NORTH QUEENSLAND BULK PORTS CORPORATION

Environmental Risk Assessment

PORT OF
HAY POINT | 2018

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Abbreviations

ABBREVIATION	DESCRIPTION
DBCT	Dudgeon Point Coal Terminal
DoEE	Department of the Environment and Energy
DPA	Dugong Protection Area
EMP	Environmental Management Plan
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GBR	Great Barrier Reef
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
GBRWHA	Great Barrier Reef World Heritage Area
HPCT	Hay Point Coal Terminal
IDF	Intensity, duration, frequency
IMO	International Maritime Organisation
IMP	Introduced marine pests
LAT	lowest astronomical tide
Mm^3	million m^3
MNES	Matters of National Environmental Significance
NAGD	National Assessment Guidelines for Dredging
NQBP	North Queensland Bulk Ports Corporation
OUV	Outstanding Universal Value
PAH	Polycyclic aromatic hydrocarbons
PAR	Photosynthetically active radiation
PMST	Protected Matters Search Tool
SAP	Sampling and Analysis Plan
Sea Dumping Act	*Environment Protection (Sea Dumping) Act 1981*
SSC	suspended sediment concentrations
SSM Project	*Sustainable Sediment Management Assessment for Navigational Maintenance Project*
TBT	TriPbutyl Tin
TC	Tropical cyclone
TEC	threatened ecological community
TSHD	Trailing Suction Hopper Dredge
UCL	upper confidence limit

Environmental Risk Assessment

Summary report

22 March 2018

PORT OF
HAY POINT

SYNOPSIS

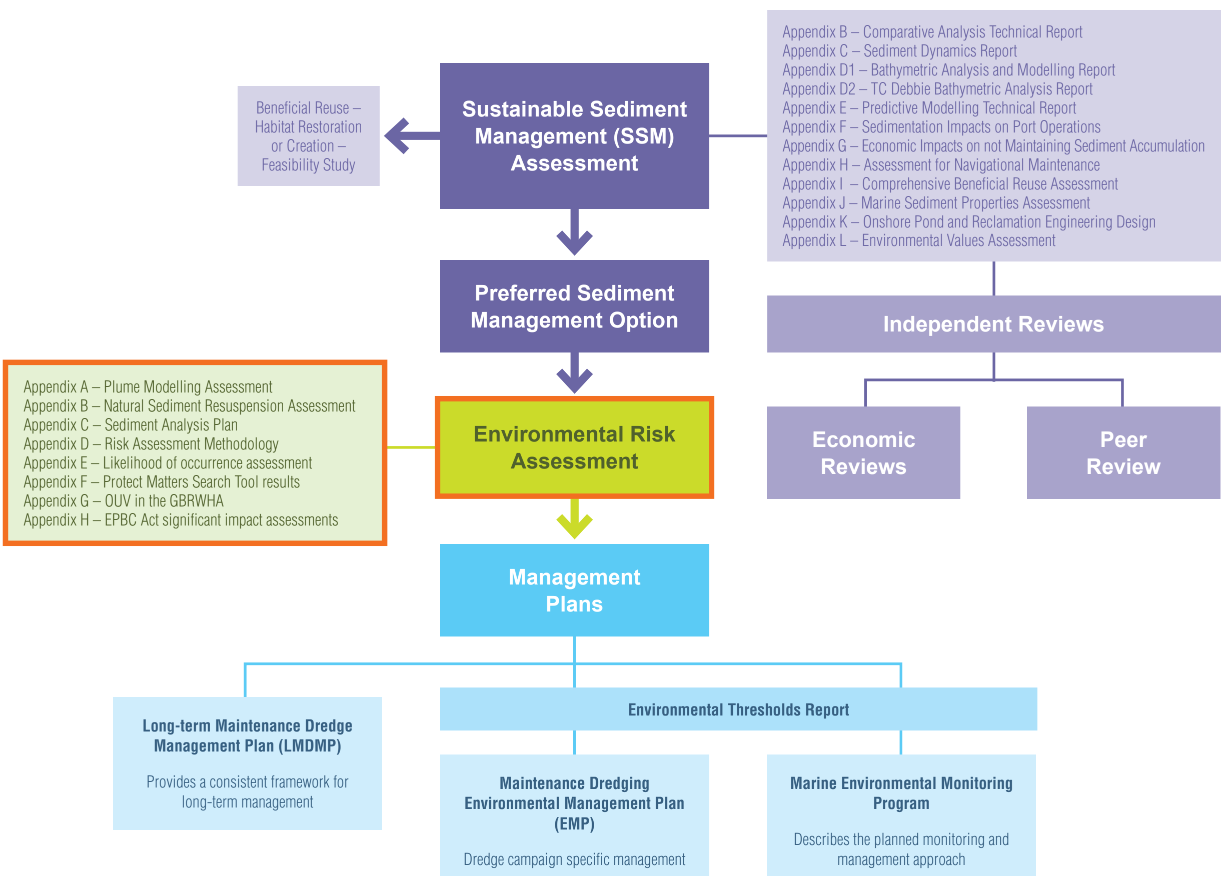
Environmental Risk Assessment

Maintenance dredging activities may interact with marine fauna and habitats both directly and indirectly. Direct effects relate more to the physical removal of the seabed, whilst indirect effects can occur in association with dredge plumes, lighting, noise and introduction of marine pests. Indirect effects arising from dredge generated sediment plumes can extend over areas outside the dredging and material placement locations and alter natural sediment deposition rates and/or turbidity levels.

Specific to the Port of Hay Point and surrounding area, this Environmental Risk Assessment has been undertaken to:

- describe the local marine environment and significant values
- put into context the interaction between maintenance dredging and material relocation, and the natural environment
- provide guidance on environmental management

A number of supporting studies have been undertaken to inform this assessment

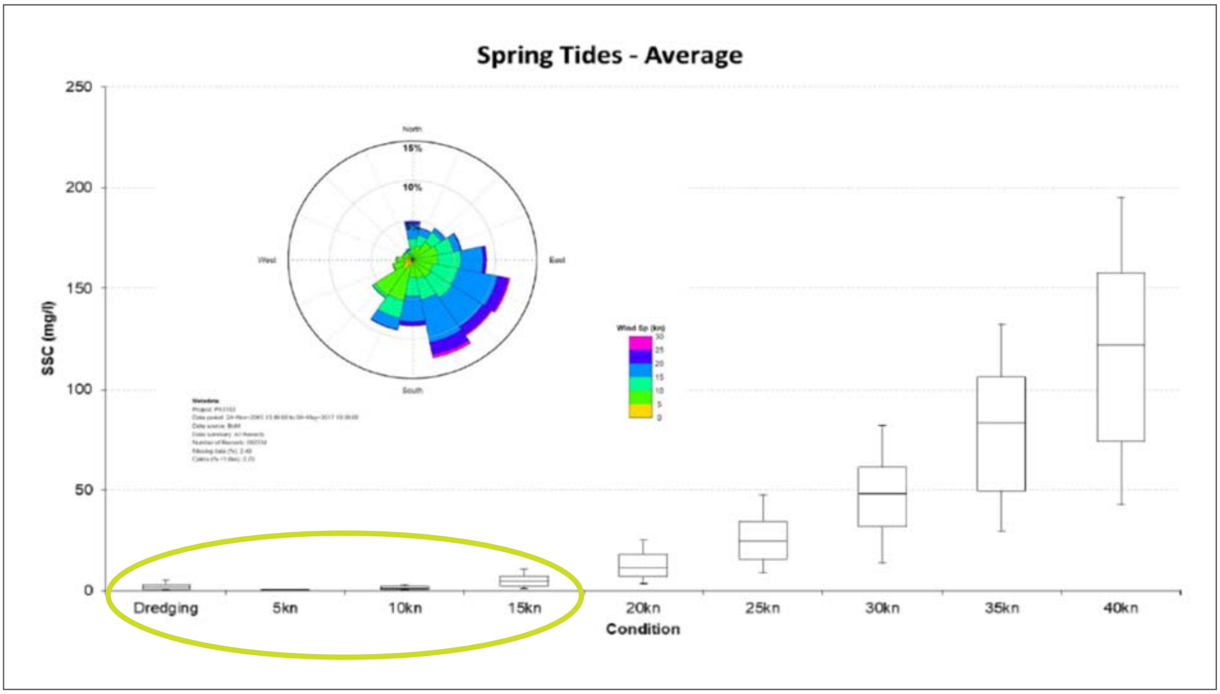


Numerical Modelling

Ongoing maintenance dredging and relocation volumes at the Port of Hay Point are relatively low and expected to be undertaken infrequently (approximately every 5 years). Numerical modelling of dredging and material relocation was undertaken on volumes of 200,000m^3 (approx. 20 days dredging) expected in 5-year period, and 400,000m^3 (approx. 40 days), more than, but approximate to, the current maintenance requirements of 356,553m^3.

Numerical plume modelling shows that for the majority of the time suspended solids concentrations resulting from dredging and relocation are less than 2mg/l, with isolated occurrences above 5mg/l.

A study of natural resuspension of marine sediments in the Hay Point area demonstrated that maintenance dredging and relocation of up to 400,000m^3 (more than the current requirement) results in low excess suspended solids concentrations (SSC), comparable to natural SSC during calm conditions (wind speeds of 15 knots and under).



A further analysis investigated the Intensity, Duration, and Frequency (IDF) of natural SSC using 3 years of continuous water quality data from NQBP Port of Hay Point Ambient Marine Monitoring Program (provided by James Cook University's, TropWater),

Further modelling showed that that SSC would remain within the natural range of the Hay Point area, up until 800,000m^3 or more was dredged and relocated in a single campaign.

Environmental Values

The environmental values at the Port of Hay Point are reasonably typical of an inshore location along the central Queensland coast. The inshore marine environments are naturally turbid, with prevailing wind being a key driver of conditions. Habitats in the area include benthic infauna communities; low density, ephemeral seagrass communities; coral communities fringing inshore islands; and coastal habitats including mangroves. There are a number of protected fauna species that are known to occur at the Port at times, including marine turtles, whales, dolphins, dugong, migratory shorebirds and the Water Mouse, but the area does not provide critical habitat resources for any protected marine species.

The features of the Port area and the Mackay region make an incremental contribution to the Outstanding Universal Value (OUV) of the GBRWHA under the majority of the Property's listing criteria, 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 critical contributions at the scale of the World Heritage Property.

Risk Conclusions

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

- Resuspension of sediments from maintenance dredging and material relocation 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. Accordingly, proposed dredging campaigns of 356,553m^3 and future 200,000m^3 will not result in impacts to sensitive environmental values
- 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 drive an adaptive management program and 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 GBR Marine Park will be low to negligible. Other marine users, such as recreational fisherman, may experience short-term disruptions to their activities

Additionally, individual assessments against EPBC Act significant impact criteria have been undertaken for Matters of National Environmental Significance (MNES), and in all cases these determined that significant impacts are unlikely.

A range of measures to avoid and reduce risks have already been implemented during project planning, and a further suite of measures will be implemented to minimise effects and avoid the risk unpredicted environmental change. A comprehensive dredging environmental management plan will enable maintenance dredging campaigns to be 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 in real time 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 volumes and duration of proposed maintenance dredging at the Port of Hay Point the levels of risk are considered low and will be effectively managed with the application of appropriate monitoring, management and mitigation measures.

Port of Hay Point Maintenance Dredging

Environmental Risk Assessment Report

Prepared for
NQBP

22 March 2018

DOCUMENT TRACKING

Item	Detail
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Project Number	17BRI-6957
Project Manager	Ailsa Kerswell (07) 3503 7191 ailsak@ecoaus.com.au
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EXECUTIVE SUMMARY

Introduction

The Port of Hay Point is located on the north-east coast of Australia and lies within the Great Barrier Reef World Heritage Area (GBRWHA). The Port is managed by the North Queensland Bulk Ports Corporation (NQBP).

Sedimentation of the navigational facilities within the Port occurs naturally and is caused by the transportation of sediment from ocean currents, swell and tides, as well as periodic cyclonic activity, including Tropical Cyclone Debbie (March 2017). Sediment accumulation impedes the overall operating efficiency of the Port and requires management.

A recent detailed study was undertaken to understand the most sustainable way to manage accumulating sediment at the Port of Hay Point – the *Sustainable Sediment Management Assessment for Navigational Maintenance*. The overall conclusion was that whilst some measures can be implemented to reduce its frequency, maintenance dredging with sea disposal of dredged material is the best method of managing accumulated sediments. NQBP are now progressing the necessary environmental approvals to facilitate maintenance dredging at the Port of Hay Point. This includes the development of a Long-term Maintenance Dredging Management Plan and an application for a Long-term (10-year) Sea Dumping Permit.

This report provides a detailed assessment of the potential risks from maintenance dredging at the Port of Hay Point.

Planned maintenance dredging

Maintenance dredging will periodically occur across the Port, in order to return areas to their design depths and ensure the safe and efficient operation of the Port. Maintenance Dredging at the Port of Hay Point is currently required (approximately 356,553m^3). Future volumes of approximately 200,000m^3 in each five period are expected. An additional allowance of a further 200,000m^3 over each 10 year period is also prudent.

Environmental values

The environmental values at the Port of Hay Point are reasonably typical of an inshore location along the central Queensland coast. The inshore marine environments are naturally turbid, with prevailing wind being a key driver of conditions. Habitats in the area include benthic infauna communities; low density, ephemeral seagrass communities; coral communities fringing inshore islands; and coastal habitats including mangroves. There are a number of protected fauna species that are known to occur at the Port, including marine turtles, whales, dolphins, dugong, migratory shorebirds and the 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 makes some contribution to the Outstanding Universal Value (OUV) of the GBRWHA under the majority of the Property's listing criteria (refer to Appendix G). 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.

Maintenance dredging activities may interact with marine fauna and habitats both directly and indirectly. Direct effects relate more to physical interactions and removal of the seabed; whilst indirect effects can occur in association with dredge plumes, lighting, noise and introduction of marine pests

In particular, indirect effects arising from 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 Hay Point. The key findings of this risk assessment are:

- 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. Accordingly, proposed dredging campaigns of 356,553m^3 and future 200,000m^3 will not result in impacts to sensitive environmental values
- 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 GBR Marine Park will be low to negligible. Other marine users, such as recreational fisherman, may experience short-term disruptions to their activities

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	Transient seagrass beds and seagrass habitat Benthic macroinvertebrate communities	Temporary loss of benthic habitat	Minor Temporary, short-term negative impact	Possible	Moderate
Dredging and placement generated sediment plume	Coral and rocky reef habitats at Round and Flat Top islands, and Slade Islet Seagrass	Changes to water quality leading to mortality or changes in coral and seagrass cover/diversity	Negligible Within the natural variation and tolerance of the system	Rare for volumes below 800,000m^3	Low
Dredging and placement generated sediment plume	Coral and rocky reef habitats at Round and Flat Top islands, and Slade Islet	Sediment deposition resulting in coral loss	Negligible Within the natural variation and tolerance of the system	Rare for volumes below 800,000m^3	Low
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 marine biota	Negligible Material is consistently suitable for at sea 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

Additionally, individual assessments against EPBC Act significant impact criteria have been undertaken for Matters of National Environmental Significance (MNES), and in all cases these determined that significant impacts are unlikely.

A range of measures to avoid or reduce risks have already been implemented during project planning, and a further suite of measures will be implemented to minimise effects or avoid the risk unpredicted environmental change. A comprehensive dredging environmental management plan will enable maintenance dredging campaigns to be undertaken in line with best practice, so that risks are avoided or reduced as far as possible. A key element of this is the application of ecologically relevant environmental triggers, which will be applied in real time 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 Hay Point the levels of risk are considered low and can be effectively managed with the application of appropriate monitoring, management and mitigation measures.

1 Introduction

1.1 Background

The Port of Hay Point is a major bulk commodities port managed by the North Queensland Bulk Ports Corporation (NQBP). The Port is located on the north-east coast of Australia and lies within the Great Barrier Reef World Heritage Area (GBRWHA). The Port has seven dedicated coal loading berths, with over 100 million tonnes of coal currently exported each year. Over 1,000 ship calls occur annually.

Sedimentation of the navigational facilities within the Port of Hay Point occurs naturally and is caused by the transportation of sediment from ocean currents, swell and tides, as well as periodic cyclonic activity. When left unmanaged, sediment accumulation impacts the depths necessary for loading, manoeuvring and transit of ships. This in turn impedes the overall operating efficiency of the Port.

From 2015 to 2017 the *Sustainable Sediment Management Assessment for Navigational Maintenance* (SSM project) (Kaveney *et al.* 2017) was undertaken to understand the most effective way to manage sediment at the Port of Hay Point. This work provided the Port with a detailed understanding of sediment dynamics and options for how best to manage sediment accumulation within an actively operating port. The overall conclusion was that whilst some measures can be implemented to reduce the frequency of maintenance dredging, maintenance dredging is required at the Port, with at sea disposal of material being the best method of disposal of sediments.

NQBP is now progressing the applications for necessary environmental approvals to facilitate maintenance dredging at the Port of Hay Point. This includes the development of a Long-term Maintenance Dredging Management Plan and an application for a long-term (10-year) Sea Dumping Permit.

1.2 Brief description of the Project

Maintenance dredging will occur across the Port, in order to return areas to their design depths and maintain such depths into the future as required, in order to enable the safe and efficient operation of the Port. The total dredging requirement over a 10-year timeframe is approximately 956,553 m^3 to be spread across a series of campaigns. An initial, approximate 40-day campaign will remove sediments accumulated over time and also infill from TC Debbie. A proposed total volume of 356,553 m^3 will be removed from the apron, departure path, berth pockets and Half Tide Tug Harbour, to complete these initial works.

Future campaigns will be undertaken where required in order to maintain the Port depth. It is proposed that a dredging campaign of up to 200,000 m^3 will be undertaken within each subsequent permit 5-year period (i.e. years 1-5 and years 6-10). An additional 200,000 m^3 cyclone contingency has been included in the expected total volume. A 200,000 m^3 campaign will take approximately 20 days to complete.

For all campaigns, dredged material will be placed at the existing dredged material placement site, located ~6 km from the apron area. It is expected that over the next 10 years dredging will be undertaken using the trailing hopper suction dredge, TSHD Brisbane or similar.

1.3 Purpose and scope of this report

The purpose of this report is to undertake an assessment of the potential environmental impacts and risks from maintenance dredging at the Port of Hay Point. The report focuses on the initial maintenance dredging volume of 356,553m^3 proposed to be dredged in 2018/19. However, future campaigns that may be undertaken during the period of currency of a 10-year Sea Dumping Permit for maintenance dredging have also been assessed.

Specifically, this report:

- Identifies environmental values that are present at the Port of Hay Point
- 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 are then used to inform the environmental management plan and related management actions
- informs environmental approvals processes, and in particular applications for Great Barrier Reef Marine Park and Sea Dumping Permits

1.4 **Relevant legislation and policy**

There is a range of legislation and policy guidance relevant to the preparation of this environmental risk assessment.

1.4.1 Commonwealth legislation

A number of key pieces of Commonwealth environmental and cultural protection legislation may apply to dredging projects undertaken within Australia, including:

- *Environment Protection and Biodiversity Conservation Act 1999*
- *Environment Protection (Sea Dumping) Act 1981*
- *Great Barrier Reef Marine Park Act 1975.*

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). A referral under the EPBC Act is required to be made if a proposed action is likely to have a significant impact on a MNES.

Environment Protection (Sea Dumping) Act 1981

Sea disposal of dredge material requires an approval under the *Environment Protection (Sea Dumping) Act 1981*The Act is administered by the Department of Environment and Energy (DoEE) or by the Great Barrier Reef Marine Park Authority (GBRMPA) for activities inside the Great Barrier Reef Marine Park.

Great Barrier Reef Marine Park Act 1975

The *Great Barrier Reef Marine Park Act 1975* is the primary Act relating to the Great Barrier Reef Marine Park. It establishes the Great Barrier Reef Marine Park and the Great Barrier Reef Marine Park Authority (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.

1.4.2 Relevant policy content

There are a number of policies and guidelines that are relevant to the assessment of dredging projects, particularly those being undertaken at Great Barrier Reef ports. These include:

- National Assessment Guidelines for Dredging (NAGD) (CoA 2009)

- EPBC Act policies (numerous, see below)
- Great Barrier Reef Marnie Park Act polices (numerous, see below)
- Reef 2050 Long-term Sustainability Plan (CoA 2015)
- GBRWHA Maintenance Dredging Strategy (SOQ 2016)
- Environmental Code of Practice for Dredging and Dredged Material Management (Ports Australia 2016)

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 *Environment Protection (Sea Dumping) Act 1981* 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 for dredged material loading and disposal and provides a suite of contamination thresholds for sediments, which determine the suitability of dredged material for ocean disposal.

EPBC Act policy guidance

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
- Industry guidelines for avoiding, assessing and mitigation impacts on EPBC Act listed migratory shorebird species
- Referral guideline for the vulnerable Water Mouse, *Xeromys myoides*
- EPBC Act referral guidelines for the Outstanding Universal Value of the Great Barrier Reef World Heritage Area
- Approved conservation advices for listed species
- Threatened species recovery plans, including the Recovery Plan for Marine Turtles in Australia (2017) and the National recovery plan for the Water Mouse, *Xeromys myoides*
- Threat abatement plan for the impacts of marine debris on vertebrate marine life

Great Barrier Reef Marnie Park Act policy guidance

GBRMPA also has a number of documents that provide advice relevant to an assessment of maintenance dredging that is proposed to be undertaken wholly, or partially within the Great Barrier Reef Marnie Park (GBRMP). These include:

- Guidelines on the use of hydrodynamic numerical modelling for dredging projects in the GBRMP 2012
- Dredging and dredge spoil material disposal policy
- Improved Dredged Material Management for the Great Barrier Reef Region (SKM 2013)

Reef 2050 Long Term Sustainability Plan

The Reef 2050 Plan was released by the Australian and Queensland governments in March 2015 and is the overarching framework for protecting and managing the Reef until 2050. The Plan is a world-first document that outlines concrete management measures for the next 35 years to ensure the Outstanding Universal Value of the Reef is preserved now and for generations to come.

The Plan sets clear actions, targets, objectives and outcomes to drive and guide the short, medium and long-term management of the Reef. The Plan firmly responds to the pressures facing the Reef and will address cumulative impacts and increase the Reef's resilience to longer term threats such as climate change.

In relation to ports the Reef 2050 Plan notes that ports have been operating along the Great Barrier Reef coast since well before its world heritage listing and are included within its boundaries. The footprint of port areas is small, covering less than 0.1 per cent of the World Heritage Area. The importance of ensuring port activities are ecologically sustainable, particularly dredge projects and the disposal of dredge material, is recognised by all levels of government and by the ports industry.

The Reef 2050 Plan includes a number of port related actions that make clear the need to port authorities to understand the sedimentation characteristics of their ports, avoid and reduce impacts where possible, and establish sustainable long-term management arrangements.

Queensland Maintenance Dredging Strategy

Queensland's *Maintenance Dredging Strategy for Great Barrier Reef World Heritage Area Ports* (SOQ 2016) provides a framework for sustainable, leading practice management of maintenance dredging at ports in the Great Barrier Reef World Heritage *(*GBRWHA). The framework builds on the current regulatory requirements to ensure the ongoing protection of the Reef's values and the continued operating efficiency of ports within the GBRWHA.

The Strategy sets up a framework for maintenance dredging management and requires ports within the GBRWHA to develop and implement long-term maintenance dredging management plans. Key principles contained in the Maintenance Dredging Strategy include:

- Developing the knowledge base, using the best science available
- Avoiding or minimising the need for maintenance dredging
- Application of the principles of ecologically sustainable development
- Maintaining and enhancing environmental values, including the OUV of the GBRWHA
- Going further than avoiding and mitigating impacts, to look for opportunities to deliver environmental protection, restoration or enhancement outcomes (working with nature principles)
- Application of comparative analysis to determine the most suitable solutions
- Application of adaptive management and continuous improvement processes
- Reporting evaluated performance and providing access to data and information from monitoring
- Favouring transparency, consultation with key stakeholders and values-based assessment

Ports Australia Dredging Code of Practice

Whilst not a government policy, the Ports Australia's *Dredging Code of Practice for Dredging and Dredged Material Management* is important to consider, as the practices it sets out will be employed during maintenance dredging at the Port of Hay Point. The Code of Practice sets out a number of environmental principles that Australian ports meet when undertaking dredging and disposal of dredged material. The principles have been defined on the basis of ecologically sustainable development principles.

2 Assessment methodology

2.1 Available information

There is considerable information available to inform the assessment of maintenance dredging at the Port of Hay Point. This includes previous environmental impact assessments for capital dredging programs, results of monitoring (both baseline and that associated with dredging) and the technical reports produced as part of the Sustainable Sediment Management Project (SSM). 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 available in the following key documents:

1. Hay Point Maintenance Dredging Dredge Plume Modelling Assessment (Royal HaskoningDHV 2018a) (Appendix A)
2. Port of Hay Point – Natural Sediment Resuspension Assessment (Symonds 2017b) (Appendix B)
3. Sediment Analysis Plan (Advisian 2017) (Appendix C)

Plus the findings from:

- Port of Hay Point – Sustainable Sediment Management Assessment for Navigational Maintenance (project summary report) (Kaveney et al. 2017), and supporting reports:
    - Hay Point Port: Bathymetric Analysis and Modelling (Symonds and Donald 2016a)
    - Hay Point Port: Bathymetric Analysis – TC Debbie Analysis (Symonds 2017a)
    - Environmental Values Assessment (Jacobs 2016)
- Port of Hay Point Apron Areas and Departure Path Capital Dredging Project Environmental Review (Trimarchi and Keane 2007)
- Port of Hay Point – IDF Analysis and Ecological Trigger Assessment (HaskoningDHV 2018b)

Other information sources have been used where relevant and have been referenced accordingly.

2.2 Risk assessment approach

The study area was defined to include the Port of Hay Point, the existing offshore dredged material placement site and a surrounding area extending from Freshwater Point to Slade Point and approximately 40 km offshore (Figure 2). This is an area that could be expected to be larger than the broadest influence of any sediment plume (RHDNV 2016b). The study area includes all marine areas and near-shore coastal environments (i.e. beaches and mangrove communities). Purely terrestrial environments and associated environmental values 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 study area is well known and is comprehensively documented in Jacobs (2016). The values and their relative importance in the Hay Point region is summarised in Section 4. It was determined that each of these values has the potential to be impacted by maintenance dredging, to varying degrees, and would require further consideration in the risk assessment (i.e. this report).

In order to understand the risks to environmental values a list of potential impacts known to occur from maintenance dredging was compiled (Section 5). Following this step, the suite of impact avoidance and reduction measures that should be implemented at the Port of Hay Point was considered (Section 6).

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 5 would affect relevant MNES and if so, the severity of these impacts was undertaken (see Section 7). 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 7. Full reports are available (www.nqbp.com.au) and should be read in conjunction with this assessment.

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 Hay Point 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. Where there are no specific guidelines available for a species, the *EPBC Act Significant Impact Guidelines 1.1* (Commonwealth of Australia 2013) were used.

Following a detailed analysis of impacts, a risk assessment was undertaken which 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 D. Based on information contained in the impact assessment detailed in Section 7 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 1. The results of the risk assessment are provided in Section 8.

Table 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

2.3 Approach to assessing multiple campaigns

Several dredge campaigns are proposed over the 10 year permit timeframe. There is certainty about the nature of the initial upcoming maintenance dredging including locations, volumes and duration (see

Section 3). While the initial campaign has been the focus of the risk assessment, with detailed analysis about how these works may impact environmental values, future campaigns have also been considered. Notably these are expected to be smaller in volume and duration and pose a reduced risk as a result.

Royal HaskoningDHV (2018a) have undertaken a detailed study to understand the potential effects of maintenance dredging and how these can vary across a range of scenarios. They considered variable dredge volumes, metocean conditions, seasons, placement site locations and sediment compositions. This approach has accounted for a range of scenarios and has been used to inform an assessment of the risks from future campaign scenarios.

In addition to the Royal HaskoningDHV (2018a) study and in order to ensure the risks of future 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* (Adaptive Strategies), and the proposed process is demonstrated in Figure 1.

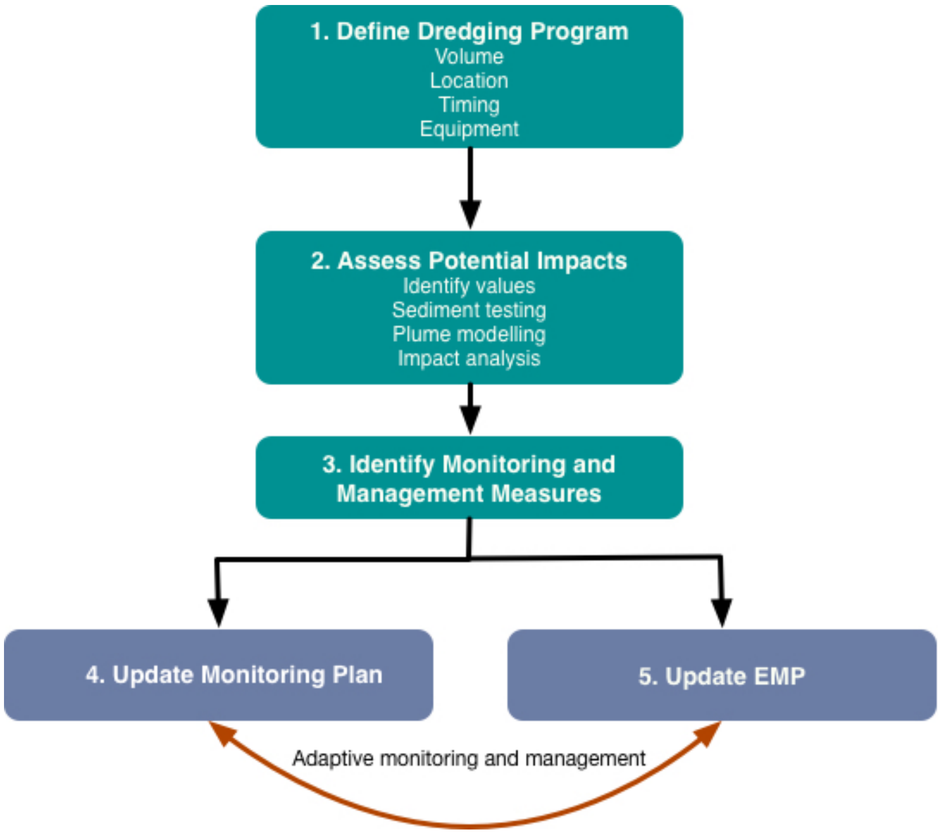

Figure 1: Process for identification of potential impacts and management measures for future campaigns

Campaigns will be staggered over the 10 year time frame, thereby reducing the impact risk with a degree of proportionality to the size of the campaign. During the time between campaigns, impacts will have ceased and recovery occurred. Studies have shown that recovery at Hay Point has occurred within 12 months of previous dredging campaigns (Trimarchi and Keane 2007, Ports Australia 2014). 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 1.2 Mm^3) and the results of this modelling have been applied in an assessment of the likelihood of significant impacts from the total dredge volume, showing that impacts are avoidable for single campaign volumes under 800,000m^3. Furthermore, 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.

3 Description of the project

3.1 Areas and volumes

Maintenance dredging will occur across the Port, in order to return areas to their design depth. The total dredging requirement over a 10-year timeframe is in the order of 956,553 m^3 spread across a series of campaigns as shown in Table 2. Exact volumes will vary depending on sediment accumulation and cyclonic activities.

Table 2: Dredge volume requirements

Period	Maintenance dredge volume requirement (m^3)
Initial campaign	356,553
1 – 5 year period	200,000
5 – 10 year period	200,000
Cyclone contingency	200,000
Total 10-year permit requirement	956,553

The areas of the Port that have the most regular need for maintenance dredging are the apron, departure channel and berth pockets. Specific requirements will be determined prior to each campaign based on hydrographic survey. For the first campaign, dredging is required in these areas as well as at the Half Tide Tug Harbour and the Hay Point Boat Ramp. Volumes for the initial campaign are indicated in Table 3 and Port areas are shown on Figure 2.

Table 3: Dredge volumes required for current campaign

Port area	Maintenance dredge volume requirement (m^3)
Apron	62,576
Departure channel	11,509
DBCT berths 1 – 4	242,525
HPCT berths 1 - 2	718 *
HPCT berth 3	7,917
Half Tide Tug Harbour	24,598
Hay Point Boat Ramp	6,710
Total	**356,553**

* Unlikely to be dredged in initial campaign

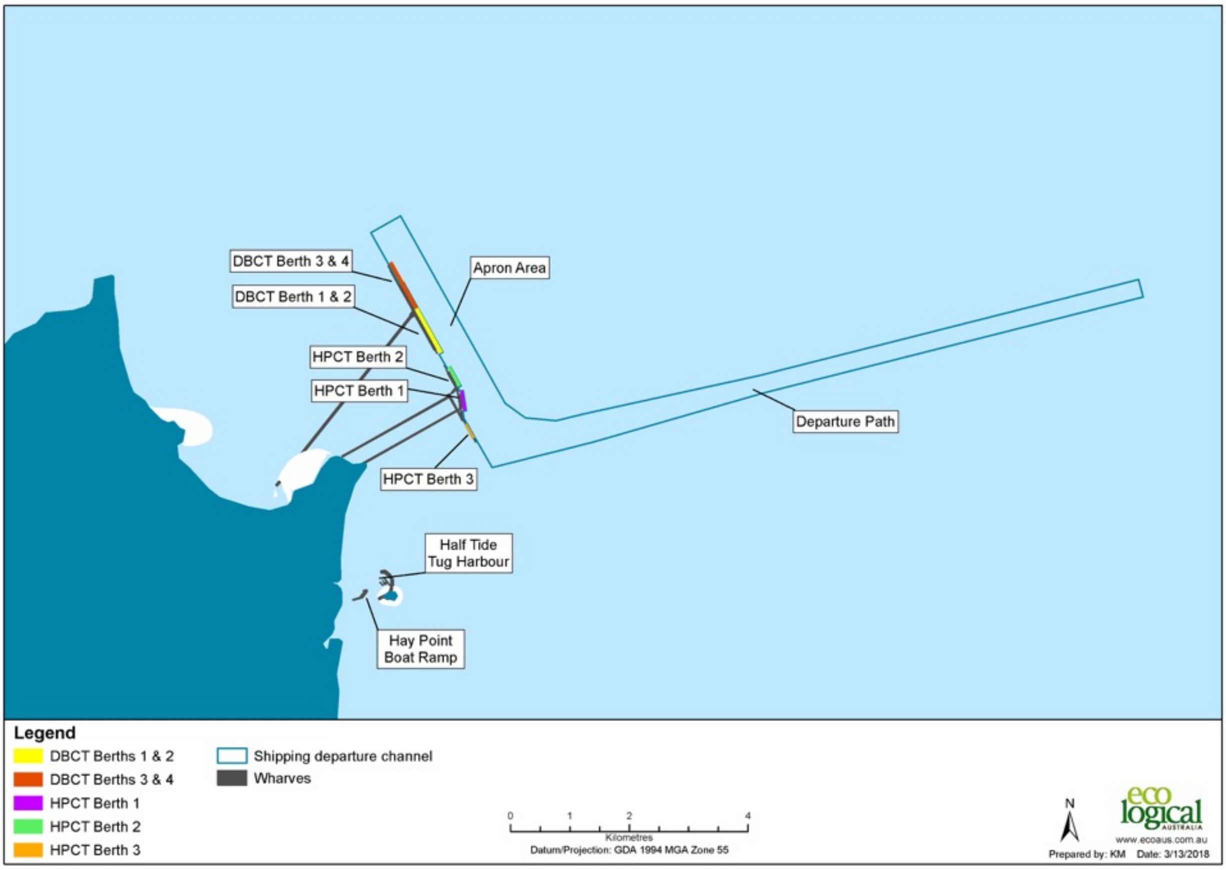

Figure 2: Port areas

3.2 Material to be dredged

Sediment sampling for the current campaign was completed in February 2018 and analysis of results is underway (see Advisian 2017 for Sampling and Analysis Plan [SAP]). The expectation is that sediments will have a similar particle size composition and contamination status as those previously sampled, and this risk assessment has proceeded based on this assumption.

Previous sampling has indicated that the sediments within the berth pockets are dominated by fine fraction silts and clays (average 60%, but as high as 74%), with sands and minor gravels making up the remainder. Sediments in the apron and departure path areas generally have higher sand fractions. Sediments in the navigational areas of the Port are generally unconsolidated resulting from siltation and migration of sediments over time from periodic extreme metocean events such as cyclones (Advisian 2017).

Previous testing has also indicated that sediments across all Port areas can be considered uncontaminated and suitable for ocean disposal. The exception is HPCT Berth 3, which was established only recently (approximately 5 years ago), and has not undergone previous sediment testing.

Further details of sediment composition and suitability for ocean disposal is provided in Section 4.2.1.

3.3 Dredged material placement site

Each campaign will utilise the existing dredged material placement site, located approximately 6 km from the apron areas of the Port of Hay Point. The location of the placement site is provided in Table 4 and

Figure 3. The placement site has been used for capital and maintenance dredging campaigns since 2006.

The area of the existing dredged material placement site is 18.4 km^2, with water depths of 11 – 15 m below the level of lowest astronomical tide (LAT). The seabed of the placement site is relatively flat and featureless and consists of silty sands. The geomorphic features of the seabed have been altered through its historical use for dredged material placement. The placement site is not an area of high productivity, with an infaunal community representative of communities common across the GBR and periodic, low density seagrass and macroalgal growth (see Section 4 for additional information).

Table 4: Location of the dredged material placement site

Site ID	Longitude	Latitude	Easting	Northing
MR1	149.301924	21.219821	738932	7651786
MR2	149.334858	21.201923	742381	7653718
MR3	149.334295	21.165522	742382	7657750
MR4	149.280609	21.194510	736759	7654621

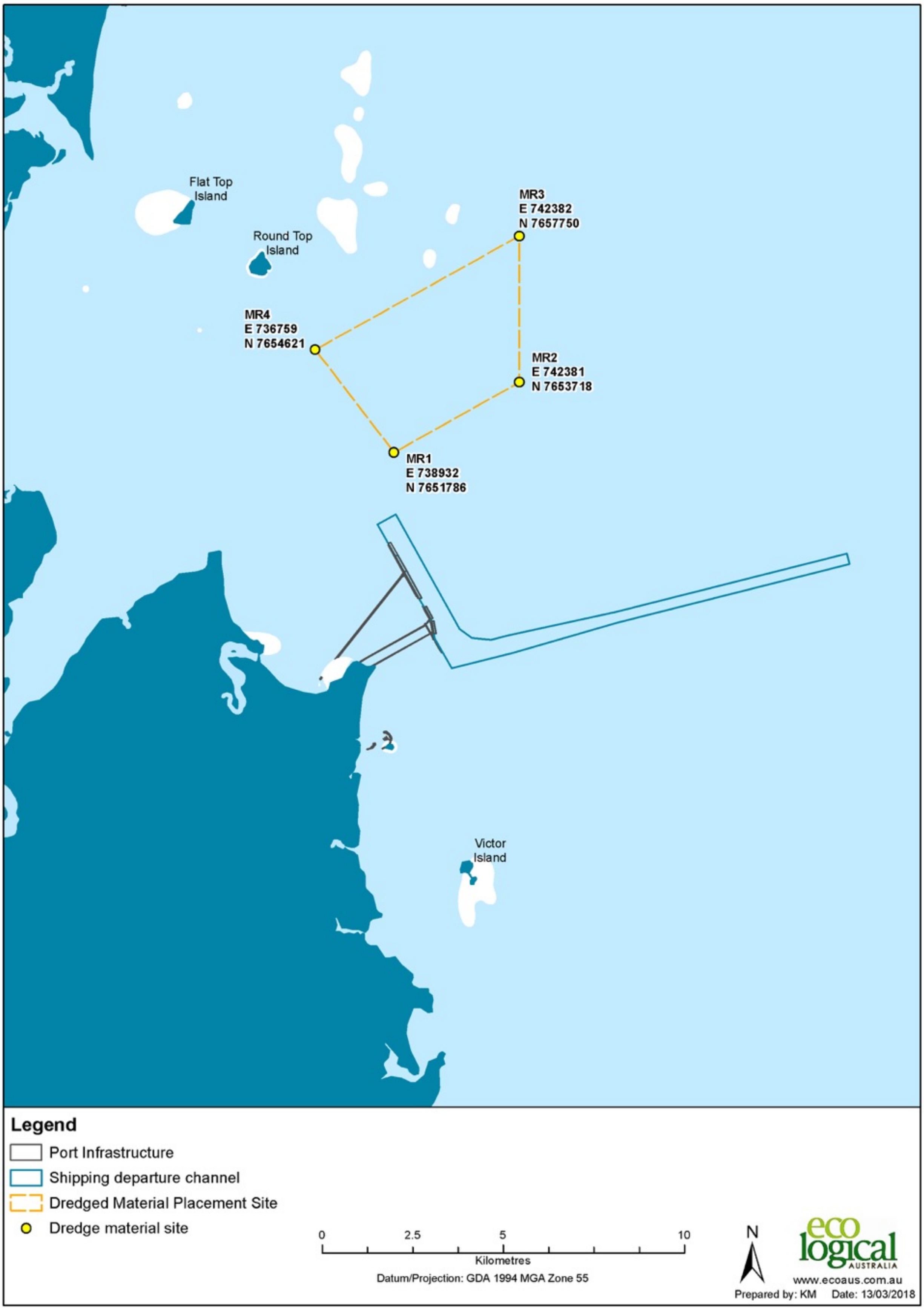

Figure 3: Dredged material placement site

3.4 Dredging methods, timing and duration

Since 2000 the majority of maintenance dredging in Queensland has been undertaken by the TSHD Brisbane. The TSHD Brisbane was specifically designed and built to operate in Queensland and the vessel has numerous environmental management mechanisms to ensure any environmental risks are minimised. It is likely that the TSHD Brisbane, or a similar vessel, would undertake future maintenance dredging at the Port of Hay Point. This vessel is currently scheduled to undertake the initial campaign.

The length of future campaigns will be proportional to the volumes required, with a 200,000 m^3 campaign lasting approximately 20 days.

As indicated above, the schedule of dredging will be up to 4 campaigns over 10 years. After the initial campaign, it is envisaged additional maintenance dredging will be required at some point during each subsequent 5-year period. Additional dredging to account for sedimentation from cyclones may be required and the timing of this is unknown.

4 Description of the environment

4.1 Climate and marine conditions

4.1.1 Wind climate

Hay Point lies in the trade wind belt for most of the year resulting in the local wind climate being governed by east to south-easterly winds. Figure 4 presents wind data measured by the BoM at Hay Point and includes data recorded between 2005 and 2015 (annual wind rose). The wind rose highlights the prevalence of the east to south-easterly winds.

During the summer months, wind conditions tend to be stronger and are predominantly from the east, with lighter north-easterly sea breezes common during the afternoon. During the winter months the wind direction is more prominent from the south with lighter land breezes from the south–west also occurring. The higher wind speeds recorded at Hay Point are a result of tropical cyclones which can influence the area. The associated speed and direction of these winds are a result of the cyclones intensity and path.

Local wind conditions are an important driver for locally generated waves and to a lesser extent, currents at Hay Point.

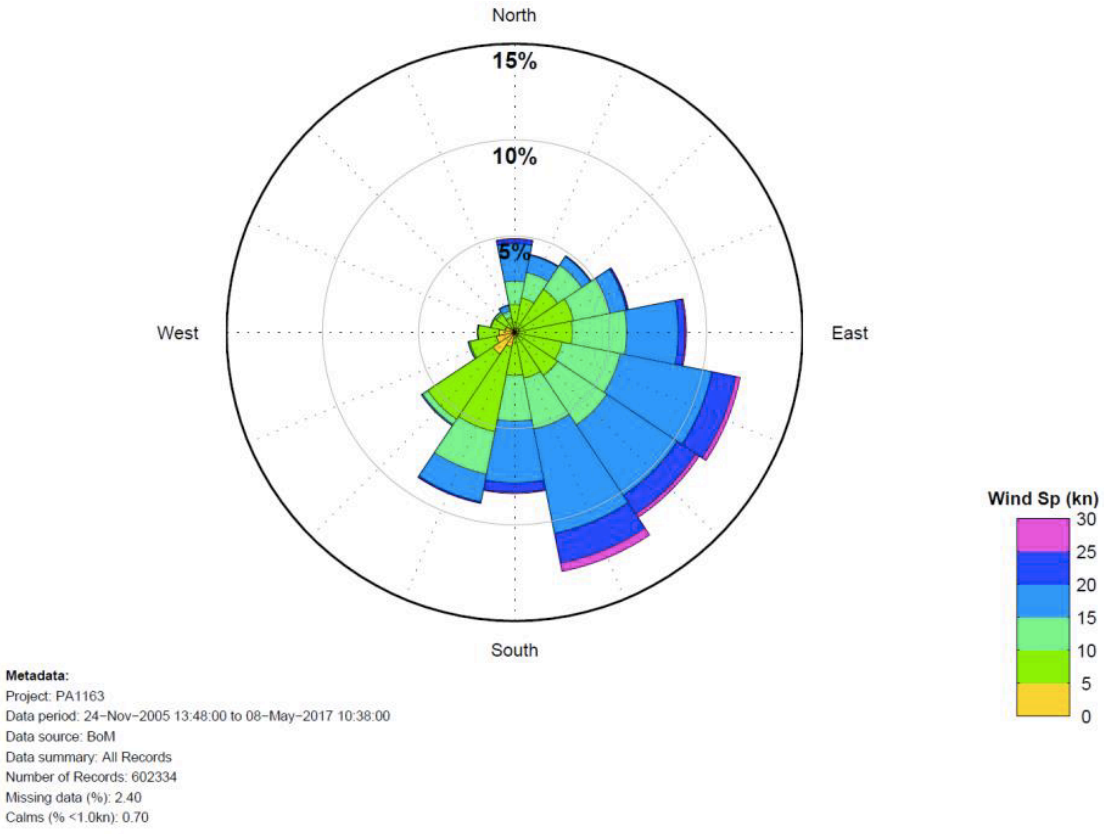

Figure 4: Annual wind roses for the BoM Hay Point weather station (2005 – 2015)

4.1.2 Rainfall

Hay Point experiences a tropical climate with a distinct monsoonal rainfall trend. On average Mackay receives 1,595 mm of rainfall each year. Average monthly rainfall measurements are provided in Table 5. 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 5: 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	310.6	346.4	263.3	164.2	90.4	62.1	34.1	32.7	24.7	35.1	83.4	126.5
Median	277.0	280.0	186.8	109.3	69.5	47.9	13.3	20.4	11.6	32.0	57.4	96.0

4.1.3 Tides

Hay Point is located in the area of the Queensland coast which experiences the highest tidal range, with mixed semi-diurnal tides with a peak tidal range of 7.14 m and a mean spring tidal range of 4.86 m. The tidal planes for Hay Point are shown in Table 6. The large tidal range at Hay Point is primarily due to local tidal amplification at Broad Sound. The tidal amplitude at Hay Point results in relatively strong tidal currents at the port.

Table 6: Hay Point tidal planes (MSQ 2018)

Tidal Level	Height above LAT
HAT	7.14m
MHWS	5.80m
MHWN	4.48m
MSL	3.37m
MLWN	2.25m
MLWS	0.94m
AHD	3.34m

4.1.4 Wave climate

Wave data is available from the DSITI wave-rider buoy (WRB) deployed at Hay Point and is from 1977 onwards. This has been analysed by Symonds and Donald (2016) and is summarised below.

The GBR and adjacent Islands located offshore of Hay Point blocks, and/or significantly attenuates, long period swell waves from reaching the port. However, occasionally large wave events generated inshore of the reef (within the GBR Lagoon) do occur due to tropical cyclones and storm events. Accordingly, the wave climate at Hay Point can be described as relatively variable.

The dominant wave direction is from the east-south-east. This is a 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 an east-south-easterly 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. Similarly, waves from the east-north-east are more prevalent during summer when winds tend to be from a more east and north-easterly direction.

The Pot of Hay Point is exposed to both sea and swell (attenuated) waves, with spectral peak periods ranging from 2 to 18 seconds. Locally generated sea waves dominate at a period of 3 to 7 seconds while swell waves tend to be lower in height and vary in peak period from 7 to 18 seconds. The dominant short period waves experienced at the port are a result of sea waves generated by local winds within the GBR Lagoon.

Cyclones passing nearby to Hay Point are responsible for the largest waves recorded at the Port.

4.1.5 Currents

Current data has been collected at Hay Point across a range of previous studies and is predominantly influenced by wind and tidal conditions (Symonds and Donald 2016a). Overall, measured data show that depth averaged current speeds vary between 0.2 m/s and 0.5 m/s (0.3 – 0.35 m/s at the seabed) during spring and neap tides respectively. Tidal induced currents flow parallel with the coastline, with flood currents to the south-southeast (170˚) and ebb currents to the north-north west (340˚). Previous current measurements collected near Mackay Harbour (approximately 18 km north) showed that the ebb tidal current to the north is slight.

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 Hay Point, their effects are considered minor relative to tidal and wind induced currents (Symonds and Donald 2016a).

4.1.6 Tropic cyclones

Hay Point is vulnerable to the effects of severe tropical cyclones during the summer months (wet season). Between 1906 and 2015, 24 cyclones have passed within 100 km of Hay Point (Symonds and Donald 2016a). 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 7.

Table 7: Recent tropical cyclones affecting the Port of Hay Point (BoM 2018)

Name	TC Ului	TC Dylan	TC Debbie
Crossing date	21 March 2010	31 January 2017	28 March 2017
Crossing location	Airlie Beach – 180 km north Hay Point	Dingo Beach – 195 north Hay Point	Airlie Beach – 180 km north Hay Point
Category when crossing coast	Cat 3	Cat 2	Cat 4
Max sustained wind speed	215 km/hr	100 km/hr	195 km/hr
Max wind gust	290 km/hr	140 km/hr	260 km/hr

4.2 Sediments

4.2.1 Characteristics

In 2012 sediment sampling works were undertaken in order to characterise maintenance dredging sediments within the Hay Point dredged areas (Ports and Coastal Environmental Pty Ltd 2013). Samples were taken at a number of locations throughout the berth pockets, apron and departure channel using both benthic grab and vibrocore techniques. Samples were analysed for their particle size distribution with the results shown in Figure 5 and indicating:

- On average, bed sediments in the dredged areas of the port are generally comprised of predominantly sand fractions
- Areas of the North Apron and DBCT berths exhibit the highest silt and clay compositions reporting 80% of finer fraction material (silts and clays)
- The majority of the departure channel and apron are primarily comprised of slightly silty, slightly clayey sands
- The outer end of the departure channel exhibits the highest sand composition, with sand and gravel fractions being greater than 90%.

Further sediment sampling was undertaken during 2016. This identified and classified marine sediment materials and investigated their acid generating capacity and geotechnical properties for consideration of potential reuse options (Advisian 2016). The results of this study indicated there would be challenges with onshore reuse of sedimentary material due to the saline content and engineering properties.

The sediment materials encountered consisted of clayey and silty sands and silty clays. In general the fine grained (clay-rich) materials were encountered inshore, in the vicinity of the existing jetties and berths. Samples obtained within the channel tended to comprise predominantly quartz sand, with some secondary gravel, with fines representing only a minor constituent. The sand portion comprises predominantly quartz, with secondary calcium carbonate, expected to be from shell fragments.

A typical feature of the fine grained sediment materials was the very high moisture content, generally in exceedance of the liquid limit of the material. All samples were identified as extremely saline and if placed on land without treatment, would likely degrade soil quality, cause vegetation toxicity and impact surface and ground waters. High Potential Acid Sulphate Soil (PASS) was detected in over half the sampling locations generally in the apron and berth pocket areas. However, analysis of the acid neutralising capacity (ANC) indicated if brought ashore, the marine sediments are unlikely to require treatment via neutralisation with lime.

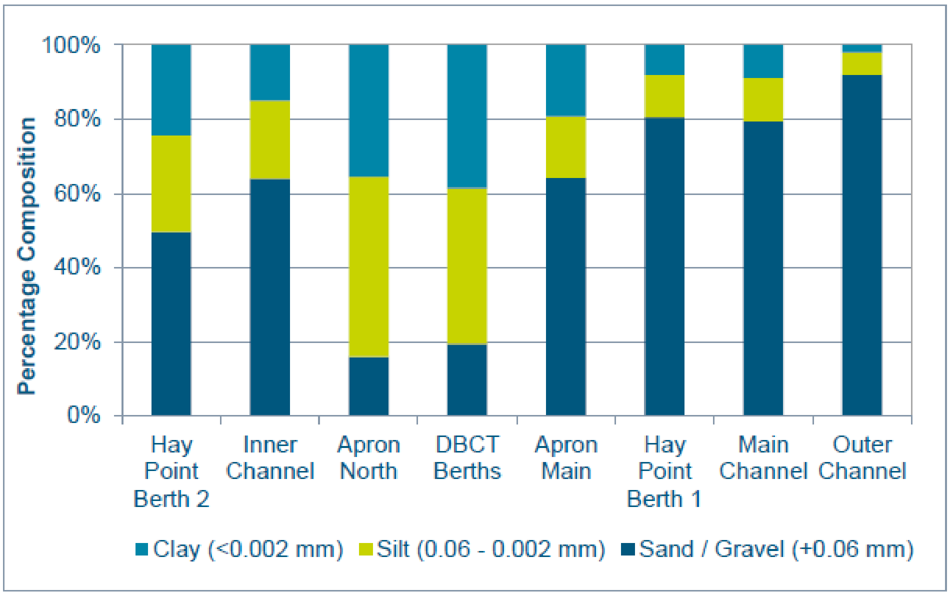

Figure 5: Summary of sediment characteristics (data from PACE 2013)

Sediment testing has occurred across the Port of Hay Point on numerous occasions. As shown in Table 8, laboratory testing has consistently shown that the sediment is suitable for ocean disposal with very low levels of contamination and bioavailability as per the NAGD (CoA 2009).

Table 8: Summary of sediment testing at the Port of Hay Point

Port area	Dates	Volume	Summary of sampling results
Departure path	May – July 2013	110,000 m^3	TBT below the laboratory detection level Metals, Hydrocarbons, PAHs below screening levels Overall conclusion: suitable for unconfined ocean disposal
Aprons	May – July 2013	110,000 m^3	TBT below screening levels Metals Hydrocarbons, PAHs below screening levels Overall conclusion: suitable for unconfined ocean disposal
Tug harbour	May – July 2013	~37,854 m^3	TBT below screening levels Metals, Hydrocarbons, PAHs below laboratory detection level or screening levels Overall conclusion: suitable for unconfined ocean disposal
HPCT Berth 1	May – July 2012 Nov 2012	30,492 m^3	TBT above screening levels (95%UCL of 15.3 ugSn/kg+). Total sediment, dilute acid extraction, elutriate testing – all below screening levels Metals, hydrocarbons, PAHs below laboratory detection level or screening levels Overall conclusion: suitable for unconfined ocean disposal
HPCT Berth 2	May – July 2012 Nov 2012	32,765 m^3	TBT above screening levels (95%UCL of 30.47 ugSn/kg). Arsenic, copper, lead, zinc above 95%UCL screening values. Total sediment, dilute acid extraction, elutriate testing – all below screening levels Hydrocarbons, PAHs below laboratory detection level or screening levels

Port area	Dates	Volume	Summary of sampling results
			Overall conclusion: suitable for unconfined ocean disposal
DBCT Berth 1	August 2014	38,500 m^3	TBT reported a 95% UCL of 6.9 ugSn/kg (< screening criteria). Five locations initially reported TBT concentrations above screening. Each sample (original plus the 3 replicates) were averaged and applied to the 95% UCL calculation. All metals remained below the screening criteria. Several individual PAHs were identified, leading to low level total PAHs. 95% UCL of 216 ug/kg and maximum of 1232 ug/kg, well below the NAGD screening criteria of 10,000 ug/kg. Overall conclusion: suitable for unconfined ocean disposal
DBCT Berth 2	July 2014	38,500 m^3	TBT reported a 95% UCL of 1.3 ugSn/kg (< screening criteria). All metals remained below the screening criteria. Several individual PAHs were identified, leading to low level total PAHs. Berth 2 reported a 95% UCL of 149 ug/kg and maximum of 636 ug/kg, well below the NAGD screening criteria of 10,000 ug/kg. Overall conclusion: suitable for unconfined ocean disposal
DBCT Berth 3 & 4	March 2016	58,504 m^3	All analytes below screening levels Overall conclusion: suitable for unconfined ocean disposal

Additional sediment sampling is currently underway (at March 2018).

4.2.2 Movement

An in-depth examination of the sediment transport and dynamics in the central Great Barrier Reef (Gibbs et al., 2016) identified and clarified the major sediment types and distributions in the region. The sediment budget calculations indicate that sediment is generally moving northwards within three defined sediment transportation processes:

- Littoral drift (long-shore transport of sediments along the Queensland coast's surf zone)
- Nearshore turbidity pathways (re-suspension due to under-wave water movements and tidal flows)
- Inner-shelf bed load transport (re-suspension due to larger waves and strong tidal currents)

Overall, the coastal system is considered balanced, with almost the same volumes of sediment entering the system as leaving. Importantly, the study found that fluvial inputs (i.e. from coastal river systems) are only a minor contributor to the overall sediment budget and that coastal catchment-based sediment control (trapping) measure would result in very little reduction in marine sediment accumulation.

To understand more specifically where and in what volumes sediments accumulate within the Port of Hay Point's navigational areas, an examination of the historical siltation of the shipping channel, apron and berths was undertaken (Symonds and Donald, 2016; Symonds and Loehr, 2016). Overall, the study showed variable patterns of siltation within navigational areas across the port since 2006. During the period from the completion of capital dredging in October 2006 and a further bathymetric survey in October 2015, the following occurred:

- Depths have been largely maintained in the channel and aprons with the bathymetry of most areas below design depth of 14.9 m below LAT

- A clear deepening along the centreline of the departure channel up to the southern corner of the apron with the erosion being most pronounced in the Outer Channel area
- Some siltation has occurred in the North Apron, between the DBCT and HPCT berths and in the Mid Outer Channel
- Siltation has occurred in DBCT and HPCT berth pockets, with 2016 declared depths shallower than design depths in all but one berth
- Berths have high sediment trapping efficiency and trap more fine grained silts and clays than the apron and departure channel (due to their relatively deeper depth compared to adjacent seabed)

4.3 Bathymetry

A detailed bathymetric analysis for the Port of Hay Point and the existing dredged material placement site was undertaken in 2016 (Symonds and Donald 2016a, b) and updated in 2017 to take account of the changes from TC Debbie (Symonds 2017a). The key findings of these studies are summarised below.

4.3.1 Port of Hay Point

The natural bed elevations at the Port of Hay Point are relatively stable, with little natural net erosion or deposition occurring in the area. Data from the ongoing ambient water quality monitoring indicate that sediment suspension and deposition in the area occurs due to a thin mobile bed layer which is regularly reworked (resuspended, transported and then deposited) by waves (resuspending the material) and currents (transporting the material). During periods when high rainfall coincides with wave action the magnitude of the suspended sediment concentration (SSC) does not increase relative to periods with just wave action; it is the wave action which seems to be the principal driver of SSC. The sediment transport rates increase inshore as the water depth reduces and waves have a greater influence on the bed. In the nearshore areas the natural sediment transport will act to return the bathymetry to how it was pre-capital dredging.

The bathymetric analysis of the Port area found that both siltation and erosion have occurred in various areas of the Port since the completion of capital dredging in October 2006. Siltation has occurred in areas of the North Apron, Inner Channel and Outer Channel regions as well as in the DBCT and HPCT berths. Regular siltation in the apron and departure channel only occurred in the North Apron region where the total siltation (above and below design depth) since the completion of capital dredging (October 2006) and prior to TC Debbie (March 2017) was 130,000 m^3 and at localised areas in the apron adjacent to the DBCT and HPCT berths. Net erosion of approximately 500,000 m^3 of the apron and departure channel has occurred between the completion of capital dredging in October 2006 and prior to TC Debbie. Erosion along the centre line of the departure channel and apron corner has occurred as well as erosion of the apron adjacent to the berths. The erosion is likely to have occurred as a result of high currents/turbulence from vessel propeller wash

Analysis of the available hydrographic data gathered at the Port of Hay Point after TC Debbie has shown how the bathymetry in the apron, departure channel and berths at the port has changed since October 2015 and as a result of the cyclone. The assessment found that TC Debbie resulted in increased accretion in a number of areas of the Port, including:

- Apron – more than 140,000 m^3 accreted in the apron due to TC Debbie and with >100,000 m^3 in the North Apron and DBCT Apron areas.
- DBCT berths – more than 250,000 m^3 accreted in the four DBCT berths during TC Debbie. Over the two months immediately after TC Debbie the volume of sediment reduced by almost 150,000 m^3, due mainly to natural consolidation of the sediment along with some erosion from bed raking and levelling and propeller wash.

- HPCT berths – more than 40,000 m^3 accreted in the three HPCT berths during TC Debbie. The largest volume was in Berth 3 where just under 18,000 m^3 accreted.

4.3.2 Dredged material placement site

The bathymetric data indicates that during the capital dredging campaign in 2006, placement of sediment occurred in five rows (southwest to northeast orientation), creating shallower ridges on the previously relatively flat and uniform seabed in the dredged material placement site. In the eight year period between 2006 and 2014, these shallow ridges have remained in place with some localised erosion of the higher points and deposition in the deeper areas.

The existing placement site has retained 64% of the sediment from capital and maintenance dredging over the eight years after the main capital dredging campaign. This period has included two tropical cyclones, one of which resulted in significant erosion in the Port of Hay Point apron and departure channel (TC Dylan).

Bathymetric analysis of the dredged material placement site was not undertaken after TC Debbie.

4.4 Water quality

4.4.1 Overview

The water quality in the marine environment adjacent to the Port of Hay Point is primarily influenced by the large tidal currents and persistent wind driven waves that occur on a day to day basis. These currents and waves resuspend sediments into the water column creating turbid plumes. Additional influences on the quality of the marine waters include inputs of fresh water; sediments and contaminants from local rivers and streams. The main rivers and streams that influence the water quality in the Port of Hay Point are from the Plane Creek and Pioneer River Catchments.

Extensive water quality monitoring has previously been undertaken at the Port associated with individual dredging and capital works programs. In 2014, NQBP established an ambient marine water quality monitoring program in the coastal zone around the Ports of Hay Point and Mackay with the aim of developing a long term water quality dataset to characterise marine water quality conditions within the Mackay region, and to support future planned port activities.

The program commenced with 12 monitoring sites covering a 60 km stretch of the coast from Slade Point to Freshwater Point and offshore to Keswick Island. The number of monitoring sites was reduced to seven and these have been monitored since 2015. Sites in the monitoring network have been chosen to spatially align with the location of key sensitive receptor habitats (e.g. corals and seagrass), along with key features in the study region (e.g. river flow points).

Overall, the results of the monitoring program show that (Waltham et al. 2015, 2016, 2017):

- The water column is well mixed, with the exception of a turbid bottom layer caused by sediment resuspension, with water turbidity and suspended solids driven predominately by wave energy
- Nutrient concentrations and chlorophyll-a levels were elevated, most likely due to persistent local sources such as runoff from local farms and urban centres
- Heavy metals were not detected around the Port of Hay Point
- Pesticides and herbicides were detected in generally low concentrations. Higher concentrations may be expected at times of high rainfall
- Plankton communities were seasonally variable
- There were periods of elevated turbidity, likely driven by resuspension of sediment during times of low rainfall. This is consistent with patterns along the Queensland coast

- There was no evidence of large sediment deposition prior to Cyclone Debbie (March 2017), with most sediments likely being resuspended by wave energy
- Cyclone Debbie caused significant increase in SSC and turbidity and reduced PAR in the months following the cyclone

4.4.2 Suspended sediment concentrations

Overall, the prevailing metocean conditions, along with the shallow nature of the inshore areas and naturally fine sediments occurring in the Hay Point area result in a marine environment that is generally highly turbid. This is summarily illustrated via satellite (bottom) data during moderate conditions of a wind speed of 20 knots. Most areas along the inshore area experience SSC above 10-25 mg/l during such moderate conditions.

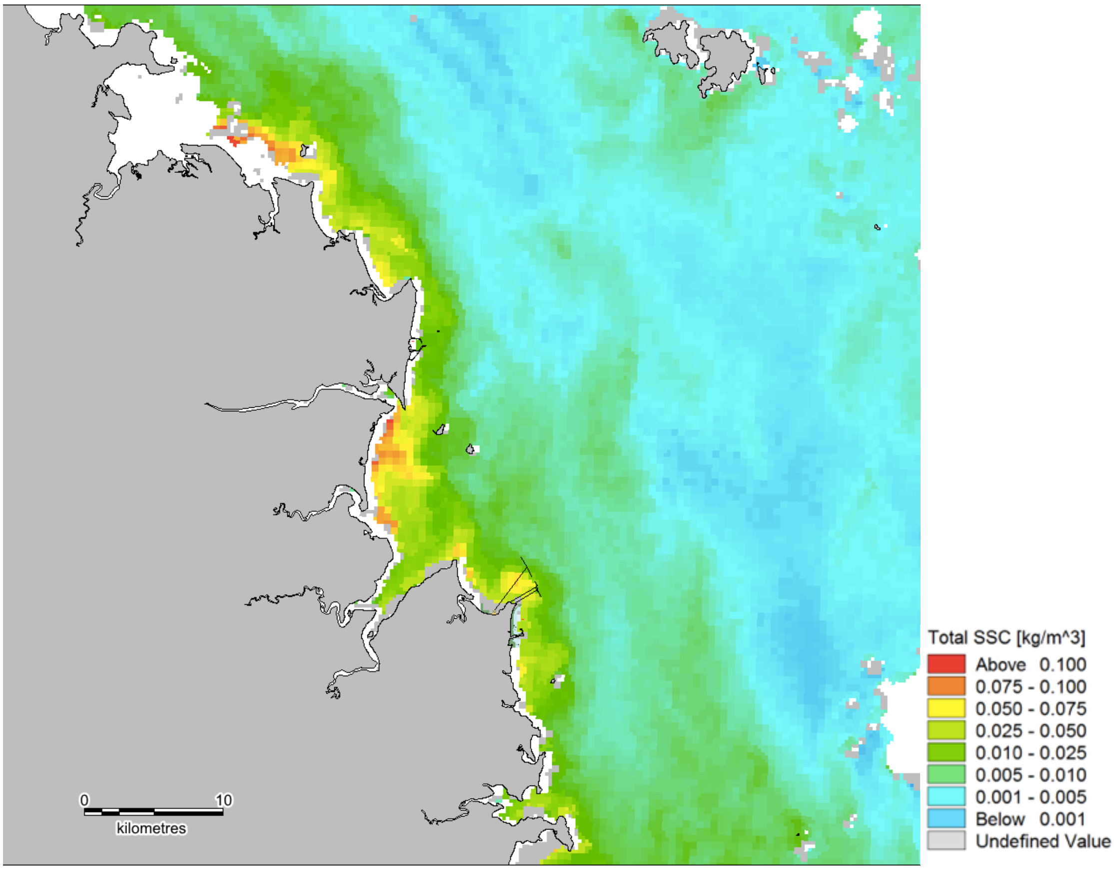

Figure 6: SSC levels derived from MODIS satellite (bottom) data during moderate conditions

Suspended sediment concentrations (SSC) in waters adjacent to Hay Point are predominantly the result of existing bed sediments being suspended through current and wave action. A number of studies have been undertaken at Hay Point to monitor and understand the variability in water quality adjacent to the Port. Most of these studies have been typically associated with development projects at the port. SSC data collected through these previous monitoring programs have been summarised by WorleyParsons (2014) and are presented in Table 9. The data presented provides a summary of background SSC measurements collected at Hay Reef between 2004 and 2012. Hay Reef is located approximately 1 km inshore of the Hay Point berths and represents the closest monitoring location to the port.

The data show that during the summer months the medium SSC (16.6 mg/l) is higher compared to the winter months (6.6 mg/l). Similarly, the upper bounds are further elevated during summer. This is due to stronger winds during the summer months resulting in increased wave conditions which promote suspension of bed sediments. In addition, cyclones and significant storm events occur in the summer months and can result in significant increases in wind, waves and SSC.

Table 9: Summary of background SSC measurements (Hay Reef 2004 – 2012)

Parameter	Summer / wet season (Oct – March)	Winter / dry season (April – Sept)
Median (mg/l)	16.2	6.6
80th percentile (mg/l)	71.9	26.6
90th percentile (mg/l)	128.8	57
95th percentile (mg/l)	208.5	101

Symonds and Donald (2016) analysed water quality data collected by James Cook University (JCU) at Hay Reef between 2014 and 2015. The results demonstrate that wave induced bed shear stresses are the primary driver responsible for elevated SSC concentrations as the data clearly shows that elevated periods of significant SSC concentrations correlate directly to periods of increased wave activity.

Tidal currents also play a role in both the daily and weekly variability in SSC concentrations, though to a lesser extent. Variations in spring and neap current speeds directly correlate to variability in SSC concentrations at a similar temporal pattern. Under limited wave conditions, spring tidal currents result in SSC readings to 7-8 mg/l while neap tides generally result in SSC readings of 1-2 mg/l (Hay Reef). This is a result of stronger currents during times of spring tides, suspending greater amounts of bed material.

4.5 Coral

Fringing coral communities can be found growing on exposed rocky outcrops in waters surrounding Victor, Round Top, Flat Top Islands and Slade Islet (Advisian 2016). Coral communities also grow on small rocky outcrops situated at Hay Reef between the existing coal terminal jetties at Hay Point (Koskela 2009). A rocky ledge extending southward from Dudgeon Point in the shallow waters of Dalrymple Bay supports a sparse coral community.

Hard coral species common to the area are those typical of highly turbid marine environments of the GBR including species from the genera *Montipora, Acropora, Pocillopora* and *Turbinaria* and genera from the families Faviidae, Siderastreidae and Poritidae. 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).

Monitoring of fringing corals has been undertaken by NQBP at key island locations surrounding the Port of Hay Point including at Round Top Island, Victor Island and Slade Islet (inshore sites) and Keswick / St Bees Islands (offshore sites). Monitoring between 2006 and 2010 was undertaken to understand any potential impacts from capital and maintenance dredging activities. In 2015, NQBP commenced an ambient coral monitoring program which is conducted twice yearly, before and after the wet season, at six monitoring sites at each of the four islands.

Overall, the results of the monitoring undertaken between 2006 and 2016 show that (Advisian 2016):

- There have been large fluctuations in algal cover at inshore locations, with an overall upward trend over time. This may be suggesting a shift towards a more algal dominate system at inshore locations
- There have been significant changes in total hard coral cover at all inshore locations. In particular:
  - TC Ului (2010) resulted in large decreases in coral cover
  - Since this time, there have been further reductions in coral cover at Round Top Island and Slade Islet due to disease, flooding and other cyclones. This trend was beginning to reverse in 2016
  - Coral cover at Victor Islet was higher in 2016 than 2006
- Soft coral cover has increased significantly at Round Top Island since 2006
- Bleaching was higher in 2015-16 surveys than previously recorded
- The 2006 capital dredging campaign resulted in some damage to corals and reductions in coral cover at Round Top Island and Victor Islet, with the following observations:
  - 3 and 6 months after dredging commencement, up to 4% (Round Top Island) and 6.5% (Victor Islet) of corals showed some patches of mortality that were related to sediment accumulation on the colony surface. This did not cause any whole-colony mortality.
  - 6 months post completion of dredging, very small reductions in hard coral cover were recorded relative to baseline conditions measured 12 months prior (1% at Round Top Island; 3% at Victor Islet)

Results of surveys undertaken in 2017 post TC Debbie indicate:

- The cyclone affected the three inshore locations, with Slade Islet the worst impacted. Coral cover at these locations reduced from a mean of 25.7% down to 18.8%.
  - On Slade Islet the three NE facing sites which had high coral cover were badly damaged with lots of reef striped of coral completely. Coral cover at these three sites halved from 42.1% to 21.8%.
  - At Round Top Island only two sites were affected (sites 1 and 2) with site 2 having very low coral cover prior to the cyclone.
  - At Victor Islet four sites were affected by the cyclone (Sites 1, 2, 5 and 6). Site 2 was worst affected with coral cover reduction from 82% to 54%.
- While there was some cyclone scouring at Keswick Island sites, this has not affected overall coral cover but did reduce algal cover markedly.
- Algal cover reduced markedly following the cyclone but by August this had recovered substantially, mainly due to rapid growth of ephemeral species.
- Coral cover has reduced slightly since the cyclone at many sites due to disease. This is suggested to be due to the corals being stressed by turbid water and large amounts of fine sediment deposition.
- Overall, however, there are still numerous healthy corals present at the monitoring sites.

4.6 Seagrass

Surveys of seagrass communities over the 15 years within the Port of Hay Point identified two distinct habitats – inshore shallow water and mid-shelf deeper water meadows – each dominated by four species of seagrass: *Halophila decipiens, Halophila ovalis, Halophila spinulosa* and *Halodule uninervis* (WorelyParsons 2014).

Surveys conducted by Thomas *et al.* (2012) in November 2011 indicated that the total extent of seagrass communities within the Port of Hay Point area had significantly declined since 2010 for both inshore and mid-shelf regions, with total coverage of seagrass reducing from 1,577.3 ha in 2010 to 115.7 ha in 2011. This decline was attributed to flooding and high rainfall associated with cyclonic events that occurred across coastal Queensland between 2010 and 2011, which led to a reduction benthic light availability for seagrass growth. Similar trends were reflected throughout much of the urbanised east coast of Queensland (Thomas *et al.* 2012).

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. Overall, the results of the monitoring program show that (McKenna et al. 2016):

- Surveys in October 2015 recorded seagrass present at 24% of inshore sites and 42% of offshore sites
- Five species of seagrass were recorded, all belonging to the genus *Halophila*
- Offshore seagrass habitat in the Hay Point area was in a satisfactory condition in 2015 with seagrass biomass the highest it has been since 2012
- Favourable climate conditions for deep water seagrasses (i.e. low rainfall and below average river flow) are likely to have facilitated the increases in biomass and area of the meadows in 2015
- Current seagrass density is still below historically high levels recorded in 2005

An 8 year monitoring program was undertaken to study the deep water seagrasses immediately offshore from the Port of Hay Point (York *et al.* 2015). Seagrass meadows were sampled on 23 occasions between 2004 and 2012, and the results indicate:

- The meadows are dominated by *Halophila decipiens*, which is the most common deep water seagrass species in the GBR lagoon
- The seagrass community was found to occur annually, being present only between July and December each year
- The seagrass community was shown to regrow every year, with the exception of 2006, during which time a large capital dredging project was underway (9 Mm^3 over 8 months)
- Post-dredging, seagrass recovery was fast, with presence recorded at all sites including the spoil disposal ground within 8 months of the completion of the dredging campaign

Overall the seagrass communities in and around the Port of Hay Point can be described as low density, ephemeral and spatially patchy. Compared to other high value seagrass meadows elsewhere in the GBRWHA, the communities at the Port 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 dugong.

4.7 Other benthic communities

4.7.1 Macroalgae

Four functional macroalgal groups have been identified within the Port of Hay Point area: erect macrophytes, erect calcareous, encrusting and filamentous algae. Species composition was found to vary across survey years and regions; the most common functional group of erect macrophytes was found generally to contain species of *Sargassum, Udotea* and *Caulerpa*. Algal communities within the Port of

Hay Point area vary greatly in their extent and percentage cover, particularly between survey years and regions (Worley Parsons 2014).

4.7.2 Benthic infauna

Hay Point is sparsely inhabited by benthic macroinvertebrate (epifauna) and macroalgae communities, with submerged rocky outcrops in the shallow waters of Dalrymple Bay. Previous studies have identified two regions where a moderate density of benthic macroinvertebrates occurred, located within and due west of the designated placement site. The substrate in these regions contained patches of rubble and supported a diverse variety of erect and encrusting bryozoans and polychaete worms. Other areas that were less densely populated with epifauna supported individuals or small communities of varying combinations of bryozoans, polychaetes, echinoids, gastropods, barnacles and bivalves. Generally, previous surveys have not found any high densities of epifauna in the Hay Point region, with the majority of areas studies containing less than 5% cover (Jacobs 2016).

The most recent surveys of benthic infauna in the Hay Point Port limits were associated with the HPCT Expansion Project (Worley Parsons 2014). Baseline (pre dredging) surveys in March/April 2010 were carried out across the Port and surrounding area. The surveys found a total of 1,855 individuals from 115 different families. Polychaete worms, bryozoans, molluscs and foraminifera were the most abundant representing 76% of all individuals. Polychaete worms represented 39% of all individuals. Infauna abundance and family richness were significantly lower at sites within the existing Hay Point dredged material placement site compared to sites outside the ground.

Post dredging surveys at the same sites were carried out in October 2011 (BMA 2012). The surveys found a total of 18,264 individuals from 337 families, considerably higher than those observed in 2010. Polychaete worms, crustaceans, molluscs and cnidarians represented over 90% of all individuals. Polychaete worms represented 46% of all individuals. The results suggest a recovery of infauna communities from the wide scale disturbance caused by TC Ului which passed through the area immediately before the baseline surveys in March/April 2010. There was no indication of impacts related to the HPX3 dredged material relocation either in or outside of the designated dredged material placement site (BMA 2012).

4.8 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 2 m – 8 m 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*).

The Hay Point peninsula has 22 ha of mangroves in enclosed wetland area on the southeast side of the peninsula. Minor stands have colonised rocky shorelines on both the northwestern and southeastern shores. There are minor stands (mostly *Avicennia marina*) on the eastern and southern sides of Hay Point. Louisa Creek has an extensive mangrove community (Jacobs 2016). Structural characteristics of the mangrove communities at Hay Point, Half Tide Tug Harbour and Louisa Creek are summarised in Table 10 (BMA 2009).

Table 10: Mangrove community description (from BMA 2009)

Locality	Substratum	Wind exposure	Height – highest stratum	Foliage projective cover	Structural formation
Hay Point	Boulders	Exposed	<2 m (shrubs)*	<10% (sparse)	*Avicennia marina* low open-shrubland
	Boulders/mud	Exposed	<2 m (shrubs)*	30 to 70% (mid dense)	*Avicennia marina* low open-scrub
	Mud/boulders	Semi-exposed	>2 m (shrubs)*	30 to 70% (mid dense)	*Avicennia marina* low open-scrub
Half Tide Beach	Boulders	Exposed	<2 m (shrubs)*	<10% (sparse)	*Avicennia marina* low open-shrubland
	Sand	Semi-exposed	5 m (trees)	30 to 70% (mid dense)	*Rhizophora* low open-forest
Louisa Creek	Mud	Sheltered	5 to 7 m (trees)	>70% (dense)	*Rhizophoral Bruguieria* low closed-forest

4.9 Terrestrial fauna

4.9.1 Migratory shorebirds

The area from Repulse Bay (to the north of the study area) to Cape Palmerston (in the south of the study area) is an important roosting and feeding habitat for migratory shorebirds. Over 1% of the East Asian – Australasian flyway population of seven migratory shorebird species uses this area and the study area is considered to be a significant staging area for these species. Migratory shorebirds use sheltered coasts with large intertidal mudflats or sandflats, often with seagrass beds. They are often recorded in saltmarsh and on mudflats fringed by mangroves, and will sometimes use mangroves.

The study area supports over 23,000 shorebirds each year during their annual migration, which is approximately 0.2% of the East-Asian – Australasian Flyway population. The area from the Port of Mackay to Armstrong Beach contains 12 significant shorebird roosting areas, and another 18 known roosting areas. Sandringham Bay is also a nationally and internationally significant area for five migratory shorebird species.

The following shorebird species have been recorded between Repulse Bay and Cape Palmerston. The Curlew Sandpiper and Eastern Curlew are frequently encountered along the coastline from Mackay Harbour to Armstrong Beach:

- *Actitis hypoleucos* Common Sandpiper
- *Arenaria interpres* Ruddy Turnstone
- *Calidris acuminata* Sharp-tailed Sandpiper
- *Calidris alba* Sanderling
- *Calidris canutus* Red Knot (endangered)
- *Calidris ferruginea* Curlew Sandpiper (critically endangered)
- *Calidris ruficollis* Red-necked Stint
- *Calidris tenuirostris* Great Knot (critically endangered)
- *Charadrius bicinctus* Double-banded Plover
- *Charadrius leschenaultia* Greater Sand Plover (vulnerable)
- *Charadrius mongolus* Lesser Sand Plover (endangered)

- *Gallinago hardwickii* Latham's Snipe
- *Limicola falcinellus* Broad-billed Sandpiper
- *Limnodromus semipalmatus* Asian Dowitcher
- *Limosa lapponica* Bar-tailed Godwit
- *Limosa limosa* Black-tailed Godwit
- *Numenius madagascariensis* Eastern Curlew (critically endangered)
- *Numenius minutus* Little Curlew
- *Numenius phaeopus* Whimbrel
- *Pluvialis fulva* Pacific Golden Plover
- *Pluvialis squatarola* Grey Plover
- *Tringa brevipes* Grey-tailed Tattler
- *Tringa incana* Wandering Tattler
- *Tringa nebularia* Common Greenshank
- *Tringa stagnatilis* Marsh Sandpiper
- *Xenus cinereus* Terek Sandpiper

4.9.2 Water mouse (*Xeromys myoides*)

The water mouse has one single nationally important population which extends along the coastline from south east Queensland to the Northern Territory. The species is known to have a particular stronghold in the greater Mackay area (Jacobs 2016).

The water mouse primarily forages at night in the intertidal zone, particularly amongst mangroves, at low tide, preying on crustaceans, molluscs and flatworms and therefore suitable habitat is available in the coastal areas surrounding the Port of Hay Point.

4.10 Marine fauna

Information presented below has been sourced from Jacobs (2016) and reference therein. The 'study area' referred to below includes the marine areas, extending in the north from the waters around Keswick and St Bees islands, west to Finlaysons 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 encompassing the area most likely to be directly influenced by port activities, including dredging.

4.10.1 Marine turtles

All six species of marine turtle that occur in Queensland have been recorded in offshore, intertidal, estuarine and shoreline habitats in the Hay Point region. Hawksbill (*Eretomochelys imbricata*) and Loggerhead (*Caretta caretta*) turtles also occur in the Mackay area, including observations of the species foraging within the Port of Mackay.

Mainland beaches in the study area are nesting sites for the Flatback Turtle (*Natator depressus*) and possibly the Green Turtle (*Chelonia mydas*) may also nest at these locations. Haliday Bay, in the north of the study area, is one of the most important Flatback Turtle nesting beaches in the Mackay region. A 2011 study of five potential nesting beach 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.

Green turtles are the most frequently observed marine turtle in the study area. The main Green Turtle breeding season occurs from September to March, with hatchlings emerging from December to May. Green turtles have occasionally been recorded nesting on beaches between Dudgeon Point and Mt

Hector Conservation Park from November to April. Low density Green Turtle nesting has been recorded within the Hay Point port limits.

The Flatback Turtle is the predominant species known to nest in the Dudgeon Point area, and is the most commonly observed species nesting on beaches in the Mackay region. The Mackay region can have between 30 and 100 nesting Flatback Turtles nest annually across the 30 beaches, with each laying around three times per season. Hay Point Beach and Salonika Beach are known to be the most heavily used beaches, with limited nesting also known to occur on McEwens Beach, Louisa Beach, Ballykeel Beach and Far Beach. A low density nesting of Flatback Turtles have been recorded within the Hay Point port limits, with the peak nesting period occurring in November to December.

There is only a single record of Leatherback Turtle (*Dermochelys coriacea*) nesting in Mackay, with no recorded nesting since 1993. Loggerhead Turtles have occasionally been sighted nesting in the Mackay region, with the first recorded sighting of a loggerhead nesting in the 2004/2005 season.

Inshore areas of the Port of Hay Point support a small resident population of Green Turtles. It has been suggested that they forage on algal covered rocky reefs and/or deepwater seagrass offshore of the coal terminals.

4.10.2 Marine mammals

Humpback whales (*Megaptera novaeangliae*) migrate through the study area June to October, peaking in August. Humpback whales use the waters off Hay Point during the migration. Females with calves were relatively common within the port limits during monitoring from 2009 to 2011. A core calving area has been identified offshore of Mackay. The exact location of this area is still unknown and further research is required to conclusively identify the breeding habitats; however, this identified calving area is outside of the study area.

Sei and Fin Whales (*Balaenoptera borealis*; *B. physalu*) are occasional visitors to the Hay Point area. While the Blue and the Southern Right Whales (*B. musculus*; *Eubalaena australis*) may occur in the study area, the study area is at the northern extent of their distribution and these species are unlikely to occur in inshore areas near the coast.

The pantropical Spotted Dolphin (*Stenella attenuate*), Indian Ocean Bottlenose Dolphin (*Tursiops aduncus*), Indo-Pacific Humpback Dolphin (*Sousa chinensis*) and potentially the Irrawaddy Dolphin (*Orcaella brevirostris*) occur in waters around Hay Point. These species are also likely to occur in the Mackay area. The Australian Snubfin Dolphin (*Orcaella heinsohni*) may also occur in the region due to the presence of its typical habitat (i.e. shallow coastal waters less than 20 m deep, often associated with tidal riverine and estuarine systems, enclosed bays and coastal lagoons).

Small herds of Dugong have been reported near Port Newry and Ince Bay. Dugongs are not known to forage in the study area due to the low abundance of seagrass (as noted above); however, seagrass in the study area could be important for transient Dugongs moving along the coast during period of food shortage.

Dugong Protection Areas (DPAs) have been gazetted south of Hay Point at Llewellyn Bay (DPA Type B) and Ince Bay (DPA Type A), approximately 20 km and 35 km south of Hay Point, respectively. These areas have high ecological value associated with abundant seagrass, as the primary food for dugongs. There are also DPAs north of the Mackay, at Sand Bay, Newry Region and Repulse Bay (outside of the study area), about 20 km, 40 km and 75 km north of Mackay, respectively.

4.10.3 Other reptiles and fishes

Reptiles other than marine turtles known to occur or that may occur in the study area include sea snakes and the saltwater crocodile. 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 is 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 the 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, butterflyfishes and snappers.

Some fish species aggregate around the wharf pylons and structures at the Hay Point coal terminals.

4.11 Tourism and recreation

Jacobs (2016) reported on the tourism and recreational use of the region. The findings are summarised below.

Tourism in the Mackay-Whitsunday Region is a regionally significant sector. In terms of the economic benefit to the Mackay Region, the overnight visitor economy is worth approximately $811 million in direct and indirect expenditure 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.

Both residents and visitors undertake recreational and tourism activities based on the region’s landscape character and areas of ecological significance. Attractions include national parks, gorges, and the GBR, as well as beaches and offshore islands.

The region’s natural assets, particularly the GBRWHA, are a key to the tourist experience. The iconic nature of the GBR gives tourists a reason to visit the region. Other natural assets that are valuable draw cards include the proximity to offshore islands. Accessibility to high-quality and diverse fishing areas, including the reef and freshwater systems and dams, is also a valuable natural asset which attracts visitors to the region.

The GBR and offshore islands are key tourist destinations within the region. Brampton and Keswick Islands are particularly important tourist destinations. Keswick Island and Brampton Islands are about 20 km and 33 km northeast of Hay Point, respectively.

Armstrong, Sarina, Salonika and Grasstree beaches are popular tourist beaches south of the Port of Hay Point. Other popular tourist beaches include Town and Far Beaches, which lie about 15 km northwest of the Port of Hay Point and about 6 km southwest of the Port of Mackay. Shoal and Slade points, north of the Port of Mackay are also popular coastal tourist destinations. The Port of Hay Point lookout is also a tourist site where tourists can view the port operations and there is a public boat ramp within Half Tide Tug Harbour.

Tourism in the region is highly reliant on the condition of natural assets to underpin the tourist experience. Both domestic and international tourism are also influenced by external factors. The global economic crisis, for example, saw a sharp reduction in international tourists, while a strong Australian dollar can result in an increase in domestic travel.

4.12 Fisheries

4.12.1 Commercial fisheries

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*).

State government data for the ten years 2004 – 2014[1] show the largest combined catches in the region 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.

Within the Mackay region, waters to the east and north of Hay Point show the greatest values of catch weight for the trawl fishery (>150,000 kg, grid refs O25S14, O25S9 and O25S15), followed by waters around Freshwater Point and Llewellyn Bay.

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).

4.12.2 Recreational fisheries

Recreational fishing is very important in the Mackay-Whitsunday Region. Approximately 28% of Mackay area residents fish recreationally, compared to the state average of 17%. Recreational fishing surveys in 2010 identified that the most popular recreational method was line fishing, with 547,000 fish caught, 308,000 of which were released.

The most commonly caught fish in the region (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 as yabbies are primarily used as bait. Emperors were also popular, with 74,000 fish caught (10% of the total), 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

[1] Data on commercial fishing activity within the Mackay region (as catch weight) between 2004 and 2014 includes net, trawl, pot fishing and combined total catches, respectively. The data are based on fisher logbooks and reflect total catches within each defined grid (10 x 10 km grid cells defined by Dept. of Agriculture, Fisheries and Forestry)

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.

4.13 **Heritage**

The most significant heritage value at the Port of Hay Point is the GBRWHA, which is also listed as a National Heritage Place. The GBRWHA is addressed in detail below (Section 4.14), while this section focuses on other heritage values

4.13.1 Brief history of Hay Point

Despite significant sailing activity past Hay and Dudgeon Points in the late eighteenth century, the first Europeans only landed on the Presto at Sandy Creek, just north of Dudgeon Point in 1862.

The process of European settlement had a significant impact on the Aboriginal people of the region. An Aboriginal reserve was established in 1871 in the area with 14,080 acres set aside near the Cape Palmerston and Homebush pastoral runs. By 1879 government funding for the reserve was cut and the land reclaimed for settlement, forcing the Aboriginal residents to move elsewhere. Between 1898 and 1967 there were 72 documented removals of Aboriginal people from the Mackay district by the Queensland Government. Most were removed to the reserves and missions at Yarrabah, Barambah (now Cherbourg), Woorabinda and Palm Island.

Development began in the southwest of Dudgeon Point in 1896, when a tramway from Plane Creek Sugar Mill to the mouth of Louisa Creek was completed.

In the late 1960s the Utah Development Company (USA) and Mitsubishi (Japan) began coal mining on a large scale at Goonyella, about 150 km south-west of Mackay. The consortium built a separate rail track, running parallel with the Queensland rail route in parts and proceeding through the Sarina district to Hay Point, the site for a large purpose built coal-export terminal. The first coal was loaded from it in 1971. Since 1983 a government-owned facility, leased to the private sector, has operated nearby at Dalrymple Bay.

4.13.2 The Indigenous people of the Hay Point area

The Yuwibara (Yuibera) People are the registered claimants of an area that includes the Port of Hay Point (QC2013/007). The Yuwibara people therefore have priority as parties as a registered native title claimant for the area covering the port including coastal waters. These rights are considered registered as an entry has been made on the National Native Title Register. They must be consulted with regard to the Indigenous cultural heritage of the area and any assessment of its significance.

The Wiri (Widi), Barada Barna Kabalbara and Yetimarla, Yuibera (Yuwibara), Birri-Gubba and Kungalburra peoples all have strong associations with the Mackay area and therefore Hay Point. They also have interests in terms of the cultural heritage of the area but recognise that the Yuwibara people have the particular care of the area related to the Port of Hay Point and therefore specific knowledge about traditions, observances, customs or beliefs associated with the area.

The port authority has consulted with the representatives of the Yuwibara people and the other Indigenous people of the area about plans for dredging (including placement of dredged material) and other development.

4.13.3 Identified Indigenous cultural heritage at Hay Point

Indigenous cultural heritage in Australia can be understood as cultural heritage relating to Aboriginal and Torres Strait Islander communities and may include traditional stories, knowledge and practices, and places with traditional stories and knowledge attached to them. An extensive legislative framework protects Indigenous cultural heritage.

It is also important to note that Indigenous people see the natural environment and the cultural landscape as integral parts of the Aboriginal heritage concept. Indigenous cultural values are viewed as being inextricably linked to the natural attributes of the landscape. The cultural significance of an area is not just due to the presence of tangible sites or objects; it is rooted in the 'connection to country' of its people.

Few Indigenous cultural heritage surveys and studies have been conducted in and around the Port of Hay Point area. Of those that have many are unpublished or not available in full. However, it is considered unlikely that there are significant unknown heritage sites in the area that have not yet been investigated. It is, however, assessed as likely that the sand dune area in the Louisa Creek area parallel to the freshwater swamp and going along the beach towards Mount Hector may contain sub-surface archaeological material.

Cultural heritage assessment consistently identifies Dudgeon Point as an area of Indigenous cultural significance. For the Yuwibara people (and other Indigenous groups in the area) the importance of Dudgeon Point is linked to Mount Hector and the coastline.

In 2003 and 2004 some areas of Aboriginal cultural significance were identified primarily in the Dudgeon Point coastal zone. The majority of these sites were concentrated on the bar of sand that extends from Dudgeon Point to Mount Hector along the coast (approximately 3 km). This dune system separates the freshwater lagoon from the littoral zone and appears to have been a focal point for subsistence activity in the past. In general the whole dune could be described as a Significant Aboriginal Area, but two main concentrations of artefacts have been located. Of these two scatters, the larger, southerly one includes material that suggests a number of activities were occurring in the area. Individual stone artefacts were also found in all of the sub-environments, from the coastal strip, to the cleared grazing land and into the remnant forest strip to the south.

From the perspective of Aboriginal people living a traditional lifestyle, the Dudgeon Point area offered a range of natural systems that feature access to fresh water and different types of food and raw materials. It was rich in resources, including food and medicine. It is reasonable to suggest that key places for resources would have been:

- Louisa Creek, where extensive shell middens are still visible.
- Sandringham Bay with its wide sandy estuarine conditions.
- Hay Point which contains the remnants of a traditional fish trap.
- The large lagoons along the coastline, such as at Dudgeon Point and west of Half Tide Beach near Hay Point.

4.13.4 Other cultural heritage

The National Heritage List, the Commonwealth Heritage List, the Queensland Heritage Register and the Mackay Regional Council Local Heritage Register do not include listings for any non-Indigenous cultural heritage sites within the Hay Point area.

Areas of local heritage interest, such as the sugar wharf at Louisa Creek, given its role in the development of the region's sugar industry, are recognised and are included in buffer areas relating to development and other port activities. In 2012, sites associated with early settlement, closer settlement pattern, pastoral and agricultural land management, small scale mining and the establishment of transport and communication networks were identified in the port area but were assessed as 'at best of local significance'.

4.14 Matters of National Environmental Significance (MNES)

A list of MNES with the potential to occur within the project region was generated through a search of protected matters using DoEE's online Protected Matters Search Tool (PMST[2]). The MNES included in this 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 Hay Point (as summarised in Jacobs 2016) and any existing data for the region more broadly.
- The habitat requirements and known distribution of species and ecological communities.
- 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 Table 11 and Table 12. Terrestrial species returned in the PMST search were not included in this assessment unless they are known to utilise nearshore habitats such as beaches and mangrove communities.

Table 11: Summary of MNES returned on PMST

MNES	Comment
World Heritage Places National Heritage Places	The proposed dredging and disposal will occur within the Great Barrier Reef World Heritage Area, which is both a World Heritage Place and a National Heritage Place
Wetland of International Importance	None
Great Barrier Reef Marine Park	The proposed dredged material relocation area is located within the Great Barrier Reef Marine Park
Commonwealth Marine Area	None
Listed Threatened Ecological Communities	Two – see Appendix E for assessment and Table 12 below for summary

[2] Search undertaken on 20 June 2017 on coordinates -21.24174; 149.25607 with a 30 km buffer (see Appendix F)

Listed Threatened Species	47 – see Appendix E for assessment and Table 12 below for summary
Listed Migratory Species	65 – see Appendix E for assessment and Table 12 below for summary

4.14.1 Great Barrier Reef World Heritage Area

The proposed dredging and material placement will occur within the GBRWHA.

Jacobs (2016) and Kaveney *et al.* (2017) provide an in depth analysis of the attributes of the project area and region that contribute to the GBRWHA's Outstanding Universal Value. This 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* (a copy of the methodology is included at Appendix G).

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

4.14.2 Great Barrier Reef Marine Park

The Port of Hay Point is excluded from the GBRMP, however the dredged material placement site and the outer section of the departure channel is inside the Marine Park boundary and the dredge vessel will move between both the Port and the GBRMP.

The GBRMP supports a wide variety of habitats, within which there is large variation. A total of 70 different bioregions have been identified, including 30 within the reef environment and 40 in the surrounding areas (GBRMPA 2009). The Great Barrier Reef Outlook Report (GBRMPA 2009) identifies the key habitats of the GBRMP. Those present within the Port of Hay Point and surrounding region include:

- Coastal habitats including islands, beaches, mangroves, and seagrass meadows
- Coral communities e.g. Round Top Island
- Seabed including the lagoon floor
- Open water, which connects all the GBRMP’s habitats.

The GBRMP also supports a number of physical, chemical and ecological processes. In addition to the environmental values, the GBRMP supports a number of social and cultural values. Those most relevant to the Port of Hay Point include:

- Aboriginal cultural values e.g. connection to Sea Country and presence of culturally important species such as marine turtles
- Local tourism
- Recreational fishing

4.14.3 Ecological communities and threatened/migratory species

The likelihood of occurrence assessment indicated that there are no threatened ecological communities (TECs) present within the Project area. However, there are a number of threatened and migratory species that are either known or considered likely to occur. These are listed in Table 12. The results of the full likelihood of occurrence assessment is provided in Appendix G.

Table 12: Threatened and migratory species known, likely or with the potential to occur at the Port of Hay Point

Scientific name	Common name	EPBC Act listing status	Likelihood of occurrence	Comment
BIRDS – THREATENED SPECIES				
Calidris canutus	Red Knot	Endangered, Migratory	Known	There are a number of significant shorebird feeding and roosting sites in the project area. The region is known to support over 23,000 shorebirds annually including this species.
Calidris ferruginea	Curlew Sandpiper	Critically endangered, Migratory	Known	There are a number of significant shorebird feeding and roosting sites in the project area. The region is known to support over 23,000 shorebirds annually including this species. This species is frequently encountered along the coastline from Mackay Harbour to Armstrong Beach.
Calidris tenuirostris	Great Knot	Critically endangered, Migratory	Known	There are a number of significant shorebird feeding and roosting sites in the project area. The region is known to support over 23,000 shorebirds annually including this species.
Charadrius leschenaultii	Greater Sand Plover	Vulnerable , Migratory	Known	As above
Charadrius mongolus	Lesser Sand Plover	Endangered, Migratory	Known	As above
Limosa lapponica baueri	Bar-tailed Godwit (western Alaskan)	Vulnerable, Migratory	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 the potential for the western Alaskan sub-species to occur.
Limosa lapponica menzbieri	Northern Siberian Bar-tailed Godwit	Critically endangered, Migratory	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 the potential for the northern Siberian sub-species to occur.
Numenius madagascariensis	Eastern Curlew	Critically endangered, Migratory	Known	There are a number of significant shorebird feeding and roosting sites in the project area. The region is known to support over 23,000 shorebirds annually including this species. This species is frequently encountered along the coastline from Mackay Harbour to Armstrong Beach.
MAMMALS – THREATENED SPECIES				
Megaptera novaeangliae	Humpback Whale	Vulnerable Migratory	Known	Humpback whales migrates through the project area from June to October, peaking in August. Whales use the waters off Hay Point during their migration and females with calves have been observed within the port limits.
Xeromys myoides	Water Mouse, False Water Rat	Vulnerable	Known	The region is considered a stronghold for this species. It inhabits the mangrove communities lining creeks and estuaries.
REPTILES – THREATENED SPECIES				
Caretta caretta	Loggerhead Turtle	Endangered Migratory	Known	Loggerhead turtles are known to foraging in the project area. There are occasional records of nesting in the region.
Chelonia mydas	Green Turtle	Vulnerable Migratory	Known	Green turtles are the most frequently observed of all turtle species in the study area. The inshore areas of the Port of Hay Point support a small resident population of Green Turtles that forage on algae covered reefs and deepwater seagrass. Low density turtle nesting has been observed within the port limits and occurred from Nov - April.
Dermochelys coriacea	Leatherback Turtle	Endangered Migratory	Known	This species has been recorded in the Hay Point region.
Eretmochelys imbricata	Hawksbill Turtle	Vulnerable Migratory	Known	This species has been recorded in the Hay Point region.

Lepidochelys olivacea	Olive Ridley Turtle	Endangered Migratory	Known	This species has been recorded in the Hay Point region.
Natator depressus	Flatback Turtle	Vulnerable Migratory	Known	This species is known to forage in the waters of the project area and nests in the region. Hay Point Beach and Salonika Beach are known to be the most heavily used nesting beaches. The region supports between 30 - 100 nesting turtles annually.
MIGRATORY SHOREBIRDS				
Actitis hypoleucos	Common Sandpiper	Migratory	Known	This species recorded between Repulse Bay and Cape Palmerston
Arenaria interpres	Ruddy Turnstone	Migratory	Known	As above
Calidris acuminata	Sharp-tailed Sandpiper	Migratory	Known	As above
Calidris alba	Sanderling	Migratory	Known	As above
Calidris melanotos	Pectoral Sandpiper	Migratory	Potential	This species has not been recorded in the project area, however suitable habitat is present.
Calidris ruficollis	Red-necked Stint	Migratory	Known	This species recorded between Repulse Bay and Cape Palmerston
Double-banded Plover	Charadrius bicinctus	Migratory	Known	As above
Charadrius veredus	Oriental Plover	Migratory	Potential	This species has not been recorded in the project area, however suitable habitat is present.
Gallinago hardwickii	Latham's Snipe	Migratory	Known	This species recorded between Repulse Bay and Cape Palmerston
Limicola falcinellus	Broad-billed Sandpiper	Migratory	Known	This species recorded between Repulse Bay and Cape Palmerston
Limosa lapponica	Bar-tailed Godwit	Migratory	Known	As above
Limosa limosa	Black-tailed Godwit	Migratory	Known	As above
Numenius minutus	Little Curlew	Migratory	Known	As above

Numenius phaeopus	Whimbrel	Migratory	Known	As above
Pandion haliaetus	Osprey	Migratory	Likely	This species is likely to forage and nest in the project area and region
Pluvialis fulva	Pacific Golden Plover	Migratory	Known	This species recorded between Repulse Bay and Cape Palmerston
Pluvialis squatarola	Grey Plover	Migratory	Known	As above
Tringa brevipes	Grey-tailed Tattler	Migratory	Known	As above
Tringa glareola	Wood Sandpiper	Migratory	Known	As above
Tringa incana	Wandering Tattler	Migratory	Known	As above
Tringa nebularia	Common Greenshank	Migratory	Known	As above
Tringa stagnatilis	Marsh Sandpiper	Migratory	Known	As above
Xenus cinereus	Terek Sandpiper	Migratory	Known	As above
OTHER MIGRATORY SPECIES				
Sternula albirfrons	Little Tern	Migratory	Potential	This species inhabit sheltered coastal environments. There are no breeding colonies in the project area or region.
Crocodylus porosus	Salt-water Crocodile	Migratory	Known	This species is known to inhabit the creeks and estuaries of the project area.
Dugong dugon	Dugong	Migratory	Known	Dugongs are known to occur in the waters off Hay Point. They are not known to forage in the project area due to the low abundance of seagrass.
Manta alfredi	Reef Manta Ray	Migratory	Potential	This species may occur in waters off Hay Point
Manta birostris	Giant Manta Ray	Migratory	Potential	This species may occur in waters off Hay Point
Orcella brevirostris	Irrawaddy Dolphin	Migratory	Potential	This species may occur in waters off Hay Point

Sousa Chinensis	Indo-Pacific Humpback Dolphin	Migratory	Known	This species occurs in the waters off Hay Point.

5 Potential impacts

The potential impacts of dredging have been well documented recently 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 Hay Point. Detailed risk assessment of how these potential impacts may effect environmental values at the Port is provided in Section 7.

5.1 Seabed disturbance

5.1.1 Within the dredging footprint

Maintenance dredging involves the removal of sediments that have accumulated in the artificially deepened channels or berths between maintenance dredging periods (generally once every few years). Each maintenance dredging campaign generally involves disturbance of the same area or dredge footprint.

Sediments at Hay Point are comprised of fine materials (e.g. silts or fine sands) that have been transported by currents into the deeper channels and berths. Most of the fauna/flora that colonises 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 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.

5.1.2 Within the dredged material placement site

Placement of dredged material at the dredged material placement site results in burial and smothering of resident benthic communities. Similar to dredging footprints, impacts to a dredged material placement site are an unavoidable consequence of placing material at-sea. Dredged material placement sites 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 dredged material placement sites generally follows consistent patterns at Queensland Ports, including the Port of Hay Point. Studies of the impacts of dredged material disposal have shown that (Ports Australia 2014):

- Seabed fauna (e.g. polychaetes, bivalves, and anemones) in the dredged material placement site 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 a fresh source 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 dredged material placement site 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 dredged material placement site). At the Port of Hay Point, the recovery period after large scale capital dredging was 6 – 12 months.

- There was some evidence of opportunistic rapid colonisers (mainly polychaetes) being more common at the dredged material placement site than at reference sites.

5.2 Impacts to water quality

5.2.1 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 dredged material placement site (e.g. through Trailing Suction Hopper Dredge discharges or barge releases) and through dispersion of placed material from the dredged material placement site.

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 dredged material placement site 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.

5.2.2 Release of contaminants and/or nutrients

All material proposed for at-sea placement is tested according to the NAGD and subject to strict testing and approval protocols to assess potential impacts relating to the resuspension or placement of contaminated material. All previously dredged material at the Port of Hay Point has undergone testing in accordance with the NAGD. Contaminant levels are all below screening criteria (some below detection levels, see Table 8) and are considered suitable for ocean disposal.

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.

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 on eutrophication related (algal bloom) water quality issues are rare because the events are short lived, there is typically fairly rapid dilution and, relative to the dilution, nutrient release is small.

5.2.3 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 garbage or untreated sewage or oily wastes in the GBR region

5.3 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.

5.4 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 upperdeck 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).

5.5 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 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.

5.6 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.

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.

Any dredge vessel contracted to undertake dredging works at the Port of Hay Point will be required to comply with best hygiene practices, including AQIS 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

5.7 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 permanent 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.

6 Measures to avoid and reduce impacts

Significant work has been undertaken to analyse the need and optimal options for managing sediments at the Port of Hay Point. The SSM project (Kaveney *et al.* 2017) did the following:

- Assessed the feasibility of avoiding or reducing the need for maintenance dredging at the Port of Hay Point
- Comprehensively investigated opportunities to beneficially reuse accumulated material that is to 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
- Considered the ‘immediate’ (1-3 years) and ‘long-term’ (25 years) suitability of alternatives.

The overarching outcome of the project was that maintenance dredging will be periodically required at the Port of Hay Point 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 Hay Point. These are discussed below.

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

- Port of Hay Point Long-term Maintenance Dredging Management Plan
- Port of Hay Point Maintenance Dredging Environmental Management Plan
- Port of Hay Point Marine Environment Monitoring Program

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

7 Impact analysis

7.1 Changes to water quality

A frequent concern related to dredging is the changes in water quality resulting from increased suspended sediments, particularly as this may result in impacts to sensitive marine environments in some circumstances. Detailed analysis of potential changes to water quality was undertaken for the proposed maintenance dredging at the Port of Hay Point (Symonds 2017b, RHDHV 2018a). Importantly, this analysis considered a range of dredge volumes, metocean conditions, seasons and sediment compositions. The work was undertaken in line with relevant policy guidance (i.e. GBRMPA 2012).

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 Hay Point 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 up to ~800,000 m^3 do not drive the system outside of what it experiences naturally and as such impacts to sensitive receptors are not anticipated from campaigns up to this volume. The analysis of volumes reflective of likely dredging campaign volumes (200,000 m^3 to 400,000m^3) are not likely to result in impacts to sensitive receptors. The analyses are discussed further below.

7.1.1 Resuspension

Symonds (2017b) undertook an assessment of the natural resuspension of sediment at the Port of Hay Point and compared that to conditions generated by maintenance dredging. The assessment found that the annual mass of sediment resuspended by typical conditions is in the order of 7 – 9 million tonnes per year in the Hay Point region[3]. In addition to this, ~4.7 million tonnes of sediment was resuspended within the Hay Point region during TC Debbie. As such, during a year when a tropical cyclone occurs, the natural resuspension could increase to 12 – 14 million tonnes per year.

Relationships between suspended solid concentrations (SSC) and wind speed for the Hay Point region show that wind is a key driver of natural turbidity conditions (Symonds 2017b). SSC concentrations increase proportionally with wind speed up to 20 knots and then exponentially after that. When natural SSC levels across a range of wind speeds are compared with a maintenance dredging scenario reflective of the initial campaign[4], the data show that SSC levels from dredging are approximately comparable to the natural SSC during calm conditions (wind speeds of 15 knots and under) (Figure 7). Such conditions (wind speeds) are the average for the region.

[3] Hay Point region is to 20 m LAT and 20 km north and south of the Port

[4] Dredging of 400,000 m^3 with placement at the existing placement site

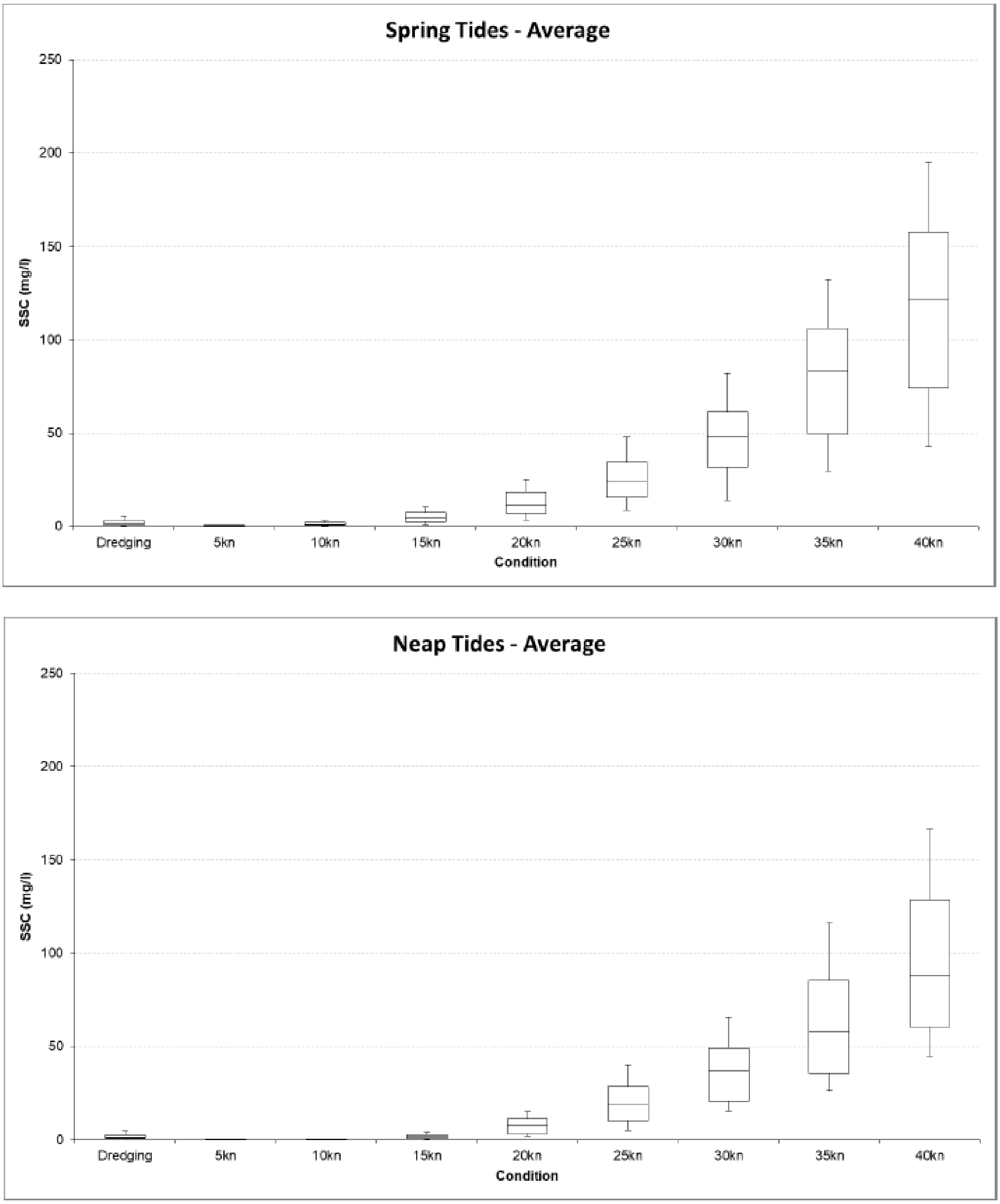

Figure 7: Natural SSC at various wind speeds versus maintenance dredging scenario (from Symonds 2017b). Box and whisker plots show average percentiles (over four sites) during spring (above) and neap (below) tides, with the box representing the 20th, median (middle line) and 80th percentile, while whiskers are 5th and 95th percentiles.

7.1.2 Sediment transport

RHDHV (2018a) undertook numerical modelling to understand both the natural sediment transport conditions along with the transport of sediment suspended by maintenance dredging activities. Modelling the natural SSC allows a better understanding of the natural spatial and temporal variability and enables the SSC resulting from maintenance dredging to be considered in the context of the natural environment (i.e. natural + dredging). This work explored a large range of scenarios (112 model simulations) and importantly considered a range of maintenance dredge volumes from 100,000 m^3 to 1.2 Mm^3, thereby encompassing the initial and potential future campaigns, as well as the total 10 year combined maintenance dredging amount.

The results show that suspended sediment resulting from the dredging and dredged material placement activity can be transported in both northerly and southerly directions due to natural wind and tidal currents. Transport in a northerly direction is dominant due to the prevailing south-easterly winds strengthening the currents to the north. Natural SSC is generally much higher than the SSC resulting from maintenance dredging, as depicted in Figure 7. In the areas away from the dredging locations and the placement site, the occurrence of an increase in SSC due to dredging and placement is typically also associated with an increase in natural SSC at the same time. This is because the increases are the result of resuspension of bed sediment (both natural and deposited material from dredging) which is typically due to a combination of tidal currents and wave energy.

For 50% of the dredging duration the SSC is less than 2 mg/l except for the area directly adjacent to the dredging and disposal location. This shows that for half the time the dredging occurs, the increases in SSC are expected to be low everywhere except for the area where the dredging and disposal is being undertaken. Short duration (less than 5% of the time) increases in SSC above 5 mg/l can occur away from the dredging location and dredged material placement areas (DMPAs) in the region from 2 km south of Half Tide Tug Harbour to Slade Islet and from the eastern edge of the existing DMPA to approximately 1 km west of Round Top Island (Figure 8).

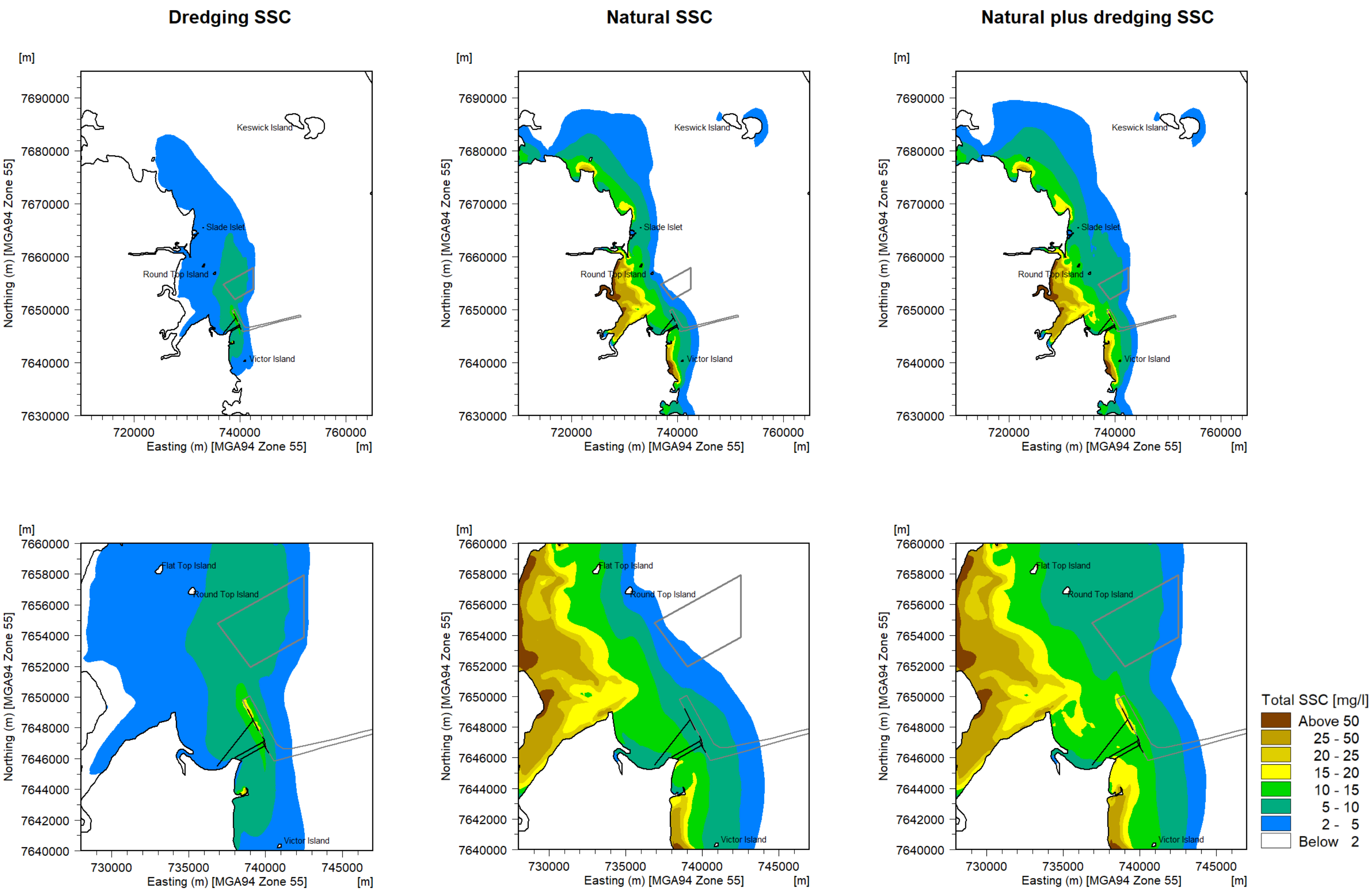

Figure 8: Areas that will experience short term (less than 5% of the time) increases in SSC above 5 mg/L

(eg. 95th percentile SSC for dredging, natural and natural plus dredging for 400,000m³ of sediment using the existing DMPA in the typical year, dry season)

7.1.3 Water quality impact thresholds

Impact thresholds have been developed in order to avoid or manage potential impacts to water quality and sensitive receptors (RHDHV 2018a). For an upfront consideration of impacts, it is also informative to understand where and under what conditions these thresholds may be exceeded.

The analysis of threshold exceedance shows the intensity and duration threshold defined for Round Top Island is consistently exceeded for large areas of nearshore waters landward of Round Top Island. This is to be expected as the threshold was defined based on measured data at Round Top Island and the areas inshore are known to be naturally of higher SSC. The addition of maintenance dredging shows an increase in SSC that extends the natural area of exceedance further offshore. This area is widest between the Hay Point apron area and Round Top Island, but for dredge volumes of 200,000 m^3 and 400,000 m^3, the exceedance does not reach Round Top Island. This demonstrates that the combined natural and dredging SSC at Round Top Island is indicated to remain within the natural range for both the current and future maintenance dredging campaigns.

The dredge duration (and therefore volume) is important to consider as the longer the duration, the higher the probability that natural events which result in elevated SSC occur. To better understand what the critical dredge durations and dredge volumes are, threshold exceedance analysis was undertaken for a range of dredge volumes between 100,000 m^3 and 1.2 Mm^3.

The assessment found that volumes up to 800,000 m^3 can be dredged without the SSC conditions at Round Top Island exceeding the thresholds (i.e. being outside the measured range of natural conditions) (

Table 13). Beyond that volume and in the dry seasons of energetic years, thresholds begin to be exceeded at Round Top Island. Exceedance plots for 800,000 m^3 show that the exceedance area has moved landward and is now limited to the landward edge of Round Top Island (Figure 9). This indicates that this volume is the limit beyond which impacts from increased SSC may not be avoided. Notably, this is only the case during the dry season and energetic years. When a typical year was analysed, thresholds were not exceeded for any dredge volume in both wet and dry seasons (

Table 14). Dredging volumes will be substantially lower (200,000 m^3 to 400,000 m^3) than these volumes which result in exceedances of natural conditions.

The results of the exceedance analysis show that the natural conditions which occur over the dredge campaign duration are very important at determining whether the threshold is exceeded at Round Top Island. This is highlighted as the threshold has only been exceeded at Round Top Island during simulations of the energetic year when natural SSC will be at its highest. The natural conditions dictate how close to Round Top Island the natural exceedance contour is, which in turn partially controls whether the SSC increases due to maintenance dredging result in the threshold being exceeded at Round Top Island.

Table 13: Comparison of modelled SSC conditions across maintenance dredging volumes against intensity (15 mg/l) and duration (hrs) threshold (for energetic year 2006)

Volume and dredge duration	Duration over threshold level[1]		Max. duration threshold	Threshold exceedance?
	Natural	Natural + dredging		
Wet season				
100,000 m^3, (~9 days)	4	5	176	No
200,000 m^3, (~18 days)	22	26	258	No
400,000 m^3, (~36 days)	231	265	280	No
600,000 m^3, (~54 days)	231	270	300	No
800,000 m^3, (~72 days)	231	270	300	No
1,000,000 m^3, (~90 days)	235	287	305	No
1,200,000 m^3 (~108 days)	239	299	305	No
Dry season				
100,000 m^3, (~9 days)	2	4	81	No
200,000 m^3, (~18 days)	12	41	109	No
400,000 m^3, (~36 days)	12	41	115	No
600,000 m^3, (~54 days)	29	66	115	No
800,000 m^3, (~72 days)	48	102	115	Limit
1,000,000 m^3, (~90 days)	64	128	115	Yes
1,200,000 m^3 (~108 days)	67	135	115	Yes

1: threshold is 15 mg/l

Table 14: Comparison of modelled SSC conditions across maintenance dredging volumes against intensity (15mg/l) and duration (hrs) threshold (for typical year 2012)

Volume and dredge duration	Duration over threshold level[1]		Max. duration threshold	Threshold exceedance?
	Natural	Natural + dredging		
Wet season				
100,000 m^3, (~9 days)	0	7	176	No
200,000 m^3, (~18 days)	6	20	258	No
400,000 m^3, (~36 days)	44	111	280	No
600,000 m^3, (~54 days)	91	204	300	No
800,000 m^3, (~72 days)	120	236	300	No
1,000,000 m^3, (~90 days)	120	236	305	No
1,200,000 m^3 (~108 days)	120	236	305	No
Dry season				
100,000 m^3, (~9 days)	0	0	81	No
200,000 m^3, (~18 days)	0	0	109	No
400,000 m^3, (~36 days)	0	0	115	No
600,000 m^3, (~54 days)	0	0	115	No
800,000 m^3, (~72 days)	0	1	115	No
1,000,000 m^3, (~90 days)	12	31	115	No
1,200,000 m^3 (~108 days)	12	36	115	No

1: threshold is 15 mg/l

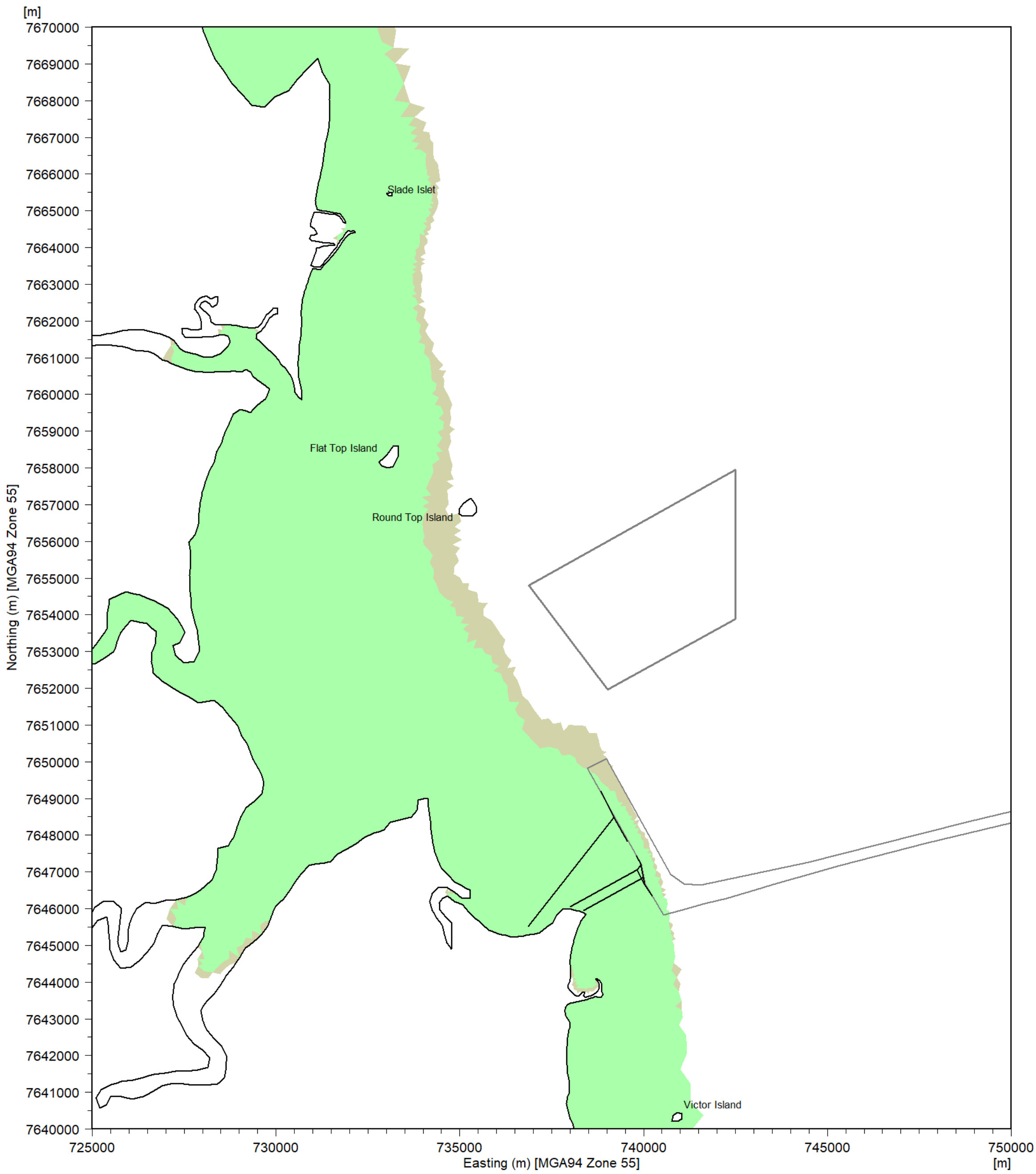

Figure 9: Exceedance plot for 800,000 m³ campaign, being the volume that SSC begins to exceed natural conditions. Green areas are where thresholds are exceeded naturally, with brown highlighting where additional exceedance occurs due to dredging. Note exceedance is just reaching south-west corner of Round Top Island.

7.1.4 Long-term resuspension

In terms of long-term resuspension of sediments from the dredged material placement site, predicted impacts are supported by observations from previous dredge campaigns (RHDHV 2018a). Long-term resuspension modelling of maintenance dredge volumes analogous to the initial (356,553 m^3) and potential future campaigns (200,000 m^3) has shown that resuspension of sediments from the dredged material placement site occurs during short duration large events (e.g. tropical cyclone) rather than regular resuspension due to tides and wave. When this occurs, resuspension results in localised increases of SSC both at the placement site and in the immediate vicinity. Importantly, SSC levels will be naturally elevated during such events, resulting in resuspension of dredged material being a minor component of overall turbidity in the region. The analysis also demonstrates that it is only likely to be freshly deposited sediments that are eroded, rather than consolidated layers. Both modelling and observations from previous campaigns, highlight that two thirds of dredged material is retained in the placement site.

7.1.5 Release of contaminants and nutrients

As discussed in Section 4.2.1, sediments from the Port of Hay Point have been previously sampled and deemed appropriate for unconfined ocean disposal. Results of current (2018) sediment sampling were not available at the time of writing, however, based on previous sampling it is not anticipated any contaminants will be recorded at levels greater than screening levels in the NAGD. Therefore, impacts from the release of contaminants are not likely to occur at either the dredge areas or placement site.

Fine sediment from riverine outputs which may have high levels of nutrients (Nitrogen, Ammonia and Phosphorus) may become trapped within the berth pockets over time. These nutrients can be released into the marine environment when the fine sediments are dredged and then relocated to the relocation ground. Previous sediment characterisation studies at the Port have found no high levels of nutrients of concern (Worley Parsons 2014) and impacts are not anticipated. However, ambient water quality monitoring results indicate elevated nutrient concentrations occur at the Port, most likely due to coastal run off. Nutrient concentrations monitoring should form part of the impact monitoring program, including pre, post and during dredging.

7.2 Impacts to sensitive habitats

7.2.1 Benthic infauna communities

The primary impacts to benthic infauna communities will be direct disturbance within the dredge footprints and smothering at the dredged material placement site. Initially, up to 356,553 m^3 of sediment will be removed, all of which is potential habitat for benthic infauna. Future campaigns will remove up to 200,000 m^3.

Smothering of benthic habitats will occur at both the dredging sites as material resettles and at the dredged material placement site. Deposition analyses (RHDHV 2018a) show that the majority of the deposition due to the dredging and material placement activity occurs at the dredging locations (north apron, DBCT berths and Half Tide Tug Harbour) and within and adjacent to the placement site. As expected, deposition increases with dredge volume.

The highest rates of deposition occur at the dredging locations, where localised deposition can exceed 1,000 mg/cm^2 (equivalent to 50 mm thickness). Outside of dredging locations deposition is below 100 mg/cm^2 (equivalent to 5 mm thickness) and close to sensitive receptors such as Round Top Island, deposition is below 20 mg/cm^2 (equivalent to 1 mm thickness). Deposition patterns for a 400,000 m^3 campaign (indicative of the initial campaign) are presented in Figure 10.

The existing dredged material placement site has been used previously for both capital and maintenance dredged material placement. Previous studies (Trimarchi and Keane 2007) have demonstrated that recovery of infaunal communities occurred within 6 – 12 months of the cessation of dredging. Similar recovery after initial and future campaigns is expected.

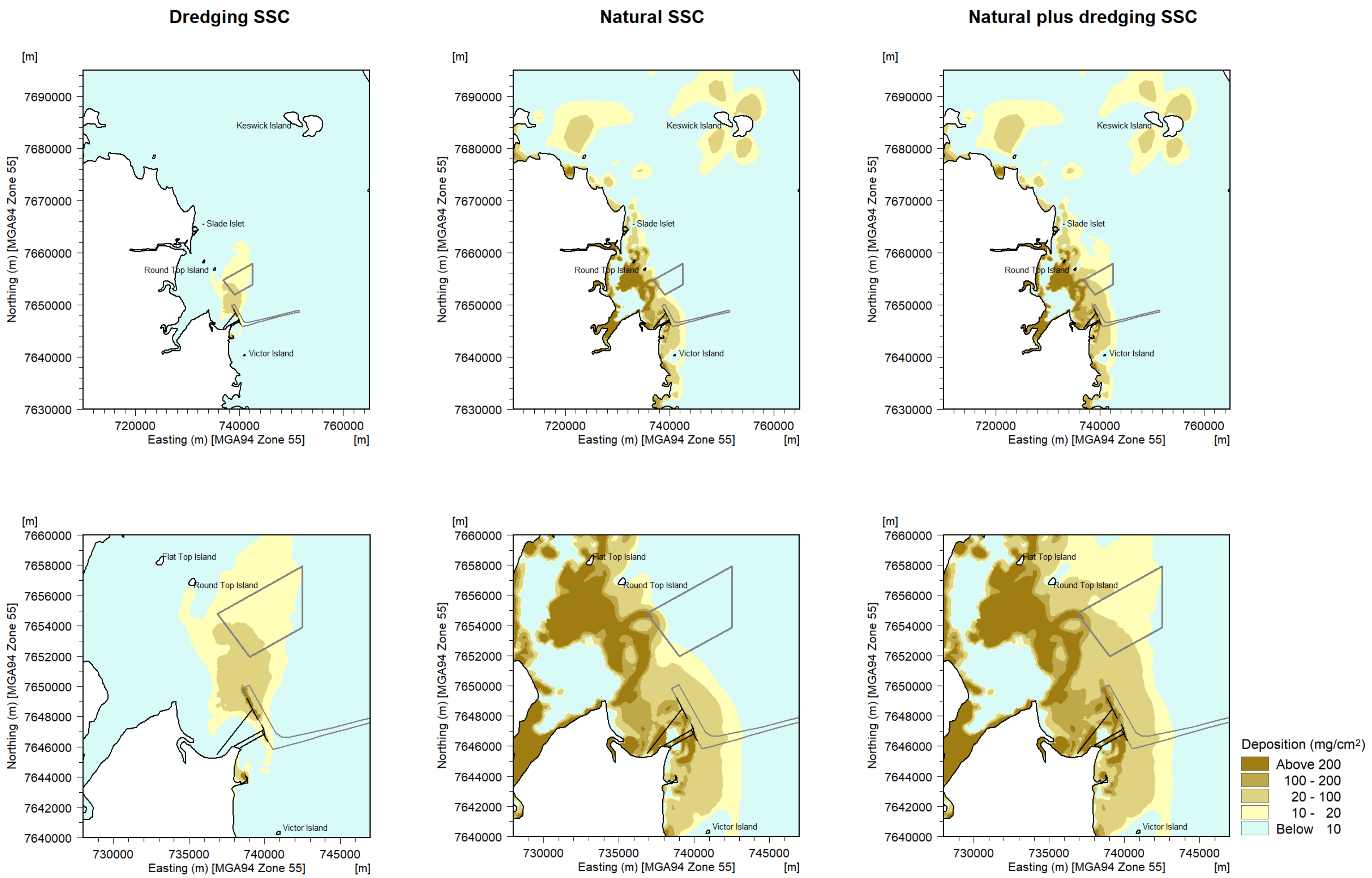

Figure 10: Deposition patterns for a typical year dry season campaign of 400,000 m³.

7.2.2 Coral communities

There are a number of inshore coral communities present in the Hay Point region that may be effected by maintenance dredging. Coral communities at Round Top Island are those of most concern, as this site has the greatest potential to be effected by altered water quality conditions during dredging (RHDHV 2018a). The coral community at this site is typical of an inshore reef, with coral diversity dominated by sediment tolerant *Montipora* and *Turbinaria* species. Average coral cover at Round Top Island is ~20 – 23% (Advisian 2016).

Impacts to coral communities at Round Top Island are not anticipated from the initial or future maintenance dredging campaigns. This is primarily because at the proposed dredge volumes impact threshold analysis shows that the alterations to water quality from dredging will not exceed the natural variability experienced at the site. Both sediment transport and deposition assessments show very low increases in sediment at the site during and immediately after dredging.

While modelled predictions indicate no expected impact, it is planned that a real time adaptive management program will be implemented to further ensure risks to coral communities at Round Top Island (and elsewhere) are minimised and appropriately managed. Based on the intensity, frequency and duration analysis described earlier, ecologically appropriate threshold will be set and applied in the Dredging Environmental Management Plan (EMP). Should water quality (SSC/NTU) 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.

Further to real time risk avoidance, pre and post-dredging coral monitoring will be undertaken. These surveys aim to detect any effects of dredging that may not have been predicted to better inform future dredging activities. Similarly, ongoing ambient monitoring of coral communities will be undertaken annually. This will provide an ongoing understanding of the health of corals in the Hay Point region and will be factored in to 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 volumes under 800,000 m^3, this includes during coral spawning seasons as dredging will not alter or exceed ambient conditions.

There is a high degree of confidence in the above impact conclusions based on the results of previous dredging campaigns. Notably, the 2006 capital dredging campaign (9 Mm^3) resulted in some damage to corals and reductions in coral cover at Round Top Island and Victor Islet, with the following observations (Trimarchi and Keane 2007):

- 3 and 6 months after dredging commencement, up to 4% (Round Top Island) and 6.5% (Victor Islet) of corals showed some patches of mortality that were related to sediment accumulation on the colony surface. This did not cause any whole-colony mortality.
- 6 months post completion of dredging, very small reductions in hard coral cover were recorded relative to baseline conditions measured 12 months prior (1% at Round Top Island; 3% at Victor Islet)

The proposed maintenance dredging is significantly smaller in magnitude that the previous capital program.

7.2.3 Seagrass meadows

Overall the seagrass communities in and around the Port of Hay Point can be described as low density, ephemeral and spatially patchy. Compared to other high value seagrass meadows elsewhere in the GRWHA, the communities at the Port 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.

Low level impacts to seagrass communities are likely to result from the current and future maintenance dredging campaigns. Patchy, low density seagrass is located throughout the Port limits and surrounding area, including at the dredged material placement site. Seagrass patches will experience sediment deposition and/or decreased light levels depending on their location. The exact extent of seagrass to be impacted cannot be accurately calculated due to the seasonal change in location of seagrass.

Results of an ecological thresholds analysis (RHDHV 2018b) has demonstrated that seagrass at the Port of Hay point experience naturally very low light conditions. Analysis of the long-term Photosynthetically Active Radiation (PAR) dataset for the Port showed that light intensity is below 1.1 – 2.0 mol photons/m^2/day for the majority of the time at most monitoring sites and these low light levels are maintained for 6 days. This is particularly relevant, as published literature suggests that a PAR threshold for the *Halophia* sp. of 1.1 – 2.0 mol photons/m^2/day, with exposure of no more than 7 consecutive days below the threshold level. The analyses have shown that seagrasses at Hay Point naturally experience conditions well below the threshold levels, potentially explaining the patchy and sparse nature of seagrass in the area.

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. Overall, the impacts to seagrass patches from maintenance dredging are expected to be localised and short-term. Previous studies (York *et al.* 2015) of seagrasses in the region have demonstrated that seagrass has regrown annually, even in years when previous maintenance dredging has been undertaken. Furthermore, after the 2006 capital dredging project was completed (9 Mm^3 over 8 months), seagrass recovery was fast, with presence recorded at all sites including the spoil disposal ground within 8 months of the completion of the campaign (Trimarchi and Keane 2007).

In the wider context of the GBR, impacts to seagrass patches as a result of maintenance dredging at the Port are not considered to be significant. The precise extent of impact cannot be quantified with certainty as the presence and extent of seagrass can vary, however, given the spatially isolated and low density nature of seagrass at Hay Point, impacts are not considered to be severe. There is also previous evidence of post dredging recovery (Trimarchi and Keane 2007). Importantly, when compared to other high value seagrass meadows elsewhere in the GBRWHA, the communities at the Port are not considered particularly notable or important (Jacobs 2016), and local impacts are not considered to be significant at a broader scale.

Seagrass patches at the Port provide a small contribution to the maintenance of local habitat values for marine species including turtles and dugong. Impacts to these species are discussed below.

7.2.4 Mangroves and coastal environments

The Hay Point peninsula has 22 ha of mangroves in enclosed wetland area on the southeast side of the peninsula and inshore coastal habitats surround the landward fringes of the Port. These areas may be impacted by maintenance dredging via deposition of disturbed sediments and/or reductions in water quality.

Deposition from dredging is not predicted to occur in coastal areas (RHDHV 2018a and see Figure 10 above). As indicated in RHDHV (2018a) and discussed above, the inshore areas of the Port of Hay Point are naturally highly turbid environments. Maintenance dredging of the volumes proposed in the current and future campaigns will not result in conditions that are outside of those that occur naturally in the region. Sediments have also been identified as being free of contamination and suitable for ocean disposal. Therefore, impacts from water quality on coastal communities are not expected.

7.3 Impacts to protected species

7.3.1 Marine turtles

All six species of marine turtle are known to occur in the waters off the Port of Hay Point. The Port does not provide any critical breeding, nesting, inter-nesting or foraging habitat for large populations of Green, Flatback, Hawksbill, Leatherback, Loggerhead or Olive Ridley Turtles. The area does, however, provide local foraging habitat for individuals including coastal and deeper-water seagrass beds and algal communities. The area also supports breeding Green and Flatback Turtles, with low density nesting occurring near the Port and in the wider region.

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 150 m of the vessel and operations not recommence until individuals have vacated the area or until 20 minutes after the last sighting. Marine fauna include turtles, dugong, whales and dolphins.

Turtles may be indirectly impacted via removal/degradation of habitat or from disturbance via artificial lighting. Direct impacts to seagrass and algal habitat as a result of dredging will be small (Section 7.2.3). There is no seagrass present in the areas proposed to be dredged. Deepwater seagrass within and adjacent to the dredged material placement site is low density and ephemeral and therefore cannot be considered a key food resource for turtle species. Limited and short term (up to one growing season) loss of seagrass is not likely to adversely affect turtle food availability in the region.

Artificial lighting will be concentrated in the dredge areas (berth pockets 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.

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

7.3.2 Dugongs

Dugong occur in the waters of the Port of Hay Point, however they are not known to forage due to the poor quality of seagrass resources. There are Dugong Protection Areas (DPAs) to the north and south of the Port that provide high quality habitat areas. These areas are north of Slade Point and south of freshwater Point, well beyond predicted water quality changes resulting from dredging.

As for marine turtles, Dugong may be directly or indirectly impacted by dredging activities. The risk of vessels strike is considered low as dredge vessel operates at very slow speeds and collision risk is known to be highest from fast moving (usually small) vessels. Interactions between Dugongs and drag heads are unlikely. Marine fauna monitoring should be implemented as described above.

Dugong may be indirectly impacted via removal/degradation of habitat or from disturbance via artificial lighting. Direct impacts to seagrass habitat as a result of dredging will be small (Section 7.2.3). There is no seagrass present in the dredge areas. Deepwater seagrass within and adjacent to the dredged material placement site is low density and ephemeral and therefore cannot be considered a key food resource for Dugong. Limited and short term (up to one growing season) loss of seagrass is not likely to adversely affect turtle food availability in the region.

Analysis of sediment transport and resuspension from maintenance dredging (RHDHV 2018a) has demonstrated that there are no predicted impacts to the DPAs.

As Dugong are listed as migratory under the EPBC Act, an assessment against significant impact criteria was undertaken (Appendix H). This concluded that impacts to Dugong from maintenance dredging at the Port are not likely to be significant.

7.3.3 Whales and dolphins

Humpback whales migrate through the Hay Point region from June to October, peaking in August. Females with calves were relatively common within the port limits during 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 poorly defined and further research is required to conclusively identify the breeding habitats; however, this identified calving area is outside of the area that will experience impacts from maintenance dredging. Sei and Fin Whales (*Balaenoptera borealis*; *B. physalu*) are occasional visitors to the Hay Point area and inshore dolphin species are also present.

Whales and dolphins may be directly or indirectly impacted by dredging activities. The risk of vessels 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.

Whales and dolphins may also be indirectly impacted via habitat removal/disturbance and from underwater noise. 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 and Australian Snubfin Dolphins have been recorded in close proximity to seagrass beds (Parra 2006). Maintenance dredging will remove a small area of inshore habitat and placement will impact the previously utilised 18 ha dredged material placement area due to smothering. This is a small total area relative to that available in the region and recovery of habitat values within the placement site is expected to occur between dredging campaigns.

Humpback and other whale species may be impacted by changes in water quality degrading the habitat quality of inshore areas. However, the coastal environments surrounding the Port of Hay Point are naturally turbid and as demonstrated in RHDHV (2018a) maintenance dredging of the volumes proposed in the current and future campaigns will not results in conditions that are outside of those that occur naturally in the region. Whales are considered unlikely to be adversely affected by water quality changes during maintenance dredging at the Port. These changes will be short-term and individuals are able to utilise coastal and deeper waters offshore of the Port, which will not be impacted by maintenance dredging. Changes to the marine water quality in the Hay Point region are considered unlikely to effect the feeding patterns of Humpback Whales, as feeding during migration and within resting areas is opportunistic and forms only a small portion of the nutritional requirements for the Humpback Whale (TSSC 2015).

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 effect individuals at the Port of Hay Point. Noise from the dredge will be low and dredging campaigns short-term (up to 40 days for 400,000 m^3). 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 over 1000 ship calls a year. Dredge related noise is not anticipated to interrupt the whales' migratory journeys given the large areas of suitable habitat nearby.

As a number of whales and dolphin species are listed as threatened and/or migratory under the EPBC Act, an assessment against significant impact criteria was undertaken (Appendix H). This concluded that impacts to relevant species from maintenance dredging at the Port are not likely to be significant

7.3.4 Coastal terrestrial species

The Mackay Region is considered to be an internationally important area for migratory shorebirds and a stronghold for the Water Mouse. However, impacts to these species from maintenance dredging are not anticipated. As terrestrial species, there will be no direct interactions between individuals and the dredge vessel. Furthermore, as discussed in Section 7.2.4, coastal habitats will not be impacted by dredging. Deposition of sediments is not predicted and alterations to water quality (i.e. turbidity) from dredging will be within the range of naturally highly turbid conditions present at the Port.

As shorebird species and the Water Mouse are listed as threatened and/or migratory under the EPBC Act, an assessment against significant impact criteria was undertaken (Appendix H). This concluded that impacts to these species from maintenance dredging at the Port are not likely to be significant.

7.4 Impacts to protected areas

7.4.1 GBRWHA

As discussed above, the Port of Hay Point and surrounds makes a minor contribution to 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 (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

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 Hay Point. Given the scale of the GBR, it is not considered likely that the size of the maintenance dredging at Hay Point 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 Hay Point as an existing industrial port.

An assessment of the potential risk from maintenance dredging at the Port of Hay Point against particular elements of integrity (wholeness, intactness, threat) is provided in Table 15.

Table 15: Assessment of potential risk to the integrity of the GBRWHA

Questions regarding risk to integrity (from Commonwealth of Australia 2014)	Response for maintenance dredging at the Port of Hay Point
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 Hay Point 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 Hay Point 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 etc. 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 Hay Point 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 effects of development, neglect or other degrading process?	No. Maintenance dredging of the port will not facilitate other development or other degrading processes. Rather, it will facilitate the optimal efficiency of the current footprint of the Port, which has been highlighted during the Independent Review of the Port of Gladstone (Tinney *et al.* 2013) as a key best practise measure for ensuring Port development does not compromise the OUV of the GBRWHA.
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 (RHDHV 2018a) have demonstrated the maintenance dredging campaigns at the Port will not results in conditions outside of those experienced naturally up to volumes of 800,000 m^3. Maintenance dredging at the Port will not facilitate any other activities that will cause deterioration of water quality.

7.4.2 GBRMP

The Port of Hay Point is excluded from the GBRMP, however the dredge material placement site and the outer section of the departure channel are inside the Marine Park boundary. Numerical analysis of sediment movement also indicate elevated levels of turbidity will occur within the GBRMP during maintenance dredging.

As the GBRMP is a matter of national environment significance, relevant policy guidance as to how an action may result in significant impacts to the Marine Park have been used to guide this assessment. The results are provided in Table 16.

Table 16: Analysis of significance of impacts from maintenance dredging on the GBRMP

Significant impact criterion (Commonwealth of Australia 2013)	Applicability to maintenance dredging at the Port of Hay Point
An action is likely to have a significant impact on the environment of the Great Barrier Reef Marine Park if there is a real chance or possibility that the action will:	
Modify, destroy, fragment, isolate or disturb an important, substantial, sensitive or vulnerable area of habitat or ecosystem component such that an adverse impact on marine ecosystem health, functioning or integrity in the Great Barrier Reef Marine Park results	Will not occur. As described in sections 7.1 to 7.3, impacts to species, their habitats and ecosystem components will be negligible to low.
Have a substantial adverse effect on a population of a species or cetacean including its life cycle (for example, breeding, feeding, migration behaviour, life expectancy) and spatial distribution	Will not occur. As described in section 7.3, impacts to protected species, including cetaceans will be negligible to low.
Result in a substantial change in air quality or water quality (including temperature) which may adversely impact on biodiversity, ecological health or integrity or social amenity or human health	Will not occur. As described in sections 7.1, detailed analyses have demonstrated that maintenance dredging campaigns at the Port will not results in water quality conditions outside of those experienced naturally up to volumes of 800,000 m^3. There will be no impacts to air quality.
Result in a known or potential pest species being introduced or becoming established in the Great Barrier Reef Marine Park	Will not occur. Strict introduced marine pest protocols form part of the EMP for the TSHD Brisbane, which will be used for the maintenance dredging. Additionally, the Port undertakes regular IMP monitoring.
Result in persistent organic chemicals, heavy metals, or other potentially harmful chemicals accumulating in the marine environment such that biodiversity, ecological integrity, or social amenity or human health may be adversely affected	Will not occur. Thorough sediment testing have been undertaken in at the Port of Hay Point (see Section 4.2.1). Dredge material is considered uncontaminated and suitable for ocean disposal as per the NADG (2009).
Have a substantial adverse impact on heritage values of the Great Barrier Reef Marine Park, including damage or destruction of an historic shipwreck	Will not occur. A detailed assessment of the World Heritage attributes has been undertaken in the preceding section and impacts to these heritage values are not considered to be substantially adverse. Other heritage values at the Port are not considerable and there are no historic shipwrecks. Impacts to these

	values are considered acceptable and importantly, local traditional owners are represented on the TACC.

7.5 Impacts to other users

The Port of Hay Point is an important feature of the Mackay region, both in terms of providing employment and local infrastructure (e.g. boat ramp at Half Tide Tug Harbour). However, the areas within the Port Limits are not generally accessible to non-Port users and therefore dredging within the Port limits will not disrupt other users. Access to the public boat ramp at Half Tide Tug Harbour will be managed during short-term (1-2 days) dredging in this location.

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.

In terms of commercial fishing activities directly at the site of the proposed dredging or placement, the commercial fishing data is of an insufficient scale to determine any spatial overlap (Worley Parsons 2014). However it is pertinent to note that commercial fishing is already restricted within operational port limits and does not occur in the berth pockets, departure path and apron areas. As such it is considered that use of the existing dredge material placement site will not restrict fisheries access substantively beyond the restrictions that currently exist. Similarly and as previously described, indirect impacts to fisheries associated with the maintenance dredging are not considered likely to be substantive, due to the minimal impact to marine habitat predicted.

8 Risk assessment

In line with the methodology at Appendix D, an assessment of the risk posed by maintenance dredging and dredge material relocation to environmental values has been undertaken. This risk assessment was based upon the results of the impact analysis undertaken in Section 7 and will be used to inform risk treatment and management measures during dredging operations.

A summary of risk assessment results is provided in Table 17. This risk assessment is based on the application of standard mitigation measures as outlined throughout this report.

Overall, the risk assessment conclusions are that all potential risks are rated as low, with the exception of smothering of benthic communities (moderate). 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. Direct impacts to benthic communities and seagrass at the dredge material placement area will be temporary in nature and will not affect a unique environment.

Table 17: Risk assessment results

Risk activity (cause)	Potential environmental receptors	Potential Impact	Consequence	Likelihood	Risk rating
Smothering from dredge material placement	Transient seagrass beds and seagrass habitat Benthic macroinvertebrate communities	Temporary loss of benthic habitat	Minor Temporary, short-term negative impact	Possible	**Moderate**
Dredging and placement generated sediment plume	Coral and rocky reef habitats at Round and Flat Top islands, and Slade Islet Seagrass	Changes to water quality leading to mortality or changes in coral and seagrass cover/diversity	Negligible Within the natural variation and tolerance of the system	Rare for volumes below 800,000m^3	**Low**
Dredging and placement generated sediment plume	Coral and rocky reef habitats at Round and Flat Top islands, and Slade Islet	Sediment deposition resulting in coral loss	Negligible Within the natural variation and tolerance of the system	Rare for volumes below 800,000m^3	**Low**
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 bioata	Potential for lethal and sub-lethal effects on marine biota	Negligible Material is consistently suitable for at sea 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	Migrating whales	Potential for alienation of habitat	Negligible No impact at the population or sub-population level	Rare	**Low**

Lighting	Foraging marine turtles	Alienation of habitat, animal mortality	Negligible No impact at the population or sub-population level	Rare	**Low**
Dredge program	GBRWHA	Changes to OUV	Negligible Impacts are not discernible	Rare	**Low**
Dredge program	GBRMP	Impacts on marine park values	Minor Short-term impact to a site which is not sensitive or unique.	Possible	**Low**
Dredge program	Marine users	Disruption of activities	Negligible Impact is confined to a small area or interest group that is not vulnerable	Possible	**Low**

9 Findings and conclusion

NQBP is proposing a program of maintenance dredging at the Port of Hay Point that will facilitate the optimal operation of the Port for the next 10 years. Dredging will be spread over 3 – 4 campaigns. The initial dredge campaign is proposed to remove 356,553 m^3 of sediment, which has accumulated over time and as a result of TC Debbie. Future campaigns will have dredge volumes of approximately 200,000 m^3 taking the total maximum volume to approximately 956,553 m^3 (including a 200,000 m^3 cyclone contingency).

A program of very detailed investigations has been undertaken to understand both the need for and potential environmental, social and heritage risks from dredging. The Sustainable Sediment Management Project demonstrated that whilst some measures can be implemented to reduce its frequency, maintenance dredging with at sea disposal of spoil is the best method of managing sediments. This report has therefore undertaken an analysis of the potential risks of maintenance dredging on environmental values of the Port.

There are a number of environmental values that occur in the vicinity of the Port of Hay Point. Whilst there is potential for some of the values to be impacted by the proposed maintenance dredging, the plume modelling and risk assessment undertaken has indicated that these impacts are highly unlikely to be residual or significant from maintenance dredging.

Additionally, individual assessments against formal guidelines have been undertaken for MNES, in all cases these determined that significant impacts are unlikely.

Overall, the conclusion is that maintenance dredging risks to environmental values at the Port of Hay Point will be negligible to low. 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.

A comprehensive dredging environmental management plan will be developed that ensures each maintenance dredging campaign is undertaken in line with best practice, and that risks and impacts 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 in real time during dredging to guide adaptive management. This is coupled with a comprehensive impact and ambient monitoring program that will detect and respond to changes in the marine environment at the Port.

Risk Conclusions

- Maintenance dredging and relocation activities are unlikely to alter water quality conditions above natural occurring levels, unless campaign volumes are 800,000 m^3 or greater, which is not proposed
- Localised changes in SSC are predicted to be minor and models do not anticipate any sensitive receiving environments will be adversely affected
- Impacts to marine fauna are not expected and mitigation measures are proposed to be employed to further reduce risk
- Although no defined impacts are predicted, monitoring of any indirect disturbance in areas close to dredging and relocation activities would constitute best practice and allow for adaptive management of unpredicted changes in water quality.

References

Advisian. 2016. *Marine Sediment Properties Assessment*. Report for North Queensland Bulk Ports, May 2016.

Advisian. 2017. *Maintenance Dredging Sampling and Analysis Plan*. Report for North Queensland Bulk Ports, December 2017.

BMA. 2009. *Mangrove and Intertidal Survey Report*. Appendix H to the HPX3 Environmental Impact Statement.

BMA. 2012. *Annual Ecological Monitoring Summary Report – 2011*. Hay Point Coal Terminal Expansion Phase 3. Report prepared by SKM for BM Alliance Coal Operations, 23 February 2012

Bureau of Meteorology (BoM). 2018. *Severe Weather Events*. http://www.bom.gov.au/announcements/sevwx/

Commonwealth of Australia. 2014. *EPBC Act referral guidelines for the Outstanding Universal Value of the Great Barrier Reef World Heritage Area*. Available at: https://www.environment.gov.au/epbc/publications/epbc-act-referral-guidelines-outstanding-universal-value-great-barrier-reef-world-heritage

Commonwealth of Australia. 2015. *Reef 2050 Long-term Sustainability Plan*. Available at: http://www.environment.gov.au/system/files/resources/d98b3e53-146b-4b9c-a84a-2a22454b9a83/files/reef-2050-long-term-sustainability-plan.pdf

Department of the Environment and Energy [DoEE]. 2017. *Recovery Plan for Marine Turtles in Australia*. Available at: http://www.environment.gov.au/system/files/resources/46eedcfc-204b-43de-99c5-4d6f6e72704f/files/recovery-plan-marine-turtles-2017.pdf

Department of the Environment and Energy [DoEE]. 2018. Statement of Outstanding Universal Value for the GBRWHA. Website: https://www.environment.gov.au/heritage/places/world/gbr/values

Erftemeijer P, Riegl B, Hoeksema B and Todd P. 2012. Environmental impacts of dredging and other sediment disturbances on corals: A review. Marine Pollution Bulletin. 64 (9): 1737-1765.

Great Barrier Reef Marine Park Authority [GBRMPA]. 2009. *Great Barrier Reef Outlook Report*. http://www.gbrmpa.gov.au/__data/assets/pdf_file/0018/3843/OutlookReport_Full.pdf

GBRMPA. 2010. *Water quality guidelines for the Great Barrier Reef Marine Park.* Revised Edition 2010. Great Barrier Reef Marine Park Authority, Townsville.

GBRMPA. 2012. *Guidelines on the use of hydrodynamic numerical modelling for dredging projects in the Great Barrier Reef Marine Park.* August 2012. Available at: http://elibrary.gbrmpa.gov.au/jspui/handle/11017/970

International Whaling Commission (IWC) 2006. IWC/58/CC3. Ship Strikes Working Group First Progress Report to the Conservation Committee. 58th Annual Meeting of the International Whaling Commission.

International Whaling Commission (IWC) 2007. IWC/59/CC4. Country Report on Ship Strikes. Submitted by the Government of Australia to the Conservation Committee of the International Whaling Commission.

International Whaling Commission (IWC) 2008. IWC/60/CC4. Country Report on Ship Strikes. Submitted by the Government of Australia to the Conservation Committee of the International Whaling Commission.

International Whaling Commission (IWC) 2009. IWC/61/CC3. Country Report on Ship Strikes. Submitted by the Government of Australia to the Conservation Committee of the International Whaling Commission.

International Whaling Commission (IWC) 2010. IWC/62/CC4. Country Report on Ship Strikes. Submitted by the Government of Australia to the Conservation Committee of the International Whaling Commission.

International Whaling Commission (IWC) 2011. IWC/63/CC12. Country Report on Ship Strikes. Submitted by the Government of Australia to the Conservation Committee of the International Whaling Commission.

Kaveney T, Archinal L, Kane K, Tolley H, Hemphill P, Hulme J and Morton R. 2017. *Port of Hay Point: Sustainable Sediment Management Assessment for Navigational Maintenance Summary Report*, Report for North Queensland Bulk Ports, January 2017.

Koskela Group. 2009. *Hay Point Coal Terminal Expansion Project – Benthic Survey,* Report prepared for BHP Billiton Mitsubishi alliance.

Maritime Safety Queensland (MSQ). 2018. *Semidiurnal Tidal Planes – 2018*. Available from: https://www.msq.qld.gov.au/Tides/Tidal-planes

McCook L, Schaffelke B, Apte S, Brinkman R, Brodie J, Erftemeijer P, Eyre B, Hoogerwerf F, Irvine I, Jones R, King B, Marsh H, Masini R, Morton R, Pitcher R, Rasheed M, Sheaves M, Symonds A, Warne M. 2015. *Synthesis of current knowledge of the biophysical impacts of dredging and disposal on the Great Barrier Reef: Report of an Independent Panel of Experts,* Great Barrier Reef Marine Park Authority, Townsville.

Parra, G.J. 2006. Resource partitioning in sympatric delphinids: Space use and habitat preferences of Australian snubfin and Indo-Pacific humpback dolphins. *Journal of Animal Ecology*. 75:862-874.

Ports Australia. 2014. *Dredging and Australian Ports: Subtropical and Tropical Ports*. Available at: http://www.portsaustralia.com.au/assets/Publications/Dredge-Report-Low-Res.pdf

Royal HaskoningDHV [RHDHV]. 2018a. *Hay Point Maintenance Dredging Dredge Plume Modelling Assessment*. Report for North Queensland Bulk Ports, February 2018.

Royal HaskoningDHV. 2018b. *Port of Hay Point – IDF Analysis and Ecological Trigger Assessment.* Report for North Queensland Bulk Ports, February 2018.

SKM. 2013. *Improved dredged material management for the Great Barrier Reef Region*, Report prepared for the Great Barrier Reef Marine Park Authority, Townsville.

State of Queensland (SOQ, Department of Transport and Main Roads). 2016. *Maintenance Dredging Strategy for Great Barrier Reef World Heritage Area Ports*. November 2016. Available at https://www.tmr.qld.gov.au/business-industry/Transport-sectors/Ports/Maintenance-dredging-strategy

Symonds A and Donald J. 2016a. *Hay Point Port: Bathymetric Analysis and Modelling*. Report for North Queensland Bulk Ports, February 2016.

Symonds A and Donald J. 2016b. *Hay Point Disposal Site Analysis*. Report for North Queensland Bulk Ports, March 2016.

Symonds A. 2017a. *Hay Point Port: Bathymetric Analysis – TC Debbie Analysis*. Report for North Queensland Bulk Ports, September 2017.

Symonds A. 2017b. *Port of Hay Point – Natural Sediment Resuspension Assessment*. Technical note for North Queensland Bulk Ports, November 2017.

Threatened Species Scientific Committee [TSSC]. 2015. *Conservation Advice* Megaptera novaeangliae *humpback whale*. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/38-conservation-advice-10102015.pdf. In effect under the EPBC Act from 01-Oct-2015

Thomas R, Leith M and Rasheed MA. 2012. *Port of Hay Point Seagrass Survey – November 2011.* DAFF, Cairns, 19pp.

Tinney A, Abal A, Kechington R and Cresswell I. 2013. Independent Review of the Port of Gladstone – Supplementary Report. Available at: http://www.environment.gov.au/system/files/resources/ae7cbcf9-2963-47d7-9029-3aa1a065db51/files/gladstone-review-supplementary-report.pdf

Trimarchi, S and Keane J. 2007. *Port of Hay Point Apron Areas and Departure Path Capital Dredging Project. Environmental Review*. Eco Port Monograph Series No. 24. Published by Ports Corporation of Queensland Ltd.

WODA. 2013. *Technical Guidance on: Underwater Sound in Relation to Dredging*. Available at: https://dredging.org/documents/ceda/html_page/2013-06-woda-technicalguidance-underwatersoundlr.pdf

WorleyParsons. 2014. *Environmental Management Plan: Port of Hay Point Maintenance Dredging.* Report prepared for North Queensland Bulk Ports, December 2014.