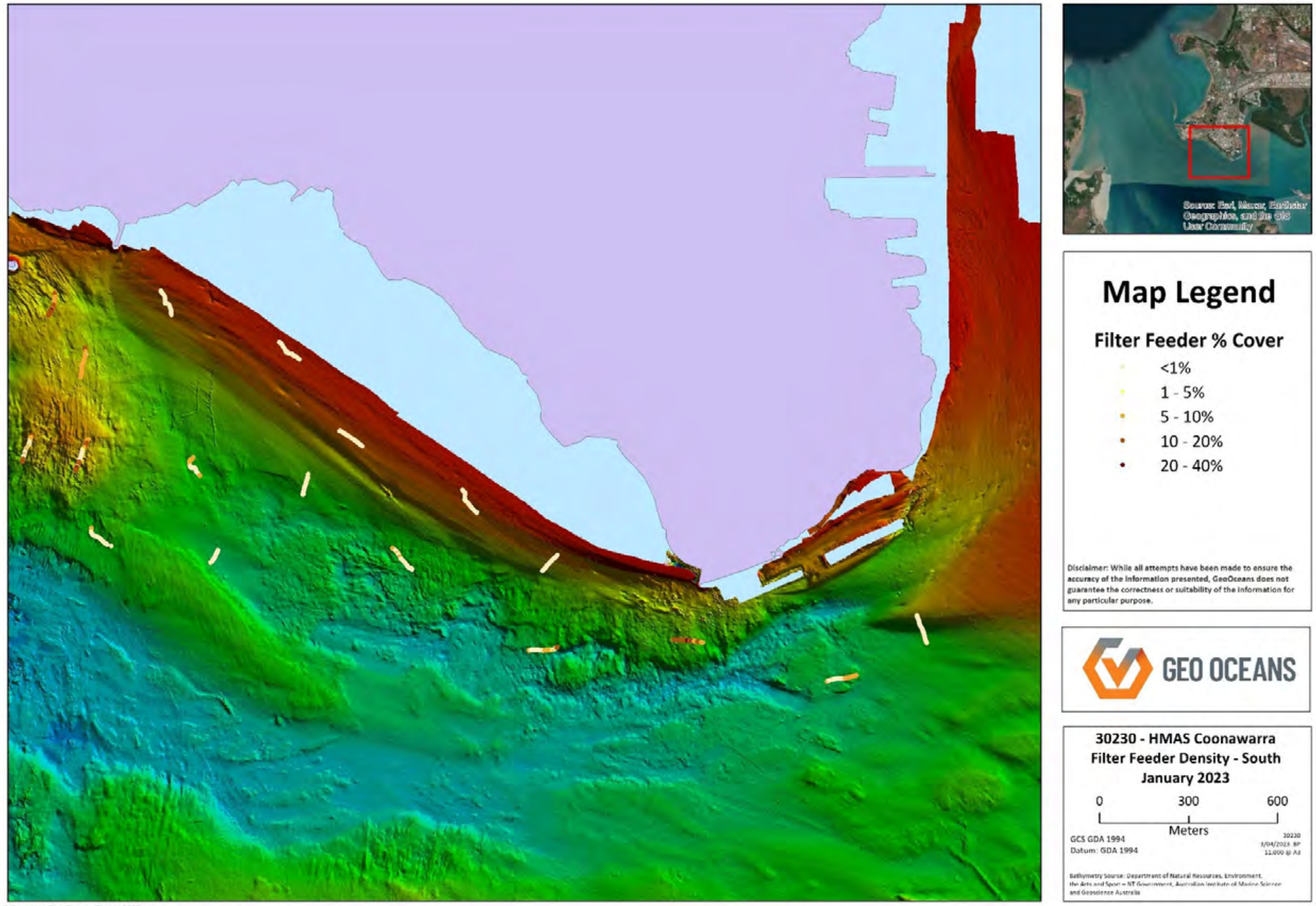


Figure 6. Map showing filter feeder density for each transect – Southern Area

4 Results

A total of 50479 points of habitat data were acquired across 73 towed camera transects. The transects ranged in length from 95m to 139m and covered a total distance of 7.5km. Throughout the survey area sparse Filter Feeder communities were predominant. Seagrass and hard coral were not observed at any point during the survey. Appendix B provides summary transect data for the survey. The habitat data was imported into ArcGIS software to display the benthic community types recorded in the survey area (Figure 16).

4.1.1 Substrate Types

Mixed Hard and Sand Substrate

This substrate was dominated by filter feeder communities, with availability of rock often determining the density of the filter feeder community. The rocks were generally boulder (>256mm) or small platforms protruding from a sandy or silty substrate.

High Profile Sand Substrate (Dunes)

This substrate type was seen to the west of the sand bar in Fannie Bay. It consisted of large dunes of sand >5m high. There was no biota present on the sand but at times there is some rock with filter feeders or the remnants of filter feeders (Figure 7) between the dunes.

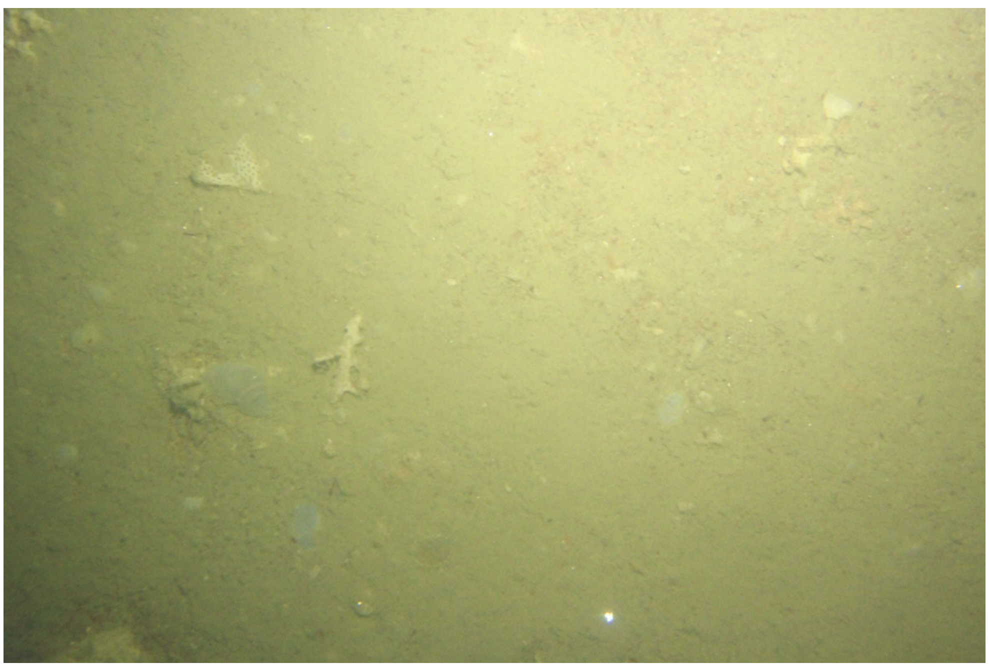


Figure 7. Filter Feeder debris seen at the base of Dune Sand Substrate

Low Profile Sand Substrate (Ripples)

Seen throughout Fannie Bay was sandy substrate with small (<10cm) ripples (Figure 9). The ripples were regular in appearance and were clear of biota. Some patches were flattened and absent of ripples, in previous surveys (Geo Oceans, 2014a) these were the substrate type more likely to contain *Halophila* seagrass communities, however no live seagrass/seagrass remnants or root systems were observed during this survey.

Flat Sand/Silt Substrate

Habitat where there is predominantly sand and silt with the occasional hard substrate protruding through (Figure 10). The rock outcrops may contain filter feeders but not in significant enough numbers to meet the 2% threshold for 2-10% Filter Feeder habitat.

Figure 8. Sponge dominated Filter Feeder habitat inshore Fannie Bay

Figure 9. Rippled Sand Substrate in Fannie Bay.

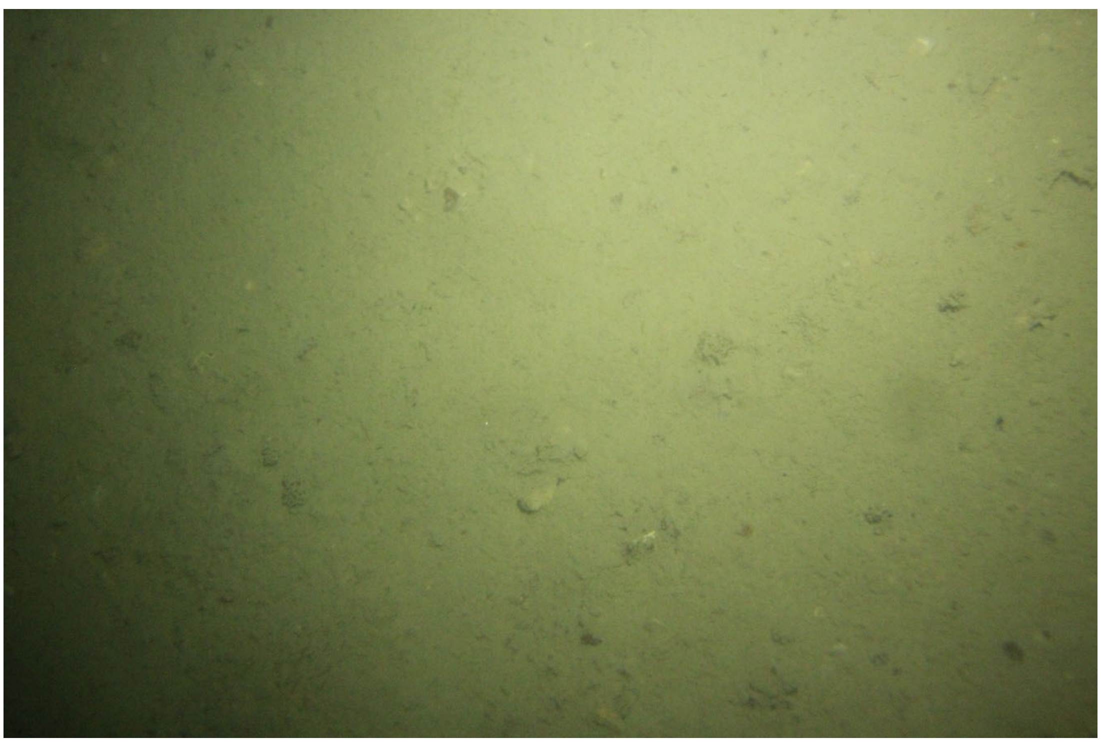


Figure 10. Example of the Flat Sand/Silt substrate seen in the survey area

4.2 Observed Habitat Types

4.2.1 Filter Feeder Assemblage Composition

The filter feeder class consisted of both Cnidarian Soft Coral filter feeders and other filter feeders such as Bryozoa, Porifera, Ascidians and other Cnidarian filter feeders not included in the soft coral category. A small inshore section of Fannie Bay contained a community of a single type of erect branching sponge (Figure 8). The filter feeder community throughout the remainder of the region was reasonably consistent throughout the region with distance from shore being the primary determinant of assemblage composition. Figures 11-15 show examples of filter feeder communities seen during the survey.

Porifera

Sponges (Porifera) were the most frequently seen biota throughout the survey area. Further from shore the sponges were dominated by the Laminar morphology followed by other erect forms, Erect Palmate, Erect Branching and Cup morphologies. Closer to shore a mixed assemblage of massive, encrusting and the erect morphologies was observed.

Soft Coral

Soft Coral were commonly observed throughout the area. Further from shore the Gorgonian and other 2d growth forms were more prevalent. Closer to shore there was a mix of the Gorgonian and 2d forms as well as more 3d bushy soft coral. Sea whips were rare but were present.

Other Filter Feeders

Bryozoans and Hydrozoans were found in patches throughout the area. Ascidians were rare but were observed.

4.2.2 Filter Feeder Categories

Filter Feeders 10-20%

This classification is used anywhere that the biota is dominated by filter feeders, that is, where average density for an entire transect was higher than 10%. The highest average filter feeder density for an entire transect is 16% and the highest observed density for any given point within a transect was 40%. It is worth noting that percentage coverages within a transect that exceeded 20% was very rare and due to the patchy nature of the filter feeder growth would only cover a very small area.

Filter Feeders 2-10%

This classification is used anywhere the average filter feeder density for an entire transect was between 2% and 10%. These sections are still dominated by bare substrate but have a sparse coverage of filter feeders. The coverage throughout these communities was very patchy and highly dependent on the available hard substrate.

Figure 11. Filter Feeder habitat containing Sponges and Colonial Ascidian

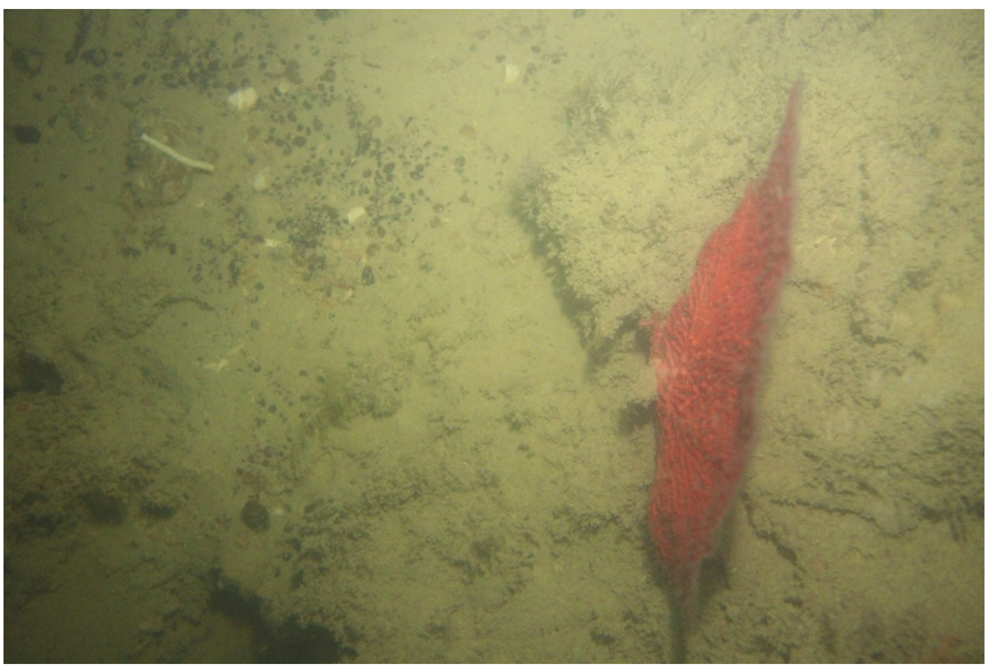


Figure 12. Filter Feeder Habitat containing a Gorgonian Fan soft coral

Figure 13. Filter Feeder Habitat containing lace Bryozoans.

Figure 14. Filter Feeder habitat containing a Hydrozoan.

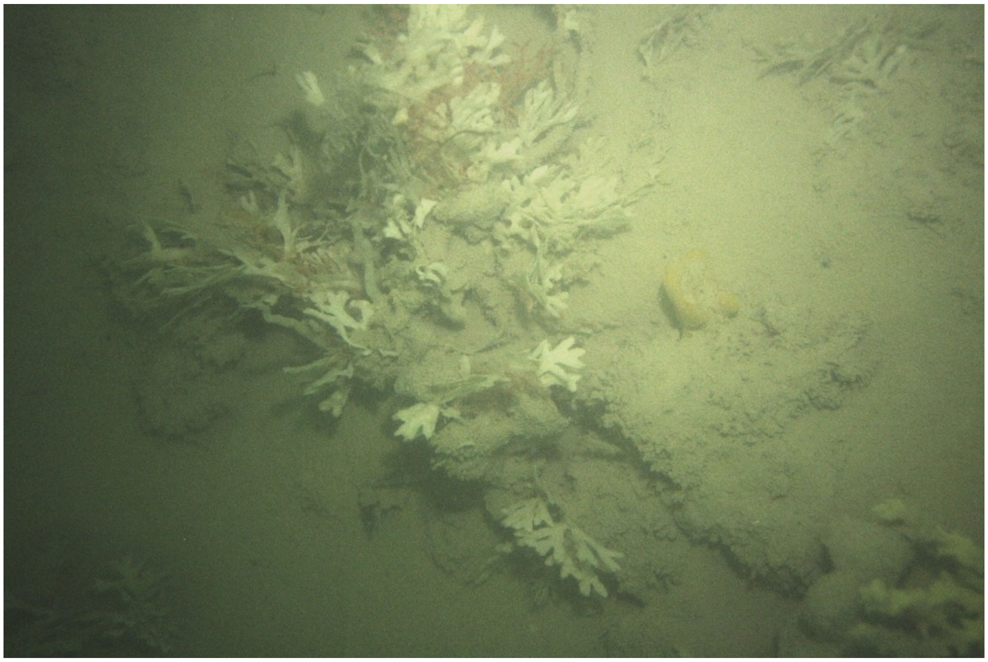


Figure 15. Filter Feeder habitat containing Bryozoan.

4.2.3 Macroalgae

Macroalgae was seen only in trace amounts throughout the survey. No significant patches were seen. This absence of macroalgae is likely due to the turbidity of the water in Darwin Harbour and lack of hard substrate in the shallow subtidal zone.

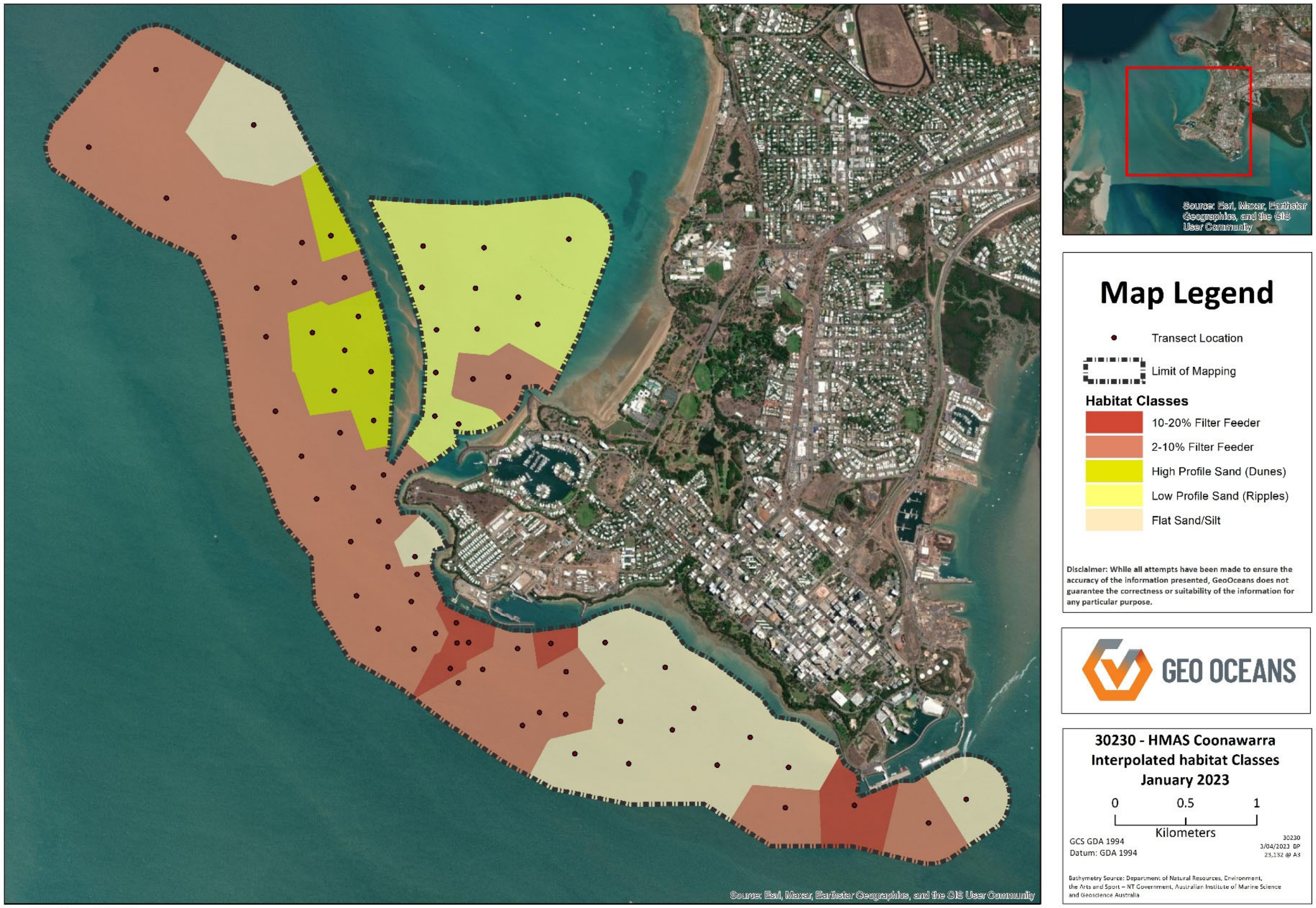


Figure 16. Map showing interpolated habitat classification

4.3 Absent Biota Types

4.3.1 Hard Coral

Hard coral was not observed within the survey area. Previous surveys within Darwin Harbour have shown that Hard Coral habitat is often limited to the shallow subtidal and lower-littoral (intertidal) areas (Geo Oceans. 2012). Suitable hard substrate within this shallow depth range is absent from this survey area.

4.3.2 Seagrass

Historically, Fannie Bay has been known to hold both *Halodule* and *Holophila* seagrass in low densities (Geo Oceans 2014a). Additional effort was made to locate any seagrass around these historical seagrass beds by capturing additional images with a DSLR camera, however no seagrass was observed. No indication of seagrass remnants or root systems was observed. The same equipment and technique were used in both the historical and current survey. Previous long term seagrass monitoring has shown that the *Halophila* beds in Fannie Bay are ephemeral, with seagrass coverage more likely to be present in June/July before a decline moving into the Monsoon season (Geo Oceans 2014b).

5 References

CATAMI Technical Working Group (2013) *CATAMI classification scheme for scoring marine biota and substrata in underwater imagery - Technical Report*. Accessed Dec 2022. Website [http://catami.org/classification] Version 1.4

Geo Oceans (2012) *Towed Camera Marine Habitat Mapping Survey, NT Department of Land and Planning – East Arm Wharf Expansion Project*. Unpublished Report.

Geo Oceans (2014a) *Ichthys Nearshore Environmental Monitoring Program, Seagrass Habitat Monitoring, October 2014. Technical Report*. Unpublished Report

Geo Oceans (2014b) *Ichthys Nearshore Environmental Monitoring Program Seagrass Habitat Monitoring, February 2014 – Technical Report*. Unpublished Report.

IX Survey (2010) *Hydrographic Survey Report for Darwin Port Corporation for Provision of Hydrographic Services.* Unpublished report.

Appendix A Habitat Classification Scheme

Community Class	Biota
Filter Feeder - Soft Coral	Massive Soft Coral
	Fans
	Branching
	Sea Pen
	Hydroid
	Zooanthid
	Whips
Filter Feeder - Other	Bryozoan
	Sponges
	Ascidian
	Bivalve
	Barnacles
Sea Grass	Elliptical
	Strap-Like
	Halophila
	Halodule
Hard Coral	Tabulate
	Sub-massive
	Staghorn
	Solitary
	Massive
	Foliose
	Encrusting
	Digitate
	Corymbose
	Columnar
	Branching
	Bottlebrush
Macroalgae	Canopy-Forming
	Erect Coarse Branching
	Erect Fine Branching
	Articulated calcareous
	Laminate
	Membranous
	Encrusting
	Filamentous

Appendix B Transect Data

Project Name	Transect #	Site #	Latitude Start	Longitude Start	Latitude End	Longitude End	Survey Date	Macroalgae Mean % Cover	Seagrass Mean % Cover	Hard Coral Mean % Cover	Filter Feeder Mean % Cover	Hard Substrate % Cover	Transect Length (m)	Points
30230	1	43	-12.4628	130.8185	-12.4636	130.8187	16-Jan-23	0.00	0.00	0.00	13.45	10.55	98.96	657
30230	3	47	-12.4627	130.8196	-12.4636	130.8191	16-Jan-23	0.00	0.00	0.00	15.53	26.44	100.86	578
30230	4	42	-12.4613	130.8187	-12.4625	130.8184	16-Jan-23	0.00	0.00	0.00	10.38	13.74	99.65	374
30230	5	48	-12.463	130.8225	-12.4641	130.8224	16-Jan-23	0.08	0.00	0.00	8.78	15.27	94.95	934
30230	6	50	-12.4628	130.8247	-12.4636	130.8245	16-Jan-23	0.32	0.00	0.00	11.07	16.24	99.60	904
30230	7	51	-12.4645	130.8256	-12.4654	130.8254	16-Jan-23	0.14	0.00	0.00	6.76	14.87	107.53	731
30230	8	52	-12.4673	130.8257	-12.4681	130.8252	16-Jan-23	0.18	0.00	0.00	7.70	10.00	125.38	963
30230	9	62	-12.4672	130.824	-12.468	130.8237	16-Jan-23	0.00	0.00	0.00	4.70	6.84	104.74	850
30230	10	49	-12.4679	130.8226	-12.4689	130.8229	16-Jan-23	0.00	0.00	0.00	3.80	10.00	108.61	625
30230	11	46	-12.4645	130.8205	-12.4652	130.8199	16-Jan-23	0.00	0.00	0.00	5.27	10.00	95.14	626
30230	12	44	-12.4644	130.8182	-12.4652	130.8181	16-Jan-23	0.00	0.00	0.00	10.26	18.58	97.00	697
30230	13	45	-12.4654	130.8185	-12.466	130.8188	16-Jan-23	0.00	0.00	0.00	6.00	10.00	98.26	812
30230	14	54	-12.4627	130.8278	-12.4636	130.8282	16-Jan-23	0.00	0.00	0.00	0.00	0.00	107.46	656
30230	15	57	-12.4644	130.8314	-12.4651	130.8322	16-Jan-23	0.00	0.00	0.00	0.00	0.00	105.23	761
30230	16	59	-12.4671	130.8333	-12.4675	130.834	16-Jan-23	0.00	0.00	0.00	0.00	0.00	102.86	817
30230	17	60	-12.4688	130.837	-12.4695	130.8375	16-Jan-23	0.00	0.00	0.00	0.04	0.00	101.75	660
30230	18	61	-12.4706	130.8348	-12.4713	130.8355	16-Jan-23	0.00	0.00	0.00	1.86	5.52	102.33	572
30230	19	1	-12.4377	130.8041	-12.437	130.8047	17-Jan-23	0.13	0.00	0.00	6.36	10.58	98.07	757
30230	20	2	-12.4374	130.8083	-12.4379	130.8092	17-Jan-23	0.14	0.00	0.00	2.16	5.84	96.63	706
30230	21	3	-12.4368	130.8105	-12.4377	130.8107	17-Jan-23	0.00	0.00	0.00	0.01	0.00	105.25	640
30230	22	4	-12.4394	130.8114	-12.4404	130.8115	17-Jan-23	0.15	0.00	0.00	3.50	8.53	112.22	672

Project Name	Transect #	Site #	Latitude Start	Longitude Start	Latitude End	Longitude End	Survey Date	Macroalgae Mean % Cover	Seagrass Mean % Cover	Hard Coral Mean % Cover	Filter Feeder Mean % Cover	Hard Substrate % Cover	Transect Length (m)	Points
30230	23	5	-12.4399	130.8079	-12.4405	130.8086	17-Jan-23	0.00	0.00	0.00	2.07	5.75	106.18	638
30230	24	6	-12.4404	130.8054	-12.4408	130.8063	17-Jan-23	0.00	0.00	0.00	4.44	3.51	107.63	771
30230	25	7	-12.4433	130.8061	-12.4441	130.8069	17-Jan-23	0.00	0.00	0.00	2.58	3.26	114.02	625
30230	26	8	-12.4431	130.8088	-12.4437	130.81	17-Jan-23	0.00	0.00	0.00	1.36	5.93	139.81	678
30230	27	9	-12.4419	130.8122	-12.4429	130.8124	17-Jan-23	0.00	0.00	0.00	0.00	0.00	101.51	458
30230	28	10	-12.444	130.8111	-12.4451	130.8118	17-Jan-23	0.00	0.00	0.00	0.10	0.00	112.02	432
30230	29	11	-12.4454	130.8136	-12.4464	130.8127	17-Jan-23	0.00	0.00	0.00	0.00	0.00	96.44	747
30230	30	12	-12.4468	130.8104	-12.4474	130.8112	17-Jan-23	0.00	0.00	0.00	0.00	0.00	100.42	416
30230	31	13	-12.448	130.8067	-12.4488	130.8074	17-Jan-23	0.00	0.00	0.00	6.00	10.00	99.40	424
30230	32	14	-12.4508	130.8082	-12.4517	130.8092	17-Jan-23	0.00	0.00	0.00	6.23	10.00	97.77	390
30230	33	15	-12.4494	130.8107	-12.4501	130.8116	17-Jan-23	0.00	0.00	0.00	5.95	9.91	100.19	452
30230	34	16	-12.4487	130.8129	-12.4493	130.8137	17-Jan-23	0.00	0.00	0.00	0.76	1.30	99.89	554
30230	35	17	-12.4519	130.8137	-12.453	130.8141	17-Jan-23	0.00	0.00	0.00	7.02	10.00	100.28	540
30230	36	18	-12.4528	130.8116	-12.4537	130.8124	17-Jan-23	0.00	0.00	0.00	6.14	10.00	99.23	560
30230	37	19	-12.4534	130.8095	-12.4545	130.8099	17-Jan-23	0.00	0.00	0.00	6.67	10.00	99.63	534
30230	38	20	-12.4376	130.8161	-12.4382	130.8168	17-Jan-23	0.00	0.00	0.00	0.06	0.10	99.71	614
30230	39	21	-12.4377	130.8199	-12.4383	130.8207	17-Jan-23	0.00	0.00	0.00	0.00	0.00	100.33	684
30230	40	22	-12.4371	130.8255	-12.4379	130.8259	17-Jan-23	0.00	0.00	0.00	0.00	0.00	99.40	619
30230	41	23	-12.4409	130.8221	-12.4414	130.8228	17-Jan-23	0.00	0.00	0.00	0.00	0.00	95.60	544
30230	42	24	-12.4403	130.8194	-12.4409	130.8202	17-Jan-23	0.00	0.00	0.00	0.00	0.00	99.96	700
30230	43	25	-12.4401	130.8161	-12.441	130.8166	17-Jan-23	0.00	0.00	0.00	0.00	0.00	107.09	570
30230	44	26	-12.4429	130.8169	-12.4435	130.8177	17-Jan-23	0.00	0.00	0.00	0.00	0.00	118.07	612
30230	45	27	-12.4428	130.8195	-12.4436	130.8203	17-Jan-23	0.00	0.00	0.00	0.00	0.00	110.23	560
30230	46	28	-12.4426	130.8233	-12.4432	130.8241	17-Jan-23	0.00	0.00	0.00	0.00	0.00	102.19	652

Project Name	Transect #	Site #	Latitude Start	Longitude Start	Latitude End	Longitude End	Survey Date	Macroalgae Mean % Cover	Seagrass Mean % Cover	Hard Coral Mean % Cover	Filter Feeder Mean % Cover	Hard Substrate % Cover	Transect Length (m)	Points
30230	47	31	-12.4459	130.8215	-12.4466	130.8222	17-Jan-23	0.00	0.00	0.00	1.94	0.00	113.71	588
30230	48	30	-12.4461	130.8192	-12.4466	130.82	17-Jan-23	0.00	0.00	0.00	2.46	0.00	114.78	608
30230	49	29	-12.4457	130.8168	-12.4462	130.8177	17-Jan-23	0.00	0.00	0.00	0.00	0.00	102.38	532
30230	50	55	-12.4677	130.8288	-12.4685	130.8291	17-Jan-23	0.00	0.00	0.00	1.85	3.30	100.57	702
30230	51	53	-12.4698	130.8258	-12.4705	130.8264	17-Jan-23	0.00	0.00	0.00	1.67	10.00	100.04	720
30230	52	56	-12.471	130.8294	-12.4706	130.8296	17-Jan-23	0.00	0.00	0.00	0.69	9.38	99.02	844
30230	53	58	-12.469	130.8322	-12.4684	130.8323	17-Jan-23	0.00	0.00	0.00	0.48	0.00	101.37	886
30230	54	63	-12.4713	130.8394	-12.4708	130.8399	17-Jan-23	0.00	0.00	0.00	0.16	0.00	101.68	745
30230	55	41	-12.4629	130.817	-12.4622	130.8175	18-Jan-23	0.00	0.00	0.00	6.29	10.00	99.31	1583
30230	56	40	-12.4639	130.8159	-12.4632	130.8158	18-Jan-23	0.00	0.00	0.00	7.04	24.30	101.71	1105
30230	57	39	-12.462	130.8132	-12.4625	130.814	18-Jan-23	0.00	0.00	0.00	6.32	23.72	108.04	952
30230	58	38	-12.4609	130.8154	-12.4602	130.816	18-Jan-23	0.00	0.00	0.00	3.71	10.00	95.11	813
30230	59	37	-12.4591	130.8157	-12.4585	130.8164	18-Jan-23	0.17	0.00	0.00	5.51	10.00	101.04	824
30230	60	36	-12.4577	130.8154	-12.4576	130.8165	18-Jan-23	0.00	0.00	0.00	0.25	0.17	106.55	635
30230	61	35	-12.4582	130.8138	-12.4584	130.8146	18-Jan-23	0.00	0.00	0.00	4.74	10.00	109.37	625
30230	62	34	-12.46	130.8117	-12.4603	130.8127	18-Jan-23	0.00	0.00	0.00	6.19	14.21	109.50	637
30230	63	33	-12.4567	130.8113	-12.4567	130.8124	18-Jan-23	0.00	0.00	0.00	8.71	30.00	105.89	650
30230	64	32	-12.455	130.8134	-12.4558	130.8138	18-Jan-23	0.00	0.00	0.00	3.08	11.67	100.33	633
30230	65	67	-12.4348	130.7997	-12.4349	130.8006	18-Jan-23	0.00	0.00	0.00	6.28	10.00	101.25	803
30230	66	68	-12.432	130.795	-12.4312	130.7954	18-Jan-23	0.00	0.00	0.00	7.14	10.00	103.22	689
30230	67	69	-12.4271	130.7992	-12.4263	130.7998	18-Jan-23	0.00	0.00	0.00	2.86	10.00	100.05	787
30230	68	70	-12.4303	130.8053	-12.4301	130.8061	18-Jan-23	0.00	0.00	0.00	0.30	0.82	100.36	870
30230	69	71	-12.4737	130.8389	-12.4735	130.84	18-Jan-23	0.00	0.00	0.00	3.63	10.00	100.25	1052
30230	70	64	-12.4734	130.8433	-12.4735	130.8444	18-Jan-23	0.00	0.00	0.00	14.40	10.00	100.15	583

Project Name	Transect #	Site #	Latitude Start	Longitude Start	Latitude End	Longitude End	Survey Date	Macroalgae Mean % Cover	Seagrass Mean % Cover	Hard Coral Mean % Cover	Filter Feeder Mean % Cover	Hard Substrate % Cover	Transect Length (m)	Points
30230	71	65	-12.4747	130.8479	-12.4745	130.8492	18-Jan-23	0.00	0.00	0.00	3.20	10.00	101.53	471
30230	72	66	-12.4726	130.8508	-12.4736	130.8511	18-Jan-23	0.00	0.00	0.00	0.27	10.00	100.02	785
30230	73	72	-12.4483	130.8171	-12.4492	130.8172	18-Jan-23	0.00	0.00	0.00	0.12	4.81	100.64	819
30230	74	73	-12.4488	130.8189	-12.4496	130.8185	18-Jan-23	0.00	0.00	0.00	0.00	0.00	104.27	772

Note: All positions in WGS84 datum.

Map Legend

• Transect Location

Labelled according to Site Number

Disclaimer: While all attempts have been made to ensure the accuracy of the information presented, GeoOceans does not guarantee the correctness or suitability of the information for any particular purpose.

30230 - HMAS Coonawarra
Site Location
January 2023

0 0.5 1
Kilometers

GCS GDA 1994
Datum: GDA 1994

30230
14/02/2023 BP
23,132 @ A3

Bathymetry Source: Department of Natural Resources, Environment, the Arts and Sport – NT Government, Australian Institute of Marine Science and Geoscience Australia

Appendix D

Supplementary Dredging Modelling Report

Appendix D is provided as a separate document.

Appendix E

Draft Dredging and Disposal Management Plan

Appendix E is provided as a separate document.