Port of **Mackay**

Environmental Risk Assessment Report

Port of Mackay Maintenance Dredging

Environmental Risk Assessment

North Queensland Bulk Ports Corporation

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Prepared by	Clair Evans and Lucy Healing		
Company	2rog Consulting		
Reviewed by	Dr Ailsa Kerswell		
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EXECUTIVE SUMMARY

Introduction

The Port of Mackay is located in central Queensland on the northeast coast of Australia and the Great Barrier Reef World Heritage Area (GBRWHA). The Port is managed by North Queensland Bulk Ports Corporation (NQBP).

Sedimentation within the Port of Mackay occurs naturally and is caused by the transportation of sediment from ocean currents, swell and tides. Periodic cyclonic activity can also increase sedimentation significantly. Sediment accumulation within channels and berthing areas impacts the depths necessary for safe loading, manoeuvring and transit of vessels. This in turn impedes the overall operating efficiency of the Port and requires management. A detailed study has been undertaken to understand the most sustainable way to manage accumulating sediment at the Port of Mackay referred to as the Sustainable Sediment Management Assessment. The overall conclusion was that whilst some measures can be implemented to reduce its frequency, traditional maintenance dredging with continued sea disposal of dredged material is the best method of managing accumulated sediments. A Sea Dumping Permit (SDP) under the *Environment Protection (Sea Dumping) Act 1981* is currently held by NQBP for sea disposal of maintenance dredge material from the Port of Mackay. The current SDP will expire in January 2022 and consequently, NQBP is seeking to obtain a new SDP for a further 10 years to provide for ongoing maintenance dredging and offshore placement activities. This report provides a detailed assessment of the potential risks from maintenance dredging at the Port of Mackay.

Planned Maintenance Dredging

Maintenance dredging will occur across the Port in order to return areas to their design depth and ensure safe and efficient movement of vessels. The anticipated volume of sediment required to be managed over a 10-year timeframe is in the order of 500,000 m^3 as shown below. Exact volumes will vary depending on sediment accumulation and cyclonic activities and an upper limit of 575,000 m^3 is being requested in the permit application that allows for over dredging. Maintenance dredging is likely to occur every 3-5 years and include volumes between 120,000 to 150,000m^3 per campaign.

Number of years	Anticipated Volume	Including 15% over dredge allowance
8 years in a 10-year period	320,000 m^3 (typical wave energy year @ 40,000 m^3 per year)	368,000 m^3
2 years in a 10-year period	180,000 m^3 (high wave energy year @ 90,000 m^3 per year)	207,000 m^3
TOTAL: 10 years	500,000 m^3	575,000 m^3

The full ten-year maintenance dredging volume may be in the order of **575,000 m^3**.

Environmental values

The environmental values at the Port of Mackay are typical of an inshore environment along the central Queensland coast. The inshore marine environments are naturally turbid, with prevailing wind being the main driver of conditions. Habitats in the study area include benthic infauna communities; low density, ephemeral seagrass communities; coral communities fringing inshore islands; and coastal habitats including mangroves. However none of these habitats are found within the Port itself or within the dredge material placement area. There are a number of protected fauna species that are known to occur in the waters off the Port and terrestrial areas within the Mackay region, including marine turtles, whales, dolphins, dugong, migratory shorebirds and water mouse. The Port and surrounding areas also have values for tourism and recreation; fisheries and heritage. Of these, of most significance is that the Port is located within the GBRWHA. The project area and region make some contribution to the Outstanding Universal Value (OUV)

of the GBRWHA under the majority of the Property's listing criteria. In all cases, this contribution is incremental, in that the area supports a subset of the features and processes identified in the listing. However, none of the area's contributions to OUV are significant at the scale of the World Heritage Property.

Potential risks

The potential risks and impacts of maintenance dredging are well known. If not appropriately managed, maintenance dredging activities may interact with marine fauna and habitats both directly and indirectly. Direct effects relate predominantly to physical interactions with the dredge vessel and removal of the seabed. Indirect effects can occur in association with dredge plumes, lighting, underwater noise and introduction of marine pests. Dredge generated sediment plumes can extend over areas beyond the dredging location and alter natural sediment deposition rates and/or turbidity levels. These effects have the potential to restrict and/or inhibit ecological processes within the natural marine environment.

All potential impacts were assessed against known environmental values and data to determine the risks posed by maintenance dredging at the Port of Mackay. The key findings of this risk assessment are:

- Resuspension of sediments from maintenance dredging is comparable to natural suspended sediment concentrations (SSC). Importantly, analysis against intensity and duration thresholds indicated that dredging would not result in impacts to sensitive environmental values under any dredging scenario, including modelled volumes as high as 1.000,000 m^3 in a single campaign
- Water quality monitoring results and numerical modelling of sediment transport demonstrates that natural day-to-day (i.e. excluding extreme weather events such as cyclones) SSC levels are much higher than those generated by maintenance dredging
- Risks to sensitive communities are likely to be low for seagrass and medium for benthic macro-invertebrate communities. Seagrass communities have been shown to recover post-dredging and post large sedimentation events (e.g. tropical cyclones). Benthic communities may be temporarily impacted at the DMPA due to smothering; however studies have indicated the communities recover and restabilise
- Other sensitive communities, such as coral and mangroves, lie outside of the area predicted to be impacted by turbidity and sedimentation and the risks from maintenance dredging are negligible.
- Protected species are also unlikely to be significantly impacted by maintenance dredging. The Port of Mackay does not support important populations of marine species and disturbance to habitats (including critical habitat for one marine turtle) will be low. Indirect disturbances can be effectively managed via best practise dredging operations. The short timeframe of each campaign will also reduce risks
- Other Port users may experience short-term disruptions to their activities, but these disruptions will not be significant.

A summary of risks is provided in in the table below. This risk assessment is based on the application of standard mitigation measures as outlined throughout this report.

Summary of key risks

Risk activity (cause)	Potential environmental receptors	Potential impact	Consequence	Likelihood	Risk rating
Smothering from dredge material placement	Benthic macroinvertebrate communities	Temporary disturbance of benthic habitat and associated communities	Minor Temporary, short term negative impact	Likely	Medium
Dredging and placement generated sediment plume	Coral reef, seagrass and mangrove communities	Changes to water quality leading to mortality or changes in the diversity or cover of coral, seagrass or mangroves	Negligible Impacts is within the natural variation and tolerance of the system	Rare	Low

Risk activity (cause)	Potential environmental receptors	Potential impact	Consequence	Likelihood	Risk rating
		Sediment deposition resulting in loss of coral, seagrass or mangroves			
Movement of dredge vessel from the Port to the dredge material placement area	Transitory threatened and migratory marine animals	Potential for marine fauna vessel strike	Negligible No impact at the population or sub- population level	Unlikely	Low
Release of contaminants and nutrients	Marine biota	Potential for lethal and sub-lethal effects on biota	Negligible Material is suitable for unconfined ocean disposal	Rare	Low
Dredging suction	Foraging marine turtles	Potential for marine fauna to be caught	Negligible No impact at the population or sub-population level	Unlikely	Low
Noise	Inshore dolphins, dugong, marine turtles	Potential for alienation of habitat	Negligible No impact at the population or sub-population level	Rare	Low
Lighting	Foraging inshore dolphins, dugong and marine turtles	Alienation of habitat, potential mortality	Negligible No impact at the population or sub-population level	Rare	Low
Introduction of marine pests	Marine biota	Potential competition with native species and changes to the ecosystem	High Significant impact on the environment in the Port and potentially in the greater region	Unlikely	Medium
Dredge program	Marine users	Disruptions of activities	Negligible Impact is confined to a small area or interest group that is not vulnerable	Possible	Low

Individual assessments against formal guidelines have also been undertaken for Matters of National Environmental Significance (MNES). In all cases these determined that significant impacts are unlikely.

A range of measures to avoid and reduce risks have been implemented during project planning, and a further suite of measures will be implemented to minimise effects and avoid unpredicted environmental change. A comprehensive dredging environmental management plan will ensure each maintenance dredging campaign is undertaken in line with best practice, and that risks are avoided and reduced as far as possible. A key element of this is the application of ecologically relevant environmental triggers, which will be applied using an assessment of satellite derived TSS concentrations during dredging. This is coupled with a comprehensive impact and ambient monitoring program that has been designed to detect and respond to changes in the marine environment at the Port.

Considering the scope and volumes of proposed maintenance dredging at the Port of Mackay, the levels of risk are considered low and will be effectively managed with the application of appropriate monitoring, management and mitigation measures.

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ABBREVIATIONS

Abbreviation	Description
ANAE	(Interim) Australian National Aquatic Ecosystems (Classification Framework)
ASL	Above Sea Level
DMPA	Dredged Material Placement Area
EPBC	*Environment Protection and Biodiversity Conservation Act 1991*
ERA	Environmental Risk Assessment
GBR	Great Barrier Reef
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
GBRWHA	Great Barrier Reef World Heritage Area
IMP	Invasive Marine Pests

LTDMP	Long-Term Dredge Management Plan
MNES	Matters of National Environmental Significance
NAGD	National Assessment Guidelines for Dredging
NQBP	North Queensland Bulk Ports Corporation
OUV	Outstanding Universal Value
SDP	Sea Dumping Permit
SSC	Suspended Sediment Concentration
SSM	Sustainable Sediment Management
TSHD	Trailing Suction Hopper Dredge
TSS	Total Suspended Solids

01 INTRODUCTION

01.1 Background

North Queensland Bulk Ports Corporation (NQBP) manages the Port of Mackay (the Port), located on the central Queensland coast near the city of Mackay. The Port is located within Mackay Harbour, approximately 4 km to the north of the Pioneer River. The Mackay Harbour is enclosed by breakwaters with a 180 m wide entrance channel.

The key export trade through the Port is sugar, with fuel for agriculture and the mining industry being the dominant import. The Port also provides for the import of a diverse range of other products. In the 2020-21 financial year the Port had a total throughput of approximately 3.2 million tonnes.

Sedimentation of the seafloor navigational infrastructure within the Port occurs naturally and is caused by the transportation of sediment from ocean currents, swells, tides, as well as periodic cyclonic activity which can increase sedimentation significantly. When left unmanaged, sediment accumulation within swing basins and berths at the Port impacts the depths necessary for safe navigation, manoeuvring and berthing of vessels. This in turn impedes the overall efficiency of the Port.

NQBP is responsible for the maintenance of the navigational areas within the Port, with the last maintenance dredging occurring in December 2020 using a trailing suction hopper dredge (TSHD). Maintenance dredge material was relocated to the approved offshore dredge material placement area (DMPA) located approximately 3 km to the east-north-east of the Port.

A Sea Dumping Permit (SDP) under the *Environment Protection (Sea Dumping) Act 1981* is currently held by NQBP for sea disposal of maintenance dredge material from the Port of Mackay. The current SDP will expire in January 2022 and consequently, NQBP is seeking to obtain a new SDP for a further 10 years to provide for ongoing maintenance dredging activities.

01.2 Project overview

Maintenance dredging will occur throughout the Port in order to return navigational areas to their design depths, maintain required depths for future operations and ensure the safe and efficient operation of the Port. The anticipated volume of sediment required to be removed over a 10-year timeframe is in the order of 500,000 m^3. Exact volumes will vary depending on sediment accumulation and cyclonic activities and an upper limit of 575,000 m^3 is being requested in the permit application to accommodate any over dredge. Maintenance dredging is likely to occur every 3-5 years and include volumes between 120,000m^3 to 150,000m^3 per campaign.

For all campaigns, dredged material will be placed at the existing offshore DMPA. During a standard campaign, dredging will likely be undertaken by TSHD ‘Brisbane’ or an equivalent type dredge.

01.3 Scope of this report

The purpose of this report is to describe the existing environment relevant to the Port of Mackay and undertake an assessment of the potential risks from maintenance dredging and offshore placement over a 10-year timeframe, beginning after January 2022.

There are a number of State and Federal approvals necessary for ongoing maintenance dredging and offshore placement at the Port of Mackay. This report has been prepared to support the approvals process.

Specifically, this report:

- Identifies environmental values that are present at the Port of Mackay
- Identifies potential environmental impacts arising from maintenance dredging, including an assessment of the impacts’ extent, severity and likely significance

- Identifies impact likelihood and consequence to determine risk levels that will be used to inform the environmental management plan and related management actions
- Can be used to support environmental approvals processes; in particular application for an SDP.

01.4 Legislative context

There are three Commonwealth Acts related to the regulation of ocean disposal, or more specifically dredging for the scope of this project:

- *Environment Protection (Sea Dumping) Act 1981* (Sea Dumping Act)
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- *Great Barrier Reef Marine Park Act* (GBRMP Act)

These Acts work under a framework to ensure a streamlined assessment process, including the possibility of assessment under a bilateral agreement between the Federal and relevant State government to minimise duplication; if approval under the EPBC Act is required.

01.4.1 *Environment Protection (Sea Dumping) Act 1981*

Dumping of waste and other material from any vessel, aircraft or platform in Australian waters is prohibited under the Sea Dumping Act, unless a permit has been issued. Permits are most commonly issued for dredging operations and the creation of artificial reefs. The Act fulfils Australia's international obligations under the London Protocol (to prevent marine pollution by controlling dumping of wastes and other matter). The Act is administered by the Department of Agriculture, Water and the Environment in this case. However, it can also be administered by the Great Barrier Reef Marine Park Authority (GBRMPA) for activities inside the Great Barrier Reef Marine Park.

01.4.2 *Environment Protection and Biodiversity Conservation Act 1999*

The EPBC Act is the Australian Government's central environmental legislation. The EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities, wetlands and heritage places which are defined in the EPBC Act as Matters of National Environmental Significance (MNES). The EPBC Act is triggered when a development proposal has the potential to have a significant impact on MNES. Approval under this Act is not required if no significant impact to MNES will occur as a result of the proposed activity.

01.4.3 *Great Barrier Reef Marine Park Act 1975*

The GBRMP Act is the primary Act relating to the Great Barrier Reef Marine Park. It establishes the GBR MP and the GBRMPA, a Commonwealth authority responsible for the management of the Marine Park. The Act provides a framework for planning and management of the Marine Park, including through zoning plans, plans of management and a system of permissions. Dredging or placement of material inside the Marine Park requires a permit issued by GBRMPA. Maintenance dredging and offshore placement activities at the Port of Mackay do not occur within the Marine Park and therefore the GBRMP Act does not apply.

01.5 Relevant policy and guidance

There is also a range of State and Federal policy guidance relevant to the assessment of dredging projects, including:

- National Assessment Guidelines for Dredging (NAGD; CoA 2009)
- Numerous EPBC Act guidance documents
- Environmental Code of Practice for Dredging and Dredged Material Management (Ports Australia 2016)

01.5.1 National Assessment Guidelines for Dredging (NAGD)

The NAGD establishes a scientific assessment framework to determine if dredged material is suitable for ocean disposal in line with the Sea Dumping Act and the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (the London Protocol). The Guidelines include an assessment framework that is applied to ensure the impacts of dredged material loading and

disposal are adequately assessed and, when ocean disposal is permitted, that impacts are managed responsibly and effectively. The NAGD provides a suite of contamination thresholds for sediments, which determine the suitability of dredged material for ocean disposal.

01.5.2 EPBC Act guidance documents

There are a range of policy documents that guide impact assessments under the EPBC Act. Those relevant to this assessment include:

- Significant impact guidelines 1.1 – Matters of National Environmental Significance (2013)
- Industry guidelines for avoiding, assessing and mitigation impacts on EPBC Act listed migratory shorebird species (2015)
- Approved conservation advices for listed threatened species
- Threatened species recovery plans, including the Recovery Plan for Marine Turtles in Australia (2017)

01.5.3 Environmental Code of Practice for Dredging and Dredged Material Placement

Whilst not a government policy, Ports Australia's Environmental Code of Practice for Dredging and Dredged Material Management is important to consider, as it sets out the practices that will be employed during maintenance dredging at the Port of Mackay. The Code of Practice outlines a number of environmental principles that Australian ports meet when undertaking dredging and disposal of dredged material; based on the National Strategy for Ecologically Sustainable Development (ESD)

01.6 Outcomes of Port of Hay Point risk assessment

In 2018, an Environmental Risk Assessment of Sustainable Sediment Management at the Port of Hay Point was undertaken using the same assessment methodology presented in this report. The key finding of the Hay Point ERA were:

- Resuspension of sediments from maintenance dredging is comparable to natural suspended sediment concentrations (SSC) during calm conditions
- Water quality monitoring results and numerical modelling of sediment transport demonstrates that natural SSC levels are much higher than those generated by maintenance dredging
- Analysis against intensity and duration thresholds indicated that dredging would not result in impacts to sensitive environmental values if the dredging volume is under 800,000m^3
- Risks to sensitive habitats such as seagrass and coral communities are likely to be negligible to low. Seagrass communities are naturally low density and ephemeral and have been shown to recover post- dredging. Coral communities lie outside of area predicted to be impacted by turbidity and sedimentation, and ecologically relevant turbidity thresholds will be used during dredging to further reduce any risk
- Protected species, listed as MNES, are also unlikely to be significantly impacted by maintenance dredging. The Port of Hay Point does not provide critical habitat resources for any marine species and disturbance to habitats will be low. Indirect disturbances can be effectively managed via best practice dredging operations. The short timeframe of each campaign will also reduce risks
- Risks to protected areas including the GBRWHA and GBRMP will be low to negligible. Other marine users, such as recreational fisherman, may experience short-term disruptions to their activities.

Maintenance dredging, relocating 353,740m^3 of material, was undertaken from 31 March to 2 May 2019, with independent reporting completed on the pre, during and post monitoring activities. The reports identified:

- Mean turbidity was generally more elevated during the dredge phase at monitoring locations compared to pre and post dredging, however weather conditions appear to have had a greater impact on turbidity than the dredging operations. Extreme wind speeds occurred during the dredging campaign.
    - The turbidity at Round Top Island exceeded the 90th percentile duration exceedance, with a subsequent investigation undertaken in accordance with the Management Plans. The

investigation concluded that the elevated turbidity was due to natural conditions, however adaptive management measures were implemented to ensure a precautionary approach.

- There was no apparent impact from maintenance dredging activities on coral health parameters, with changes between the pre and post dredge surveys being attributable to seasonal variation or regional metocean influences.
- Analysis of bathymetric survey data confirmed that material removed from the approved dredge areas and placed in the approved DMPA was consistent with both the volume and depth requirements of the approval permits.
- No other appreciable impacts to environmental values (MNES and the GBRWHA) or sensitive users were recorded.

Overall, the monitoring and reporting demonstrated that the maintenance dredging program was completed in compliance with all approval conditions and management plan requirements and there were no impacts to environmental values identified. The results indicate that the ERA methodology utilised for Port of Hay Point was fit-for-purpose and adequately assessed the risks and consequences of maintenance dredging. Importantly, no risks or consequences have manifested at Hay Point that are outside of or were not predicted by the ERA assessment.

Consequently, there in confidence in utilising the same methodology for the ERA of SSM for Port of Mackay. The environment context, impact mechanisms and potential impacts are well understood and can be suitably assessed and managed.

The full assessment methodology that was used for Hay Point and is being used for this Port of Mackay assessment is presented in Section 2 below.

02 ASSESSMENT METHODOLOGY

02.1 Available information

There is considerable information available to inform the assessment of maintenance dredging at the Port of Mackay. This includes previous maintenance dredging programs, the results of monitoring (both baseline and that associated with dredging) and the technical reports produced as part of the Sustainable Sediment Management Assessment (SSM). The SSM is aimed at informing whether sedimentation can be managed to avoid or reduce the need for maintenance dredging. In addition, a range of studies have been undertaken to specifically understand the maintenance dredging requirements at the Port over the upcoming 10 years.

In this context, this risk assessment has been developed primarily based on the information and findings available in the following key documents:

- Port of Hay Point North Queensland Bulk Ports Corporation Environmental Values Assessment Rev 2 (Jacobs 2016)
- Port of Mackay Environmental Values Assessment 2021 Addendum North Queensland Bulk Ports, 12/11/2021 (2rog 2021).
- Port of Mackay: Avoid and Reduce Assessment Long-term Dredge Management Plan Report No. P012_R02v02 (PCS 2021a)
- Port of Mackay: Sustainable Sediment Management Assessment Dredge Plume Modelling Report No. P033_R02v02 (PCS 2021b)
- Port of Mackay: Sustainable Sediment Management Assessment. Environmental Thresholds Report No. P033_R01v02 (PCS 2021c)
- Port of Mackay: Sediment Resuspension Assessment – Technical Note v 0.2 (PCS 2021d)
- Port of Mackay Benthic Infauna Survey 202005_004 (PaCE 2021)
- Maintenance Dredging Sediment Characterisation Report Port of Mackay (Advisian 2018)

02.2 Risk assessment and approach

The project area was defined to include the Port of Mackay, the existing offshore DMPA and the largest extent of influence of any sediment plume generated by dredging or material placement activities, as per dredge plume modelling (PCS 2021a). The project area is shown in (Figure 2-1). A wider area, referred to as the study area (Figure 2-2), was adopted as part of the environmental values assessment (Jacobs 2016, 2rog 2021) and includes all marine areas and near-shore coastal environments (i.e. beaches and mangrove communities), as well as terrestrial environments and associated environmental values. The marine extent of the study area extends in the north from the waters around Keswick and St Bees Islands, west to Finlayson's Point on the mainland, and in the south from Digby Island and west to Llewellyn Bay. The boundaries of the study area were defined to provide a manageable spatial scale for the assessment, while the 'project area' encompasses the area most likely to be directly influenced by dredging activities. The terrestrial environments will not be impacted by the proposed maintenance dredging and are therefore not considered in this assessment.

The suite of environmental values that occur in the project area is well known and is comprehensively documented in Jacobs (2016) and 2rog (2021). The values and their relative importance in the Mackay region are summarised in Section 04. In order to understand the risks to environmental values, a list of potential impacts known to occur from maintenance dredging was compiled (Section 05). Following this step, the suite of impact avoidance and reduction measures that could be implemented at the Port of Mackay was considered (Section 06). This included consideration of the suite of recommended monitoring and associated adaptive management actions that may be implemented as required.

A further analysis of whether the potential impacts identified in Section 05 would affect relevant MNES and if so, the severity of these impacts was undertaken (see Section 07). This included consideration of the effectiveness of relevant avoidance and reduction measures. This analysis was supported by in-depth investigations into dredge plume generation and movement, natural sediment resuspension and an

environmental thresholds analysis. These studies are discussed as applicable in Section 07. Full reports are available and should be read in conjunction with this assessment.

Figure 02-1: Project area

Figure 02-2: Study area

Where appropriate, known impact thresholds were applied to determine the significance of impacts. In some instances these were derived from literature and data analysis and applied specifically to the Mackay environment (e.g. environmental thresholds for water quality). In other instances, and specifically for matters protected under the EPBC Act, relevant policy guidance was applied. The thresholds applied depended on the MNES under consideration. Some MNES (e.g. migratory shorebirds) have specific policy advice about what comprises a significant impact. For others, the more generic *EPBC Act Significant Impact Guidelines 1.1* (Commonwealth of Australia 2013) were used.

Following a detailed analysis of impacts, a formal risk assessment was undertaken and considered likelihood and consequence of each potential impact. The method applied was based on the GBRMPA risk Assessment – Permission System (GBRMPA 2017), provided at Appendix A. Based on information contained in the impact assessment detailed in Section 07, the likelihood and consequence has been evaluated and a risk rating assigned to potential risk events. The risk rating levels used are outlined in Table 02-1. The results of the risk assessment are provided in Section 08.

Table 02-1: Risk levels (GBRMPA 2017)

Risk level	Risk evaluation in the permission system
Low	A few low risks may be accepted. However, multiple low risks may require a broad mitigation or monitoring strategy. These risks should be recorded and monitored.
Medium	Medium risks require further mitigation. Consider whether the activity could be done differently (or in a different location) to reduce the risk. Where the applicant does not propose further measures, the managing agencies may place conditions on the permission. Multiple medium risks may be grounds for refusing approval, if suitable mitigation or offset measures cannot be agreed.
High	If uncontrolled, a risk event at this level may have a significant impact on the Marine Parks. High risks require further mitigation and may be grounds for refusing approval. Mitigation measures need to be reliable, well-tested, and have a high likelihood of success. Mitigation and offset measures should be closely monitored.
Very High	Risk events at this level have the potential to cause irreversible damage to the Marine Parks. Activities with unmitigated risks at this level should be avoided and are likely be refused permission.

02.3 Approach to assessing multiple campaigns

Up to three maintenance dredge campaigns are proposed over the 10-year permit timeframe to manage predicted sedimentation volumes and there is good certainty about the nature of the campaigns with respect to locations, potential volumes and timing (see Section 03). The volumes to be dredged are expected to be similar for each future campaign, noting a campaign has recently been completed in 2020.

Ports and Coastal Solutions have undertaken a detailed study to understand the potential effects of maintenance dredging and how these can vary across a range of scenarios and volumes (up to 1 million m^3). They considered variable dredge volumes, metocean conditions, seasons, placement site location and sediment composition.

In addition to the PCS studies and in order to ensure the risks of maintenance dredging campaigns are appropriately addressed prior to any dredging being undertaken, future assessments will be undertaken once the details of works are known. A process for this will be included in the Long-Term Maintenance Dredging Management Plan (LMDMP) and is summarised below.

Prior to each maintenance dredging campaign, a risk assessment of potential changes to environmental, social or cultural values will be undertaken. The assessment will help to determine the level of potential impact that environmental, social or cultural values may be exposed to from the proposed dredging program. The assessment will assist in identifying where refined management measures to avoid, reduce or mitigate

impacts are needed. Identified measures can then be incorporated into revisions of the Maintenance Dredging Environmental Management and Monitoring Plans. This process is outlined in Figure 02-3.

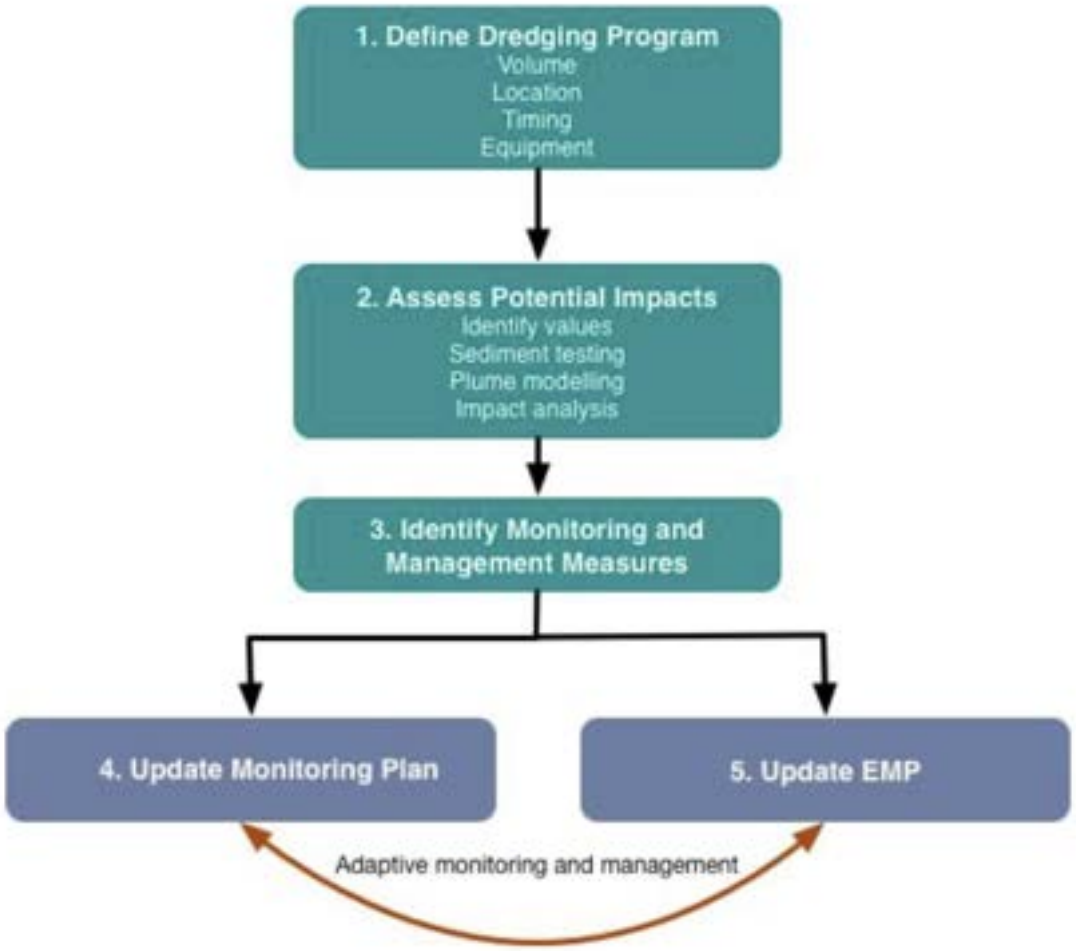


Figure 02-3: Risk assessment process for identification of potential impacts and management measures for future campaigns

Information needed to inform the risk assessment will include:

- Up to date environmental values, including data from baseline surveys of coral, seagrass, benthic infauna, mangroves, marine fauna and water quality.
- Dredging program design including: dredge type, volumes, locations, duration, seasonal timing.
- Up to date sediment characteristics: particle sizes, contamination results.
- Sediment plume modelling.

Campaigns will be staggered over the 10-year time frame, thereby reducing the impacts with a degree of proportionality to the size of the campaign. Dredging events will also generally be separated by at least 3-5 years. During this time, impacts will have ceased, and recovery occurred. As such, it is considered appropriate to assess each campaign as an independent event, with little risk of cumulative impacts. However, as discussed above, plume modelling has been undertaken at a range of volumes (up to 1 million m^3). A program of long-term monitoring and continual improvement will be implemented to assess and respond to any changes to environmental values over several campaigns.

03 PROJECT DESCRIPTION

03.1 Areas and volumes

Maintenance dredging will occur across the Port, in order to return navigational areas to their design depth. The anticipated sedimentation volume over a 10-year timeframe is in the order of 500,000 m^3 as shown in Table 03-1. Exact volumes will vary depending on sediment accumulation and cyclonic activities and an upper limit of 575,000 m^3 is being requested in the permit application to account for any over dredge.

Table 03-1: Dredge volume requirements

Number of years	Anticipated Volume	Including 15% over dredge allowance
8 years in a 10-year period	320,000 m^3 (typical wave energy year @ 40,000 m^3 per year)	368,000 m^3
2 years in a 10-year period	180,000 m^3 (high wave energy year @ 90,000 m^3 per year)	207,000 m^3
TOTAL: 10 years	500,000 m^3	575,000 m^3

The areas of the Port where sedimentation most frequently occurs and therefore has the most regular need for bed levelling and/or maintenance dredging activities are:

- West, North, South East and South West regions of the Swing Basin and within the Siltation Trench; and
- Within the four berths pockets

Specific requirements will be determined prior to each campaign based on hydrographic survey. However, it is anticipated that 120,000 m^3-150,000 m^3 of sediment will require relocation every three to five years across the Port areas (refer Figure 03-1).

Figure 03-1: Maintenance Dredging Area

03.2 Material to be dredged

Sediment sampling of maintenance dredging areas within the Port was most recently undertaken by Advisian in 2018 in accordance with the provisions of the NADG 2009 and commitments set out in the LMDMP. It is expected that current and future sediments will have a similar particle size composition and contamination status as those previously sampled, and this risk assessment has proceeded with this assumption.

The 2018 sampling event indicated the sediment characteristics vary across the Port area. The channel entrance and swing basin range from silty sandy to sandy clays. The mean Particle Size Distribution (PSD) of sediments in this area comprised sand (42%), followed by silt (31%) and clay (23%) (Advisian 2018). Sediments within the Tug Berth are generally evenly distributed with the majority comprised of silt (45%) and clay (39%). Sediment textures within the Berth Pockets are relatively similar, comprised of silt and clay with a combined fine content of 79%. However, each sample contained portions of sand greater than 10% (Advisian 2018). Previous testing has indicated that sediments across all Port areas can be considered uncontaminated and suitable for ocean disposal (Advisian 2018).

Further details of sediment composition, movement and suitability for ocean disposal is provided in Section 04.2 and Advisian 2018.

03.3 Dredged material placement area

Each dredging campaign will utilise the existing Mackay offshore DMPA, which is located approximately 3 km to the east-north-east of the Port. The location of the DMPA is provided in Table 03-2 and Figure 03-2.

Table 03-2: DMPA location

Easting	Northing
735007.34	7666765.52
736237.26	7666341.15
735921.02	7665397.82
734703.16	7665818.78

The DMPA is approximately 130 ha (or 1.3 km^2) in area and has been used for placement of capital and maintenance dredge material since the early 1960's with regular placement occurring from 1971.

The latest bathymetric survey for the DMPA shows that the seabed is shallowest at the western side and deepest at the eastern side (PCS 2021a). Depths across the DMPA range from approximately -12m LAT generally in the west to -15m LAT to the east. The topography of the DMPA is undulating and driven by the prevailing coastal processes (natural movement of sediment along the coast).

Sediments within the DMPA are generally comprised of sand and gravel with only 2% or less of silt and clays (Advisian 2018).

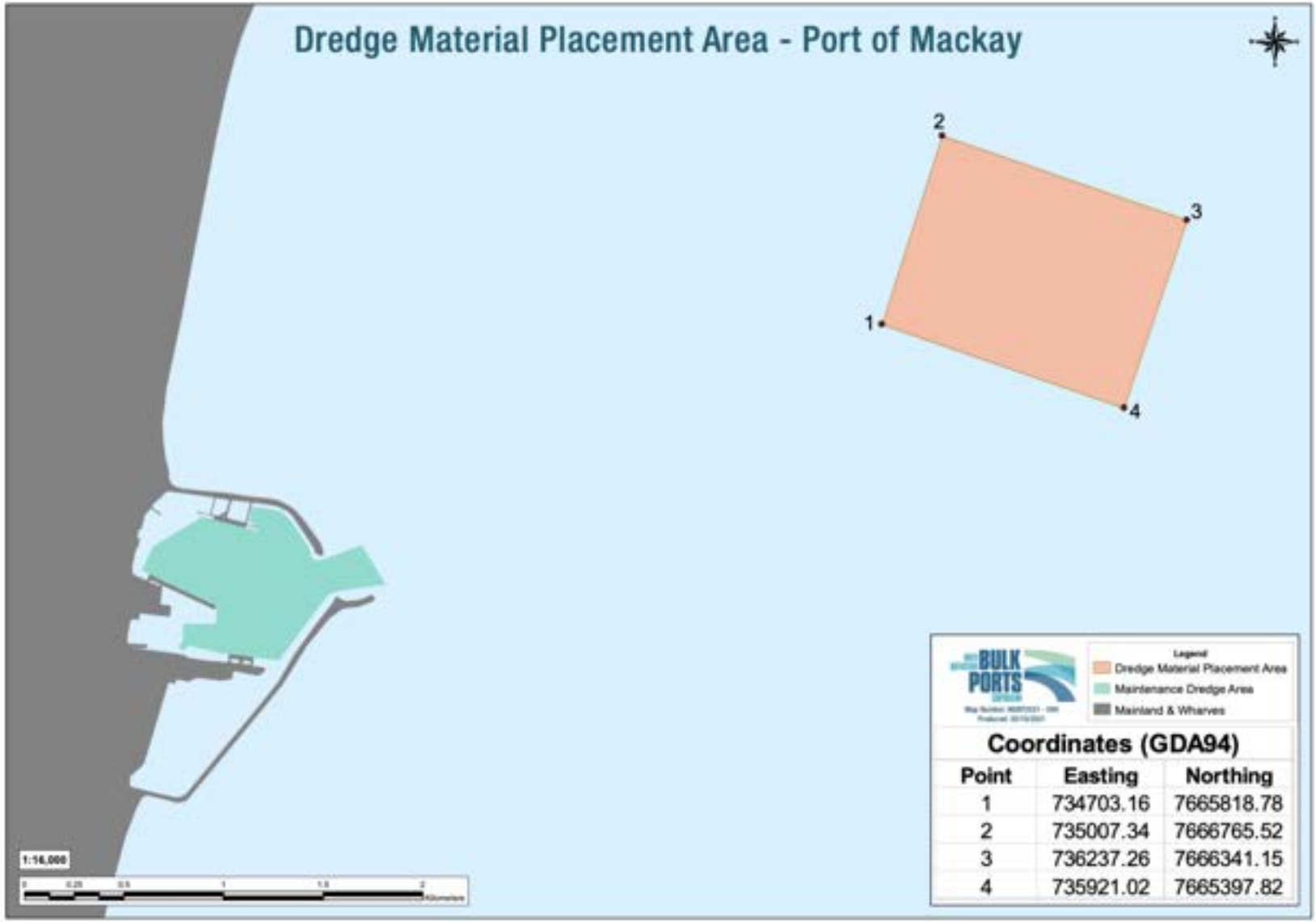


Figure 03-2: Dredge Material Placement Area

03.4 Dredging methods, timing and duration

Since 2000, the TSHD ‘Brisbane’ has undertaken the majority of maintenance dredging at the Port of Mackay. The TSHD ‘Brisbane’ was specifically designed and built to operate in Queensland and has numerous environmental design features to ensure any environmental risks are minimised. Design features include central weir discharge system, below keel discharge, low wash hull design, turtle exclusion devices on intake heads. It is likely that the TSHD ‘Brisbane’, or a similar vessel, would undertake future maintenance dredging at the Port.

Dredging at the Port of Mackay is anticipated once every 3-5 years and can occur at any time during the calendar year subject to availability of the TSHD ‘Brisbane’ (or another suitable dredge vessel) which currently undertakes dredging activities at a number of Queensland Ports each year. The length of future campaigns will be proportional to the volumes required, but typically will be between 6 and 12 days in duration.

04 EXISTING ENVIRONMENT

04.1 Climate and marine conditions

04.1.1 Rainfall

The climate of Mackay is tropical with a distinct monsoonal rainfall trend. The Port of Mackay receives on average 1542 mm of rainfall each year. Average monthly measurements are provided in Table 04-1. Rainfall in the region can be summarised as:

- The wet season occurs between January and March and a significant proportion of the annual rainfall occurs during this period
- The dry season occurs between June and October
- The months of April to May and November to December are the transition periods between the wet and dry seasons.

Table 04-1: Long term mean and median rainfall since 1950 (BoM weather station Mackay Aero)

Rainfall (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	306	331	260	165	87	60	33	33	23	34	77	139
Median	615	669	446	426	275	145	133	115	145	101	223	335

04.1.2 Wind

The Port of Mackay lies in the trade wind belt for most of the year resulting in the local wind climate being governed by south to south-easterly winds. Figure 04-1 presents wind data measured (at 9 am and 3 pm) by the BoM at Mackay M.O and includes data recorded between 2005 and 2016 (annual wind rose). The wind rose highlights the prevalence off the south to south-easterly winds.

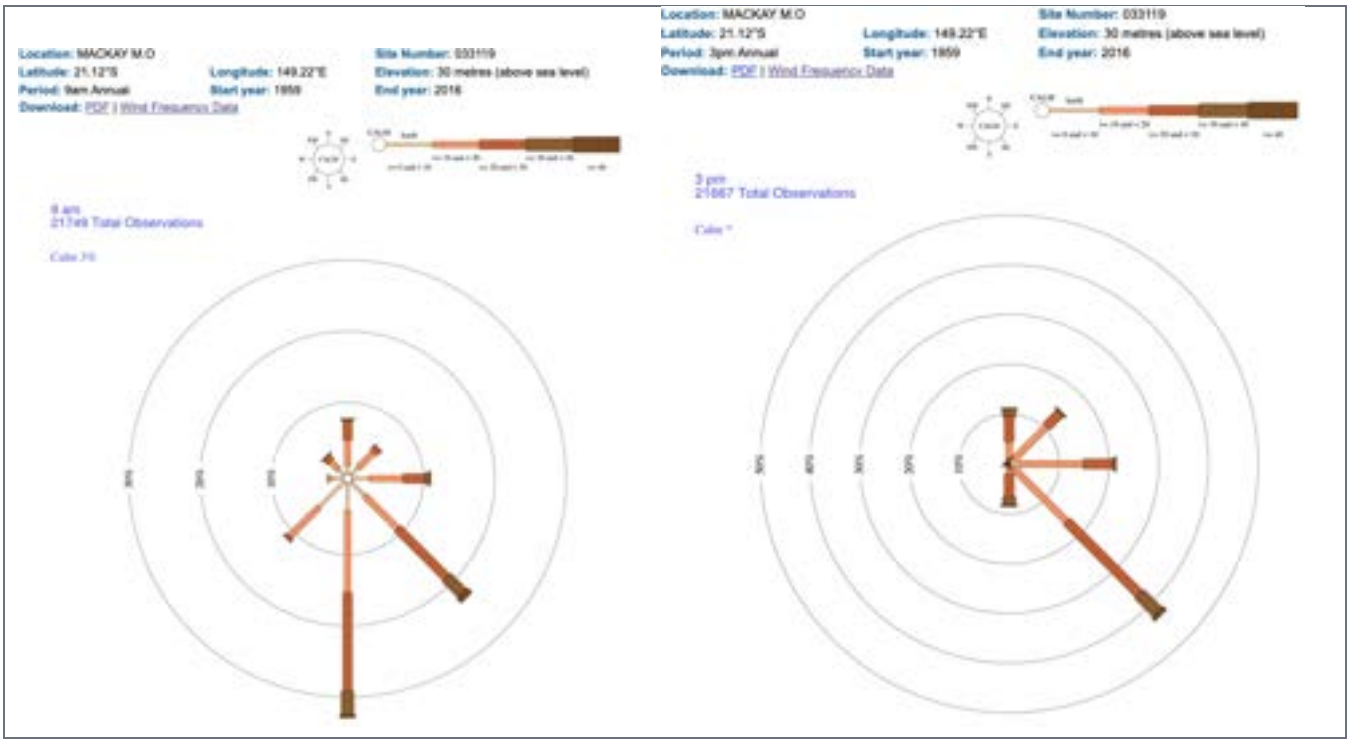


Figure 04-1: Annual wind roses for the BoM Mackay M.O weather station (2005 – 2016)

04.1.3 Tides

The Port of Mackay tides are semi-diurnal (high tide occurs twice daily). Mackay is located in the area of the Queensland coast which experiences the highest tidal range, with a peak semi-diurnal tidal range of 6.58m and a mean spring tidal range of 4.55m. The tidal planes for Mackay Outer Harbour are shown in Table 04-2.

The large tidal range is primarily due to local tidal amplification at Broad Sound. The tidal amplitude results in relatively strong tidal currents at the Port. Spring tidal ranges drive currents that can be more than 0.5 m/s (2 knots) and dominate inshore areas beyond wave-driven longshore current. Tidal currents generally flood towards the south-southeast and ebb towards the north-northeast. The ebb currents are slightly stronger than the flood currents.

As highlighted by PCS (2021b), storm surges, usually associated with cyclones, occur in the Mackay region. These surges during high water spring tides have the potential to exceed the Highest Astronomical Tide (HAT) level (PCS 2021b).

Table 04-2: Mackay Outer Harbour tidal planes (MSQ 2021)

Tidal Level	Height above LAT
HAT	6.58
MHWS	5.29
MHWN	4.07
MSL	3.02
MLWN	1.96
MLWS	0.74
AHD	2.941

04.1.4 Waves

Wave data is available from the DSITI wave-rider buoy (WRB) deployed offshore at the Mackay monitoring site and nearshore at the Hay Point WRB. This data has been analysed by PCS (2021b) to provide an understanding of wave conditions in the Mackay region and is summarised below.

Offshore wave direction is mostly from the east to south-east and significant wave height (H_s) is less than 2.5 m. The largest wave measured was over 5.5 m, and larger wave events typically arose from an east to south-east direction.

The nearshore wave directions were found to be more variable. The majority were from the east but were regularly interspersed with waves from the east to north-east and east to south-east. The H_s was generally less than 1.5 m with the largest wave height recorded at just below 4 m. Wave direction of the larger waves was also similarly variable, between east and north-east.

Tropical cyclones (TC) were the cause of the largest waves at both monitoring locations. Further analysis demonstrated that there was a relationship between wind speed and wave height (refer Figure 04-2).

As highlighted by Symonds and Donald (2016) the dominant east to south-east wave direction is the result of a large open fetch from the south-east combined with predominant south-easterly trade winds which dominate the local wind climate. The large fetch which extends towards the south-east between the GBR and the coastline is known as the Capricorn Channel and is responsible for the larger more developed waves from the east and east to south-eastly sectors. The higher energy wave conditions generally occur during the summer months which is consistent with the stronger wind speeds and cyclonic conditions experienced during these months. This observation by Symonds and Donald (2016) is consistent with the PCS (2021b) analysis.

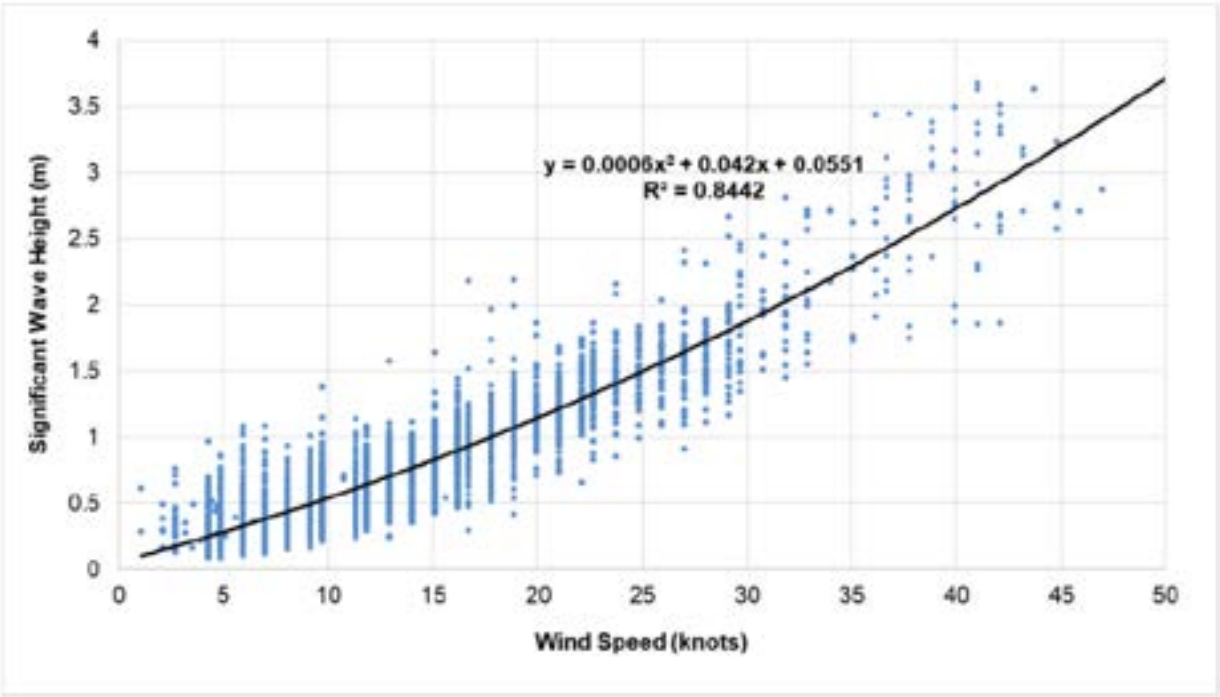


Figure 04-2: Extract of *Figure 6* illustrating wind speed and H_s relationship (RHDV 2017), sourced from PCS (2021a)

04.1.5 Currents

Tide data has been collected by RHGDHV (2017) from January to April 2017 from a location approximately 1 km to the east of the entrance to Mackay Harbour. This data and results of previous numerical modelling (RHVDHVs 2017) showed that tidal currents close to the entrance to Mackay Harbour, as summarised by PCS (2021a), have the following features and characteristics:

- Peak tidal current speeds range from 0.3 to 0.8 m/s, with stronger currents occurring during the spring tides and weaker currents during neap tides
- Peak flood current direction is to the south-east and the peak ebb current direction is to the north
- Flood currents are to the south-east rather than the south (which would be expected given the general alignment of the shoreline) due to the flow being deflected by Slade Islet and Mackay Harbour
- Northerly ebb currents are generally stronger across the Mackay region with a net northerly residual transport direction expected
- Currents increase around Slade Islet and adjacent to the Mackay Harbour breakwaters and are generally strongest between the Harbour breakwaters and Slade Islet.
- Within the Mackay Harbour modelling predicts peak flood current speed to be significantly higher than the peak ebb speed. Peak ebb speeds within the Harbour will usually remain below 0.1 m/s, suggesting the Harbour will act as a net importer of sediment. Resuspension of deposited sediment (over the high-water slack period) is found to be unlikely due to low ebb current speeds being unlikely to resuspend any sediment which is deposited in the Harbour.

Local currents are primarily driven by the tides but, especially on the mid- and outer shelf, are influenced by the predominantly southeast winds and large-scale oceanic currents and inflows from the Coral Sea. Geomorphology, for example water depth, the passes between reefs and islands, and estuaries and bays also shapes circulation on the GBR.

The southeast winds are generally strongest between May and October and drive a general northward flow of lagoonal waters. The south-easterlies weaken from November to April, and the predominantly northward lagoonal flow sometimes reverses. The study area is protected to some degree from wave energy by the GBR, but the distance of the outer reefs, some 100 km east, provide a south-easterly fetch of about 500 km,

allowing the development of significant localised wave energy. When the waves strike the coast, they generate northward-flowing longshore currents in and up to tens of metres offshore of the surf zone. These longshore currents transport large amounts of sediment to the north, and generate the northward-facing points, spits, sand islands, and bays and estuaries seen all along the Queensland coast. Very strong winds during tropical cyclones can also result in increased current speeds and changes.

As well as tide and wind induced currents, regional scale circulation currents can occur in the GBR Lagoon. These regional scale currents are dynamic and intermittent as they are primarily driven by a complex interaction between oceanic inflows caused by the North Vanuatu Jet and local wind driven circulation. Although these regional scale ocean circulation processes have the potential to intermittently influence current regimes at the Port of Mackay, their effects are considered minor relative to tidal and wind induced currents (Symonds and Donald 2016a).

04.1.6 Tropical cyclones

Port of Mackay is vulnerable to the effects of severe tropical cyclones during the summer months (wet season). Since 1969, 29 cyclones have passed within 200 km of Mackay. Recent notable cyclones which have affected the Port include TC Ului (March 2010), TC Dylan (January 2014) and TC Debbie (March 2017).

Key information about each of these cyclones is shown in Table 04-3.

Table 04-3: Recent tropical cyclones affecting Port of Mackay (BoM 2021)

Name	TC Ului	TC Dylan	TC Debbie
Crossing date	21 March 2010	31 January 2014	28 March 2017
Crossing location	Airlie Beach – 150km north of Mackay	Dingo Beach – 165km north of Mackay	Airlie Beach – 150km north of Mackay
Category when crossing coast	Cat 3	Cat 2	Cat 4
Max. sustained wind speed	215km/hr	100km/hr	195km/hr
Max. wind gust	290 km/hr	140km/hr	260km/hr

04.2 Sediments

04.2.1 Characterisation

As part of the LMDMP, sediment characterisation assessments are undertaken to ensure that sediment remains suitable for placement in the DMPA. The 2018 assessment is the most recent and was used to inform this risk assessment (Advisian 2018).

Sediment characteristics (including particle size) in each area of the Port and the DMPA are provided in Figure 04-3. Sediment within different areas of the Port varies slightly depending on the location. Throughout the Channel and Swing Basin sediments vary from silty sand to sandy clay, with the most common sediment being sand (42%). The Tug Berth and Berth Pockets are less sandy (~18% compared to 42%), with higher percentages of clay and silt. The DMPA was comprised almost equally of sand (53%) and gravel (45%), with very low portions of clay and silt (1% each).

The offshore reference sites indicate that the natural seabed is composed mostly of sand (68%), with a portion of gravel (31%) and very small amounts of silt and clay. Across the areas to be dredged, silt is the most common sediment type (40%), followed by clay (32%), sand (26%) and small portions of gravel (4%).

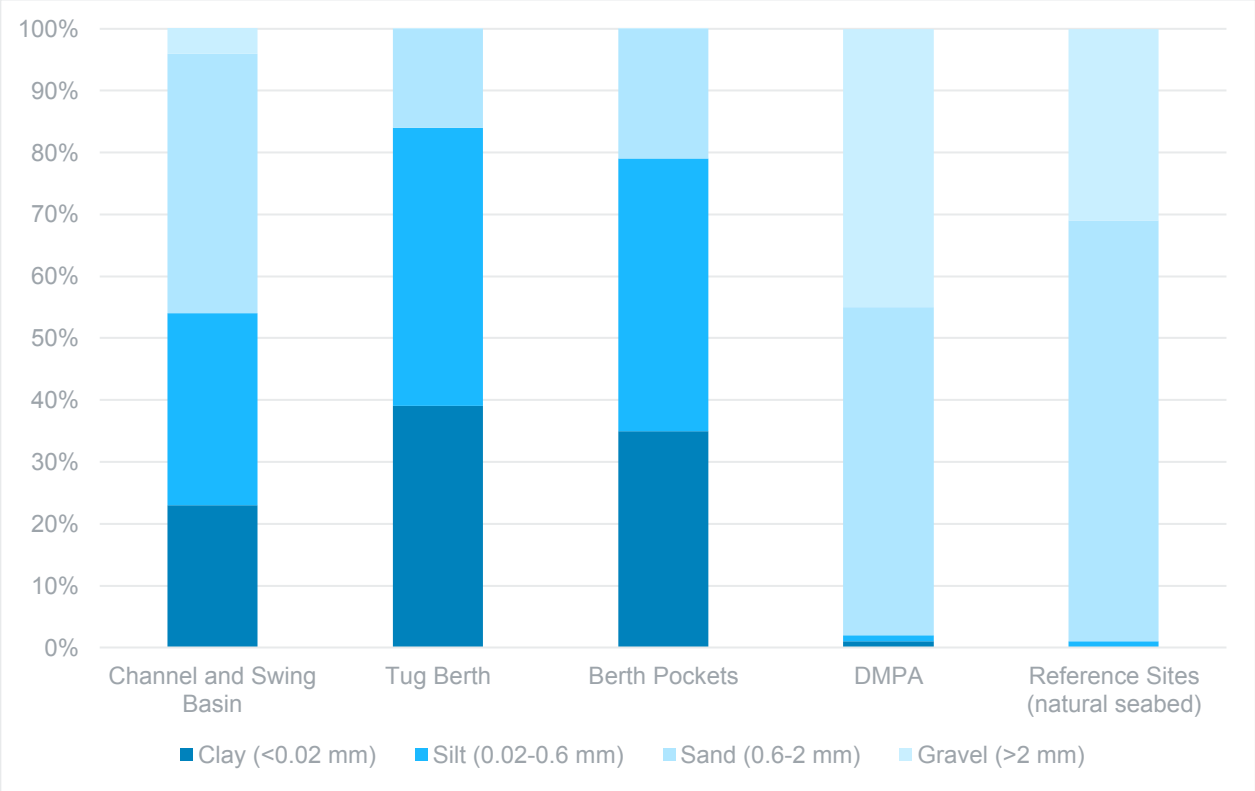


Figure 04-3: Summary of sediment characteristics

Sediment quality has been regularly assessed at the Port of Mackay to ensure suitability for ocean disposal in accordance with the approach provided in the NAGD. These previous assessments have shown that the sediment in the Port has been suitable for ocean disposal. The 2018 survey found no concentrations of contaminants (including TBT, metals, hydrocarbons, BTEXN and PAHs) to be above screening levels and therefore the sediment has been deemed suitable for ocean disposal (Advisian 2018).

04.2.2 Movement

There are a number of processes that influence the supply, resuspension, transport and deposition of sediment within the dredged areas of the Port. The Port is located within the Mackay Harbour between two large breakwalls. The spatial distribution of the sedimentation within the Harbour itself will be controlled by a combination of the local bathymetry (i.e. more sedimentation in areas with high trapping efficiency such as berths), the vessel routes (i.e. high traffic routes will have more propeller wash which will limit sedimentation) and the local metocean conditions (i.e. the higher current speeds and larger waves at the entrance to the Harbour will limit the deposition of fine-grained sediment) (PCS 2021a).

Wave action is the dominant driver for the resuspension of fine-grained sediment in the Mackay region and waves are indirectly also expected to be the dominant driver for sedimentation in the dredged areas of the Port. The majority of the sedimentation which occurs within the Port of Mackay is due to fine- grained sediment being imported into the Harbour as suspended load during the flood tide. This is natural sediment which has been resuspended from the seabed within the adjacent nearshore coastal region around Mackay due to wave action and tidal currents (PCS 2021a).

The suspended sediment is transported by tidal currents until the wave and tidal energy reduce sufficiently to allow the sediment to start to settle and be deposited. The tidal currents in the area result in some of the suspended sediment from the adjacent coastal region being transported into the Harbour during the flood tide. Due to the relatively low ebb tidal currents in the Harbour and at the entrance to the Harbour, combined with the fact the Harbour is sheltered from wave action, it is expected that much of the suspended sediment transported into the Harbour will settle out and be deposited. The metocean conditions within the Harbour

suggest that it is unlikely for any sediment which has been deposited to subsequently be resuspended by natural conditions.

Analysis of historic bathymetric data has found that the Port of Mackay has been subject to ongoing natural sedimentation and sediment sampling indicates that the deposited sediment is predominantly made up of fine-grained silt and clay. The majority of the sedimentation has occurred in the swing basin, with on average three times more sediment deposited in the swing basin (average = 18,000 m^3/yr) compared to the berths (average = 6,000 m^3/yr).

04.3 Bathymetry

A detailed bathymetric analysis for the Port of Mackay has been conducted by PCS (PCS 2021a) using hydrographic survey data collected by Maritime Safety Queensland (MSQ). Survey data from 2009 to 2021 has been used to analysis bathymetric changes, with key findings summarised below.

04.3.1 Port of Mackay

The annual total change in bathymetry within the Port has been variable over the 11-year period of data that was analysed. The change was net sedimentation of approximately 85,000 m^3 which occurred between 2013-14 and 2016-2017, coinciding with the occurrence of TC Dylan and TC Debbie. The minimum change was erosion of approximately 19,000 m^3 that occurred between 2015-2016, which coincided with a drag barring program. The overall mean change over the nine years has been sedimentation of approximately 26,500 m^3/yr (PCS 2021a).

The bathymetry to the east of the Port is naturally deep, with bed elevations typically below -10 m LAT, with the analysis within the Port suggesting that natural sedimentation occurs within the swing basin. Sedimentation above design depth occurs most commonly occurs in Berths 3 and 5 and in the South East, South West, North and West regions of the swing basin as well as in the eastern half of the Siltation Trench (PCS 2021a). There are also deeper sections within the swing basin due to erosion caused by propeller wash of vessels operating within the Port. The berth areas of the Port are significantly deeper than the adjacent natural bathymetry on the opposite side to the swing basin, with differences of up to 5 m. As such, the berths are expected to act as sediment traps and be subject to natural ongoing sedimentation (PCS 2021a).

04.3.2 DMPA

Sediment from previous Port of Mackay maintenance dredging programs has historically been placed at the DMPA, with bathymetric survey data available from 2010, 2011, 2013, 2020 and 2021. Over this period two maintenance dredging programmes were undertaken at the Port with just under 100,000 m^3 placed at the DPMA in August 2013 and 120,000 m^3 placed in December 2020 (PCS 2021a).

Results from the bathymetric analysis suggest that there are periods when the DMPA is relatively stable over time (e.g. July 2011 to August 2013) and periods when natural erosion can occur (e.g. September 2013 to November 2020). The reason for the loss of sediment from the DMPA is likely to be due to two Tropical Cyclones resulting in large waves and strong winds in the Mackay region over this period (TC Dylan in January 2014 and TC Debbie in March 2017) which appear to have resulted in erosion of just under 250,000 m^3 of sediment from the DMPA (PCS 2021a).

The bathymetry is shallowest at the western side of the DMPA and deepest at the eastern side, with undulations (ridges/mega ripples) present in with elevations of approximately 2 to 3 m PCS 2021a).

Analysis of the bathymetric results can also be interpreted to provide an indication of the short-term retention of maintenance dredge sediment at the DMPA (PCS 2021a). It can be determined that over the short-term the DMPA can be considered to be partially retentive. Over the longer-term the DMPA can be considered to be stable during typical metocean conditions and then during extreme events with large waves (e.g. Tropical Cyclones) erosion of the DMPA can occur. It is noted that natural erosion of the seabed adjacent to the DMPA would also be expected during these events (PCS 2021a).

04.4 Water quality

The Port of Mackay (and Hay Point) Ambient Marine Water Quality Program has been implemented since July 2014 to identify potential impacts of the port and its operations on water quality and to characterise the natural variability in key water parameters within the adjacent sensitive habitats. The program extends coastally for south of the Port of Hay Point to the north of the Port of Mackay and includes the enclosed marina complex. The program, incorporates a combination of spot field measurements and high frequency continuous data loggers, laboratory analysis for a range of nutrients, herbicides and heavy metals.

Information presented in this section has been sourced from Waltham et al. (2019) and references therein.

04.4.1 Overview

The drivers of water quality throughout the study area and the surrounds are recognised at a regional level, that is they are not being drive by the port or port related activities. Ambient water quality data indicates that there is a strong seasonal effect on water temperatures in the region, with fluctuations in temperatures being consistent throughout the water column, indicating that the water column profile is vertically well mixed (Waltham et al. 2019). Electrical conductivity and turbidity were also relatively consistent across the water column, with both dissolved oxygen and pH showing some fluctuations. The following was identified and discussed by Waltham et al. 2019:

- Dissolved oxygen saturation levels ranged between 80 to 125 %
- Local variability was recorded among sites with the lowest levels recorded at AMB11 (Mackay Marina) at the bottom horizon, a common observation over the years
- Lower dissolved oxygen in the Marina was potentially due to the enclosed nature of the facility, with reduced tidal exchange and circulation of waters, and, a small wind fetch further limiting re-oxygenating the water column profile
- Regardless of these findings, surveys found fish were continually present in the Marina, suggesting conditions are not critical nor require management intervention, and fish can easily leave the Marina if conditions are not suitable
- For all other sites, the water column continues to be well mixed although there is a subtle oxycline with dissolved oxygen concentrations decreasing with depth

Surface water was slightly more acidic in comparison to bottom measurements, although still within the range expected for marine waters.

Particulate nitrogen (PN) levels exceeded Water Quality Guidelines for the Great Barrier Marine Park (GBRMPA 2010). These guidelines were used to provide context to NQBP other Ports in the Great Barrier Reef Region. Despite the high concentrations during certain months, the PN level are relatively similar across all monitoring sites. Phosphorus concentrations were variable from both survey periods and site to site, with no distinct seasonal pattern being observed. Highest concentrations are thought to potentially be related to local urban stormwater runoff. Chlorophyll-a concentrations were generally elevated above the guidelines, which has been a trend since the program commenced over all monitoring periods.

All heavy metals, except for copper, were below the thresholds outlined in the ANZECC and ARMCANZ water quality guidelines. Herbicide and pesticide concentrations were not detected at concentrations above reporting limits and were all well below the 95% protection values for the GBRMP. The Mackay-Whitsunday Water Quality Improvement Plan's water quality objectives (2014), uses a lower guideline than the GBRMP and as such Hexaninone, Diuron and Atrazine were detected, and probably represent pollution from catchments in the local area, which land use is predominately sugar cane (Waltham et al. 2019).

A total of 91 phytoplankton species and 54 zooplankton species were recorded in the most recent survey period. Overall, the species composition of phytoplankton and zooplankton communities differed primarily between years. In particular, the species composition of plankton communities were distinct in 2015 and 2016, while phytoplankton species composition was similar across surveys conducted in 2017-2019. For zooplankton, species composition in 2017 was distinct from highly similar communities in 2018 and 2019 (Waltham et al. 2019).

04.4.2 Suspended sediment concentrations

Previous investigations in the Mackay region have found that suspended sediment concentrations in the coastal waters are predominantly the result of existing bed sediments being resuspended by current and wave action (PCS 2021a). The statistics show that the SSC can be considered to typically be relatively low (less than 20 mg/l), but with the potential of becoming very high during infrequent events.

The water quality monitoring undertaken at Slade Islet indicates there is seasonal variability, with higher SSC during the wet season and lower SSC during the dry season. This is primarily due to variable wind and wave conditions in the wet season (i.e. peaks in SSC are due to periods of increased wind/wave energy), while during the dry season variability is driven by both the spring and neap tidal cycle, as well as wind and wave conditions (PSC 2021d). In the dry season stronger currents during spring tides resuspend more bed material than during neap tides.

An updated assessment undertaken for the SSM found the following (PCS 2021d):

- relationships between resuspension mass/SSC and wind speed for the Mackay region are relatively linear for wind speeds of less than 25 knots, with more of an exponential increase in SSC when wind speeds increase above 25 knots.
- the annual mass of sediment resuspended by typical conditions is in the order of 5,000,000 tonnes per year in the Mackay region; and
- between 4,100,000 and 4,600,000 tonnes of sediment was estimated to have been resuspended within the Mackay region during TC Debbie. As such, during a year when a tropical cyclone results in very strong winds and very large waves in the region the natural resuspension could increase to just under 10,000,000 tonnes per year.

04.5 Coral

Reefs in the vicinity of the Port of Mackay include fringing reefs at Slade Islet, Round Top, Keswick Island and St Bees Island. The reefs have some hard and soft corals, but the majority are dominated by microalgae. Slade Islet is a small inshore island about 2 km northeast of Mackay Harbour. There is a large benthic community about 558 ha in size between Round Top Island and Slade Island which is dominated by soft corals, sea stars and sponges (Jacobs 2016).

Coral monitoring at Round Top Island and Slade Islet is undertaken twice yearly as part of an ambient monitoring program for the Ports of Mackay and Hay Point. Ayling *et al.* (2020) noted that from the start of monitoring there were measurable differences in coral community composition with the following differences highlighted:

- Corals at Round Top Island are dominated by *Turbinaria* corals, composing 32% of hard coral cover, with siderastreids, favids and *Montipora* also important
- At Victor Islet and Slade Islet *Montipora* corals are dominant, accounting for 50% and 59% of coral cover respectively; *Turbinaria* corals and faviids were also important at Victor Islet
- *Acropora* corals are dominant at Keswick Island comprising 40% of coral cover, and *Montipora* corals and poritids are also important
- Only slight changes in coral composition have been recorded in the 13 years of monitoring, with a decrease in cover of Acropora corals in inshore areas.

Natural processes in the area regularly expose corals on fringing reefs, such as those found in the study area, to turbid conditions from resuspension of sediment during strong wind events (Ayling, T, *et al.* 2020). The hard coral species common to the area are those found in highly turbid marine environments of the GBR including species from the genera *Montipora* and *Turbinaria*. Associated with these coral communities and the habitat they occupy are a sparse but diverse range of soft corals, sponges, sea fans, ascidians and hydroids (Advisian 2016).

Key findings from the recent 2019/2020 monitoring program (Ayling, *et al.* 2020) are as follows:

- Macroalgal cover has generally followed a gradual increase on the three inshore locations since the 2006 baseline and reached a peak of 47% in July 2018, but had dropped dramatically by the 2019/2020 survey, potentially due to high temperatures in early 2020
- A mass bleaching event in early 2020 saw 50% and 20% of hard and soft corals bleached, with signs of some mortality of hard corals by April 2020 (consistent with bleaching observed throughout the GBR)
- Significant reduction of inshore hard coral due to cyclonic impacts
- In the 42 months since TC Debbie, recovery of coral has been slow at all locations
- New coral recruits found to have increased to more normal levels during the 2019/2020 survey following the significant drop recorded in 2018 after TC Debbie
- Sediment level on corals increased following TC Debbie, but not as high following previous cyclones nor the Hay Point 2006 capital dredging campaign. During the 2019/2020 ambient surveys, both the number of corals with sediment and sediment depth were at moderate to high levels. Sediment levels on corals were high in all locations during the bleaching event
- Major driver of change on fringing reefs has been from cyclonic events, with other impacts minor and not significant, though the bleaching event may have a significant future impact.

As discussed by Ayling, *et al*, the 2019 Reef Report Card reported all Mackay locations as 'very poor', due to the high macroalgae cover and the relatively low number of recruits recorded. Warm early 2020 water temperatures saw macroalgae cover significantly reduced and reef indices improved. However there was no adjustment to ratings except at Slade Islet where rating was increased to 'poor'. The overall regional rating was 'very poor' during both the 2019 and 2020 surveys.

04.6 Seagrass

Seagrass communities were initially mapped in 2001 by Rasheed et al. (2001) during a survey the Port of Mackay and offshore areas. Three seagrass species were recorded with distribution confined to three meadows as follows:

- Two offshore meadows of *Halophila decipiens* 7 km and 12 km to the east of the Port
- A small shallow coastal meadow of and *Halodule uninervis* and *H. ovalis* adjacent the north-western shore of Round Top Island.

No seagrass meadows were recorded within the Port or within the DMPA during this initial survey.

A long-term seagrass monitoring program and strategy was developed for the Mackay-Hay Point region following a broad scale baseline survey of the region in 2014. The program builds on previous surveys and assesses five offshore monitoring areas between Mackay and Hay Point, an inshore region between Dudgeon Point and Hay Point, and two inshore subtidal meadows at the Keswick Island group.

In 2020, a total of 483 sites were surveyed as part of the annual and extended monitoring by York and Rasheed (2021). Observation of seagrass extent and species include the following:

- Seagrass was present at 17.8% of coastal sites, including 44.7% of sites at the Keswick and St Bees Islands annual monitoring areas
- Seagrass was present at 27.4% of all the of all the offshore sites in the extended survey (including 73.1% of sites in the Mackay offshore annual monitoring area)
- Deep-water seagrass communities in the extended survey area offshore from Hay Point and Mackay covered an area of 3,784.5 ± 684.3 ha
- Coastal meadows covered 112.0 ± 14.6 ha around Dudgeon Point which included a non-monitoring meadow of 103.4 ± 11.4 ha
- Seagrass adjacent to Keswick and St Bees Islands covered 154.5 ± 40.3 ha.

Five seagrass species were observed in 2020:

- *H. decipiens* dominant in deepwater assemblages at Hay Point and Mackay; smaller amounts recorded at Keswick and St Bees Islands
- *H. tricostata* and *H. spinulosa* dominated the two meadows at Keswick and St Bees Islands
- *H. ovalis* also observed at the two meadows at Keswick and St Bees Islands
- *Halodule uninervis* (both wide and narrow forms) dominated the inshore meadows at Dudgeon Point
- *Zostera muelleri* had been previously recorded at Dudgeon Point coastal meadow but was not recorded in 2020.

The condition of seagrass meadows is assessed by their distribution, abundance, species diversity and other factors. The most recent 2020 Healthy Rivers to Reef Report Card for the inshore Mackay area rated seagrass condition as moderate overall. This was an improvement from the previous score of poor following recovery post TC Debbie in 2017. Seagrass meadows have a natural variability in the region, including both seasonally and inter-annually. However, results of monitoring undertaken in 2020 York and Rasheed (2021) (refer Figure 04-4) indicated:

- Coastal meadows at Dudgeon Point were classified down from good in 2019 to satisfactory in 2020 from a reduction in meadow area extent, losing significant gains observed in the 2019 monitoring event
- Similarly, the Hay Point offshore deepwater seagrass was classified down from satisfactory to poor due to a significant reduction in meadow area extent, and moderate decline in biomass
- The Mackay offshore monitoring area saw an increase in seagrass area, the largest area since sampling began in 2017
- Meadows at Keswick and St Bees Islands maintained their overall good condition, with the highest biomass recorded since monitoring began in 2014, notwithstanding a decrease in extent at St Bees Island
- It was noted that overall growing conditions were favourable for seagrass growth however reductions in seagrass condition may be attributed to sediment resuspension from higher-than-average wave heights in September 2020 prior to monitoring.

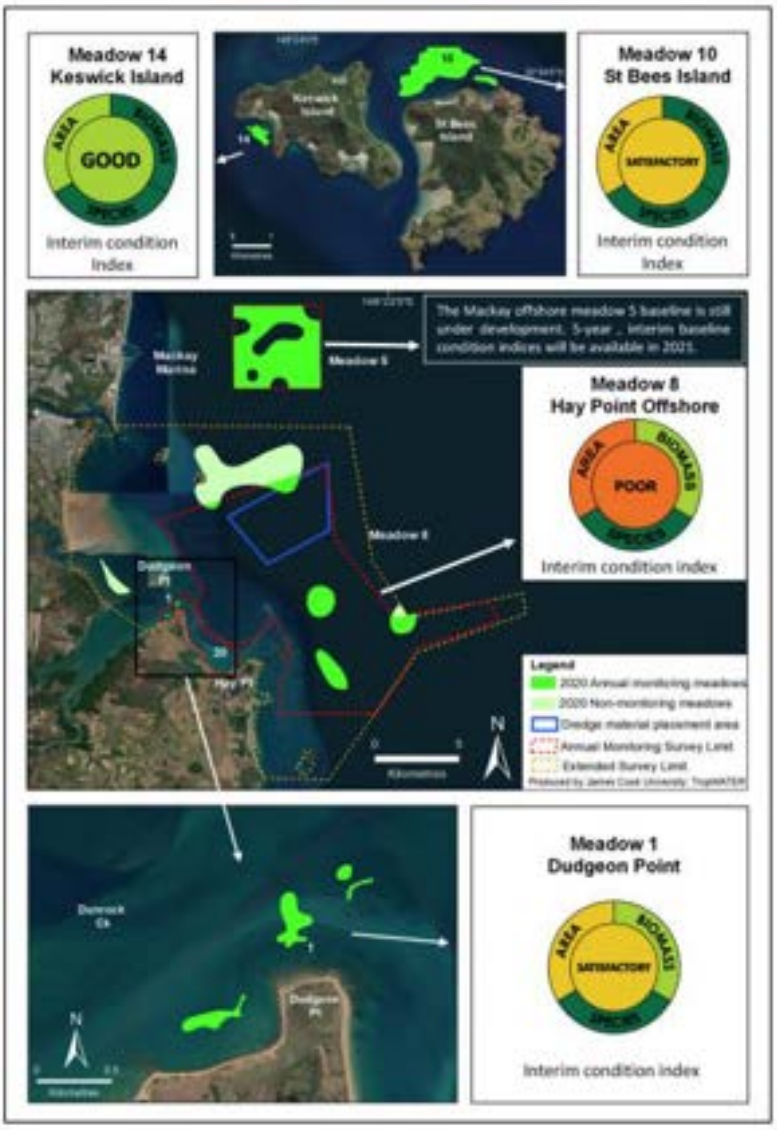


Figure 04-4: Extract of Figure 1 illustrating seagrass monitoring locations and condition (York and Rasheed 2021)

04.7 Benthic fauna

Benthic fauna include animals and protozoans that live within seabed sediments (infauna) and animals that live on the seabed (epifauna). Infauna communities are typically dominated in the study area and elsewhere, by polychaete worms, molluscs (mainly bivalves and snails) and small crustaceans. Benthic epifauna include macroinvertebrates such echinoids, sponges, ascidians, bivalves, hydroids, byrozoans and crustaceans.

Substrates in the Port of Mackay area support a low diversity and density of epifauna, with habitats primarily consisting of open substrates. Areas that support higher densities of epifauna have been found to be primarily located ~3 km offshore around islands and rocky reefs (e.g. Round Top Island, Slade Island), which are dominated by soft corals, sea stars and sponges.

Infauna community structure is strongly affected by sediment characteristics, especially sediment grain size, and depth, as well as the disturbance regime. Turbidity, sedimentation rate, nutrient availability and other water quality factors are also important. One of the key drivers of the structure and function of infauna assemblages is sediment particle size, so natural or anthropogenic changes in sediment characteristics are often reflected in changes to infauna communities.

Monitoring within the DMPA, and adjacent northern and eastern monitoring transects, by Ports and Coastal Environmental (PaCE 2021) of sediment and macrobenthic infauna before and after the 2020 maintenance dredging campaign (refer Figure 04-5) at the Port of Mackay concluded the following:

- The macrobenthic fauna community before and after the deposition of material at the DMPA was dominated (in abundance) by annelids, crustacea, molluscs and nematodes
- Declines in species richness and diversity were observed after placement of dredge material, with the greatest decline in the DMPA and adjacent northern monitoring location
- Changes in trophic structure of the benthic assemblage (identified as four feeding guilds - grazers, predators, suspension feeders and deposit feeders) was observed within DMPA, northern and eastern transects post placement of dredge material
- Monitoring prior to the 2020 dredging recorded all four feeding guilds, across the DMPA and northern and eastern monitoring locations. This is considered evidence of recovery from previous spoil deposition events
- The impacts to the structure and function of the infauna assemblage are considered minor
- Timeframe for recovery is likely to be measured in months.

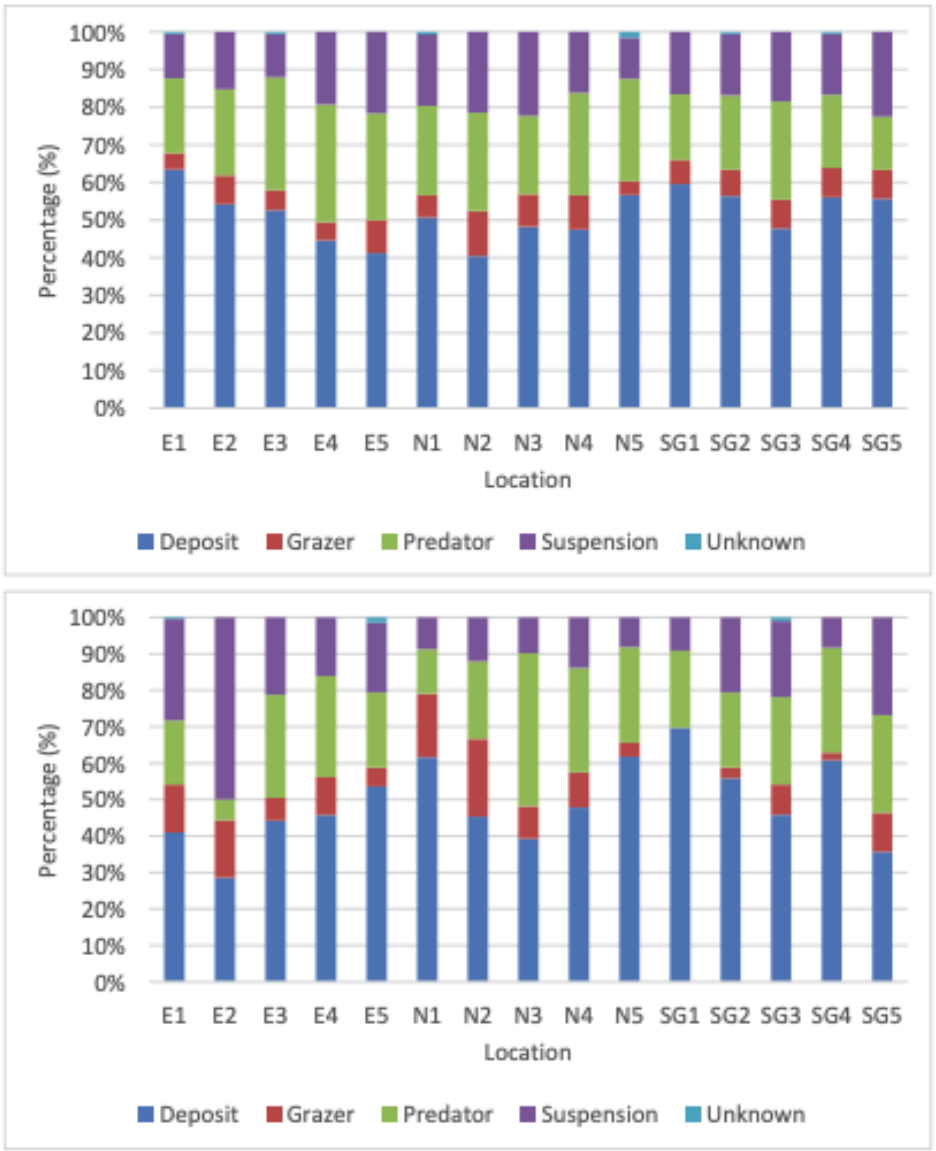


Figure 04-5: Extract *Figure 3-11* showing infauna assemblages pre and post material placement (PaCE 2021)

04.8 Mangroves

Mangroves and estuarine wetlands are a dominant feature along the Mackay Whitsunday coast occupying 64,094 ha of tidal land in the region. There are 21 species of mangrove in the Mackay region. Mangrove structural formations in the region range from closed forest to low scrubland, with 2m – 8m high closed scrubs being most common. Most communities are monospecific stands of Red Mangrove (*Rhizophora stylosa*), Grey Mangrove (*Aviciennia marina*), or Yellow Mangrove (*Ceriops tagal*).

Mangroves in the Mackay Region are concentrated around the Pioneer River, Bakers Creek/Sandringham Bay and McCreadys Creek/Slade Point areas, as well as in Sand Bay. The Pioneer River, which runs through the city of Mackay, and Bassett Basin lie south of the Port of Mackay. Basset Basin is an estuary of the Pioneer River and provides important fish nurseries.

Regional Ecosystems (RE) mapped in the study area supporting mangrove species are outlined in Table 04-4.

Table 04-4: Regional Ecosystems supporting mangrove species in the Port of Mackay study area

RE	Short description	VMA Status	Biodiversity Status	HVR (ha)	Total within study area (ha)
8.1.1	Mangrove closed forest of marine clay plains and estuaries	LC	NC	80.5	4,502.0
8.1.2	Samphire open forbland on saltpans and plains adjacent to mangroves	LC	OC	2.1	717.6
8.1.3	Sporobolus virginicus tussock grassland on marine sediments	OC	OC	69.2	559.7
8.1.4	Schoenoplectus subulatus and/or Eleocharis dulcis sedgeland or Paspalum vaginatum tussock grassland	OC	E	39.2	271.0
8.1.5	Melaleuca spp. and/or Eucalyptus tereticornis and/or Corymbia tessellaris woodland with a ground stratum of salt tolerant grasses and sedges, usually in a narrow zone adjoining tidal ecosystems	OC	E	35.7	123.1

Note. CE= Critically Endangered, E= Endangered, V= Vulnerable, LC = Least Concern, CR = Critically Endangered, NR= Near Threatened, NC = No Concern At Present

04.9 Terrestrial fauna

04.9.1 Migratory shorebirds

Migratory shorebirds use sheltered coasts with large intertidal mudflats or sandflats, often with seagrass meadows. They are often recorded in saltmarsh and on mudflats fringed by mangroves and will sometimes use mangroves. The area from Repulse Bay (to the north of the study area) to Cape Palmerston (in the south of study area) is an important roosting and feeding habitat for shorebirds (Jacobs 2016).

Over 23,000 shorebirds each year use the study area during their annual migration. This equates to approximately 0.2% of the East Asian - Australasian population. The area from the Port of Mackay to Armstrong Beach contains 12 significant shorebird roosting areas, and an additional 18 known roosting areas. Sandringham Bay is also a nationally and internationally significant area for five migratory shorebird species (Jacobs 2016).

Shorebird species listed as threatened under the EPBC Act that have been recorded (Jacobs 2016) in the study area include:

- Bar-tailed godwit (vulnerable)
- Curlew sandpiper (critically endangered)
- Eastern curlew (critically endangered)
- Great knot (critically endangered)
- Greater sand plover (vulnerable)
- Lesser sand plover (endangered)
- Red knot (endangered)

Additional migratory birds that are known or may frequent the region are listed in Section 04.14.3.

The eastern curlew and curlew sandpiper are frequently encountered along the coastline. The lesser sand plover, grey-tailed tattler, whimbrel and red-necked stint are known to rest and feed in the study area for an extended period to build energy reserves on the northward migration. Grey-tailed tattler, whimbrel, pacific golden plover and greater sand plover rest and feed in the study area on the southward migration (Jacobs 2016).

As reported by Jacobs (2016), key habitat areas include:

- The area from the Port of Mackay to Armstrong Beach, which contains 12 significant shorebird roosting areas, and another 18 known roosting areas.
- Internationally important shorebird habitat at Sandringham Bay and Mackay Town Beach
- Nationally important shorebird roosting sites at the mouth and banks of the Pioneer River, Armstrong Beach, and Sandfly Creek.
- Other locally important sites for shorebirds, including Bakers Creek, Dudgeon Point, Shellgrit Creek and Shellgrit Creek entrance, McEwens Beach, McEwens Beach Swamp, Dunnrock South Arm and Lake Barfield
- Wetland, mangrove areas surrounding the Port of Mackay, where the eastern curlew is known to occur.

04.9.2 Other threatened terrestrial fauna

Other threatened terrestrial fauna that has been recorded (as per Jacobs 2016) in the study area include:

- Australian painted snipe (endangered EPBC Act)
- Beach stone curlew (vulnerable NC Act)
- Glossy black-cockatoo (vulnerable NC Act)
- Grey falcon (vulnerable NC Act, vulnerable EPBC Act)
- Bare-rumped sheathtail bat (endangered NC Act, vulnerable EPBC Act)
- Coastal sheathtail bat (near threatened NC Act)
- Koala (Vulnerable NC Act, vulnerable EPBC Act)
- Northern quoll (endangered EPBC Act)

Threatened fauna species that use the creeks and estuaries include the water mouse, and tusked frog, both listed as vulnerable under the NC Act. The water mouse has a particular stronghold in the Mackay area (Jacobs 2016) and is listed as vulnerable under the EPBC Act. The water mouse primarily forages at night in the intertidal zone, particularly amongst the mangroves, at low tide, preying on crustaceans, molluscs and flatworms. There is therefore suitable habitat available in the coastal areas surrounding the Port of Mackay.

04.10 Marine fauna

Information presented below has been sourced from Jacobs (2016) and 2rog (2021) and referenced therein.

04.10.1 Marine turtles

All six species of marine turtle that occur in Queensland have been recorded in offshore, intertidal, estuarine and shoreline habitats in the Mackay region (Jacobs 2016). The following summary of marine turtle presence in the area is provided from Jacobs (2016):

- Green turtles are the most frequently observed marine turtle, and the flatback turtle is the predominant species observed nesting in the Mackay region. The green and loggerhead turtles have also been recorded nesting on beaches in the Mackay mainland area, but in lower numbers.
- Haliday Bay, in the north of the study area, is one of the most important flatback turtle nesting beaches in the Mackay region.
- Hawksbill (*Eretomochelys imbricata*) and loggerhead (*Caretta caretta*) turtles have also been observed foraging within the Port of Mackay. There is only a single record of leatherback turtle (*Dermochelys coriacea*) nesting in Mackay, with no recorded nesting since 1993.
- A 2011 study of five potential nesting beaches around Hay Point and Dudgeon Point identified Louisa Creek Beach as the only site suitable for turtle nesting. However, turtle nesting has also been observed at McEwens Beach, Louisa Beach, Ballykeel Beach and Far Beach.

Turtles have been recorded nesting on beaches to the north and south of the Port seawalls (pers.comm. NQBP 2021).

04.10.2 Marine mammals

Humpback whales (*Megaptera novaeangliae*) migrate through the study area June to October, with numbers peaking in August. Females with calves have been observed during monitoring from 2009 to 2011 within the port limits of Hay Point, which is in close proximity to the Port of Mackay. A core calving area has been identified offshore of Mackay. The exact location of this area is still unknown however, this identified calving area is outside of the study area and approximately 80 km offshore of Mackay.

Sei and fin whales (*Balaenoptera borealisi*, *B. physalu*) are occasional visitors to the Mackay region. While the blue and southern right whale (*B. musculusi Eubalaena australis*) are unlikely to occur in the study area. The study area is at the northern extent of their distribution and these species and are unlikely to occur in inshore areas near the coast.

The snubfin dolphin (*Orcaella heinohni*) may also occur in the region due to the presence of its typical habitat (ie. shallow coastal waters less than 20 m deep, often associated with tidal riverine and estuarine systems, enclosed bays and coastal lagoons). The Indo-Pacific humpback (*Sousa chinensis*) is also known to occur in the waters off Hay Point (Jacobs 2016) and is likely a transient visitor in the project area.

Dugongs are cited as one of the World Heritage values of the GBR. Dugong Protection Areas (DPAs) have been gazetted at Llewellyn Bay (DPA Type B) and Ince Bay (DPA Type A, outside the study area), approximately 20km and 35km south of Hay Point respectively. These areas have high ecological value and associated with seagrass, the primary food source for dugongs. DPAs are also located to the north of Mackay at Sand Bay, and Newry Region and outside the study area in Repulse Bay, about 20 km, 40 km and 75 km from Mackay respectively. Small herds of dugong have been reported near Port Newry and Ince Bay.

There are no seagrass meadows within or adjacent to the Port of Mackay, or within the DMPA. As such, while dugongs may be present in the study area, the project area is not known to be important for dugong foraging.

04.10.3 Other marine fauna

There are a number of other marine fauna values relevant to the Port of Mackay.

There have been sightings of saltwater crocodiles at the Tug Harbour and Mackay marina (2018).

The Bassett Basin Fish Habitat Area (FHA) is located near the mouth of the Pioneer River, about 1.5 km south of the Port of Mackay and 17 km north of the Hay Point. FHAs are established to protect inshore and estuarine fish habitats from disturbance by coastal development, while still allowing fishing.

Fish surveys in the Hay Point area from 2006 to 2008 found fish abundance to be very low compared to denser inshore seagrass habitats sampled elsewhere in Queensland. More recent surveys indicated that fish abundance and diversity are also low on open sandy bottoms between the loading berths and the

shoreline. Fish abundance and diversity are considerably higher in reef habitats, such as fringing reefs at Victor Islet, Round Top Island and Flat Top Island, which is typical on the inshore GBR. At these locations, the fish community is dominated by typical inshore species such as wrasses, damselfishes, angelfishes, butterfly fishes and snappers.

Reef Manta Ray (*Manta alfredi*) and Giant Manta Ray (*Manta birostris*) may occur in the waters offshore from Mackay.

04.11 Heritage

Cultural heritage is considered to be items or places with aesthetic, historic, scientific or social significance for current and future generations.

04.11.1 Brief Non-indigenous history of Mackay

Mackay was named after the explorer John Mackay who ventured to the area in 1860 from NSW in search of new grazing lands (CGQ 2018). He reached the Pioneer River which he named after himself but in 1862 was changed to its current name. Within a few years Mackay had a local newspaper, church, primary school and first experimented with growing sugar cane (CGQ 2018). The sugar industry expanded rapidly and by 1874 the Mackay district had 16 mills, 5000 acres of cane and produced more than a third of Queensland's sugar (CGQ 2018).

By 1903 Mackay had become a town and in 1918 it had grown to be given city status. A severe cyclone saw many important town buildings destroyed in 1918 and sugar crops and mills were lost (CGQ 2018). The rail line connected Mackay to Brisbane in 1921 and to Townsville in 1923. Tourism was introduced to North Queensland including Mackay through the rail line and coastal shipping services in the 1930s. Popular destinations included the Whitsundays Islands.

The then Queensland Premier, William Forgan Smith, officially opened the Mackay Harbour on the 26th of August 1939. The construction of the Harbour began in 1935 and was the largest infrastructure project undertaken to date in the region (Queensland Museum, 2019). Mackay's original port was located at the mouth of the Pioneer River, however it was shallow with a large tidal range which was problematic to large vessel entry (Queensland Museum, 2019). In 1927, John Love proposed a plan to construct two stone break walls extending out from the shore to form a harbour, to the north of the Pioneer River. While a costly plan, it had many merits and when Forgan Smith was elected, Mackay's local member, he negotiated a loan from the Queensland Government, and an additional grant, for its construction (Queensland Museum, 2019).

The Mackay outer harbour began to be used as a bulk loading facility in conjunction with the opening of the sugar terminal in 1957. The 1960s through to the 1990s saw urban Mackay expand and the population double. This trend continued into the early 2000s with the mining boom of 2004-06 (CGQ 2018).

04.11.2 Non-indigenous cultural heritage

The GBR is the only Commonwealth listed cultural heritage site in the study area. It is listed on both the National Heritage List and Commonwealth Heritage List. The GBR was declared a World Heritage Area in 1981, internationally recognised by the World Heritage Committee for its Outstanding Universal Value (OUV). The GBR as a whole, presents a globally outstanding example of the following:

- An ecosystem that has evolved over millennia through glacial cycles
- Significant diversity of reef and island morphologies reflecting geomorphic, oceanographic and environmental processes
- Complex string of reef structures along the coast
- World's largest coral reef ecosystem, including examples of all stages of reef development

The GBRWHA extends from the mean low water mark and covers an area of about 348,000 km^2.

Other non-indigenous heritage places currently listed for protection in the study area are generally restricted to sites within the developed, urban area of Mackay.

At the State level, 34 sites listed on the Queensland Heritage Register are in the Mackay Regional Council LGA, which includes areas outside the study area. The closest State heritage listed site is located approximately 5km from the Port of Mackay on the Pioneer River (WH Paxton & Co. Offices and Warehouse).

The Australian National Shipwreck Database identifies a number of shipwrecks within the study area. The majority of the shipwrecks are located in or around the mouth of the Pioneer River. None of these are listed as National maritime cultural heritage.

04.11.3 Indigenous cultural heritage

The Yuwibara People are the Traditional Owners and Native Title holders of the land and sea country within the Port of Mackay and Port of Hay Point Areas. NQBP has a Cultural Heritage Management Plan with the Yuwibara People which guides management of future development within the area (2rog 2021).

Cultural heritage surveys of the Port of Mackay and Port of Hay Point strategic port lands has identified areas of high cultural heritage significance.

Important areas include (refer Jacobs 2016):

- The Mount Hector Conservation Park
- A fish trap of archaeological significance has been located in the small bay between the Dalrymple Bay Coal Terminal and Hay Point Coal Terminal.

04.12 Fisheries

04.12.1 Commercial fisheries

Commercial and recreational fishing is important to the Mackay-Whitsunday Region. Important areas for fisheries include (Jacobs 2016):

- Newry Island and Newry Bay
- Llewellyn Bay
- Dudgeon Point and the Hay Point coastline
- Newry Region

As highlighted by Jacobs (2016), fisheries support:

- The local economy
- Tourism – as the principal extractive use of the GBR
- Approximately 34 000 people, or 24.8% of the Mackay-Whitsunday population, were recreational fishers

Queensland's diverse fisheries include the commercial, recreational, charter and Indigenous sectors. The commercial sector is Queensland's fourth most valuable fishery (which includes the Mackay region). In 2017–18 the total gross value product (GVP) of Queensland's fisheries production was $294.4 million, a decrease of 5% ($14.9 million) from 2016–17. ($4 million in 2009-2010: Jacobs, 2016) (ABARES, 2020).

Prawns are the most valuable catch in the study area ($155,860), making up almost half of the total commercial fishery value for the year. However, other species targeted in the Mackay-Whitsunday Region include coral trout, red throat emperor (*Lutjanus sebae*), spangled emperor (*Lethrinus nebulosus*), saddletail snapper (*Lutjanus malabaricus*), stripey snapper (*Lutjanus carponotatus*) and rockcod (*Epinephalus ergastularius* and *E. octofaciatus*).

Data summarised from years 2004 through to 2014 (refer Jacobs 2016) revealed the largest combined catches have been observed in waters containing Freshwater Point and Llewellyn Bay (>500,000 kg) and to the west of Hay Point (>20,000 kg). In the grids containing Hay point and Sandringham Bay (grid ref,

O25S13), Sarina Inlet (O23S23), and grids O25S9 and O24S16, catches were in excess of 100,000 kg. Outside of these areas, total catches were all below 10,000 kg.

The trawl fishery is Queensland's largest commercial fishery, with about 600 vessels producing up to 10,000 ton of product worth about $110 million each year. Approximately 95% of the reported commercial catch of Coral Reef Fin Fishery (CRFF) over the 2010 to 2011 period was taken from areas within the GBRMP.

Data from commercial net fishing relates only to coastal fringes. The highest catch weights were recorded in waters surrounding Freshwater Point and Llewellyn Bay (>300,000 kg). Elsewhere along the coast, catch weights across the years were below 1,000 kg.

Pot fishing is relatively small and largely confined to waters around Freshwater Point and Llewellyn Bay (~60,000 kg) and to the very east of the Mackay region (N24S19).

Species-specific information about fin fish, based on 2010-11 data, showed:

- Catches of coral trout (CT) are high throughout the extent of the GBR east and north of Shoalwater Bay
- The catch of red throat emperor (RTE) was highest in the central section between Townsville and Mackay. High catch of other coral reef species recorded in the southern regions were driven by catches of deep water bar rockcod (*E. ergastularius* and *E. octofaciatus*)
- In the north, high catches comprised of spangled emperor (*Lethrinus nebulosus*) but also red emperor (*Lutjanus sebae*), saddletail snapper (*Lutjanus malabaricus*) and stripey snapper (*Lutjanus carponotatus*).

04.12.2 Recreational fisheries

Recreational fishing is very important in the Mackay-Whitsunday Region. Approximately 28% of Mackay area resident's fish recreationally, compared to the state average of 17%.

State-wide recreational fishing surveys found the 64,000 people in the Mackay region had been fishing in 2018/2019. Table 04-5 shows the number of fish caught and released in the Mackay Coastal Waters between 2000 and 2019. In 2018/2019 recreational fishing expenditure for the Mackay Whitsunday region was $56,227,000. In that region the most caught fish types were Prawns and Yabbies (48%), followed by finfish (45%) and then small baitfish (5%) (2rog 2021).

Table 04-5: Recreational fishing data in the Mackay Coastal Waters 2000-2019 (DAF, 2020, in 2rog 2021)

Year	2000	2010	2013	2019
Caught (individuals)	1,753,000	748,000	712,000	763,000
Released (individuals)	627,000	352,000	337,000	411,000

As discussed by Jacobs (2016) the most commonly caught fish (by species group) are tropical snappers and sea perch, with 91,000 caught in 2010, 12% of the total catch for the year. It is estimated that close to half of the catch was released. Yabbies were also a popular catch, also with an estimated total of 91,000 (12%) in 2010; however, 90% of yabbies caught were kept; yabbies' are primarily used as bait. Emperors were also popular, with 74,000 fish caught (10% of the total) in 2010, with about half of them released.

In 2014, a more detailed species-level study indicated that the most commonly targeted species by Mackay - Whitsunday residents were sand whiting, mud crab, barred javelin, barramundi, coral trout and yellowfin bream. Barred javelin had high release rates. Mud crabs were the most commonly caught non-fish species, but many more were released than kept as a result of size and bag limits and the prohibition of retaining males.

04.13 Tourism and recreation

Tourism and associated public amenities in the Mackay-Whitsunday Region is significant. In terms of the economic benefit to the Mackay Region, the overnight visitor economy is worth approximately $811 million across sectors including transport, accommodation, food services and retail. Tourism is also a major employment sector, with about 7,510 tourism jobs (either directly or indirectly) in the Mackay region. Tourism contributes approximately 3% of the economic output from the region, generating an estimated output of $457,403 million (Jacobs 2016).

All offshore islands and large sections of the coastal fringe have been identified as having landscape character and/or forming part of the image corridor. The coastal fringe north and south of Hay Point is also mapped as part of the landscape character.

Popular tourist destinations also include the offshore islands. Keswick and St Bees are popular for walking snorkelling and diving. These islands are located approximately 27 km from the Port of Mackay. Lindeman and Whitsunday Islands to the north of the Port of Mackay (approximately 75 km and 97 km) offer resort-style accommodation and activities.

Harbour Beach, Sarina Beach and Armstrong Beach are popular tourist beaches. The closest of these to the Port of Mackay is Harbour Beach, located approximately 8 km southwest of the Port.

Regionally important park and recreation facilities/precincts include the Mackay city centre riverfront (including Bluewater Lagoon, Bluewater Quay and Bluewater Trail), Regional Botanic Gardens, John Breen Park/Gooseponds precinct, Mulherin Park and Queens Park. Sporting and event facilities/precincts include South Mackay regional sporting precinct, Mackay and Sarina showgrounds, Ooralea Racecourse, Beaconsfield–North Mackay precinct and Golf Course, Brewers Park sub-regional sporting precinct in Sarina and the Sarina golf course.

Regionally important natural recreation areas include Mackay beaches, the Slade Point Nature Reserve and the Marian riverfront. Seaside foreshores and the East Point area in Mackay provide recreational and low intensity tourism opportunities that respect environmental constraints and benefits from the unique location on the riverine and seaside foreshore. In 2012, it was estimated that approximately 1,634 km^2 of the LGA was held as protected areas (e.g. national park, reserve). National parks make up about 845 km^2 (52%) of the protected area within the Mackay Local Government Area (LGA).

04.14 Matters of National Environmental Significance (MNES)

A list of MNES with the potential to occur in the project area was generated through a search of protected matters using DAWE's online Protected Matters Search Tool (PMST) in November 2021 (Appendix D). A summary of this search is provided in Table 04-6. The MNES included in the list were then assessed to determine their likelihood of occurrence within the project area. This assessment took into account:

- Results of studies undertaken within the vicinity of the Port of Mackay and any existing data for the region more broadly
- The habitat requirements and known distribution of the species
- Professional judgement from this assessment's authors.

The likelihood of occurrence assessment categorised MNES into five categories as follows:

- Known: the species or ecological community was or has been observed on the site
- Likely: a medium to high probability that a species or ecological community occurs on the site
- Potential: suitable habitat for a species or ecological community occurs on the site, but there is insufficient information to categorise the species or ecological community as likely to occur, or unlikely to occur
- Unlikely to occur: a very low to low probability that a species or ecological community occurs on the site
- Not occurring: habitat on the site and in the vicinity is unsuitable for the species or ecological community.

The results of this assessment are provided in Appendix B.

Table 04-6: Summary of MNES identified through the PMST

MNES	Comment
World Heritage Places	1 – Great Barrier Reef World Heritage Area (Section 04.14.1)
National Heritage Places	1 – Great Barrier Reef National Heritage Place (Section 04.14.1)
Wetlands of International Importance	None
Great Barrier Reef Marine Park	35 – Multiple Zones (Section 04.14.2)
Commonwealth Marine Area	None
Listed Threatened Ecological Communities	2 – Section 04.14.3. See Appendix B for full list of threatened ecological communities.
Listed Threatened Species	44 – Section 04.14.3. See Appendix B for full list of threatened ecological communities.
Listed Migratory Species	66 – Section 04.14.3. See Appendix B for full list of threatened ecological communities.

04.14.1 Great Barrier Reef World Heritage Area

The proposed dredging and material placement will occur within the GBRWHA. Jacobs (2016) and Kaveney et al. (2017) undertook an in depth analysis of the attributes of the project area and region that contribute to the GBRWHA's Outstanding Universal Value as part of the environmental values assessment for the Hay Point SSM. The assessment covered the Port of Mackay and as such is appropriate for use in this risk assessment.

The assessment was based primarily on the presence and importance of each attribute in the study area. The method used is in line with the approach adopted by the Queensland Department of State Development for use in preparing an evidence base for Priority Port Master Planning under the *Sustainable Ports Development Act 2016*.

None of the specific locations referred to in the World Heritage listing for the GBR (e.g. Green Turtle breeding on Green Island and the Cod Hole tourist attraction), occur within or near the study area. There are no coral cays in the study area, so it does not contribute to aspects of OUV specific to cays. Dugongs are sometimes seen in the study area, but there are no major feeding grounds and no resident population. Similarly, while low density sea turtle nesting occurs there are no regionally significant rookeries. No major seabird breeding sites are known in the study area. Significant reef fish spawning aggregations are unlikely to occur on the fringing reefs in the study area. Spawning aggregations typically occur on prominent features, such as spurs, channels, bommies, or steep drop-offs, often on the outer edges of reefs, which have strong currents flowing into deep water.

The project area and region does make some form of contribution to OUV under the majority of the Property's listing criteria. In all cases, this contribution is incremental, in that the area supports a subset of the features and processes (e.g. natural beauty, biodiversity, coral reef accretion) identified in the listing. However, none of the area's contributions to OUV are critical contributions at the scale of the World Heritage Property.

Of the environmental values present in the region, three are considered to provide a higher contribution to the OUV of the GBRWHA (Kaveney et al. 2017). These are:

- Internationally recognised migratory shorebird roosting sites at Sandringham Bay and Mackay Town Beach that support 23,000 shorebirds each year during their annual migration

- A core aggregation/calving area for the east-coast population of humpback whales approximately 80 km east of Mackay
- A high diversity of mangrove species within estuarine areas.

04.14.2 Great Barrier Reef Marine Park

The Port of Mackay is excluded from the GBRMP and the dredged material placement site is not located within the Marine Park boundary. The dredge vessel will not need to move between or within the GBRMP while undertaking maintenance dredging. The dredge plume modelling indicates that the plume may extend in to the GBRMP. However, the plume and associated turbidity is not expected to be significantly higher than natural conditions (refer Section 07.1) Consequently, no impacts to zones of the GBRMP are anticipated and the area is not assessed further.

04.14.3 Listed communities and species

The likelihood assessment indicated a number of threated communities, threatened species and migratory species that are either known or considered likely or potential to occur, as listed in Table 04-6. The results of the full likelihood of occurrence assessment is provided in Appendix B.

Table 04-7: Threatened and migratory species known, likely or with the potential to occur at Port of Mackay

Scientific name	Common name	EPBC Act Status	Likelihood of Occurrence	Comment / justification
BIRDS				
Calidris canutus	Red Knot	E M	Known	The species inhabits mudflats, sandflats and sandy beaches of sheltered coasts, in estuaries, bays, inlets, lagoons and harbours. The Mackay region is known to supports this species this species and there are a number of significant shorebird feeding and roosting sites located in the project area.
Calidris ferruginea	Curlew Sandpiper	CE M	Known	This species is frequently encountered along the coastline from Mackay Harbour to Armstrong Beach and inhabits mudflats, sandflats and sandy beaches of sheltered coasts, in estuaries, bays, inlets, lagoons and harbours. The Mackay region is known to supports this species this species and there are a number of significant shorebird feeding and roosting sites located in the project area.
Calidris tenuirostris	Great Knot	CE M	Known	The species prefers sheltered coastal habitat with large intertidal mudflats or sandflats, including inlets, bays, harbours, estuaries and lagoons. The Mackay region is known to supports this species this species and there are a number of significant shorebird feeding and roosting sites located in the project area.
Charadrius mongolus	Lesser Sand Plover	E M	Known	The species occurs in coastal littoral and estuarine environments where it inhabits large intertidal sandflats or mudflats in sheltered bays, harbours and estuaries. The Mackay region is known to supports this species this species and there are a number of significant shorebird feeding and roosting sites located in the project area.
Limosa lapponica baueri	Bar-tailed Godwit (western Alaskan)	V	Potential	This is a sub-species of the Bar-tailed Godwit and is known to occur in northern Australia. There are no current records of its occurrence in the project area or region, however there are many records of the Bar-tailed Godwit and therefore there is also potential for the western Alaskan sub-species to occur.
Numenius madagascariensis	Eastern Curlew	CE M	Known	This species is frequently encountered along the coastline from Mackay Harbour to Armstrong Beach and is known to forage in intertidal mudflats, often with beds of seagrass, on sheltered coasts, especially estuaries, mangrove swamps, bays, harbours and lagoons. The Mackay region is known to supports this species this species and there are a number of significant shorebird feeding and roosting sites located in the project area.
MAMMALS				

Scientific name	Common name	EPBC Act Status	Likelihood of Occurrence	Comment / justification
Megaptera novaeangliae	Humpback Whale	V M	Known	Humpback whales migrate through the project area using the offshore waters from June to October peaking in August. Females with calves have been observed within the port limits of Hay Point, which is in close proximity to the Port of Mackay.
Xeromys myoides	Water Mouse	V	Known	The Mackay region is considered a stronghold for this species. It inhabits the mangrove communities lining creeks and estuaries.
REPTILES				
Caretta caretta	Loggerhead Turtle	E M	Known	The species has been recorded in the Mackay region. Species has been observed foraging at Hay Point and is likely to be transient in the waters adjacent to Port of Mackay as it forages in the surrounding reef systems or seagrass meadows. There are occasional records of the species nesting in the region.
Chelonia mydas	Green Turtle	V M	Known	The species has been recorded in the Mackay region. There is a small resident population at Hay Point and the species is likely to be transient in the water adjacent to Port of Mackay as it forages on algae covered reef systems and seagrass meadows. Low density nesting has been observed in the region between November and April.
Dermochelys coriacea	Leatherback Turtle	E M	Known	The species has been recorded in the Mackay region and may be a transient visitor in the water adjacent to the Port of Mackay as it forages in the surrounding reef systems.
Eretmochelys imbricata	Hawksbill Turtle	V M	Known	The species has been recorded in the Mackay region and may be a transient visitor in the water adjacent to the Port of Mackay as it forages in the surrounding reef systems.
Lepidochelys olivacea	Olive Ridley Turtle	E M	Known	The species has been recorded in the Mackay region and may be a transient visitor in the water adjacent to the Port of Mackay as it forages in the surrounding reef systems.
Natator depressus	Flatback Turtle	V M	Known	The species has been recorded in the Mackay region. Species has been observed foraging at Hay Point and is likely to be transient in the waters adjacent to Port of Mackay as it forages in the surrounding reef systems or seagrass meadows. Hay Point Beach and Salonika Beach are known to be the most heavily used nesting beaches, with the region supporting between 30-100 turtles annually.
MIGRATORY MARINE BIRDS				
Sternula albifrons	Little Tern	M	Potential	The species occurs in sheltered coastal environments, with suitable habitat present in the project area. The are no known breeding colonies in the study area or wider region.
MIGRATORY MARINE SPECIES				

Scientific name	Common name	EPBC Act Status	Likelihood of Occurrence	Comment / justification
Crocodylus porosus	Salt-water Crocodile	M	Known	The species in known to inhabit creek and estuaries of the study area.
Dugong dugon	Dugong	M	Known	The species has been recorded in the Mackay region. Species has is likely to be transient in the waters adjacent to Port of Mackay as it moves to preferred foraging areas.
Manta alfredi	Reef Manta Ray	M	Potential	Manta ray species have previously been anecdotally reported in shark nets off of Mackay. The species may occur in the waters adjacent to the project area.
Manta birostris	Giant Manta Ray	M	Potential	Manta ray species have previously been anecdotally reported in shark nets off of Mackay. The species may occur in the waters adjacent to the project area.
Orcaella heinsohni	Australian Snubfin Dolphin	M	Potential	Records and distributions are not well known, however all available data on distribution and habitat preferences indicates that the species mainly occur in shallow and coastal estuarine waters of Queensland, Northern Territory and north Western Australia. The species may occur in the waters adjacent to the project area.
Sousa chinensis	Indo-Pacific Humpback Dolphin	M	Known	The species has been recorded in the waters off of Hay Point and may be a transient visitor in the project area.
MIGRATORY WETLAND SPECIES				
Actitis hypoleucos	Common Sandpiper	M	Known	The species has been recorded between Repulse Bay and Cape Palmerston.
Arenaria interpres	Ruddy Turnstone	M	Known	
Calidris acuminata	Sharp-tailed Sandpiper	M	Known	
Calidris alba	Sanderling	M	Known	
Calidris melanotos	Pectoral Sandpiper	M	Potential	The species has not been recorded in the project area, however suitable habitat is present.
Calidris ruficollis	Red-necked Stint	M	Known	The species has been recorded between Repulse Bay and Cape Palmerston.
Charadrius bicinctus	Double-banded Plover	M	Known	
Charadrius veredus	Oriental Plover	M	Potential	The species has not been recorded in the project area, however suitable habitat is present.
Gallinago hardwickii	Latham's Snipe	M	Known	The species has been recorded between Repulse Bay and Cape Palmerston.
Limicola falcinellus	Broad-billed Sandpiper	M	Known	
Limnodromus semipalmatus	Asian Dowitcher	M	Known	
Limosa lapponica	Bar-tailed Godwit	M	Known	
Limosa limosa	Black-tailed Godwit	M	Known	

Scientific name	Common name	EPBC Act Status	Likelihood of Occurrence	Comment / justification
Numenius minutus	Little Curlew	M	Known	The species has been recorded between Repulse Bay and Cape Palmerston.
Numenius phaeopus	Whimbrel	M	Known	
Pandion haliaetus	Osprey	M	Potential	The species has not been recorded in the project area, however suitable habitat is present.
Pluvialis fulva	Pacific Golden Plover	M	Known	The species has been recorded between Repulse Bay and Cape Palmerston.
Pluvialis squatarola	Grey Plover	M	Known	
Tringa brevipes	Grey-tailed Tattler	M	Known	
Tringa glareola	Wood Sandpiper	M	Known	
Tringa incana	Wandering Tattler	M	Known	
Tringa nebularia	Common Greenshank	M	Known	
Tringa stagnatilis	Marsh Sandpiper	M	Known	
Xenus cinereus	Terek Sandpiper	M	Known	

05 POTENTIAL IMPACTS

The potential impacts of dredging have been well documented in Ports Australia (2014) and McCook et al. (2015). These impacts are discussed below, with particular focus on those relevant to maintenance dredging at the Port of Mackay. Detailed impact analysis and risk assessment of how these potential impacts may affect environmental values at the Port are provided in Sections 07 and 08 below.

05.1 Seabed disturbance

05.1.1 Within the dredging footprint

Maintenance dredging occurs within the confines of the constructed seawalls of the Port and involves the removal of sediments that have accumulated in artificially deepened areas between maintenance dredging periods. Each maintenance dredging campaign generally involves disturbance of the same area or dredge footprint.

Across the areas to be dredged at Port of Mackay, silt and clay are the most common sediment types (40%), and small portions of gravel. Wave action is the dominant driver for the resuspension of fine-grained sediment in the Mackay region and waves are indirectly also expected to be the dominant driver for sedimentation in the dredged areas of the Port.

Most of the fauna and flora that colonise the accumulating sediments between dredging episodes are species that are adapted to exploiting disturbed habitats and typically involve common and widespread species such as shellfish, crabs, worms and algae. Material to be dredged is almost always unvegetated (other than microalgae).

Unless environmental conditions change markedly, direct impacts associated with maintenance dredging (removing the seabed) are generally localised and short term.

05.1.2 Within the material placement area

Placement of dredged material at the DMPA results in burial and smothering of resident benthic communities. Similar to dredging footprints, impacts to a DMPA are an unavoidable consequence of placing material at-sea. DMPAs are designated for this impact process and are specifically located in recognition of the inevitability of such impacts and the need to minimise adverse effects to adjacent areas.

Recovery within DMPAs generally follows consistent patterns at Queensland Ports, including the Port of Mackay. Studies of the impacts of dredged material disposal have shown that (Ports Australia 2014):

- Seabed fauna (e.g. polychaetes, bivalves, and anemones) in the DMPA were initially adversely impacted due to burial and smothering (reduced abundance and diversity)
- Community recovery (increased biomass and diversity) began within a short time (<2 months) after the completion of placement activities
- Placement of dredged material may have provided an abundance of nutrients for organisms at the site with some species rapidly colonising the new material
- Surveys undertaken 3 – 11 months after placement activities (port and year dependent) indicated the benthic community of the DMPA had recovered and was not substantially different from adjacent or reference locations (some minor changes in community structure occurred but were restricted to close areas to the DMPA).
- There was some evidence of opportunistic rapid colonisers (mainly polychaetes) being more common at the DMPA than at reference sites.

Surveys conducted in 2020 and 2021 at the Port of Mackay DMPA assessed the benthic community pre and post dredging (5 weeks later) and also undertook a comparison with results from the 2013 pre and post dredging assessment. The 2021 assessment found that placement of material presented an impact at the DMPA, with declines in species richness and species diversity observed post dredging (PCS 2021).

However, comparison to the pre dredge survey during 2013 demonstrates that these imposts are short lived, and that over time the macrobenthic infaunal assemblage regains a homogenous dynamic amongst the DMPA (PCS 2021). The infaunal assemblage in the Mackay region is typical of that found in coastal sedimentary regions of the Great Barrier region – it is not unique in terms of structure or function; and it is an assemblage that occurs over a very large spatial area (PCS 2021).

05.2 Impacts to water quality

05.2.1 Turbidity and sedimentation

Dredging and dredged material placement may cause sediment to be introduced to the water column (turbidity) and result in impacts as these sediments settle (sedimentation).

Turbidity and sedimentation effects can result from the dredging operation (e.g. through hopper overflow waters, disturbance to the seabed by the dredge draghead or propeller wash), the placement of material at the DMPA (e.g. through TSHD discharges or barge releases) and through dispersion of placed material from the DMPA.

The level of impacts and rates of recovery from turbidity and sedimentation effects depend on several factors such as the timing, duration, intensity, and scale of the dredging and dredged material placement works as well as the type of species affected.

Suspended materials may either settle at the dredge and/or DMPA, contributing to direct effects or cause indirect effects as they are transported by currents to adjacent areas (depending upon the sediment particle sizes involved and the hydrodynamic regime of the dredge area). Settled suspended sediments may smother benthic communities, such as corals and seagrass, impacting growth rates and in extreme cases, result in mortality. Sedimentation on intertidal shores also has the potential to impact mangrove communities.

05.2.2 Release of contaminants and/or nutrients

All dredged material at the Port of Mackay has undergone testing in accordance with the NAGD. Testing and approval protocols are followed to ensure potential impacts relating to the relating to the resuspension or placement of material are assessed. Contaminant levels are all below screening criteria and are considered suitable for ocean disposal (Advisian 2018).

Dredging and dredged material placement may release nutrients held within the seabed sediments. The ecological impact of additional nutrients depends on a broad range of factors including the background concentrations in the water column, nutrient release rates and dredging techniques, and needs to be considered on a site-specific basis. The NAGD does not provide guidance in relation to nutrient levels in marine sediments.

Elevated nutrient levels in the water column are of interest as there may be a potential to stimulate algae growth with both positive and negative effects. Whilst increases in nutrient levels may increase the risk of algal blooms, the turbidity created by dredging reduces light and hence may reduce the risk of blooms.

Most assessments of nutrient-related impacts have indicated any increase in nutrient concentrations is likely to be localised and short-lived and comparable to the effects of storms which impact much more extensive areas. Adverse effects of eutrophication related (algal bloom) water quality issues are rare because the events are short lived, there is typically a fairly rapid dilution and relative to the dilution, nutrient release is small.

05.2.3 Spills and leaks from dredge vessel

Ship-sourced oily wastes are those produced during the normal operation of ships and include lubricating oil and hydraulic oil, fuel residues, oily sludges, oily bilge water, oily tank washings, oily cargo losses, and used oil filters and oily rags. Most oily wastes are liquids, albeit with suspended solids, except for oil filters and oily rags which are solid wastes.

Ship sewage is typically considered to be human waste (from urinals and toilets) but is defined by the IMO as also including drainage from onboard medical areas. Any material that is mixed with sewage is to be treated as sewage and in some ships, this may include greywater (i.e. drainage water from dishwashers, sinks, showers, laundries, baths and washbasins) that is drained into common holding systems.

Garbage is generated in ships as an inevitable consequence of the operation and routine maintenance of the ship and the sustenance of those onboard (i.e. crew and passengers if carried). Much of the garbage generated in ships is analogous to that generated in residential premises, offices and light industrial workshops.

Under IMO regulations, ships are not permitted to discharge treated sewage (from an approved sewage treatment plant) within three nautical miles of the nearest land or twelve nautical miles for untreated sewage; only when the ship is travelling at no less than 4 knots and discharge is at an approved rate. Discharge of garbage and waste material is prohibited except for food waste, cargo residues, cleaning agents and additives and animal carcasses which are subject to specified discharge provisions under MARPOL Annex V.

05.3 Underwater noise

Large ships generate broadband noise which can radiate throughout the underwater marine environment. This originates from their propellers, engines, auxiliary machinery, gear boxes and shafts, plus hull wake and turbulence and can be substantial in an aggregated sense.

The radiated noise spectrum from TSHD vessels is typically in the range of 30 Hz to 500 Hz (WODA 2013). Low frequency acoustic energy propagates well in marine waters, particularly the deep oceans, and ships' low frequency noise components contribute significantly to the amount of low frequency ambient oceanic noise, particularly in regions with heavy ship traffic.

Low frequency broadband noise from shipping is of potential concern as it may impede use of the acoustic spectrum by marine fauna, particularly cetaceans. This concern centres upon the possibility that such noise may:

- Mask echolocation vocalisations or communications
- Acoustically mask predators or prey
- Lead to separation of calves from mothers
- Alienate the animals from preferred aggregation areas or migration pathways, if intense and localised.

05.4 Ship lighting

Ships emit light from a variety of sources at night. These include compulsory navigation lighting as required by the Convention on the International Regulations for Preventing Collisions at Sea (COLREGs), with the actual configuration dependent upon ship size and type and activity engaged upon, particularly whether underway or at anchor. In addition to mandatory lighting, COLREGs also encourage ships to maximise upper deck illumination as a means of enhancing a ship's visual presence, intended to reduce collision risks.

During dredging, the dredge vessel will be operating 24 hours a day and therefore operational lighting will be required at night.

Artificial lighting has the potential to impact marine fauna through a range of processes including:

- Dis- or mis-orientation
- Attraction/repulsion
- Decrease in habitat suitability
- Alteration in foraging and breeding behaviours
- Change in fauna community interactions (competition and predation).

05.5 Interactions between the dredge and marine fauna

Ship strike can be defined as a collision between a vessel and a marine species causing either injuries or death to the marine animal and/or damage to the vessel and sometimes to its passengers. Ships strikes occur anywhere that vessels and marine fauna distributions' overlap, mostly within coastal zones, however, there have been reports of high seas collisions. Vessel speed is a significant factor in the likelihood of collisions occurring. Marine fauna may be slow to react and avoid fast, highly mobile craft (such as speed boats and jet skis) and these pose a particularly significant risk to smaller fauna such as turtles and dugongs.

Ship strike injuries to marine animals tend to fall into two categories – lacerations from sharp objects, most commonly propellers and/or injuries from impact with the hull resulting in fractures and/or bruising. Both these risks are considered low during dredging operations due to the slow speeds at which dredge vessels operate. Specific risks are also associated with dredging, whereby marine fauna (particularly turtles) may collide with or become entrained with the drag head. Resultant injuries can result in fauna mortality.

05.6 Introduction of marine pests

Introduced marine pests are marine plants or animals that are not native to Australia that have been introduced by human activities such as shipping. They have the potential to significantly impact marine industries and the environment. Introduced marine pests are known to be introduced or translocated by a variety of vectors, including ballast water, biofouling, aquaculture operations, aquarium imports, marine debris and ocean current movements.

NQBP developed the Early Detection Marine Pest Plate Monitoring Program in 2009 which monitors larval plates deployed adjacent to Berth 1 and Berth 5 within the Port of Mackay, on a quarterly basis (NQBP 2020). Additionally, NQBP have been working with Biosecurity Queensland to develop a new survey technique where collected plankton samples are analysed using e-DNA technology to detect a range of potential invasive species (NQBP 2020).

This new method has confirmed that the colonial sea squirt (*Didemnum perlucidum*) is present in the Mackay area. The sea squirt fouls submerged and floating infrastructure such as pylons, pontoons, boats and buoys. Biosecurity Queensland have advised that although it is not possible to eradicate this pest, regular maintenance and cleaning of vessels is recommended to prevent spread (NQBP).

The black scar oyster (*Magallana bilineata*) has been detected in the Far North Queensland locations of Cairns, Port Douglas and Cooktown.

Ballast water is able to act as a vector for marine organisms when species are entrained in the ballast, able to survive the intervening voyage, and then successfully establish in the new environment after discharge from the conveying vessel. Dependent upon where and how the vessel loads ballast, the ballast water may also include sediments and sludges, which can also act as a vehicle for the transfer of exotic species.

05.7 Impacts to other users

Impacts from dredging to other users of the region will be limited both due to the short duration of maintenance dredging and restrictions on usage of Port areas. Fisheries are likely to have the greatest potential for impacts, both direct and indirect.

Direct impacts include loss or modification of access. Indirect impacts can be through changes to productivity principally through modification or loss of habitat. Indirect impacts can also arise on fishing activities that may be impacted by the displacement of fishing effort when access arrangements change. Changes to the economic structure of a region may also have impacts on the availability of business services that support commercial fishing and the cost of accessing such services.

06 MEASURES TO AVOID AND REDUCE IMPACTS

Significant work has been undertaken to analyse the optimal options for managing sediments at the Port of Mackay. The SSM project did the following:

- Assessed the feasibility of avoiding or reducing the need for maintenance dredging at the Port of Mackay
- Comprehensively investigated opportunities to beneficially reuse accumulated material that must be dredged
- Considered alternatives to at-sea disposal, based on environmental values and constraints in the region
- Compared the range of alternatives in a way that considers (at a minimum) risks to the environment, health and safety, social and economic values and the exclusion of future uses.

The overarching outcome of the project was that ongoing maintenance dredging will be required at the Port of Mackay in order to maintain the operational efficiency and safety of the Port. The outcomes of the SSM project provide a range of measures that will be implemented to avoid and reduce impacts of sediment management at the Port of Mackay. These are discussed below.

In addition to the SSM, a framework has been developed to reduce frequency, extent and severity of any actual or potential impacts from maintenance dredging at the Port. The framework is based on three key documents:

- Port of Mackay Long-term Maintenance Dredging Management Plan
- Port of Mackay Marine Environment Monitoring Plan
- A works specific Environmental Management Plan
    - This will be developed prior to the commencement of each dredging campaign and will be developed in partnership with the relevant dredging vessel operator.

Together, these documents will provide a series of measures to reduce and manage impacts from maintenance dredging based on the findings of this impact assessment.

In undertaking this risk assessment, it has been assumed that standard best practice mitigation measures will be applied. In addition, a number of specific measures and adaptive management approaches are noted and recommended throughout the text.

07 IMPACT ANALYSIS

07.1 Impacts to water quality

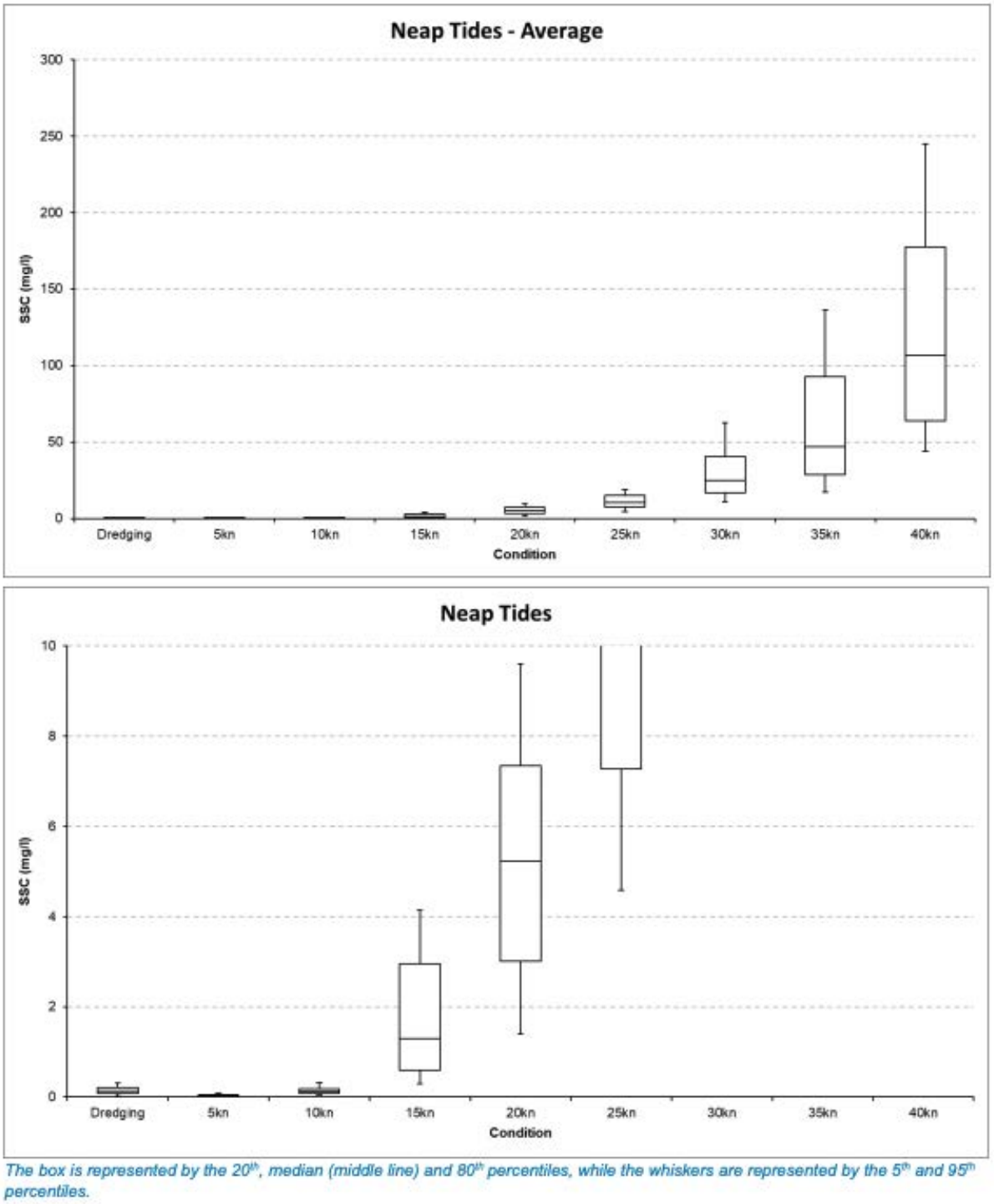
Impacts to water quality as a result of increased suspended sediments is one of the key concerns relating to dredging. Increases in suspended sediments have the potential to result in impacts to sensitive marine environments in some circumstances. A detailed analysis of potential changes to water quality has been undertaken for the proposed maintenance dredging at the Port of Mackay. The analysis has considered a range of dredge volumes, metocean conditions, seasons and sediment composition.

A key outcome of the above analyses has been an understanding of the natural sediment regimes in addition to the natural plus dredging scenario i.e. what additional effects is the maintenance dredging likely to have on sediment regimes at the Port of Mackay when taken in the context of natural conditions. Across analyses, the data show that the region around the Port is naturally turbid, with natural resuspension of sediments occurring due to wind and wave regimes. Maintenance dredging campaigns do not drive the system outside of what it experiences naturally and as such impacts to sensitive receptors are not anticipated from campaigns. The analysis of volumes reflective of likely dredging campaign volumes are not likely to result in impacts to sensitive receptors. The analyses are discussed further below.

07.1.1 Resuspension of sediments

Resuspension of sediments was analysed as part of a series of assessments for the SSM (PSC 2021d). The analysis predicted that maintenance dredging at the Port of Mackay would result in elevated SSC within Mackay Harbour and Mackay DMPA throughout the duration of the dredging. The Mackay Region is naturally turbid with a strong seasonal variation between wet and dry season and results from the numerical modelling of sediment resuspension indicated that the nearshore natural SSC was predicted to generally be much higher than the SSC resulting from maintenance dredging (PCS 2021d). The SSC in Mackay Harbour during maintenance dredging remains higher than at the nearby water quality monitoring sites of Slade Islet and Round Top Island, showing that the Harbour acts to retain a lot of the sediment suspended by the maintenance dredging activity (PCS 2021d).

A comparison of maintenance dredging relative to the natural SSC showed that the 2020 maintenance dredging program (120,000 m^3 placed at the existing placement site) resulted in very low excess SSC at the closest water quality monitoring sites (95th percentile SSC of less than 1 mg/l), which is approximately comparable to the natural range in SSC during calm conditions (wind speeds of 10 knots and under) (refer Figure 07-1 and Figure 07-2). The only area outside of the Harbour where increases in SSC from maintenance dredging were predicted to result in a clear increase in total SSC was within and adjacent to the Mackay DMPA where the natural SSC is typically low (PCS 2021b). Importantly, there are no sensitive receptors located within the areas to the north and south of the DMPA where this elevated SSC is predicted to occur (PCS 2021b).



The box is represented by the 20th, median (middle line) and 80th percentiles, while the whiskers are represented by the 5th and 95th percentiles.

Figure 07-1: Extract of *Figure 14* (PCS 20121c). Box and whisker plot showing average percentiles (over the two sites) during neap tidal conditions for natural SSC during different wind speeds and excess SSC from maintenance dredging of 120,000 m3 using the existing placement site. *The top plot shows the entire SSC range (0 – 300 mg/l) and the bottom plot is zoomed in on the lower SSC values (0 – 10 mg/l) so the relative impact of dredging can be seen. (***PCS 2021c)**

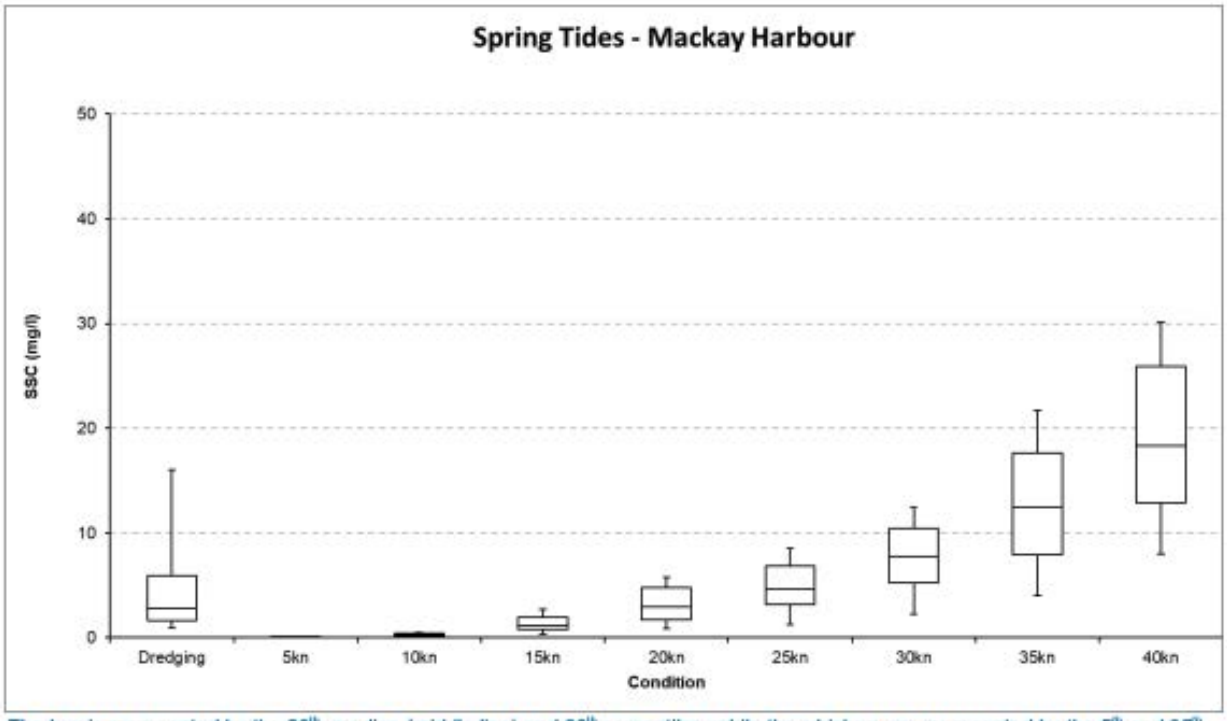


Figure 07-2: Extract of *Figure 15* (PCS 20121c). Box and whisker plot showing average percentiles within Mackay Harbour during spring tidal conditions for natural SSC during different wind speeds and excess SSC from maintenance dredging of 120,000 m3 using the existing placement site. (PCS 2021c)

Long-term resuspension modelling was undertaken as part of the dredge plume modelling and predicts that sediments placed in the DMPA will only be resuspended and transported outside of the DMPA during relatively short, discrete events coinciding with large wave events. The modelling was also used to estimate that ~75% of the sediment from maintenance dredging would still be present at the DMPA one year after placement. The model also predicted that the sediment resuspended from the Mackay DMPA would be deposited as a very thin layer of sediment and was not predicted to result in increased deposition at any nearby sensitive receptor or within the dredged areas of the Port of Mackay (PCS 2021a).

07.1.2 Sediment transport

PCS (2021b) undertook sediment transport and dredge plume modelling to understand the potential impacts from maintenance dredging. As mentioned previously sediment movement in the Mackay region is driven by current and wave action, with a strong relationship between wind speed and wave height. Tropical cyclones also have the potential to generate large waves, strong currents and increased river discharge, which causes significant resuspension of sediment and increased transport of the suspended sediment (PCS 2021b).

The dredge plume modelling indicates that the plume resulting from the maintenance dredging activity in Mackay Harbour will predominantly remain within the Harbour, with the Harbour breakwaters preventing the majority of the suspended sediment from being transported out of the Harbour. The sediment deposition resulting from maintenance dredging showed a similar pattern to the SSC, with the majority of the sedimentation associated with the dredge locations within the Harbour and sedimentation occurring within and to the north and south of Mackay DMPA. It was therefore only within Mackay Harbour and to the north and south of Mackay DMPA where it was possible to clearly distinguish between the natural and natural plus dredging deposition (PCS 2021b).

Dredged sediment will be placed in unconfined ocean disposal away from dredge areas. The sediment will remain in the system and over time the natural process that drive sedimentation and transport will inevitably result in the sediment making its way back to the dredge areas. Importantly, maintenance dredging campaigns have historically been conducted within the Port of Mackay with no alteration to the natural sediment transport regime. Future maintenance dredging works are also not expected to significantly alter the natural sediment transport regime of the Port of Mackay.

07.1.3 Release of contaminants and nutrients

As discussed in Section 04.2.1, the sediments from the Port of Mackay have previously been sampled and deemed appropriate for unconfined ocean disposal. The most recent sampling (2018) confirmed that no concentrations of contaminants (including TBT, metals, hydrocarbons, BTEXN and PAHs) were above the NAGD screening levels (Advisian 2018). Consequently, impacts from the release of contaminants are not likely to occur at either the dredge areas or DMPA.

07.1.4 Water quality impact thresholds

07.1.4.1 Developing impact thresholds

Water quality impact thresholds have been developed in order to avoid and manage potential impacts to water quality and sensitive receptors. The thresholds have been developed by PSC (2021c) based on a statistical analysis of site-specific measure water quality and deposition data using an intensity, duration and frequency (IDF) approach. This approach has been used to understand the natural variability in the environment in terms of turbidity, benthic light availability (benthic PAR) and sediment deposition. The analysis undertaken was based on approximately seven years of measured data around the coastal waters in the Mackay and Hay Point region.

Seagrass beds and coral communities are the primary sensitive environmental receptor that may be impacted by changes in water quality in the Port of Mackay. Environmental thresholds for seagrass are generally defined in term of benthic PAR rather than turbidity. The analysis undertaken by PCS (2021c) indicated that the threshold values for benthic PAR as recommended in the literature are not suitable for the adaptive management of dredging activities at the Port of Mackay for areas where seagrass can occur. This is because the threshold values are regularly exceeded naturally (that is to say the light levels are too low). As such, turbidity data has been adopted as the appropriate parameter for monitoring during dredge durations for both coral and seagrass.

Intensity and duration values have been derived which consider both the intensity and duration of natural conditions and dredging events. IDF percentiles were calculated for a 6 day, 12 day and 20 dredging campaign to capture a range of scenarios, with the 90th percentile adopted as a suitable turbidity intensity threshold (PSC 2021c). The calculated IDF parameters for the NTUe (and SSC) data measured at the two ambient water quality monitoring sites for the wet and dry seasons are presented in Table 07-1 to Table 07-3. These define the natural conditions in terms of both the intensity and duration, providing a basis for trigger limits if adaptive monitoring is required during future maintenance dredging programs.

Table 07-1: Threshold values and cumulative durations above thresholds (6-day period)

Site	Intensity (mg/l)	Intensity (NTUe)	Average durations (hours)	90th percentile duration (hours)	Maximum duration (hours)
Wet season					
Round Top Island	15	11	3	47	153
Slade Islet	53	45	3	46	177
Dry season					
Round Top Island	16	12	2	11	73
Slade Islet	41	34	2	12	93

Table 07-2: Threshold values and cumulative durations above thresholds (12-day period)

Site	Intensity (mg/l)	Intensity (NTUe)	Average durations (hours)	90th percentile duration (hours)	Maximum duration (hours)
Wet season					
Round Top Island	15	11	26	88	241
Slade Islet	53	45	26	87	228
Dry season					
Round Top Island	16	12	9	29	99
Slade Islet	41	34	9	33	95

Table 07-3: Threshold values and cumulative durations above thresholds (20-day period)

Site	Intensity (mg/l)	Intensity (NTUe)	Average durations (hours)	90th percentile duration (hours)	Maximum duration (hours)
Wet season					
Round Top Island	15	11	43	138	298
Slade Islet	53	45	43	120	248
Dry season					
Round Top Island	16	12	14	51	103
Slade Islet	41	34	14	45	98

07.1.4.2 Plume modelling and assessment against thresholds

Changes in water quality and associated impacts to sensitive environmental values has been assessed as part of dredge plume modelling. An example map plot comparing the modelled natural SSC and natural plus dredging SSC is shown in Figure 07-3 and Figure 07-4. These present ‘best case’ (e.g. lowest dredge volume in ambient dry) and ‘worst case’ (e.g. highest dredge volume in energetic wet).

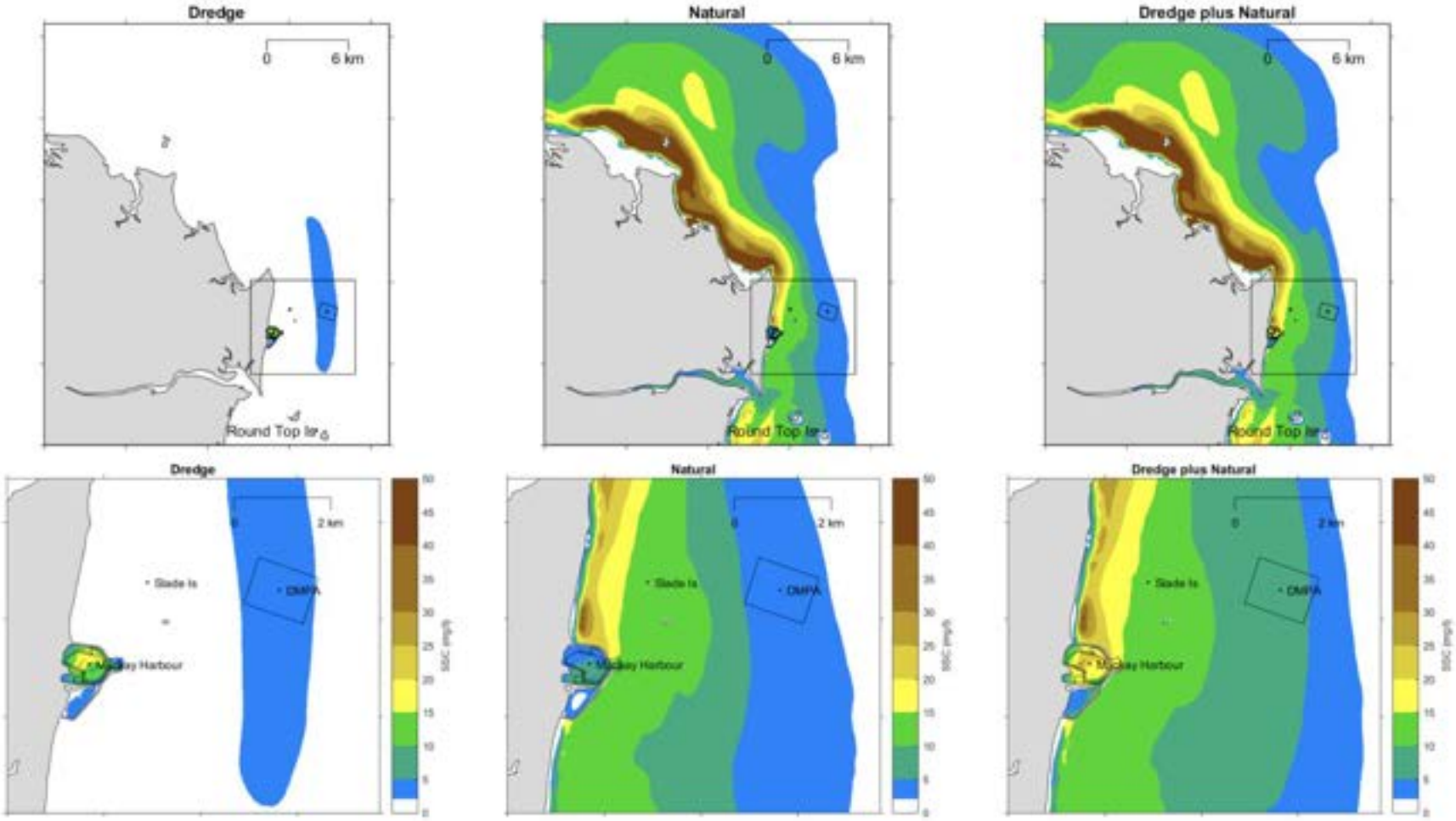


Figure 07-3: 80th percentile SSC for dredging, natural and natural plus dredging for 125,000 m3 of sediment in the ambient dry season (PCS 2021b)

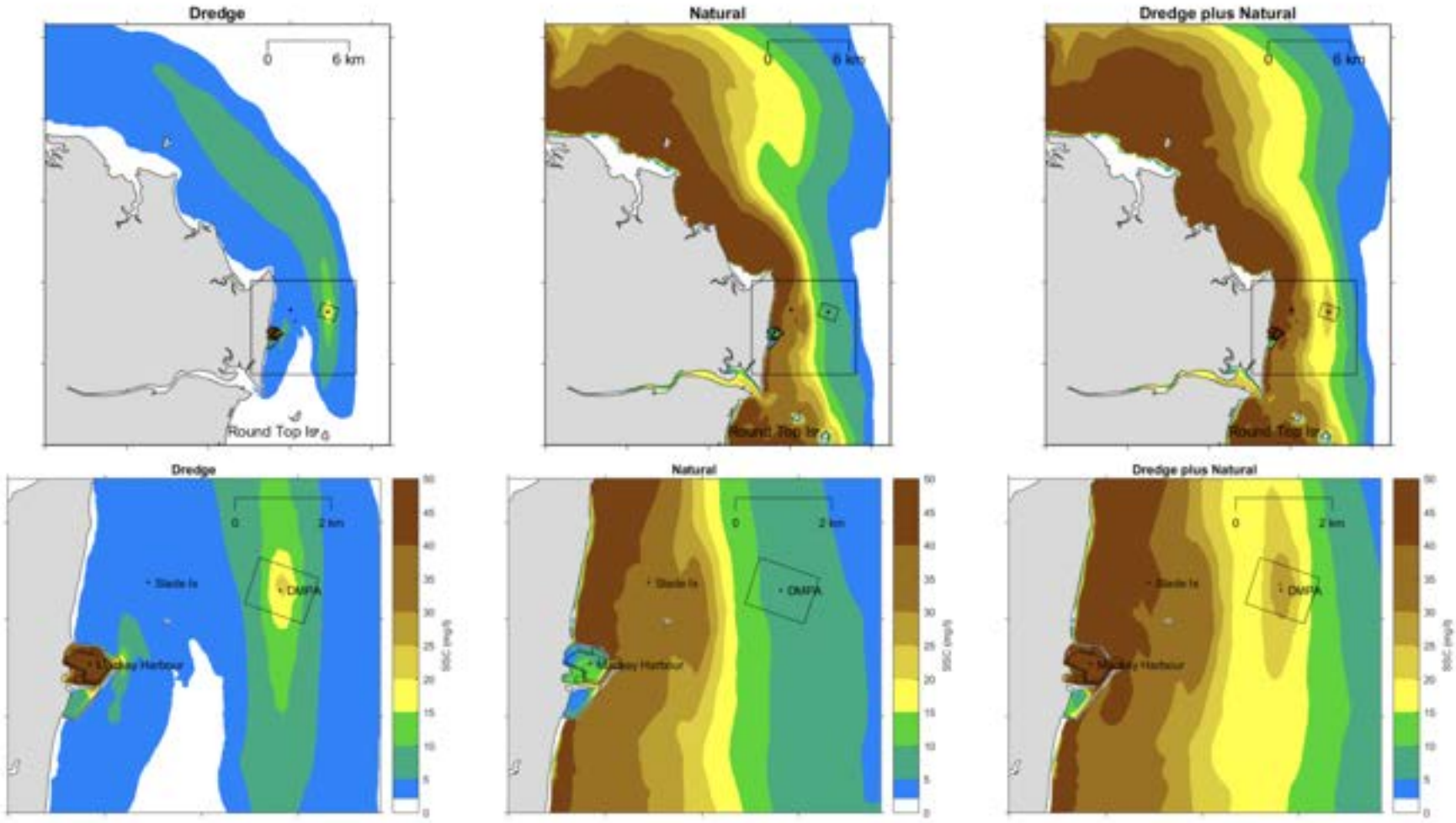


Figure 07-4: 95th percentile SSC for dredging, natural and natural plus dredging for 1,000,000 m3 of sediment in the energetic wet season (PCS 2021b)

Two sensitive receptors were identified and adopted (PCS 2021b):

- Slade Islet: closet area of coral to the Port of Mackay
- Round Top Island: another area of coral which is to the south of Mackay Harbour and the Mackay DMPA and could potentially be influenced by plumes from either. In addition, there are seagrass meadows located close to Round Top Island and to its east and so the site can also be used to indicate the potential for any impacts to seagrass.

The natural and natural plus dredging exceedance of intensity thresholds have been calculated for the two sensitive receptors for five dredge volume scenarios from 125,000m^3 to 1,000,000m^3

For each scenario the disposal method is unconfined ocean disposal at the Mackay DMPA. The modelling and analysis demonstrated that natural turbidity is higher than the SSC predicted to result from maintenance dredging. Turbidity is predicted to remain within natural conditions for the two sensitive receptors for all dredge scenarios and climatic conditions considered (Table 07-4 to Table 07-7).

The only simulation that predicted that the average duration trigger would be exceeded was the energetic wet season when the duration exceedance at Round Top Island was 14 hours more than the average duration (55 hours compared to 41 hours) (PCS 2021c). However, the exceedance was just due to natural conditions, with maintenance dredging not predicted to result in any increase to the natural duration exceedance, i.e. both natural and natural plus dredging had the same exceedance value.

Overall, the results show that for all dredge volumes, the maintenance dredging and unconfined ocean disposal is not predicted to result in an increase in SSC at either sensitive receptor which could result in the SSC being beyond natural range. There are only small increases in turbidity and deposition and the increases are negligible in relation to the natural conditions at the sensitive receptors. Therefore, future dredging programs are not anticipated to have any significant impact on water quality within the Port of Mackay.

Table 07-4: Comparison of modelled SSC conditions across typical maintenance dredging volumes against intensity and duration threshold (for ambient dry season)

Volume and dredge duration	Duration over threshold limit (hours)				Max duration threshold (hours)	Threshold exceedance	
	Natural		Natural plus dredging				
	Slade Islet	Round Top Island	Slade Islet	Round Top Island		Slade Islet	Round Top Island
125,000	0	0	0	0	44	No	No
250,000	0	0	0	0	88	No	No
500,000	0	0	0	0	175	No	No
750,000	0	0	0	0	264	No	No
1,000,000	3	15	5	16	352	No	No

Table 07-5: Comparison of modelled SSC conditions across typical maintenance dredging volumes against intensity and duration threshold (for energetic dry season)

Volume and dredge duration	Duration over threshold limit (hours)				Max duration threshold (hours)	Threshold exceedance	
	Natural		Natural plus dredging				
	Slade Islet	Round Top Island	Slade Islet	Round Top Island		Slade Islet	Round Top Island
125,000	0	0	0	0	44	No	No
250,000	11	11	12	12	88	No	No
500,000	11	12	12	12	175	No	No
750,000	11	12	12	13	264	No	No
1,000,000	11	12	12	13	352	No	No

Table 07-6: Comparison of modelled SSC conditions across typical maintenance dredging volumes against intensity and duration threshold (for ambient wet season)

Volume and dredge duration	Duration over threshold limit				Max duration (hours)	Threshold exceedance	
	Natural		Natural plus dredging				
	Slade Islet	Round Top Island	Slade Islet	Round Top Island		Slade Islet	Round Top Island
125,000	0	0	0	0	132	No	No
250,000	1	15	1	17	264	No	No
500,000	1	17	1	20	525	No	No
750,000	1	20	1	24	792	No	No
1,000,000	1	20	1	24	1,056	No	No

Table 07-7: Comparison of modelled SSC conditions across typical maintenance dredging volumes against intensity and duration threshold (for energetic wet season)

Volume and dredge duration	Duration over threshold limit				Max duration (hours)	Threshold exceedance	
	Natural		Natural plus dredging				
	Slade Islet	Round Top Island	Slade Islet	Round Top Island		Slade Islet	Round Top Island
125,000	3	16	3	17	132	No	No
250,000	10	55	11	55	264	No	No
500,000	10	55	11	55	525	No	No
750,000	10	55	11	55	792	No	No
1,000,000	10	56	11	57	1,056	No	No

07.2 Impacts to sensitive habitats

07.2.1 Coral

The closest area of coral to the Port of Mackay is located at Slade Islet (~1.4 km to the NE). Additional areas of coral that may be impacted by the maintenance dredging are located at Round Top Island, ~8 km to the south of the Harbour and the DMPA. The coral communities present are typical of inshore reefs, with coral diversity dominant by sediment tolerant *Montipora* species.

Impacts to coral communities at Slade Islet and Round Top Island are not anticipated from future maintenance dredging campaigns. The impact threshold analysis for the proposed dredge volumes shows that changes in key water quality parameters (NTU/SSC) will not exceed the natural variability experienced at these sites. Both sediment transport and deposition assessments also indicate low increases in sediment at the sites during and immediately after dredging.

While modelled predictions indicate no expected impact, it is planned that satellite derived total suspended solids (TSS) concentrations will be used to monitor and identify the need to implement adaptive management measures, to further ensure risks to coral communities are minimised and appropriately managed. Based on the intensity, frequency and duration analysis described earlier, ecologically appropriate thresholds will be set and applied in the Marine Environment Monitoring Plan (MEMP). Should water quality (NTU/SSC) exceed these, a range of management measures will be implemented to avoid any unexpected impact. Measures will include relocation of the dredge, alternative placement patterns, reduced placement volumes and stop dredging.

In addition, results from the ongoing ambient coral monitoring program (conducted twice yearly) will be assessed to identify any dredge related impacts on the years that dredging is undertaken. Th ambient coral monitoring program will provide an ongoing understanding of the health of corals in the Mackay/Hay Point region and will be factored into future dredge campaign planning and risk assessment. This program of monitoring is also designed to detect any longer-term cumulative effects of multiple maintenance dredging and other pressures in the region. Plume modelling and impact analysis indicate that impacts to coral communities are highly unlikely at any of the modelled volumes, as dredging will not alter or exceed ambient conditions.

Impacts to coral communities through the introduction of marine pests are unlikely. Potential impacts will be managed and avoided though ongoing early monitoring programs, including collaboration with Biosecurity Queensland, and vigilant washdown procedures. Additionally, dredge vessels contracted to undertake the maintenance dredging will be required to implement best practice hygiene protocols for management of ballast water.

There is a high degree of confidence in the above impact conclusions based on the results of previous dredging campaigns, as discussed in Section 01.6.

07.2.2 Seagrass

The seagrass communities in the vicinity of Port of Mackay are predominantly low density, ephemeral and spatially patchy. Compared to other high value seagrass meadows elsewhere in the GRWHA, the communities near the Port and the DMPA are not considered particularly notable or important (Jacobs 2016). However, they do provide a small contribution to the maintenance of local habitat values for marine species including turtles and potentially dugong.

Seagrass communities and their inherent values have the potential to be impacted as a result of sediment deposition and/or decreased light levels resulting from maintenance dredging. Impacts to seagrass may be avoided if dredging is undertaken prior to July, as above ground biomass is only present during July and December. If this is not possible, impacts are not expected to be significant. Monitoring has demonstrated seagrass has regrown annually, even in years post maintenance dredging (York *et al.* 2015). As such, the impacts to low density seagrass patches from maintenance dredging are expected to be localised and short term.

Impacts to seagrass communities through the introduction of marine pests are unlikely. Potential impacts will be managed and avoided though ongoing early monitoring programs, including collaboration with Biosecurity Queensland, and vigilant washdown procedures. Additionally, dredge vessels contracted to undertake the maintenance dredging will be required to implement best practice hygiene protocols for management of ballast water.

As discussed in Section 07.1, impacts to water quality are expected to negligible, with turbidity not expected to exceed the natural variation present within the project area.

07.2.3 Benthic infauna

Benthic infauna has the potential to be directly impacted by disturbance within the dredge footprints, smothering at the dredged material placement site and the translocation and establishment of pest species by the dredge vessel to the DMPA, causing changes in benthic infauna communities. The potential for translocation and establishment of marine pest species is considered to be low considering the management measures NQBP has in place including:

- Early Detection Marine Pest Plate Monitoring Program
- Ensuring that any TSHD dredger contracted complies with marine pest protocols, including National and Queensland biosecurity requirements in relation to ballast water and marine pest management

Overall the operation of the dredge vessel and movement of material from the vessel to the DMPA is considered to be a small contributing factor to the overall risk of establishing IMPs and impacted benthic infauna communities.

Smothering of benthic habitats will occur within the dredge footprint and at the Mackay DMPA due to placement and deposition of sediments. Deposition analysis indicates it is only possible to distinguish between natural deposition and natural plus dredging deposition at either the dredging and/or placement locations (PSC 2021b) and not within surrounding areas.

Benthic infauna studies within the Port of Mackay have reported declines in species richness and diversity after placement of dredge material, with the greatest decline in the DMPA and adjacent northern monitoring location (PaCE 2021). However previous monitoring events pre and post-dredging continue to show evidence of recovery from spoil deposition events (e.g. recovery of species assemblages) and the impacts to the structure and function of infauna assemblages in the area is considered in minor. Based on the results of previous monitoring events, the timeframe for recovery from decline in richness and diversity is likely to be measured in months. Consequently, any impacts to benthic infauna will be localised, temporary and are unlikely to be significant.

07.2.4 Mangroves and wetlands

Mangroves and estuarine wetlands are a dominant feature along the Mackay Whitsunday coast and they may be impacted by maintenance dredging via deposition of disturbed sediments and/or reduction in water quality.

These communities are already subject to variation in sediment deposition due to the natural deposition rates throughout the Port of Mackay. In addition to this, the Mackay region is naturally turbid, particularly in nearshore waters. The sediment deposition resulting from maintenance dredging shows the majority of the sedimentation associated with the dredge locations within the Harbour and sedimentation occurring within and to the north and south of Mackay DMPA. There are no substantial changes in deposition as a result of maintenance dredging in comparison to natural deposition (PSC 2021a). Sedimentation is largely confined to the Harbour and sensitive environments including mangroves and wetlands to the north and south of the port will not be impacted by any changes in sedimentation patters.

Maintenance dredging of the volumes proposed in the current and future campaigns will not result in turbidity conditions that are outside of those that occur naturally in the region, limiting the potential for impacts on sensitive coastal environments, including mangroves and wetlands. Sediments have also been sampled

and been deemed suitable for unconfined ocean disposal. Consequently, impacts from water sedimentation on mangroves and wetlands are not expected.

07.3 Impacts to protected species

07.3.1 Terrestrial fauna

07.3.1.1 Migratory birds

The Mackay region including the area surrounding the Port of Mackay is known as an important roosting and feeding habitat for migratory shorebirds and wetland birds. Migratory shorebird and wetland species are predominantly terrestrial and will not have any direct interactions with the dredge vessel, limiting the potential for any injury or mortality.

Potential indirect impacts to shorebirds are restricted to short-term decrease in nearshore water quality within the intertidal area of the Port of Mackay. Dredge plume and suspended sediment modelling (PCS 20021a) has shown that there is a minor increase in turbidity from dredging largely confined to the Harbour. Shorebird feeding and roosting habitat to the north and south of the port will not be impacted. Shorebird intertidal feeding habitat within the Harbour itself is limited, due to the presence of port infrastructure and the ongoing operations of the port. Indirect impact from the short-term increase in turbidity in inter-tidal areas is unlikely to affect shorebird feeding or roosting.

As the SSC from dredging has been shown to be mostly confined to within the Port, and there is no riparian connection between the Port and the wetland area to the south, dredging will have no discernible impact on habitat for wetland birds from the localised and minor increase in water turbidity.

Any minor increase in turbidity in the vicinity of the offshore DMPA will not impact shorebirds or wetland birds.

As a number of the migratory shorebird species, that are known or have the potential to occur in the Mackay region, are listed as threatened under the EPBC Act, an assessment against significant impact criteria was undertaken (Appendix C). This concluded that direct and indirect impacts to migratory shorebirds from maintenance dredging at the Port are not likely to be significant.

As wetland habitat is not located within the project area, and there is no potential for indirect impacts from the proposed maintenance dredging, an assessment against the significant impact criteria for wetland species has not been undertaken.

07.3.1.2 Water mouse (*Xeromys myoides*)

The water mouse occurs in the Mackay region, which is known as a stronghold for the species. The species mainly forages in intertidal areas, particularly amongst mangroves. As a terrestrial species there will be no direct interactions between individuals and dredge vessels.

The intertidal area of the Port does not support mangrove vegetation, with the closest mapped remnant mangrove community located to the south, separated from the Port by industrial development with no riparian connection. Mapped remnant vegetation to the north is a coastal dune complex dominated with native grasses. As such, indirect impacts to water mouse foraging habitat will not occur. Dredge plume and sediment resuspension modelling has indicated dredging activities will have only localised and temporary impacts to inshore turbidity, largely confined to the Port of Mackay.

As there is no habitat, and no connectivity to water mouse habitat, at the Port and no potential for direct or indirect impacts from the proposed maintenance dredging, an assessment against the significant impact criteria has not been undertaken.

07.3.1.3 Other terrestrial fauna

Potential impacts from the proposed maintenance dredging will not impact terrestrial species. There will be no interaction between terrestrial species individuals and dredge vessels. Indirect impacts including from localised, minor and temporary increase in turbidity, noise, and lighting will not impact terrestrial fauna.

Species found in wetland habitats including Australian painted snipe, will also not be impacted. Dredge plume and sediment resuspension modelling indicating dredging activities will have only localised, minor and temporary increase in turbidity, largely confined to the Port of Mackay. And, as highlighted above, there is no riparian connectivity between the Port and wetland habitats.

As above for the migratory shorebirds, any indirect impact from the minor elevation in turbidity in intertidal areas is unlikely to affect shorebird feeding or roosting, including the resident beach stone-curlew. Beach stone-curlew are also known to favour beaches with mangroves or estuaries nearby (Birdlife Australia, 2021), habitat not found adjacent the Port.

07.3.2 Marine turtles

All six species of marine turtle are known to occur in the waters off the Port of Mackay.

Marine turtles may be impacted both directly and indirectly by maintenance dredging. Direct impacts are possible from interactions with the dredge vessel and/or drag head. These impacts are considered highly unlikely to occur. The dredge vessel operates at very slow speeds and collision risk is known to be highest from fast moving (usually small) vessels. Standard mitigation procedures will be implemented, including turtle exclusion devices as these have proven successful in preventing turtle mortality at ports throughout Queensland. Also, suction pressure will not occur unless the drag head is in contact with the seabed, further reducing risk. Furthermore, marine fauna monitoring should be implemented as part of the adaptive management strategy. These controls require dredging/placement to cease (or relocate) if marine fauna are sighted within 300 m of the vessel and operations not recommence until individuals have vacated the area or until 20 minutes after the last sighting.

Turtles may be indirectly impacted via removal/degradation of habitat or from disturbance via artificial lighting. Artificial lighting will be concentrated in the dredge areas (within Mackay harbour and placement site) and will come from a single dredge vessel. The increase in light will be negligible compared to that generated continually by the operating port.

No important foraging habitat including seagrass meadows or coral reefs are present within the Port or the DMPA. While marine turtles are known to nest in the Mackay region, including mainland beaches, turtles have not been recorded utilising the Port beaches for nesting in high numbers. As such the project area does not support critical breeding, nesting, inter-nesting for green, flatback, hawksbill, leatherback, loggerhead or Olive Ridley turtles. Regardless, proposed maintenance dredging will not impact the availability of nesting within the Port. Impacts to water quality from increased SSC, will only extend to intertidal areas, and are anticipated, from modelling and monitoring, to be too small to measure any discernible change in water quality from natural levels of turbidity. Further, limited and short term (up to one growing season) loss of low density and ephemeral seagrass is not likely to adversely affect turtle food availability in the region.

As all six turtle species are listed as threatened and migratory under the EPBC Act, an assessment against significant impact criteria was undertaken (Appendix C). This concluded that direct and indirect impacts to marine turtles from maintenance dredging at the Port are not likely to be significant.

07.3.3 Marine mammals

Humpback whales migrate through the study area June to October, peaking in August. Jacobs (2016) reported females with calves were relatively common within the port limits during Port of Hay Point monitoring from 2009 to 2011. A core calving area has been identified well offshore (approx. 80 km) of Mackay. The exact location of this area is still unknown however is outside the study area. The blue and southern right whales are unlikely to occur in inshore areas near the coast. Inshore dolphin species are also present. Dugongs are known from the Mackay region and cited as one of the World Heritage values of the GBR. There is critical habitat for dugong and DPAs gazetted in the region however these areas are not present within the Port or DMPA.

Whales, dolphins and dugongs may be directly or indirectly impacted by dredging activities. The risk of direct impact from vessel strike is considered low as the dredge vessel operates at very slow speeds. Of the known

vessel strikes to humpback whales within Australian waters between 2006 and 2010 there is no record of a collision between a humpback whale and a dredger (IWC 2007, 2008, 2009, 2010, 2011). Although many of the strikes recorded are by vessels of an unspecified type, the likelihood of a dredger being involved is very small compared to the number of commercial and recreational vessels operating in marine waters. To further reduce the risk of vessel strike, marine fauna monitoring will be implemented as described above.

Indirect impacts to whales, dolphins and dugongs include the removal and/or disturbance of habitat. Inshore dolphin species are known to utilise a variety of inshore coastal habitats for foraging including mangroves, sandy bottom estuaries, and embankments, rocky and/or coral reefs. Australian snubfin dolphins have been recorded near seagrass meadows (Parra 2006), which are also the feeding habitat of dugongs. These habitats are not present within the Port or DMPA and will not be directly impacted from removal or disturbance. Impacts from sedimentation on coral and mangrove habitat areas are not expected (refer Section 07.2.1 and 07.2.4 respectively), and a range of measures management measures will be implemented to avoid any unexpected impact on coral communities. Further, impacts to seagrass meadows, from resuspension of sediment and increases in turbidity are expected to negligible, with turbidity not expected to exceed the natural variation present within the project area.

Humpback and other whale species may be impacted by changes in water quality degrading the habitat. Analysis of water quality monitoring indicates only small increases in turbidity and deposition were recorded during previous dredging campaigns and the increases are negligible in relation to the natural conditions (refer Figure 07-3 and Figure 07-4). Historical maintenance dredging campaigns have also been conducted without any significant impacts to water quality. Consequently, future dredging campaigns are not anticipated to have any significant impact on water quality within the Port of Mackay or feeding patterns of humpback whales.

Whales and dolphins can be adversely affected by underwater noise, with responses ranging from behavioural changes to damage to auditory systems. However, it is considered unlikely that impacts from dredging-related underwater noise will affect individuals at the Port of Mackay. Noise from the dredge will be low and dredging campaigns short-term (typically 6 -12 days). Noise will not be at levels that may cause auditory damage and is expected to be within the range normally associated with an operational port with 200 ships a year on average. Dredge related noise is not anticipated to interrupt the whales' migratory journeys given the large areas of suitable habitat nearby.

As humpback whale is listed as vulnerable under the EPBC Act an assessment against significant impact criteria was undertaken (Appendix C). As the dolphin species and dugong are listed as migratory under the EPBC Act, an assessment against the migratory species significant impact criteria was also undertaken (Appendix C). Both assessments concluded that impacts to these species from maintenance dredging at the Port are not likely to be significant.

07.3.4 Other marine fauna

The saltwater crocodile is known to inhabit riparian habitat in the study area including waterways and estuaries. Riparian habitat is not present within or adjacent the Port or DMPA. The nearest riparian habitat is the waterway and associated wetland area 1km to the south of the Port, however this waterway flows south a further 2km into the Pioneer River. No indirect impacts from reduction of water quality are likely.

Manta ray species have previously been reported in shark nets off Mackay. Both species may occur in the inshore waters adjacent to the project area. Manta ray feed on plankton species, and likely to include the species found within the Port of Mackay. The extent to which manta rays use the Port and DMPA are not known however, impacts to plankton species on which they forage from reduced water quality are likely to be localised, minor and temporary.

07.4 Impacts to GBRWHA

The Port of Mackay and surrounds makes a minor contribution to the OUV of the GBRWHA under the majority of the Property's listing criteria. None of the study area's contributions are considered critical contribution at the scale of the Property. Of the environmental values present in the region, three are considered to provide a higher contribution to the OUV of the GBRWHA:

- Internationally recognised migratory shorebird roosting sites at Sandringham Bay and Mackay Town Beach that support 23,000 shorebirds each year during their annual migration
- A core aggregation/calving area for the east-coast population of humpback whales approximately 80 km east of Mackay
- A high diversity of mangrove species within estuarine areas to the south of the Port.

Each of these matters is addressed individually above and the assessment indicates risks to these values from maintenance dredging will be negligible.

An assessment of any potential risks to the GBRWHA also requires an assessment of integrity, which considers the property's wholeness, intactness and threat (Commonwealth of Australia 2014).

The Statement of OUV for the GBRWHA (DoEE 2018) concludes (among other things) that:

- The integrity of the reef is sound and is "enhanced by the unparalleled size and current good state of conservation across the area" and
- Given the scale of the GBR "most habitats or species groups have the capacity to recover from disturbance or withstand ongoing pressures".

It is considered highly unlikely for the integrity of the GBRWHA as a whole to be impacted by activities at Port of Mackay. Given the scale of the GBR, it is not considered likely that the size of the maintenance dredging at Port of Mackay alone would be capable of influencing the integrity of the reef. Rather, integrity would be more likely effected by a multitude of large scale developments (particularly in greenfield sites) along substantial areas of the coast. This supports the optimisation of the Port of Mackay as an existing industrial port. An assessment of the potential risk from maintenance dredging at the Port of Mackay against particular elements of integrity (wholeness, intactness, threat) is provided in Table 07-8.

Table 07-8: Assessment of potential risk to the integrity of the GBRWHA

Questions regarding risk to integrity (Commonwealth of Australia 2014)	Response for maintenance dredging at Port of Mackay
Will the proposed action of itself, or in combination with other relevant impacts, result in the loss of any elements necessary for the property to express its OUV?	No. As discussed above, the elements of OUV that are expressed at the Port of Mackay will not be impacted by maintenance dredging.
Will the proposed action of itself, or in combination with other relevant impacts, reduce the size or change the boundary of the property?	No.
Will the proposed action of itself, or in combination with other relevant impacts, impact on any of the features and processes that convey its OUV?	No. As discussed above, the elements of OUV that are expressed at Port of Mackay will not be impacted by maintenance dredging.
Will the proposed action of itself, or in combination with other relevant impacts result in a 'greenfield' development or the fragmentation, loss and degradation of any ecological, physical or chemical processes of the key features processes and attributes of the property that express its OUV?	No. Maintenance dredging is not a greenfield development. Fragmentation, loss and degradation of any ecological, physical or chemical processes of the key features processes and attributes will not result from maintenance dredging, as this is an activity the simply returns areas to their previous, optimal state – Port areas will be returned to the appropriate design depth and the existing dredged material placement site will be used.
Will the proposed action of itself, or in combination with other relevant impacts, impact on the key interrelated and interdependent relationships within the property?	No. The interrelated and interdependent relationships that are most relevant at the Port of Mackay are those between species and their habitats. As described in sections 7.1 to 7.3, impacts to species and their habitat will be negligible to low.
Will the proposed action of itself, or in combination with other relevant impacts, result in increased adverse	No. Maintenance dredging of the port will not facilitate other development or other degrading processes.

Questions regarding risk to integrity (Commonwealth of Australia 2014)	Response for maintenance dredging at Port of Mackay
effects of development, neglect or other degrading process?	Rather, it will facilitate the optimal efficiency of the current footprint of the Port.
Will the proposed action of itself, or in combination with other relevant impacts, result in an increase in process that may cause deterioration?	No. Poor water quality is the most relevant process that can cause deterioration to the GBR in the context of maintenance dredging. Detailed analyses (PCS 2021) have demonstrated the maintenance dredging campaigns at the Port will not result in conditions outside of those experienced naturally under a range of different climatic conditions and sedimentation loads. Maintenance dredging at the Port will not facilitate any other activities that will cause deterioration of water quality.

07.5 Impacts to other users

The Port of Mackay is an important feature of the Mackay region, both in terms of providing employment and access to local infrastructure (e.g. Mackay Marina). However, the areas within the operational areas (inside the breakwalls) of the Port are not generally accessible to non-Port users and therefore dredging within the operational areas will not disrupt other users. Access to the public marina will be managed during short-term (6-12 days) dredging in this location.

07.5.1 Fisheries

Placement of dredge material and changes to water quality may affect other users, primarily recreational and commercial fishers. Impacts to both will be short-term and recreational fishers have ample alternative sites within the region to utilise.

Commercial fisheries utilise a range of areas including shallow coastal areas, inshore areas and deeper offshore areas for larger species. Maintaining healthy fisheries is of importance to the Mackay region due to the significant economic contribution they have. Key areas for commercial fisheries include inshore mangrove and seagrass habitats that provide spawning and nursery areas for prawns and target fish species. As discussed in Section 07.2, impacts to seagrass and mangrove communities are not considered likely. As such, no significant impact on sensitive environments important to commercial fisheries is likely.

07.5.2 Cultural heritage

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The Port of Mackay is situated within the waters of the GBRWHA, and Traditional Owner connection and cultural association with the GBRWHA and adjacent coastal area is well recognised. There may be indirect impacts to cultural values via the interaction with the marine environmental values (which are a key component of Country). As addressed in previous sections, it is unlikely significant impacts to environmental values of the GBR will result from the proposed dredging campaigns. Direct or indirect impacts to indigenous cultural heritage are therefore unlikely.

There are no places of Local, State, or Commonwealth listed non-indigenous heritage places within marine areas, aside from the GBRWHA, within the study area. As previously highlighted, impacts from the proposed maintenance dredging campaign on water quality, and associated indirect impacts to sensitive receptors like coral, seagrass and benthic infauna, are anticipated to only be localised and short-term. Additionally, no significant direct or indirect impacts to protected species is likely to occur. As such, the impacts to the OUV of the GBRWHA is unlikely.

08 RISK ASSESSMENT

A risk assessment has been completed based on the results of the impact analysis undertaken in Section 7. The risk assessment will be used to inform risk treatment and management measures during the maintenance dredging operations.

The results of the risk assessment are provided in Table 08-1. The risk assessment has been completed based on the application of mitigation measures as outlined throughout this report (refer Section 06).

Overall, the risk assessment conclusions are that all potential risks are rated as low, with the exception of smothering of benthic communities within the DMPA and the introduction of marine pests, both rated as medium.

The benthic communities that will be impacted are not unique in the region. As previous monitoring has demonstrated direct impacts to these communities to be short-term and temporary in nature, no on-going monitoring is proposed.

NQBP will continue their ongoing ambient early detection marine pest plate program, ensuring that the plates are removed, inspected and a photo log recorded prior to the commencement of maintenance dredging with follow up surveys completed post dredging.

In addition, the TSHD will:

- use only potable water for ballast during the maintenance dredging program
- undertake a high pressure wash down of dredging infrastructure (dredge head, hopper and associated dredging structures)
- ensure necessary marine pest inspections are undertaken prior to arrival if the dredge vessel has been operating in a high risk area, interstate or overseas in accordance with Australian Quarantine and Inspection Service and Bio- Security Queensland requirements in relation to ballast water and marine pest management. This includes the National System for the Prevention and Management of Marine Pest Incursions, in particular the National Biofouling Management Guidance for Non-Trading Vessels

Consequently, the potential for an outbreak of an introduced marine pest as a result of maintenance dredging activities is considered to be unlikely.

Maintenance dredging is short in duration and changes to water quality are within the range of natural variability of the region. This in turn limits the likelihood of flow on impacts to species and their habitats, as well as protected areas and other users. Satellite derived TSS concentrations will be used to monitor and identify the need to implement adaptive management measures, to further ensure impacts from increased sedimentation are minimised and appropriately managed.

Table 08-1: Risk assessment results

Risk activity (cause)	Potential environmental receptors	Potential impact	Consequence	Likelihood	Risk rating
Smothering from dredge material placement	Benthic macroinvertebrate communities	Temporary disturbance of benthic habitat and associated communities	Minor Temporary, short term negative impact	Likely	Medium
Dredging and placement generated sediment plume	Coral reef, seagrass and mangrove communities	Changes to water quality leading to mortality or changes in the diversity or cover of coral, seagrass or mangroves	Negligible Impacts is within the natural variation and tolerance of the system	Rare	Low
		Sediment deposition resulting in loss of coral, seagrass or mangroves			
Movement of dredge vessel from the Port to the dredge material placement area	Transitory threatened and migratory marine animals	Potential for marine fauna vessel strike	Negligible No impact at the population or sub-population level	Unlikely	Low
Release of contaminants and nutrients	Marine biota	Potential for lethal and sub-lethal effects on biota	Negligible Material is suitable for unconfined ocean disposal	Rare	Low
Dredging suction	Foraging marine turtles	Potential for marine fauna to be caught	Negligible No impact at the population or sub-population level	Unlikely	Low
Noise	Inshore dolphins, dugong, marine turtles	Potential for alienation of habitat	Negligible No impact at the population or sub-population level	Rare	Low
Lighting	Foraging inshore dolphins, dugong and marine turtles	Alienation of habitat, potential mortality	Negligible No impact at the population or sub-population level	Rare	Low
Introduction of marine pests	Marine biota	Potential competition with native species and changes to the ecosystem	High Significant impact on the environment in the Port and potentially in the greater region	Unlikely	Medium
Dredge program	Marine users	Disruptions of activities	Negligible Impact is confined to a small area or interest group that is not vulnerable	Possible	Low

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