PORT OF TOWNSVILLE LIMITED
PORT EXPANSION PROJECT
CHANNEL UPGRADE

Townsville Port Expansion Channel Upgrade Project

Marine Megafauna Monitoring Plan

February 2020

Document Control Sheet

Revision history

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Review history

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Document approval

Approval of the final Marine Megafauna Monitoring Plan was issued by DAWE on 26 February 2020.

The Marine Megafauna Monitoring Plan is published on the CU Project's website on 11 March 2020.

This document has been prepared to meet the Commonwealth Government's EPBC Approval No. 2011/5979 Conditions and the Queensland's Coordinator General's Conditions for the Port of Townsville Limited's Port Expansion Project (ACN 130 077 673).

DECLARATION OF ACCURACY

EPBC Number	2011/5979
Project Name	Port of Townsville Port Expansion Project
Approval Holder	Port of Townsville Limited
ACN / ABN	130 077 673 / 44 411 774 236
Approved Action	To expand the Port of Townsville, in Townsville Queensland. The action is for dredging, land reclamation and construction of infrastructure.
Location of the Action	Townsville, Queensland

In making this declaration, I am aware that section 491 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) makes it an offence in certain circumstances to knowingly provide false or misleading information or documents to specified persons who are known to be performing a duty or carrying out a function under the EPBC Act or the *Environment Protection and Biodiversity Conservation Regulations 2000* (Cth). The offence is punishable on conviction by imprisonment or a fine, or both. I am authorised to bind the approval holder to this declaration and that I have no knowledge of that authorisation being revoked at the time of making this declaration.

Signed

Full name (please print)

Marissa Wise

Organisation (please print)

Port of Townsville Limited

Date 14 / 02 / 2020

GLOSSARY

AEIS	PEP Additional Information to the Environmental Impact Statement
Baseline	Environmental conditions prior to the commencement of the CU Project
CEMP	Construction Environmental Management Plan
CU Project	Channel Upgrade Project
CVTMP	Construction Vessel Traffic Management Plan
Department / DAWE	The Australian Government Department of Agriculture, Water and the Environment, or any other agency administering the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) from time to time
DES	Queensland Government Department of Environment and Science
DMP	Dredge Management Plan
DPA	Dugong Protection Area
EIS	PEP Environmental Impact Statement
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GBR	Great Barrier Reef
GBRMPA	Great Barrier Reef Marine Park Authority
GBRWHA	Great Barrier Reef World Heritage Area
GIS	Geographic Information Systems
GPS	Global Positioning System
ITAC	Independent Technical Advisory Committee
JCU	James Cook University
Listed Dolphin Species	Australian snubfin dolphin (*Orcaella heinsohni*) and indo-pacific humpback dolphin (*Sousa chinensis*)
Listed Turtle Species	Green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricate*); flatback turtle (*Natator depressus*); loggerhead turtle (*Caretta caretta*); olive ridley turtle (*Lepidochelys olivecee*); and leatherback turtle (*Dermochelys coriacea*)
Marine Megafauna	Listed turtle species, dugong (*Dugong dugon*), listed dolphin species, and all other cetaceans
Mechanical Dredge	A dredger that removes sediments via mechanical methods. Can include grab dredges (clamshells and buckets) or backhoe dredges.
MEMP	Marine Environmental Management Plan
Minister	The Minister administering the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) and includes a delegate of the Minister
MFO	Marine Fauna Observer
MMMP	Marine Megafauna Monitoring Program

MNES	Matters of National Environmental Significance: In the context of this approval: Great Barrier Reef World Heritage Area, Great Barrier Reef National Heritage place, listed turtle species, listed dolphin species and all other Cetaceans, Dugong (*Dugong dugon*), Commonwealth marine area and the Great Barrier Reef Marine Park
NATA	National Association of Testing Authorities
PEP	Port Expansion Project
PIT	Passive Integrated Transponder
POTL	Port of Townsville Limited
RMP	Reactive Monitoring Plan
Site	The new reclamation area (not yet a declared lot) at the northern extent of the Eastern Reclaim Area at the Port (Lot 791 on EP2348 Strategic Port Land)
TSHD	Trailer Suction Hopper Dredge – a self-propelled ship with a hold (hopper), and a dredging mechanism comprised of suction pipes connected to draghead(s), by which it can fill the hopper with dredge material
WWF	World Wildlife Fund

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1 INTRODUCTION

1.1 Project Summary

Port of Townsville Limited (POTL) is a Government Owned Corporation established under the *Government Owned Corporations Act 1993*, which manages the Port of Townsville (the Port). The Port is located on Cleveland Bay, approximately three kilometres east of the city centre of Townsville, North Queensland. It is a multi-purpose port that handles predominantly bulk and general cargo with a land and sea jurisdiction in excess of 450 km^2. The Port is situated in the Great Barrier Reef World Heritage Area and outside of the Great Barrier Reef Marine Park. Surrounding the Port of Townsville is Cleveland Bay and the community of Townsville. Townsville is a long-established city with a history of urbanisation and industrial activities in the Ross River and Ross Creek drainage system.

The Channel Upgrade Project (CU Project) is Stage 1 of POTL's long-term Port Expansion Project (PEP). The CU Project involves:

- Supply and haulage of marine-grade armour rock required for rock walls and revetments at the Port;
- Creation of a ~62-hectare reclamation area (Figure 1) via the construction of rock walls and revetments forming initial receival ponds for beneficial use of all capital dredge material from the channel widening works;
- Capital dredging on the western side to widen the Platypus Channel (Figure 1) from 92 metres width to 180 metres (at the harbour entrance) tapering to 135 metres (at the seaward end); and
- Capital dredging on the eastern side to widen the Sea Channel (Figure 1) from 92 metres to 120 metres along its length.

The capital dredging, construction activities and infrastructure development for the CU Project will occur inside the existing port limits; the designated water areas in which navigation falls under the control of the Regional Harbour Master. The land-based construction activities will occur on the new reclamation area, namely Lot 794 on SP308904 adjacent to the northern extent of the East Port Area, namely Lot 791 on EP2348 (the site), which is current strategic port land (Figure 1).

The capital dredge campaign will last approximately 2 to 3 years and dredge approximately 3.9 million cubic metres predominantly using a mechanical dredge, with support from a trailer suction hopper dredge (TSHD) in the deeper northern sections of the channel. All the capital dredge material will be placed within the new revetment bunds as part of land reclamation activities. Dewatering and ground improvement of emplaced sediments will also be undertaken.

For the purposes of this monitoring plan the Project area relates to all seabed and waters across the footprint of all project construction areas.

Collectively, the geographic landscape of Cleveland Bay, including Magnetic Island, is the area of focus for the marine megafauna monitoring plan, referred to herein as the Study Area. The Project Area lies within the Study Area and is defined as the areas that are predicted to be affected by the CU Project, as indicated in Figure 2. It is noted that the Project Area (including the channel and reclamation), have limited to no key megafauna habitats (i.e. corals and seagrass), although megafauna species are known to move within and transit the CU project areas.

Figure 1: Locality Plan of the Port of Townsville & CU Project

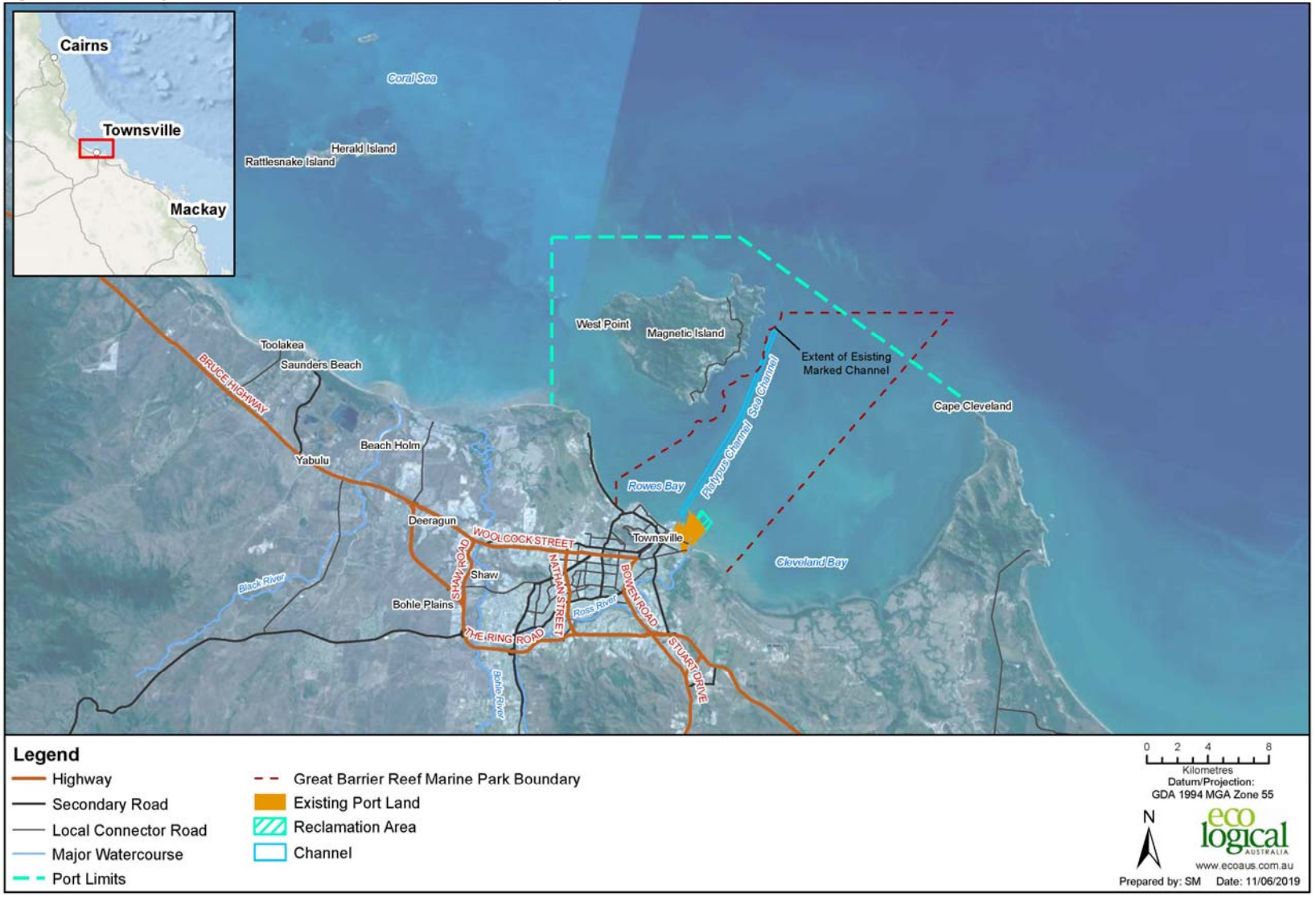
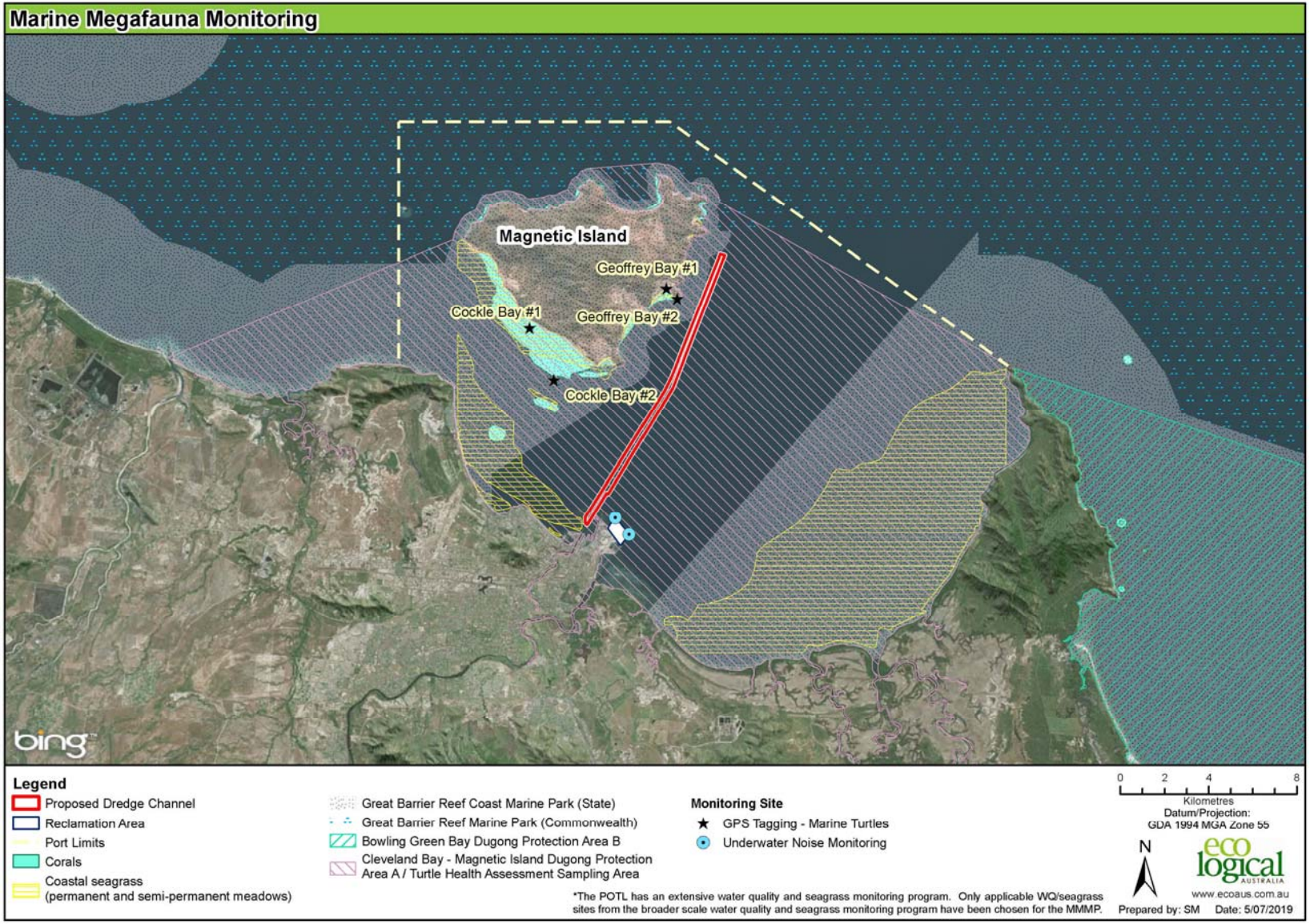


Figure 2: Project monitoring location in relation to conservation areas



1.2 Legislative Overview

The PEP was the subject of a rigorous environmental assessment and approvals process under both Queensland and Commonwealth legislation. This process was supported by the preparation of an Environmental Impact Statement (EIS) and Additional Information to the Environmental Impact Statement (AEIS), which assessed potential impacts under the frameworks of the *State Development and Public Works Organisation Act 1975* (Qld) (SDPWO Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act).

The PEP was approved under the EPBC Act on 5 February 2018, subject to a number of conditions (EBPC 2011/5979). The Queensland Coordinator-General (CG) issued an evaluation report on the PEP's EIS in September 2017. The CG-report contains conditions to be included in the Development Permits and Environmental Authorities, for the various stages of the PEP.

EPBC Act Condition 12 requires the development and approval by the Minister of a Marine Environmental Management Plan (MEMP). The MEMP must include measures to mitigate impacts to MNES from activities in the marine environment, before the commencement of the action. Specifically, the MEMP must include, as per Condition 12(d):

> *A program to monitor the potential impacts to marine fauna before and during construction activities in the marine environment; where marine fauna are defined as Listed turtle species, Dugong (*Dugong dugon*), listed dolphin species, and all other Cetaceans.*

This Marine Megafauna Monitoring Plan has been developed to specifically fulfil the requirement of EPBC Act Approval Condition 12(d).

1.3 Scope of monitoring plan

This plan is a sub-component of a broader Marine Environmental Management Plan (MEMP), the development of which is also a condition of approval. A key overarching objective of the MEMP is to avoid or minimise impacts to Matters of National Environmental Significance (MNES) from the Project's construction and operational activities in the marine environment.

This Marine Megafauna Monitoring Plan has been developed in parallel with several other plans. It has been specifically designed to be complementary with these plans, and leverage information and outcomes across environmental values, particularly those that support the habitat quality of marine megafauna (e.g. seagrass and water quality). The listed inshore dolphins, Australian snubfin dolphin (*Orcaella heinsohni*) and Australian humpback dolphin (*Sousa sahulensis*), are not specifically addressed in this plan as they are subject to a standalone Inshore Dolphin Monitoring Program.

The monitoring plan has also been developed in collaboration with recognised marine megafauna experts.

1.4 Marine Megafauna Monitoring Objectives

The overarching requirement of approval Condition 12(d) is the development and implementation of a program to monitor the potential impacts of the Project on marine megafauna before and during construction activities in the marine environment.
Accordingly, this Marine Megafauna Monitoring Plan has been developed with the overarching objective to monitor for, and provide increased understanding of, potential impacts to marine megafauna from marine activities associated with marine construction and dredging associated with the CU Project.

Following feedback through the workshop of megafauna research specialists (see Appendix A), in order to fulfil the overarching objective, it was considered that the Marine Megafauna Monitoring Plan needs to:

- Provide an understanding of the pre-construction conditions, depending on natural abundance of each species, of selected aspects of marine megafauna and their key habitats prior to commencement of Project activities;
- Collect data during CU Project works to identify potential impacts from construction activities and increase understanding of the magnitude of these potential impacts with reference to approved impact limits (i.e. confirm EIS predictions of potential impacts);
- Monitor and report on selected aspects of marine megafauna, during construction activities in the marine environment, to provide an increased understanding of the marine megafauna response to potential impact pathways;
- Provide recommendations on key areas of potential impact to allow the implementation of mitigation measures, if impacts are detectable and beyond what was predicted in the EIS (approved); and
- Increase understanding and scientific knowledge of marine megafauna within Cleveland Bay (where relevant).

Individual monitoring program components have specified objectives to describe the focus of those components in contributing the overarching objectives.

It should be noted that this Plan covers megafauna monitoring for Stage 1 of the PEP project only; it is not designed cover the monitoring plan for further stages of the PEP. Environmental monitoring during Stage 1 will increase the existing dataset which will assist in future decision making and management measures during the PEP. These will be subject to further Monitoring Plans relevant for the applicable stage/s.

Information from this monitoring program will be used to assist with improving the control measures associated with the CU Project to minimise impacts on marine megafauna. As such, this monitoring plan forms part of the MEMP for the project. The MEMP provides the environmental management requirements for Matters of National Environmental Significance (MNES) from project activities in the marine environment. Once the Dredge Management Plan (DMP) is developed, the MEMP will also incorporate a number of the strategies and actions detailed in the DMP which addresses impacts specifically from the dredging operations.

This Marine Megafauna Monitoring Plan is Appendix G of the *CU Marine Environmental Management Plan (MEMP POT 2135).* As this plan specifically covers the monitoring of marine megafauna in the study area; this document is to be read in conjunction with the MEMP to ensure all management actions and controls are captures to prevent potential impacts to marine megafauna.

2 EXISTING ENVIRONMENTAL VALUES

Marine megafauna species are commonly migratory or have distinct life stages in different coastal landscapes of the Great Barrier Reef and further abroad. For example, dugongs may move several hundreds of kilometres in herds in search of foraging habitat. Many cetaceans are also transient visitors to the region, either opportunistically, or during seasonal migrations (e.g. humpback whale). For marine turtles, adult Green Turtles forage in Cleveland Bay within small 'home ranges', unless undertaking a breeding migration. However, other turtle species may move through the area from time to time or live in low numbers on the reef patches to the north and east of the Study Area.

Detailed assessment of the environmental values within the Project Area and more widely within Cleveland Bay was undertaken to support the environmental impact assessment process. The Environmental Impact Statement (EIS) and Additional Information to the EIS (AEIS), along with their technical appendices provide a suite of information that has been utilised in the development of this monitoring plan.

2.1 Cleveland Bay

Cleveland Bay is a north-facing bay comprised of a narrow coastal plain fringed by a coastal escarpment, which dominates the inland topography approximately 5 – 10 km from the coast (PEP EIS 2012). The coastline is sheltered by Cape Cleveland and shaped predominantly by prevailing low energy waves with the occasional high energy cyclone wave, created by severe weather events.

The entrances of Ross River and Ross Creek flow into Cleveland Bay, bordering the Port. Since its establishment in 1864, the Port and surrounding coastal areas have undergone modification, including from the use of reclaimed land to create the Port, redevelopment of the Strand Beach west of the Port and development in the near coastal river basin, which has modified the Ross Creek estuary (particularly the entrance) from its natural state. However, despite such modifications, the Ross Creek estuary still provides important contiguous aquatic habitat in its lower reaches.

Water quality in the Townsville region of the Great Barrier Reef is influenced by a variety of factors. Urban areas of Townsville city discharge stormwater to adjacent foreshores, with some likely influence on local water quality. More broadly, the inshore waters of the Great Barrier Reef have been subject to declines in water quality from vegetation clearing in the catchment and agricultural runoff. The Burdekin and Fitzroy River catchments are the largest contributors to catchment loads, and together contribute more than 50% of catchment sediments into the GBR (BMT WBM, 2018). Sediment and nutrient discharges from river systems such as the Burdekin are a key focus of water quality improvement initiatives of government and industry. Water quality has an impact on the health and extent of key megafauna habitat and food resources (e.g. seagrasses, coral) and can indirectly impact on marine megafauna abundance and health.

Water quality monitoring data from previous studies, *Townsville Marine Precinct Project Environmental Impact Statement* (GHD, 2009a) and the PEP EIS (2012) show that frequently turbid water occurs near-shore in Cleveland Bay and less turbid waters occur in the outer bay. Higher levels of nutrients and contaminants (compared with relevant water quality guidelines) were also recorded in the vicinity of the Ross River estuary. Freshwater flows into the bay from the Ross River, the Burdekin River and other systems can temporarily increase the turbidity and nutrient load during storm events.

2.2 Marine Conservation Areas

Marine conservation areas are established for the protection of locations with high conservation values. Conservation areas in Cleveland Bay and adjacent areas that are protected under legislation include:

- Great Barrier Reef World Heritage Area (and national heritage place);
- Cleveland Bay-Magnetic Island Dugong Protection Area A;
- Bowling Green Bay Dugong Protection Area B;
- Cleveland Bay Fish Habitat Area;
- Bowling Green Bay Ramsar site;
- Magnetic Island National Park; and
- The Great Barrier Reef Marine Park (Commonwealth) and Great Barrier Reef Coast Marine Park (State) – both adjacent to the Project Site.

Areas to be disturbed by Project activities are located within the GBRWHA, but outside of the boundary of the Great Barrier Reef Marine Park. Figure 2 identifies the location of several of these conservation areas in relation to the Project Site.

2.3 Marine megafauna

2.3.1 Overview of marine megafauna values

Cleveland Bay contains significant foraging grounds and habitat for numerous marine megafauna, including species listed as threatened, migratory or otherwise protected under the EPBC Act. For the purposes of this plan, species of marine megafauna and their habitats as listed in the EPBC Act approval are the primary focus. Other marine megafauna (e.g. crocodiles, sea snakes, sharks and rays) may be detected incidentally through implementation of some elements of the plan, but are not a key focus. The CU project will be working towards a zero harm goal for any marine fauna located directly adjacent to the construction areas.

Table 1 provides a summary of the key marine megafauna addressed in this plan, including a brief indication of their presence within, and usage of, Cleveland Bay. This is further expanded in following sections with information summarised in BMT WBM (2012a & b) and GHD (2011). The migratory and life history stages of these marine megafauna have been considered when designing the monitoring plan and establishing associated performance indicators, to target monitoring activities towards the most relevant species.

Table 1: Key marine megafauna addressed in this plan

Species	EPBC Act status	NC Act status	Presence in Cleveland Bay
Dugongs (*Dugong dugon*)	Migratory	Vulnerable	Abundant in Cleveland Bay Highest foraging densities occur near coastal seagrass meadows Cleveland Bay is a Dugong Protection Area and provides regionally-important dugong habitat.
Green Turtle (*Chelonia mydas*)	Vulnerable Migratory	Vulnerable	Accounts for ~90% of the turtles within Cleveland Bay. Known to forage within Port Limits and within Cleveland Bay, with highest foraging density near coastal seagrass meadows. Low density nesting occurs on beaches in Cleveland Bay
Flatback Turtle (*Natator depressus*)	Vulnerable Migratory	Vulnerable	Uncommon; recorded foraging in Cleveland Bay. Low density nesting occurs on beaches in Cleveland Bay. Predominantly deepwater species
Loggerhead Turtle (*Caretta caretta*)	Endangered migratory	Endangered	Uncommon; transient visitors foraging on nearby reefs. Predominantly deepwater species
Leatherback Turtle (*Dermochelys coriacea*)	Endangered Migratory	Endangered	Uncommon; transient visitors foraging within nearby oceanic areas
Olive Ridley turtle (*Lepidochelys olivacea*)	Endangered Migratory	Endangered	Uncommon; recorded foraging within soft bottom habitats of Cleveland Bay. Predominantly deepwater species
Hawksbill Turtle (*Eretmochelys imbricata*)	Vulnerable Migratory	Endangered	Uncommon; recorded foraging in Cleveland Bay
Humpback Whale (*Megaptera novaeangliae*)	Vulnerable Migratory	Vulnerable	Known to migrate through deeper waters of Cleveland Bay primarily during the southern migration. More common in deeper, offshore waters of Cleveland Bay.

2.3.2 Available Marine Megafauna information

Numerous marine megafauna studies have been carried out in Cleveland Bay, with the most comprehensive assessments of the distribution, abundance and habitat use being associated with a survey completed by GHD (2011) to support the development of the EIS for the Project (BMT WBM, 2012b). That survey involved four assessment methods:

- Aerial surveys at three times (August 2010, November/December 2010 and June 2011) at a whole- of-Cleveland Bay spatial scale. This information was used to assess the relative density and potential patterns in habitat usage of marine megafauna species.

- Boat-based surveys at three times (May 2010, October 2010 and May 2011) within nearshore environments of Cleveland Bay. This information was used to assess the relative density of marine megafauna and potential patterns in habitat usage.
- Passive acoustic monitoring between November 2010 and May 2011 within nearshore environments of Cleveland Bay and Cockle Bay (south of Magnetic Island). This method was used to assess inshore foraging behaviour of Green Turtles.
- Passive Acoustic detection of cetaceans (C-Pods) as a complementary survey tool for acoustic monitoring.

The results of this survey and its implications for the design and implementation of the monitoring program are discussed in the following sections.

2.3.3 Marine turtles

As identified in Table 1, all six species of marine turtles that inhabit the Great Barrier Reef use habitats in Cleveland Bay to varying degrees. Overall Cleveland Bay does not represent a critical turtle nesting area and most turtles in the area are likely to have originated in rookeries elsewhere along the Queensland coast, or overseas. The exceptions to this are flatback and green turtles (BMT WBM (2012a)). There are some turtle foraging resources within the study area (but not directly in the Project Area), with relatively dense and abundant coastal seagrass meadows and coral reef communities existing to the east and west of the Project Area.

Throughout Cleveland Bay, the areas with the highest numbers of marine turtles are those where foraging resources are the greatest (i.e. within seagrass and reef habitats). Such areas have been prioritised for monitoring in this plan, and were noted by GHD (2012) to include:

- Cockle Reef at southern Magnetic Island
- Coastal seagrass meadows between the Strand and Cape Pallarenda
- Offshore areas of the Port in central Cleveland Bay
- Coastal seagrass meadows near the mouth of Alligator Creek to Cape Cleveland.

The above areas support mainly Green Turtles, with this species representing ~90% of all turtles sighted during previous surveys (Preen 2000; BMT WBM, 2012b). Green Turtles feed directly on seagrass and algae (Brand-Gardner et al. 1999) and the seagrass meadows of Cleveland Bay are considered to be a regionally important foraging resource for Green Turtles (BMT WBM, 2012a). The distribution of seagrass meadows for turtle foraging has informed the design of this monitoring plan (refer **Section 4**).

Other species of marine turtles have also been recorded in Cleveland Bay, but are considered to be less common, making up ~10% of the overall marine turtle community (Preen 2000). Flatback turtles (*Natator depressus*) are carnivorous, feeding on soft-bodied invertebrates, such as sponges, soft corals and sea cucumbers (Wilson 2005). They have been reported foraging on soft-bodied invertebrates within Cleveland Bay and nesting in low densities at beaches within Cleveland Bay (PEP EIS 2012). Flatback turtles are likely to utilise reef areas for foraging in low numbers, and adjacent deeper waters of the Cleveland Bay area during nesting season. Unlike other species of marine turtle in Australia, the distribution of the flatback turtle is generally restricted to the continental shelf, extending into southern PNG and Indonesia (QPWS unpublished data). Long term monitoring data collected for the eastern Australian population, from index rookeries at Wild Duck and Peak Island, show no signs of a declining population (Hamann 2007).

The remaining turtle species have been recorded in low numbers and are expected to forage primarily in the following areas (GHD 2011):

- Loggerhead Turtles – carnivorous, feeding on crustaceans, echinoderms and molluscs around reef and seagrass areas of Magnetic Island and Middle Reef.
- Leatherback Turtles – feed on jellyfish and soft bodied invertebrates in deeper waters.
- Olive Ridley turtles – typically found in deeper waters around Magnetic Island; does not favour shallow reef or seagrass habitats. Feeds mostly on echinoderms, small crabs and molluscs.
- Hawksbill Turtles –inshore reefs where the species feeds primarily on sponges, seagrasses, algae, soft corals and molluscs.

Due to their lower numbers in Cleveland Bay and less reliance on habitats with potential to be impacted by the project, these species will not be a focus of this monitoring plan. Additionally, these species are more difficult to capture for tagging purposes.

The availability of food resources is a critical element to the resilience of turtle populations in coastal locations, and Green Turtles in particular. Previous loss of seagrass beds associated with very wet years between 2009-2011 (including Tropical Cyclone Yasi and a subsequent flooding event) coincided with a significant spike in marine turtle strandings in the Great Barrier Reef region. In particular, the Townsville region was highlighted as a 'stranding hot-spot' in 2011, with 262 reported strandings (BMT WBM 2012a). This is in comparison with previous years, when strandings ranged between 35 and 93 individuals per year. More recently, the number of marine turtle strandings confirmed in the Townsville region has been relatively stable, with an average of approximately 50 per year (e.g. 51 in 2015, 29 in 2016, 42 in 2017 and 27 in 2018; DES 2019).

There are some indications that Green Turtles may be able to utilise other foraging resources such as algae and mangroves, particularly when seagrass densities are low. However, the resilience of turtle populations in Cleveland Bay is expected to be lower during periods when seagrass resources are less plentiful (BMT WBM 2012a). This reduced resilience may be seen via observations of fewer individuals, increased strandings and/or declines in the health of individual turtles.

While cohorts of some species, such as adult Green Turtles, can be expected to be relatively site-attached when foraging within their home range, satellite tracking in parts of the Great Barrier Reef has revealed movements over spatial scales of tens of kilometres from time to time (Babcock *et al.* 2015; Hamann and Limpus 2015). Regardless, Green turtles are the most abundant turtle species in the region and are distributed across Port areas and within Cleveland Bay, transiting through the Project Area when moving between their known habitat areas located outside the direct project impact area. Their assumed high site fidelity within Cleveland Bay makes them a suitable marine turtle species of focus for this megafauna monitoring Plan.

Green turtles can be captured during the project to undertake analysis of their health and movement patterns, to explore potential responses to project-related influences. Also, some monitoring of green turtles has been completed by other parties within the Cleveland Bay region, prior to this project commencing, providing a potential source of long-term data.

2.3.4 Dugongs

The dugong has a relatively broad geographic range with the most important Queensland areas including Hinchinbrook Island, Cleveland Bay, Shoalwater Bay, Hervey Bay and Moreton Bay (Marsh *et al* 2002). Dugongs are abundant in Cleveland Bay and the area is considered to provide important dugong habitat at a regional scale (Sheppard 2007; Sobtzick et al 2012). The entire bay is formally recognised as a Dugong Protection Area (DPA) under the *Great Barrier Reef Marine Park Regulation 1983*.

The greatest densities of Dugong are found within the eastern areas of Cleveland Bay away from the direct project impact area. The pattern of abundance of Dugongs reflects the spatial distribution of seagrass meadows throughout Cleveland Bay, with the densities of Dugong in eastern Cleveland Bay overlapping spatially with the largest and most abundant seagrass meadows present during surveys in 2008 – 2011 (GHD 2011). Dugong are principally herbivores and show strong foraging preferences for seagrass in the *Halophila* and *Halodule* genera. It is therefore assumed that the Dugong use of habitat throughout Cleveland Bay is linked with the presence of high quality seagrass meadows. Dugong are also known to calve in Cleveland Bay, in areas that are likely to include sandbanks and estuaries. There are indications that Dugong move throughout Cleveland Bay as they travel between feeding areas, although previous aerial surveys have indicated Dugong are sparsely distributed within the Project Area where dredging and reclamation are planned.

Movement behaviour of dugongs are known to be individualistic and heterogeneous, with tracked dugongs moving from less than 15km to over 200kms (Sheppard et al. 2006). As shown in Dugongs in Hervey Bay, in times when food sources (i.e. seagrass) are under stress or supply has failed, individual dugongs either emigrate to seagrass fields outside the affected area or remain at the stressed food source and risking mortality and reduced breeding (Sobtzick et al 2012).

Like marine turtles, the resilience of Dugong to impacts is considered to be linked to the prevalence of foraging resources. The number of Dugong strandings per year in the Townsville region is highly variable, ranging from one or two individuals, to over 50 strandings in 2011 following Cyclone Yasi (Meager 2016). Boat strike is generally responsible for a small proportion of dugong strandings each year (Meager 2016). Based on the limited monitoring techniques for dugong at the bay scale that are implementable, the focus of dugong related monitoring will be on stranding information (see Section 4).

2.3.5 Other marine megafauna

Cleveland Bay is not located within an identified core over-wintering area for Humpback Whales within the Great Barrier Reef region. Humpback whales are known to occur in Cleveland Bay, usually using the deeper waters within the bay and adjacent to Cape Cleveland. Pilot Whales are also known to enter Cleveland Bay and have been seen breaching in the Berth 11 (outer harbour) deeper berth pocket water. The timing of reported records indicates that whales visit during their southward migration. Both adults and calves have been recorded.

The Indo-Pacific (inshore) Bottlenose Dolphin occurs throughout coastal waters of the Great Barrier Reef, including Cleveland Bay. There are a suite of human-related threats to the species throughout its range, including incidental capture in nets, habitat degradation and increased noise pollution (GBRMPA 2012). It is expected that several incidental sightings of the species will occur during implementation of the monitoring program. The bottlenose dolphin will also be monitored as part of the separate Inshore Dolphin Monitoring Plan.

There are a number of other marine megafauna that may utilise the marine habitats of Cleveland Bay. Two threatened shark species, Whale Shark (*Rhincodon typus*) and Green Sawfish (*Pristis zijsron*), have

been previously recorded. However these are occasional records, representing sporadic and transient use of the area. Estuarine crocodiles (*Crocodylus porosus*, listed as migratory on the EPBC Act) are also known to be present in Cleveland Bay. While there are no specific known nesting sites, there are areas that would typically represent potential zones of preferred habitat along mangrove and soft sediment lined creeks and animals are likely to be transient visitors to the bay.

While not a focus of this marine megafauna monitoring plan, observations for other fauna (e.g. protected sharks, crocodiles etc) will be undertaken as part of fauna spotting across the relevant workfronts and steps taken to minimise project related impacts on these species.

2.4 Seagrass

Seagrass provides a range of critically important and economically valuable ecosystem services including coastal protection, support of fisheries production, nutrient cycling and particle trapping (e.g. Hemminga and Duarte 2000).

The seagrass meadows in and surrounding Cleveland Bay also provide important feeding and habitat resources for a range of species including fishes, dugongs, marine turtles and some invertebrate species. The Project EIS showed that central Cleveland Bay (called Eastern Near Shore in the EIS) represents the largest near-shore seagrass meadow in Cleveland Bay. Deep-water seagrass located in Cleveland Bay is generally non-contiguous, with low diversity and cover (PEP EIS 2012).

High quality shallow seagrass meadows are located near Cape Cleveland, The Strand, Cape Pallarenda and around Magnetic Island. Eight species of seagrass have been recorded in Cleveland Bay, namely *Zostera muelleri*, *Halodule uninervis*, *Syringodium isoetifolium*, *Cymodocea serrulata, Halophila spinulosa*, *Halophila ovalis*, *Halophila decipiens* and *Thalassia hemprichii* (Rasheed and Taylor, 2008).

Seagrass meadows show measurable responses to changes in water quality, making them ideal candidates for monitoring the long-term health of marine environments (Orth *et al.* 2006; Abal and Dennison 1996; Dennison *et al.* 1993). Changes in seagrass abundance and distribution can largely be attributed to the availability of light. Suspended sediment caused by wave (including currents) and wind driven events smother the seagrass when deposited to the seabed and limits the amount of light available. Other contributing factors can also be related to large changes in salinity as a result of influxes of fresh water. This is thought to be a key driver of the observed long-term temporal patterns of seagrass occurrence in Cleveland Bay.

Seagrasses have been monitored annually in the Port of Townsville since 2007. Strong La Nina weather patterns occurred across Queensland in 2010 and 2011, and combined with tropical cyclone Yasi in February 2011, resulted in higher than average rainfall and flooding in local catchments. Such events can negatively impact seagrasses through physical removal, sediment de-stabilisation, increased runoff resulting in sediment burial, high nutrient and herbicides inputs, large freshwater pulses with extended periods of high turbidity and associated light reduction (Campbell and McKenzie 2004; Waycott et al. 2007; Chartrand et al. 2010; Chartrand et al; 2012).

Townsville seagrasses were impacted prior to 2012 by regional-scale climate events that also resulted in declines to seagrasses in other areas of tropical Queensland, including Cairns, Mourilyan, Bowen/Abbot Point and Gladstone. The greatest losses in Townsville were recorded in the Cape Cleveland and Cape Pallarenda meadows and their subsequent expansion drove gradual increases in total meadow area in the following years.

In 2017, TropWATER identified total meadow areas remained stable and continue to sit well above the long term average. Continued improvement in seagrass area and condition was the result of favourable climatic conditions and the absence of destructive tropical cyclones (Bryant, CV and Rasheed, MA 2018).

2.5 Reef Communities

Cleveland Bay supports a range of reef habitats around Magnetic Island, at Middle Reef and Virago Shoal. Over half of the total number of hard coral species recorded in the Great Barrier Reef are located within the Cleveland Bay area. These coral communities are of high biodiversity significance, particularly around Magnetic Island. Hard coral cover varies across the bay and is generally considered highest at Middle Reef, which supports a well-developed reef platform. The shallow fringing reefs and rocky shores surrounding Magnetic Island typically have the highest hard coral cover along the reef slopes and Virago Shoal has smaller, less developed reef areas (BMT WBM, 2012a).

Turtles are known to inhabit the inshore reefs of Cleveland Bay, foraging on sponges, seagrass, algae, soft corals, and a variety of benthic shellfish. Loggerhead turtles (*Caretta caretta*), and Flatback turtles (*Natator depressus*) inhabit the reefs and shallows around Magnetic Island and Middle Reef, foraging on jellyfish, crustacea, and soft bodied invertebrates (PEP EIS 2012). To adequately design a megafauna program that should take account of how these turtles may be affected by the CU Project it is relevant to understand where the species may occur and what habitats they may depend upon in Cleveland Bay.

Like seagrass, reef communities can be sensitive to changes in water quality and increases in turbidity caused by weather events, that can be exacerbated from anthropogenic activities that may add further pressure (e.g. land clearing, specific types of dredging methodologies). The coral communities of Cleveland Bay are subject to frequent disturbance from rainfall events and variable climatic conditions. However, they are generally considered resilient to these periodic disturbances and are able to maintain a moderate level of species richness (compared with the broader GBRMP) (BMT WBM 2012a). Previous studies have suggested that coral reefs at Cockle Bay comprise species that are better adapted to high siltation and turbidity than species in Geoffrey Bay (Bell and Kettle 1989) and will better support marine megafauna through disturbances.

2.6 2019 Flood event

In early 2019 the convergence of a slow-moving tropical low and a monsoonal trough caused widespread and intensive rainfall in the Townsville region resulting in extensive flooding of the Townsville region and adjacent inland areas. Townsville received >1,400 mm of rainfall over 13 consecutive days (27 January – 8 February), which is more than the long-term average annual rainfall for the area (1,128 mm; BOM 2019).

A large flood plume originating from the Burdekin River, south of Townsville was evident on satellite imagery (Figure 3) with associated reports that the effects were noticeable on the outer Great Barrier Reef, at sites up to 60 km offshore (ABC, 2019). A review of satellite imagery indicates that the extensive plume does not appear to have spatially overlapped with Cleveland Bay. However, Cleveland Bay may experience effects ranging from localised impacts from flood waters from the Ross River to regional scale impact as marine megafauna respond to changing conditions in the inshore areas of the GBR adjacent to the Burdekin River.

It is recognised that while this monitoring plan focuses on project related risks; natural events, such as cyclones and other severe weather events (i.e. floods), can and will have a much more significant impact on the ecology of Cleveland Bay and associated influence on marine fauna populations. The large-scale

natural impacts to the wider marine environment in the Townsville region during February 2019 will be an important consideration in understanding monitoring results obtained under this plan. The timing of the flood, occurring approximately 5 months prior to the commencement of project activities, may create difficulty in identifying whether measured environmental impacts (if detectable) were caused by Project activities, or are a legacy of the natural flood event. However, initial indications from the CU Project baseline assessments are that habitat impacts are not as extensive as first predicted. Ongoing context on the pre-construction condition of Cleveland Bay will be captured by baseline monitoring prior to commencing project related dredging. This will provide valuable context in relation to the potential resilience of megafauna populations and/or the impact of this natural event.

Figure 3: Flood plume from Burdekin River, south-east of Townsville (NASA 2019)

3 PROGRAM REQUIREMENTS

3.1 Identified modes of impact relevant to megafauna

A risk assessment was completed for each of the potential Project impacts on marine megafauna for the PEP EIS and summarised below in Table 2. To ensure the Project was managing the most relevant construction activities risk, the POTL (including Ecological Australia and GHD Pty Ltd) and a panel of Industry research specialists including Prof Helene Marsh (James Cook University), Dr Christophe Cleguer (Murdoch University) and Dr Col Limpus (DES) refined the PEP risk in a workshop undertaken on 11 March, 2019. The notes from the workshop are provided in Appendix A of this report, with Table 2 summarising the consolidated findings. This provides insight into the key modes of impact likely to affect marine megafauna associated with CU Project activities, including the risk of impacts following the implementation of mitigation measures.

Risks have been assessed by considering the likelihood of an impact occurring on a megafauna or its habitat, rather than the risk of a single incident occurring. While focusing on project related risks, it should be noted that natural events, such as cyclones and other severe weather events (i.e. floods) will have more significant impact on the ecology of Cleveland Bay and associated influence on marine fauna populations.

Without appropriate mitigations, some construction activities have the potential to impact on marine megafauna and their habitat and were considered as having a high initial risk. However, when mitigations are implemented, residual risks were reduced to medium and low ratings. Results of the risk assessment are presented for the residual risks to megafauna and corresponding habitats following the implementation of mitigation and management strategies.

Construction activities that remain at a medium residual risk rating include:

- Rock placement associated with the reclamation area (physical injury);
- Underwater noise generated from construction activities, particularly dredging and piling (auditory injury or displacement of fauna);
- Vessel strike due to increase vessel movements during construction (physical injury);
- Hydrocarbon spill, resulting in the pollution of fauna or habitat.

Aside from direct impacts to marine megafauna from vessel strike, rock placement, or interaction with the dredger, indirect impacts are mostly associated with:

- Turbidity plumes reducing habitat quality
- Displacement of megafauna to adjacent areas
- Deterioration in the health of megafauna, through impacts to habitat or mobilisation of contaminants
- Impact on and loss of habitat due to dredging activities and rock wall footprint (displacement of fauna).

Figure 4 provides a conceptual diagram of the key impact pathways associated with the CU Project.

The overarching objective of this Marine Megafauna Monitoring Plan is to verify that the actual environmental impacts of the Project are at or below the levels predicted (and therefore approved)

through the Project environmental impact assessment process. Accordingly, the risks listed above are those that are addressed in most detail in this plan.

The monitoring plan has considered the results of hydrodynamic modelling from the EIS (BMT WBM 2016) in the selection of monitoring sites, which predicts a highly localised sediment plume that may extend in a westerly direction towards Magnetic Island. If impacts on habitats were to occur, it would be on the habitats to the west of the project activities.

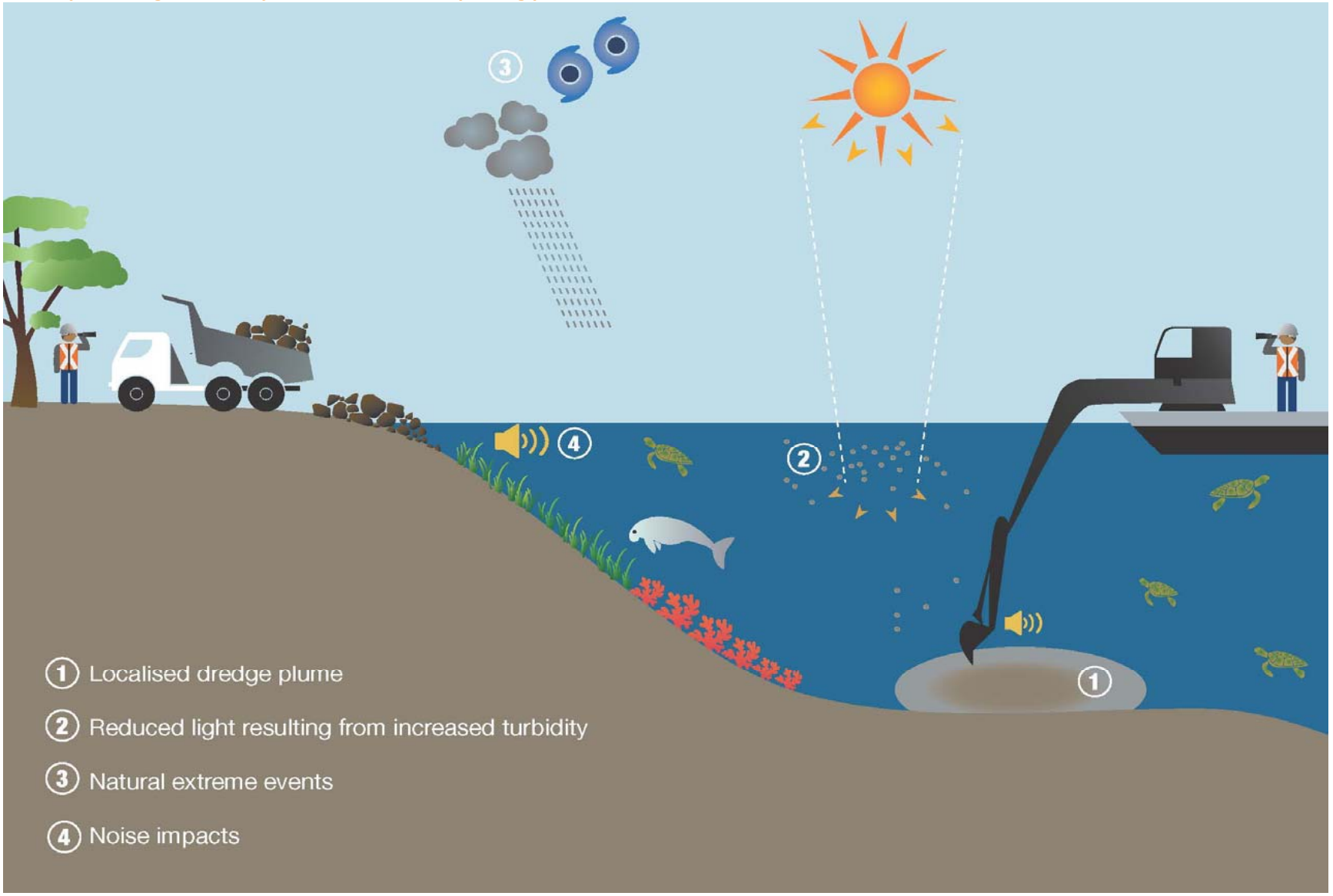
Table 2: Summary of Potential Impacts and Mitigations Measures

Activity	Impact	Likelihood	Mitigation Measures	Residual Risk
Rock Placement and Piling				
Rock Placement for construction of reclamation area	Physical damage to marine megafauna	Likely -turtles Unlikely for other species	Implementation of the Marine Environmental Management Plan (MEMP). Fauna observers to determine the construction zone to be megafauna free prior to soft-start piling and/or rock placement. Fauna observers to implement exclusion zones.	Medium
Rock placement for construction of reclamation area	Underwater noise causing displacement of megafauna from breeding, feeding, and/or migratory habitat loss	Unlikely – turtles (short term) Unlikely – dugongs Unlikely-whales Possible - dolphins	Implementation of the Marine Environmental Management Plan (MEMP). Fauna observers to determine the construction zone to be megafauna free prior to soft-start piling and/or rock placement. Fauna observers to implement exclusion zones.	Medium
Piling for construction activities	Underwater noise causing displacement of megafauna from breeding, feeding, and/or migratory habitat loss	Likely – turtles (short term) Likely – dugongs Likely – dolphins Unlikely - whales	Implementation of the Marine Environmental Management Plan (MEMP). Exclusion zones Fauna observers to implement exclusion zones. Underwater noise assessment in relation to piling	Medium
Rock Placement and Piling	**Entrapment of megafauna during the closure of the reclamation area**	Likely – Turtles Rare – all other species	Implementation of the CEMP	Low

Activity	Impact	Likelihood	Mitigation Measures	Residual Risk
Dredging Activities				
Vessel Movement	Increased vessel movements / on water equipment leading to impact from Hydrocarbon spill	Possible for all species (depending on size of spill)	Implementation of the exclusion and speed zones, where appropriate, as detailed in the Construction Vessel Traffic Management Plan (CVTMP), DMP and MEMP. Implementation of Implement hazardous material handling mitigation measures Implement emergency response procedure in general accordance with the *Queensland Coastal Contingency Action Plan*	Medium
Vessel Movement	Increased vessel movements leading to potential collision between barge or construction vessel with megafauna	Possible – turtles Unlikely – Dugongs/ whales Rare - dolphins	Implementation of the exclusion and speed zones, where appropriate, as detailed in the CVTMP, DMP and MEMP.	Medium
Dredging activity	Strike between dredging equipment with megafauna	Possible – turtles (backhoe and TSHD) Unlikely – dugongs, dolphins, whales	Implementation of the Dredge Management Plan (DMP) and related controls Fauna observers to determine the 'watch zone' to be megafauna free prior to, and during dredging activities	Medium
Port Construction and Operation	Loss of marine turtle and dugong food resources and habitat	Likely – turtles Unlikely – dugongs Possible - dolphins	Implementation of the Dredge Management Plan (DMP) Ensure monitoring of Habitats (Seagrass, Marine Water and Coral programs) continues as contracted throughout the program of works.	Medium
Dredging Activity	Underwater noise leading to displacement from area	Unlikely – Turtles, Marine Mammals	Implement standard mitigation measures as per the DMP/MEMP. Conduct visual checks for marine megafauna Implement strategies to avoid interactions with marine megafauna	Low

Activity	Impact	Likelihood	Mitigation Measures	Residual Risk
Dredging Activity	Dredge plume reduces water quality impacting marine habitats and subsequent displacement of megafauna	Rare – all species	Implement dredge operations practices/action to reduce dredge plume.	Low
Dredging activity	Dredge plume contains contaminants that are available for species uptake	Unknown – all species Significance unlikely to be determined due to mobility of animals	Implementation of the Dredge Management Plan (DMP) Water quality triggers	Low

Figure 4: Conceptual Diagram of Project Activities and impacting processed



Given the habitat preferences for the key megafauna species are not within the footprint of the CU Project rockwall or dredging footprint, it is expected that any individuals encountered in these areas will be transient and not remain in these footprint areas for long periods. Additionally, the number of individuals expected to be encountered would be low. As a result, direct effects from the project activities is expected to be minimal, or short term in both temporal and spatial extent.

As demonstrated by the impact pathway examination, the potential impacts associated with project activities will largely be indirect effects associated with habitat impacts. Measuring project level impacts through indirect effects will be difficult, with the monitoring programs to be implemented taking on a greater focus of providing increased understanding of the species characteristics within Cleveland Bay which may be influenced by project activities.

3.2 Development of this Plan

3.2.1 Development of the Plan

The Marine Megafauna Monitoring Plan has been developed to meet the relevant condition of approval by achieving the overarching objectives of the plan as outlined in Section 1.3. Importantly, the plan's development has been a collaborative exercise drawing on the expertise of a range of scientists who have a long history of studying marine megafauna in Cleveland Bay and more widely across Queensland.

The key steps taken to develop this Plan include:

- Review of marine megafauna environmental values within the Project area and surrounds. This information was used to set the environmental baseline for monitoring and/or to identify where potential gaps in baseline data exist;
- Identification of the potential modes of impact to marine megafauna and relative risk posed by various Project activities;
- Development of specific objectives for monitoring each potential mode of impact and the associated response by marine megafauna to Project-related disturbance;
- Selection of the most appropriate and effective monitoring techniques to meet each specific monitoring objective (see Section 4);
- Development of a reporting and continuous improvement framework that is linked to performance objectives to ensure the monitoring is achieving the desired outcomes.

Section 4.1 provides a detailed discussion on the rationale for the preferred methodologies. A range of potential monitoring techniques were reviewed in the context of the project, the approval conditions, the species of interest and the local marine environment. In summary, the suite of monitoring techniques has been put forward because they:

1. Provide a direct link to the modes of impact that present the highest risk to marine megafauna;
2. Can be effectively implemented in a repeatable and robust manner;
3. Have been recommended and endorsed by marine megafauna specialists.

3.2.2 Survey and monitoring programs

There are a number of other surveys and monitoring programs to be delivered for the CU Project, or undertaken by third parties, that are relevant to this Marine Megafauna Monitoring Plan. Those studies are useful in providing an understanding of pre-construction conditions and/or the types of marine megafauna responses that may be observed in response to CU Project activities and/or potential changes in habitat condition. A summary of these studies and their expected value to this monitoring program is provided below.

Baseline data from the EIS

Collated data provided in the EIS provides a useful dataset with which the results of future surveys and monitoring can be compared. It also provides context and rationale for the choice of monitoring methods and locations. Key information from the EIS has been summarised in Section 2. Specific data that provide an indication of the environmental baseline (i.e. conditions pre-construction) are provided for each variable in the monitoring tables in Section 4.3.

Seagrass monitoring

In accordance with Conditions 3, 4, 5 and 9 of the EPBC Act approval, seagrass monitoring will be completed within the dredge footprint and surrounding areas likely to be affected by dredging and the reclamation area. Condition assessments will be completed of areas likely to be affected by dredging prior to the commencement of works, with ongoing seagrass monitoring in place to detect lethal or sub-lethal impacts from the Project and identify the role of extreme weather events. The sampling design involves monitoring twice per year at the port scale at numerous locations in control and impact zones. Additionally, POTL commissions an annual Seagrass Health Survey in Cleveland Bay which is undertaken by James Cook University's Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER). Details of the Channel Upgrade Project seagrass monitoring are provided in the CU Project Seagrass Monitoring Program.

Coral monitoring

In accordance with Conditions 3, 4 and 5 of the EPBC Act approval, coral monitoring will be completed in areas around the project works likely to be affected by dredging. Condition assessments will be completed of areas likely to be affected by dredging prior to the commencement of works, with ongoing coral monitoring in place to detect lethal or sub-lethal impacts from the Project and identify the role of extreme weather events. The sampling design involves monitoring quarterly at numerous locations in control and impact zones. Details of the Channel Upgrade Project coral monitoring are provided in the CU Project Coral Monitoring Program.

Water quality monitoring

Water quality monitoring will be undertaken before, during and after dredging to validate risk assumptions, modelling results and predicted effects of the Project as component of Dredge Management Plan (Condition 5h of the EPBC Act Approval). Monitoring will be conducted at a number of sub-tidal sites and inter-tidal sites using continuous water monitoring equipment deployed along with monthly collection and analysis of physical samples. Logger data from subtidal sites will include turbidity, sediment deposition, multispectral light, dissolved oxygen, pH, temperature, electrical conductivity and depth. Inter-tidal loggers will collect data on light and temperature. Further to these, physical near field sampling will also be undertaken from around the dredge and reclamation works, with samples collected analysed for dissolved metals, nutrients and total suspended solids. During construction data will be

used to understand if changes in water quality conditions may result in sub-lethal impacts to sensitive habitats. This will be used to support environmental protection management activities during construction. Details of the Channel Upgrade Project water quality monitoring are provided in the Baseline Marine Water Monitoring Program.

Marine turtle health monitoring

The Department of Environment and Science (DES) and WWF have undertaken several years of Green Turtle monitoring in Cockle Bay, to the west of the Project Area. The project has involved the capture of Green Turtles and assessment of their health through the collection and analysis of blood samples. Turtles have also been tagged and released, providing a baseline of results for individuals. This work provides an environmental baseline for Green Turtles foraging close to the Project area, in a location that may possibly be affected by construction works from time to time. DES has indicated a willingness to continue this program of work during the Project to add to the research knowledge and observe any changes to the health of Green Turtles during Project timeframes.

4 MARINE MEGAFAUNA MONITORING PROGRAM

4.1 Rationale for preferred methodology

There are numerous monitoring methods that could be applied to assess the response of marine megafauna and their habitats to disturbance associated with a dredging and reclamation project. It is important that selected methods are able to collect data that will address the specific objectives of the CU Project. This will avoid the collection of data which provides minimal information on the actual effects of Project activities and will ensure that data collected can be used to compare observed environmental effects with those predicted in the EIS (and approved by the relevant regulators). This will inform relevancy and adequacy of identified environmental protection measures and/or enable adaptive management intervention.

Common approaches to marine megafauna monitoring implemented at other locations during dredging projects include aerial and vessel based surveys, complemented by monitoring of key habitat characteristics, such as seagrass and water quality. However, one of the factors complicating the monitoring of marine megafauna using such methods is their mobile and at times unpredictable behaviour and patterns of habitat use. An additional challenge with monitoring megafauna is that they often occur naturally in low and highly variable numbers at a local scale and therefore detecting local scale impacts can be difficult.

To identify and address the challenges in identifying megafauna monitoring methods of relevance for the CU Project dredging campaigns, POTL convened a workshop with marine megafauna research experts Prof Helene Marsh (James Cook University), Dr Christophe Cleguer (Murdoch University) and Dr Col Limpus (DES) in Townsville on 11 March 2019. The focus of the workshop was to discuss the monitoring approaches available to POTL and to identify those methods best suited to meeting the megafauna related condition of approval for the CU Project. The potential values of all recognised marine megafauna monitoring methods were discussed, with strengths and weaknesses identified and recorded, based on expert knowledge and experience with similar projects. Details from the workshop discussions are provided in Appendix A.

The workshop resulted in the following design principals being applied for the megafauna monitoring plan:

1. The selection of monitoring variables has been focussed on those indicators that are influenced by Project activities, and therefore have a direct link to environmental management of the CU Project.
2. Selected monitoring methods are capable of detecting any form of change at a scale relevant to CU Project activities and will facilitate the collection of data of sufficient quality and quantity to determine whether, on the weight of available evidence, the Project has had an impact on marine megafauna or their habitat.
3. Marine megafauna habitat features are site-relevant and provide a more reliable means of evaluating potential Project impacts, than monitoring megafauna individuals, which often occur naturally in low and highly variable numbers at a local scale and are therefore more difficult to measure.
4. Some actual modes of impact can be measured, to verify the predictions about the magnitude of impact on marine megafauna and their habitats from the impact assessment. Examples of relevant indicators include the distribution and concentration of suspended sediment plumes created by dredging activities and the magnitude of underwater noise generated by piling and rock placement at varying distances from the source.

A key tenet of the workshop was to review the available marine megafauna monitoring techniques and critically appraise their applicability to the CU Project, with a focus on the specific impact pathways associated with the project. A summary of this appraisal is provided in Table 3, with full details found at Appendix A.

Understanding the spatial patterns of distribution of megafauna and the factors contributing to such patterns is a key foundation for any program aiming to detect change arising from the impacts of Project activities (which if occurring, are most likely to manifest through the displacement of animals from the vicinity of the Project area). Conversely, the persistence of animals adjacent to Project activities may lead to conclusions of minimal Project impacts, when such behaviour may result in an increased risk of direct impacts, from vessel strike or reduced habitat quality (resulting in poor nutrition). Individual variation in megafauna responses to pressures increase subjectivity when interpreting the results of monitoring tasks and warrant careful consideration when designing a marine monitoring program. Likewise, it is valuable to understand the role of natural events such as floods and cyclones in causing impacts on marine megafauna of Cleveland Bay.

A common short-coming of many marine megafauna programs designed for impact assessment is that they are unable to determine what role, if any, project activities had in causing any observed patterns of distribution, either due to a lack of statistical power, or because of limited understanding of the other factors that may influence the distribution of individuals. In this context, a monitoring program that is focussed on the assessment of habitat quality and confirming the magnitude of actual project impacts is likely to be most informative on potential megafauna impact.

As an outcome of the expert workshop, a range of monitoring indicators were selected, based on the advice of experts, to comprise the primary components of the megafauna monitoring program. These monitoring measures have been tailored to the identified modes of impact and the relevant megafauna species at risk, to have greatest value to the environmental management of the Project. Table 4 provides the activity impact pathway and details the monitoring program to address each pathway.

Table 3: Summary of Potential Megafauna Monitoring Tools

Monitoring tool	Applicability for each species group			Relevance / Comment
	Turtle	Dugong	Other Cetaceans	
Aerial (person)	Yes (but not at bay scale) Limited for project	Yes (but not at bay scale) Limited for project	Yes but infrequent visitors so limited	Pop size; relative density; fecundity; area of occupancy; threat exposure More relevant at scale of GBR, not bay scale. Long time periods required. Won't separate project impacts from natural changes. Species level detection difficult for turtles and dolphins
UAV	No Detector being trained; not at species level.	Yes	No Detector being trained; not at species level.	Relative abundance; Pop size; relative density; fecundity; area of occupancy; threat exposure – at local scale. Fine scale habitat use. UAV surveys can be conducted at variable spatial and temporal scales: Small UAVs could be used to focus on dredge and dredge area, use of core areas. Potential to detect pop size response, will be dependent on number of individuals detected. Unlikely to be enough individuals except possibly turtles – need trial to determine. High precision positioning of animals in relation to plume or noise and in relation to habitat characteristics possible. Repeatability of survey.
Vessel based visual	No	No	No	Not effective for project requirements. Less effective in turbid environments and for dugongs that surface for only a short interval.
Passive underwater visual	No	No	No	Requires clear water, often with bait attraction. Restricted value in turbid environment
Mark Recapture				
Visual/ Photo id	No In development	No	Yes	Abundance estimate, movement in and out of area; site fidelity Requires clear water; in turbid env likely need to catch them to ID

Satellite	Yes	Yes some	No given large range	Home range, habitat use; migratory corridors. Health assessment linkages Safety concerns with capturing individuals (mammals). Also, movements are individualistic so need sample size of at least 10 to be meaningful. Once individual caught can then do stomach content assessment, blood work etc.
Pit tag (microchip)	Yes	Yes some	Yes some	Life history information. Survivorship, growth etc. Health Assessment linkage Flatbacks and Leather backs it is routinely used for. Looking at long timeframe. Limited value for mammals given have to catch the animals
Flipper tag	Yes	Yes ?	No	Life history. Survivorship, growth etc. Health assessment linkages. Population performance (trends etc) rather than pop counts/abundance. Relevant for broad impacts (flooding etc). Flatbacks and Leatherbacks it is routinely used for. Looking at long timeframe. Once individual turtle caught can then do stomach content assessment, blood work etc.
Molecular tag	No	Yes	No	Some pop info. Health indicators. Not viable for turtles, large number of individuals in Bay. Genetic stock info may be viable through these systems (and origins) – turtles and dugongs.
Acoustic tags	Yes ?	Yes ?	No	Habitat prevalence/preference. Counts only. Need an acoustic array. Very expensive to establish depending on scale and area to be covered. Array needs to be monitored on a regular basis
Strandings	Yes	Yes	No	Mortality cause (if possible). Won't give total numbers, but trends. Can do health assessments where not too decomposed. For disease issues, need fresh corpse and dedicated approach to respond. Need negotiation with DES for StrandNet program. GBRMPA and DES discussion needed on focus on health assessments to defend/ demonstrate not port impacts. Perception management.

Habitat quality (feeding trails)	No	Yes	No	Habitat use; difficult to interpret. Not likely to be valuable in this project. Shallow water areas only on Eastern side of Cleveland Bay. Cockle Bay sea grass unlikely to show trails.
Health investigations	Yes	No?	No	Pathological investigations On live animals, very valuable for turtles. More difficult for dugongs given turbid water etc. Human safety issues with capture, animal stress concerns.
Beach nesting	No	No	No	Population stats from nesting Inter-nesting movement very important – need satellite tagging. Shows use of deeper water areas (not feeding etc) which is relevant for dredging. 2 week period to make eggs and then nest to lay. Flatback Nov – Jan nesting, Green – 5 mth period. May not be relevant for Cleveland Bay. Academically interesting – sat tag flatbacks on Maggie Is prior to dredging and then monitor during dredging and look for changed behaviour (inter-nesting)
Construction marine observers (structured/qualified)	Yes	Yes	No	Presence/absence. Injury from activity where observed. Upfront investment in megafauna training and agreed recording protocol (to be developed with megafauna experts) for observers needed to build strong dataset. As robust as can be if designed well.
Incidental sightings	Yes ?	Yes ?	Yes ?	Presence/absence. Soft data Unstructured, review of eye on reef in 2017 found quite a significant level of mis-id and spatial location not QA'd. Not clear how good GBRMPA QA is on Eye on the reef. Promote public reporting of strandings so that an expert can id and do health and cause of impact review. Focus should be on reporting and responding by expert.

Table 4: Summary of Monitoring Measures for each Potential Impact

Activity	Impact	Likelihood	Residual Risk	Monitoring Measure (relevant plan section for details in brackets)	Link to Monitoring Program Objectives (From Section 1.4)
Rock Placement and Piling					
Rock Placement for construction of reclamation area	Physical damage to marine megafauna	Likely -turtles Unlikely for other species	Medium	Marine Fauna Observers to implement relevant exclusion zones for megafauna (marine turtle and dugong)/review of daily log (4.3.7) Stranding program – Vet to focus on cause of fractures and wound dimensions (4.3.5)	2, 3
Rock placement for construction of reclamation area	Underwater noise causing displacement of megafauna from breeding, feeding, and/or migratory habitat loss	Unlikely – turtles (short term) Unlikely – dugongs Unlikely- whales Possible - dolphins	Medium	Marine Fauna observers to implement relevant exclusion zones for megafauna (marine turtle and dugong)/review of daily log (4.3.7) Underwater noise modelling review / monitoring against the modelled data for the PEP EIS (4.3.3)	2, 3
Piling for construction activities	Underwater noise causing displacement of megafauna from breeding, feeding, and/or migratory habitat loss	Likely – turtles (short term) Likely – dugongs Likely – dolphins Unlikely - whales	Medium	Piling acoustics and sound model validation (as per condition 15 and 4.3.3). Marine Fauna observers to implement relevant exclusion zones for megafauna (marine turtle and dugong)/review of daily log (4.3.7)	2, 3
Rock Placement and Piling	**Entrapment of megafauna during the closure of the reclamation area**	Likely – Turtles Rare – all other species	Low	Marine Fauna observers to determine the construction zone of the reclamation area is megafauna free prior to enclosing the rock wall. (4.3.7)	3

Activity	Impact	Likelihood	Residual Risk	Monitoring Measure (relevant plan section for details in brackets)	Link to Monitoring Program Objectives (From Section 1.4)
Dredging Activities					
Vessel Movement	Increased vessel movements / on water equipment leading to impact from Hydrocarbon spill	Possible for all species (depending on size of spill)	Medium	Fauna observations from vessel master/crews / review of daily log Vessel movement/tracking – speed, location etc.	2, 3
Vessel Movement	Increased vessel movements leading to potential collision between barge or construction vessel with megafauna	Possible – turtles Unlikely – Dugongs/ whales Rare - dolphins	Medium	Fauna Observations from vessel master/crews/ review daily log. Vessel movement/ tracking – speed, location etc. Stranding Program review of cause of injury/death (4.3.5)	2, 3
Dredging activity	Strike between dredging equipment with megafauna	Possible – turtles (backhoe and TSHD) Unlikely – dugongs, dolphins, whales	Medium	Marine Fauna observers to implement exclusion zones for megafauna (marine turtle and dugong) /review of daily log. (4.3.7) Vessel movement/ tracking – speed, location etc. Stranding Program review of cause of injury/death (4.3.5)	2, 3
Port Construction and Operation	Loss of marine turtle and dugong food resources and habitat	Likely – turtles Unlikely – dugongs Possible - dolphins	Medium	Review of TropWATER seagrass monitoring reports and O2Marine Coral monitoring reports to identify changes in habitat abundance. (4.3.4) Turtle Health Assessments (4.3.2) Satellite tracking of green turtle movement - Tagging of green turtles to identify individual use of habitats (4.3.1)	1, 2, 3, 5
Dredging Activity	Underwater noise leading to displacement from area	Unlikely – Turtles, Marine Mammals	Low	Marine Fauna observers to indicate behavioural change in megafauna associated with dredging. (4.3.7) Satellite tagging of green turtles where available to inform habitat use and use change (4.3.1)	2, 3, 5

Activity	Impact	Likelihood	Residual Risk	Monitoring Measure (relevant plan section for details in brackets)	Link to Monitoring Program Objectives (From Section 1.4)
Dredging Activity	Dredge plume reduces water quality impacting marine habitats and subsequent displacement of megafauna	Rare – all species	Low	Review of CU Project habitat monitoring programs for potential impact on megafauna (4.3.4)	2, 3
Dredging activity	Dredge plume contains contaminants that are available for species uptake	Unknown – all species Significance unlikely to be determined due to mobility of animals	Low	Extension of Cockle Bay turtle health assessments if there is plume impact that far. (4.3.2) Informed by: • SAP to inform risk. • Marine Water Monitoring program to show contaminant levels.	2, 3, 5

4.2 Summary of Monitoring Activities

Table 5 summarises the key monitoring activities of the Marine Megafauna Monitoring Plan. The EPBC Act Approval 2011/5979 Condition 12 (d) requires a program to monitor the potential impacts to marine fauna before and during construction activities in the marine environment. Monitoring will therefore be completed for a period of four years, with details of the frequency, timing and aspects of implementation provided in Table 5. For each individual monitoring task, a more detailed description is also provided in Section 4.3. This includes specific objectives, methods, baseline trending information and details of the approach to implementation for each monitoring task.

It is to be noted that vessel-based surveys and aerial surveys of marine megafauna were not selected as key monitoring methods for implementation, based on the advice of experts at the workshop in March 2019.

Key limitations identified with these methods for application to the Project monitoring program included:

1. It is rarely possible to collect data in sufficient quantity and at sufficient spatial and temporal scales to provide the statistical power necessary to detect change in megafauna indicators
2. Aerial surveys typically have a low precision, except at spatial scales much larger than those relevant to a site-based dredging project
3. There is difficulty accounting for variability in water clarity across the Study Area, which affects the sighting of individuals
4. Turtles and dolphins are difficult to identify to species level from an aircraft.

However, it should be noted that while aerial surveys are not included as part of this MMMP, POTL is engaging with a contractor to fund aerial surveys in 2019 that will be conducted prior to capital dredging and prior to rock wall construction. That survey information will provide general data linkages between this stage of development (i.e. CU Project) and future stages of PEP, while also contributing to the scientific knowledge of large megafauna in Cleveland and surrounding Bays.

Table 5: Summary of marine megafauna monitoring activities

Monitoring Activity	Description[#]	Frequency*	Objective and Implementation
GPS Tracking of foraging Green Turtles inhabiting the project area	Satellite tracking of 20 Green Turtles over a period of four years, captured in the Cockle Bay area adjacent to the Project Area	Annually for four years	Increase the understanding of the Green Turtle habitat use adjacent to and during Project activities, particularly home range, water depth and movement of individuals. Monitor the habitat use of foraging Green Turtles during construction to identify any behavioural changes that may be associated with habitat impacts from project activities.

Monitoring Activity	Description#	Frequency*	Objective and Implementation
Health Assessments	Complete health assessments on up to 30 Green Turtles per year in the Cockle Bay, and 30 Green Turtles per year in Southern Cleveland Bay, adjacent to the Project	Annually for four years	Provide data on the health of Green Turtles in Cleveland Bay during the CU Project. Provide information and increased understanding of the potential influence of project-related activities on the health of Green Turtles of Cleveland Bay. Monitor the health (pathology/histology) of Green Turtles before and during the project using the published WWF/DES Health Assessment for Cleveland Bay as a baseline.
Underwater Noise	Measurement of underwater noise during rock placement. Marine fauna observers monitoring exclusion zone to prevent injury to marine megafauna produced by underwater noise.	During the initial four week period of rock placement activities.	Monitor underwater noise during key Project construction activities (i.e. rock placement) to validate the underwater noise level modelling from the EIS and confirm levels do not exceed those predicted to occur in the EIS. To confirm that exclusions zones being implemented are adequate to provide protection to marine megafauna from the risk of injury from underwater noise.
Seagrass/Coral Health	Review seagrass and coral monitoring data and interpret with regard to turtles and dugong habitat values	Annually for four years	Assess the magnitude and extent of changes to turtle and dugong foraging habitats (seagrass; coral) as an indicator of potential impacting processes on turtle and dugong movement and/or health within Cleveland Bay. Review the findings of seagrass and coral monitoring completed at key sites. Seagrass and coral health indicators will be compared with baseline and those predicted in the EIS, to describe habitat values for turtles and dugong.
Stranding Program	Collection and analysis of stranding program data. A systematic necropsy of up to 20 suitable (non-degraded) marine megafauna carcasses per year (where accessible) by a qualified veterinarian	Ongoing for four years	Determine changes in the stranding rate of marine megafauna during the CU Project when compared with pre-project numbers. Provide increased understanding of the cause of strandings and deaths (where possible) and assess the potential for project-related mortality. Provide increased understanding on cause of death through necropsy examinations (where suitable specimens are available), particularly project related causes.

Monitoring Activity	Description[#]	Frequency*	Objective and Implementation
Inshore Dolphin	Collate and review any incidental marine megafauna sightings recorded during the Inshore Dolphin Monitoring Program	Annually for four years	Utilise incidental sightings and observation data of marine megafauna from the IDMP as supplementary information to assist in the interpretation of other monitoring data.
Fauna Observers	Trained megafauna observer to enforce exclusion zones for marine megafauna around certain Project activities. A daily log will be maintained.	Monthly for 12 months	Utilise sightings and observation data of marine megafauna from the Marine Fauna Observers as supplementary information to assist in the interpretation of other monitoring data. Review of fauna observer daily log to identify any trends in megafauna presence/absence or behaviours.

[#] Numbers of target animals is subject to availability of animals for each activity/method.
* Frequency of monitoring may vary if large scale natural event occurs (i.e. may expand seagrass surveys).

4.3 Details of Monitoring

4.3.1 GPS Tracking

A key potential mode of Project impacts on marine megafauna is the displacement of individuals from the vicinity of Project activities to alternative locations. For example, in the event of project-related disturbances associated with underwater noise and increased construction vessel movements, marine megafauna may be expected to move to adjacent areas, which are subject to less disturbance. However, the scale of displacement (e.g. hundreds of metres through to hundreds of kilometres) is difficult to predict and is likely to be species-specific or unique to individual animals.

Green Turtles are the most abundant marine megafauna species in the Project area and forage within a defined home range. Green turtles may therefore have a stronger preference than other species to persist within their home ranges, despite ongoing disturbances from Project activities. Given the predicted small magnitude of environmental impacts from the Project, it is expected that Green turtles will continue to utilise habitats adjacent to the Project area during reclamation and dredging works.

There are several studies from Queensland and internationally, which demonstrate the strong site fidelity of foraging green turtles. Babcock et al. (2015) tracked the movement of 49 green turtles in Port Curtis, Gladstone, using GPS satellite and acoustic tag methods. They found that Green turtles had small home ranges that persisted for periods of at least several months. Adjacent to Wiggins Island in the western section of Gladstone Harbour, the average cumulative home range was 1.3 km^2 (50% Kernel Utilisation Distribution; KUD) and 6.7 km^2 (95% KUD). Further east in on the Pelican Banks of Port Curtis, home ranges were larger at 2.2 km^2 (50% KUD) and 14.7 km^2 (95% KUD).

While Babcock et al. (2015) reported that home ranges were generally small and stable on average, there was individual variability in home range size and shape, with some turtles utilising multiple locations within Port Curtis. Adults tended to forage over larger distances that juveniles, and juveniles

were more likely to establish a smaller home range for longer periods than adults. Some turtles on the Pelican Banks moved a distance >100 km from where they were tagged.

Gredzens et al. (2014) tracked six green turtles in Shoalwater Bay, Queensland, and found a median 50% core area of 0.4 km^2 and a median 95% home-range area of 3.5 km^2. Five of the six turtles tracked had very small coastal home ranges, while the sixth turtle was more mobile. Three turtles tracked in the Torres Strait also showed strong site fidelity in reef habitats, while a fourth turtle was transient across several reef areas (Gredzens et al. 2014).

Such studies correlate closely with similar work internationally, which has demonstrated the long-term site fidelity of juvenile and adult green turtles. Mendonca (1983) found daily movements were confined to areas up to 5 km^2 on shallow flats in Florida, and Brill et al. (1995) found an average home range of 2.6 km^2 at Kaneohe Bay, Hawaii.

Of particular interest for the monitoring program at Cleveland Bay are Green Turtles living in and adjacent to the Project area, particularly those located down current from dredging activities. Such turtles may experience some form of disturbance from Project activities, including increased risk of vessel strike, and temporary reduction in habitat quality from localised suspended sediment plumes. Capturing and tracking the location of Green Turtles in areas likely to be directly or indirectly affected by Project works is therefore an important monitoring task to increase understanding of turtle behaviour and of potential Project impacts.

Details of this monitoring task objective, methods and associated analysis and reporting are provided in Table 6.

GPS satellite transmitters will be attached to Green Turtles captured from inter-tidal and sub-tidal waters adjacent to the southern and eastern foreshores of Magnetic Island, including Cockle Bay. While Babcock et al. (2015) found that both acoustic tags and satellite tags were effective at monitoring green turtles in Port Curtis, satellite tags will be utilised in this monitoring program as they have the advantage of transmitting location data for tagged turtles that move outside of a receiver array established for acoustic tags.

While satellite tracking of Green turtles has not been completed in the Project Area in recent years, a recent study of Green Turtle health in this location has resulted in many individual Green Turtles being captured and tagged (PIT and flipper), providing some information on habitat use in the region. Such data may be useful if these individuals are re-captured during Project monitoring activities and subsequently tracked using GPS satellite tags.

Turtles will be captured using the turtle rodeo method of jumping from catch boats to restrain the turtle (Limpus, 1978), or through the use of attended nets located on seagrass and grazing beds, in accordance with relevant animal ethics, marine park, scientific and fisheries permits. GPS satellite tags will be attached on up to five individuals per year during the Project, provided they are outwardly healthy and there is no indication that the tags would comprise their health or activity.

Once released, GPS satellite tags will collect data on the location of each tagged Green Turtle, with data transmitted on a daily basis through the ARGOS satellite network. Data on temperature and dive depth will also be collected by the tag. Often (as indicated by previous tracking programs), only limited temperature and depth data are transmitted through the satellite network, with turtles generally required to be recaptured to download data directly from the tag. However, if obtained, dive depth data may provide information on the diving behaviour of turtles in the area.

A total of 20 turtles will be captured and tracked throughout the project over four years, with the monitoring effort spread evenly (i.e., five per year) so that a small number of tags are regularly transmitting data. Based on the impact pathways and background understanding of green turtles, given the site fidelity of green turtles in the Townsville region it is considered that tagging 20 turtles over the four years of the project would be allow observation of habitat use by individual turtles and potential avoidance strategies during the dredging campaign. This has been supported through feedback from subject matter experts from DES and JCU through the expert workshop and some follow up discussions. Cockle Bay is approximately 5km from the channel dredging works and represents the closest feeding grounds for Green Turtles to the Project works.

While it is possible to attach satellite tags to dugong, such monitoring is not proposed, due to the low numbers of dugong known to occur in the immediate surrounds of the Project area, the fact that the project area is likely to only be a transit area for dugongs (not a key habitat) and the larger spatial scales over which dugong are likely to move throughout Cleveland Bay and beyond (compared with Green Turtles). Additionally, the capturing of dugong will pose a significant safety risk to personnel attempting to capture them and is likely to cause increased stress and impact on the captured individuals.

POTL recognises the significant experience of personnel from DES and James Cook University (JCU) in undertaking similar satellite tracking work on marine turtles across the Great Barrier Reef and will seek to partner with DES and JCU to implement this aspect of the monitoring program.

While the expert workshop identified satellite tagging of nesting Flatback Turtles to understand their inter-nesting movement and use of deeper waters (including potentially the shipping channels) as a possible monitoring approach, this will not be implemented at this stage. The decision to not tag Flatback Turtles has been made due to their low nesting densities in Cleveland Bay and Magnetic Island reducing the likely success of any tagging program (given the challenge with actually encountering a turtle nesting on any given night). Additionally, the attachment of the tags by harness (rather than adhesive) is a specialised approach. POTL will continue to engage with local Turtle Experts during the project and will consider extending this tagging program to cover inter-nesting of Flatback turtles if the opportunity arises.

Table 6: Details of GPS tracking in the region

Details of Monitoring Program – GPS Tracking	Implementation
Objectives	Increase understanding of Green Turtle habitat use adjacent to and during Project activities, particularly the home range, water depth and movement of individuals.
Methods	Green turtles will be captured in areas adjacent to the Project area using the rodeo method or attended nets in accordance with scientific and ethics approvals. Cockle Bay will be an area targeted for the capture of turtles, due to its location as the closest feeding grounds adjacent to Project activities (approx. 5km from dredging areas), within the area predicted to potentially be influenced by dredge plumes. Also, turtles have successfully been captured in this location previously during a joint WWF/DES study. Once captured, a GPS satellite tag will be attached to adult or sub-adult foraging Green Turtles using an epoxy adhesive. The turtle will be subsequently released in the vicinity of the capture location, with its location monitored for a period of approximately 4-6 months, or until the tag ceases transmission.

	A total of **20 turtles** will be captured and tracked throughout the project over four years. The intent is to spread the monitoring effort evenly (i.e., five per year) so that a small number of tags are regularly transmitting data. The strong site fidelity and small home range of green turtles will allow greater understanding of habitat use and potential changes to use to be informed with a sample size of 20 turtles. ARGOS and Fastloc GPS Data will be filtered using software such as RStudio and plotted on GIS software products. Home ranges will be plotted using Gaussian kernel density estimates and geospatial modelling software utilised. Data analysis will contribute to understanding of habitat utilisation by tagged turtles during various stages of the Project.
Baseline	GPS tracking data will build on limited habitat use data sets for the region, and information about home range and habitat utilisation from other ports (Preen 2000) (e.g. Gladstone).
Environmental variables to be monitored and interpretation	Habitat use by Green Turtles in the vicinity of the Project Area will be monitored in real time (data available daily). Depth and temperature data will also be collected, if transmitted through the satellite system. GPS location data will be monitored regularly (monthly) with analysis of all data occurring on an annual basis. Patterns in habitat use by individuals within and adjacent to the Project area will be summarised and considered in light of known potential stressors that might result in displacement of marine turtles (e.g. reduction in the condition and extent of seagrass habitats, location and timing of construction activities). The EIS predicted that the Project will have little to no impact on marine turtles and their habitat; monitoring data will provide an opportunity to verify this prediction, while building knowledge of Green turtles utilisation of the project area.
Performance and Limitations	Data of turtle movement is noted as unlikely to provide a scientifically robust determination of change. As noted, turtle behaviour can be individualistic, and therefore the number of turtles being tagged is likely to include variation due to this aspect. However, this sample size being used will provide general information on the pattern of habitat use. Overall confidence in capturing turtles for tagging is high, given the habitat preference of turtles in Cleveland Bay and success achieved in other turtle monitoring programs.
Reporting and Corrective Actions	An annual report will be prepared on the home range and movement patterns of tagged green turtles in the Project area during the preceding year, and any relationships with Project activities. This will increase understanding of green turtle habitat use in the Project Area and assist in managing potential project impacts. In the event of a decline in key habitat features (e.g. seagrass or coral reefs) from natural or Project-related influences, the GPS satellite data will inform multiple line of evidence assessments of potential effects on foraging Green turtles. This information will support the management measures listed in the relevant management plans (MEMP, CEMP, DMP) and be a fundamental part of adaptive management reviews of those plans.

4.3.2 Health Assessments

Impacts on the health of marine megafauna through the loss or reduction in food resources and habitat from project activities, was identified as a medium level risk through the EIS. The potential to impact on the health of dugongs and dolphins was considered of a lessor concern than the impact on turtles given their mobility.

The Green Turtle has been proposed as a sentinel indicator of environmental health, due to its high site fidelity, use of local resources and long-lived nature (Aguirre and Lutz 2004). There are established links between declines in coastal environmental values and reduced health of Green Turtles. One such example is a major flood of Port Curtis (Gladstone) in 2011, which caused temporary loss of seagrass communities, and was followed by an increase in strandings and a decline in Green Turtle health indices (Eden *et al*. 2011).

The health of foraging Green Turtles captured from inter-tidal and sub-tidal waters adjacent to the southern and eastern foreshores of Magnetic Island (including Cockle Bay) will be monitored. Turtles in the southern part of Cleveland Bay will also be targeted. These locations are adjacent to the main shipping channel where dredging will be completed (Cockle Bay ~5km from the dredging activity) and is the where an ongoing program of Green Turtle health surveys have previously been implemented by DES and WWF. This previous work has established a baseline for Green turtle health indicators over a five year period, prior to the commencement of Project activities.

From 2014 to 2018, a total of 374 individual green turtles were captured by DES and WWF from waters along the southern and eastern edges of Magnetic Island, before being tagged and released (Bell et al. 2018). The diet and health status of captured turtles was examined through a range of methods, including the sampling of stomach contents and blood. Approximately 64% of the green turtles captured were juveniles, with analysis of stomach contents indicating a diet dominated by the seagrasses *Cymodocea serrulata* and *Halodule univervis.*

In 2014, blood was collected from 40 green turtles and analysed for a range of biochemical and haematological indicators for which reference ranges have been established for healthy green turtles (Flint et al. 2010). In 2017, turtles were re-sampled, with analysis of blood samples focussed on recaptured turtles (n=10), to allow the results of individuals to be monitored through time.

While the majority of blood indicators in 2014 were within the published reference ranges, concentrations of Creatinine Kinase were elevated, leading the authors to conclude that a degree of environmental stress was present from unknown sources (Flint et al. 2018). Subsequent monitoring in 2017 showed that Creatinine Kinase levels had returned to within the range expected for healthy sea turtles.

These results indicate that green turtles at Cleveland Bay, as with other locations studied along the Queensland coast, are subject to a range of environmental stressors that may influence the occurrence of poor health indicators, when compared with turtles from control sites located far away from urban and industrial land uses (Flint et al. 2018).

Blood samples from the DES/WWF study were also analysed for heavy metals, with the concentrations of manganese, antimony and cobalt above the reference range for Green Turtles (Villa et al. 2018). Similar results were obtained for other studied locations along the Queensland coast. With regard to Cleveland Bay, Villa et al. (2018) concluded that green turtles face chronic trace element exposure conditions, based on the combined results of metals and haematological analyses.

These studies highlight that green turtles living within and adjacent to the Project Area are subject to existing environmental stressors, which are likely to be influenced in some part by the urbanised and industrialised coastal landscape and catchment of the region. This previous work provides POTL with an opportunity to continue to monitor green turtle health indices during Project activities, to increase understanding of patterns in green turtle health and identify any trends that coincide with or may potentially be influenced by project activities.

It is difficult to make direct links between observed declines in health indices of marine turtles and the associated causal influences. A range of natural and anthropogenic factors may result in a reduction in health and condition, and identification of these causes is unlikely to be possible at a high degree of certainty. However, results of the health studies will provide data that can be used in combination with data from other Project monitoring programs (e.g. seagrass, coral, water quality) to inform line of evidence assessments of the potential role of Project activities on the environmental health of relevant indicators. Monitoring will also increase the understanding of the long-term health status of Green turtles within the Project Area and their potential sensitivities to ongoing port activities in the region.

Health monitoring will include an assessment of physical abnormalities (injuries or growths), body condition scoring, the assessment of breeding condition (laparoscopy) and the sampling of blood for analysis of haematology, biochemistry and heavy metals parameters. Pathological and chemical analysis of blood samples will provide information on the health of individual turtles when compared with reference ranges published from undisturbed areas (Flint *et al.* 2010; Villa *et al.* 2017).

All work will be undertaken under the guidance of a veterinarian and in accordance with scientific and animal ethics approvals. POTL recognises the significant experience of DES in undertaking similar work in the region and will seek to partner with DES to implement this aspect of the monitoring program. The involvement of veterinary experts from James Cook University will also be sought. It is intended that the turtle tagging and health assessment programs will be integrated with turtles selected for tagging included in the health assessment program.

Details of the health assessment monitoring of Green Turtles are provided in Table 7.

Table 7: Details of health assessment monitoring in the region

Details of Monitoring Program – Health Assessment	Implementation
Objective	Provide data on the health status of live Green Turtles, as sentinel indicator of megafauna health, in Cleveland Bay during the life of the CU Project. Provide information and increased understanding of the potential influence of project-related activities on the health of Green Turtles of Cleveland Bay.
Methods	Health assessments will be undertaken on turtles captured using rodeo methods or attended netting from the inter-tidal and sub-tidal waters adjacent to the southern and eastern edge foreshores of Magnetic Island, including Cockle Bay, and southern sections of Cleveland Bay. Once captured, turtles will be transported by vessel to a facility or temporary processing area on shore to be assessed and sampled, prior to being released. Up to **30 turtles** per year in each of two locations

	east and west of the dredging activity (nominally Magnetic Island foreshore and southern Cleveland Bay) will be targeted. A veterinarian will assist with completing the health assessments, which will include measurement of length, weight, body scoring, laparoscopy, and the collection of blood samples for analysis of biochemistry, pathology and heavy metals, using the methods described by Flint et al. (2018) and Villa et al. (2018). An assessment will be completed prior to dredging works commencing, to provide an overview of conditions prior to dredging, including the potential influence of the 2019 flood event.
Baseline	Previous health assessments of Green Turtles have been completed by DES and WWF in the region from 2014, with baseline data published (Flint et al. 2018, Villa et al. 2018). POTL will seek to work with these stakeholders to continue these assessments during the Project and utilise previously collected data as a comparative baseline for future comparisons and assessment of ongoing green turtle health.
Environmental variable to be monitored and interpretation	Live turtle health (physical examination, body condition scoring), length, weight, breeding status (laparoscopy) Collection of blood samples for analysis of biochemistry and pathological parameters, and heavy metals per Flint et al. (2018) and Villa et al. (2018).
Performance and Limitations	This assessment alone will not provide unequivocal evidence of project impact given the life histories of turtles and the mobility of individuals. However, this data will be used in combination with data from other Project monitoring programs to inform assessment of the potential role of Project activities on the overall ecosystem health. This monitoring will also contribute to the understanding of the long-term health status of Green turtles within the Project Area and their potential sensitivities to ongoing stresses in the region. Overall confidence in capturing turtles for undertaking health assessments is high, given the habitat preference of turtles in Cleveland Bay and success achieved in other turtle monitoring programs.
Reporting and Corrective Actions	The health status of Green Turtles will be assessed annually, with results included in annual reports. The results will be utilised as a source of data to inform line of evidence assessments of the potential for Project activities to be adversely affecting Green turtle health. Other data, or lines of evidence, will include the results of monitoring of seagrass, coral and water quality. The results of health assessments of live turtles will also inform the interpretation of results of strandings assessments, to determine whether there are any patterns in the types of conditions affecting live and stranded marine turtles. Collectively, this information will support the management measures listed in the relevant management plans (MEMP, CEMP, DMP) and be a fundamental part of adaptive management reviews of those plans.

4.3.3 Underwater Noise

Underwater noise pollution poses a threat to marine life through noise-induced displacement from habitat, heightened physiological stress, masking of biologically important sounds (e.g. for communication, predator/prey detection), auditory injury, and in extreme cases, direct or indirect mortality (Popper *et al.* 2014; Southall *et al.* 2007). Underwater noise monitoring data is available from the Port of Townsville Marine Precinct Project, and the Port's Berth 8/10 and 12 upgrade project (GHD and Savery & Associates (2011)). This Project will result in the creation of construction related underwater noise, particularly during rock placement and piling activities, and to a much lesser extent during ongoing dredging operations.

Noise generated by construction activities has the potential to adversely affect marine megafauna. The risks of auditory injury will be managed through a range of measures, including the implementation of soft start piling, and through the use of exclusion zones from construction or dredging activities.
Monitoring of underwater noise will be completed using a series of hydrophones deployed at fixed sites established at selected distances from the noise source. Monitoring will be undertaken during the early phase of relevant underwater noise generating construction activities to ensure that underwater noise levels do not exceed those levels predicted in the EIS through modelling.

While specific details of each underwater noise monitoring are still to be confirmed, it is intended that within the first two to four weeks of commencing rockwall construction and piling activities, underwater noise monitoring over a 2 day period across both low and high tides will be undertaken. Monitoring will be undertaken at a range of distances from the activity (up to 1km) and at a range of depths (where applicable). Where possible, sampling will be consistent with the EIS underwater noise assessment works (East, North transects) to provide comparable noise measurements to those collected during the EIS process. Finalisation of the underwater noise assessment program will occur with the chosen underwater noise monitoring specialist, and the project ITAC will also be consulted on the design of the program and impacts/amendments of the outcomes.

Any exceedance of noise levels predicted in the EIS will result in a review of Project activities and mitigation measures, as impacts on marine megafauna would have the potential to be greater than originally assessed and approved by the Department.

Details of the monitoring tasks for underwater noise are provided in Table 8.

Table 8: Details of underwater noise monitoring associated with construction

Details of Monitoring Program – Underwater Noise	Implementation
Objective	Monitor underwater noise during key Project construction activities (i.e. rock placement) to validate the underwater noise level modelling from the EIS and confirm levels do not exceed those predicted to occur in the EIS. To confirm that exclusions zones being implemented are adequate to provide protection to marine megafauna from the risk of injury from underwater noise.
Methods	Measure underwater noise at fixed sites set at varying distances (up to 1 Km) from the source, using a series of hydrophones. This will be undertaken within 2-4 weeks of noise generating construction activities (i.e. rock wall construction, piling) commencing across high/ low tide.

	Compare field data of underwater noise with modelling predictions applied in the EIS. Reassess the adequacy of exclusion zones around piling and rock placement activities, based on the results of underwater noise monitoring data. Review daily logs of marine megafauna observers to ensure that exclusions zones have been implemented and determine behavioural responses by marine megafauna
Baseline	Baseline underwater noise data were previously collected by POTL during earlier construction works (e.g. Townsville Marine Precinct and Townsville Port Inner Harbour Expansion Projects). That data provides insight into the expected noise levels for related activities planned to be completed as part of the CU Project.
Environmental variable to be monitored and interpretation	Underwater noise (peak pressure levels and single-strike sound energy levels (SEL)) at selected distances from the source up to 1km. Results of actual noise measurements will be compared with those predicted in the noise modelling during the EIS and compared to species threshold levels for temporary and permanent threshold shift. Presence and behaviour of marine megafauna observed in and adjacent to exclusion zones.
Performance and Limitations	Noise assessment will be focused and will provide tangible data for assessment of the potential impacts from the relevant activities. While it will be a theoretical impact assessment based on species threshold levels, Marine Fauna Observer (MFO) observational data will provide infield context of likely impact.
Reporting and Corrective Actions	As rock placement and piling activities are expected to be completed at different stages of the Project construction schedule, a report will be prepared for each activity. In the event that measured underwater noise is greater than that predicted in the EIS and/or exceeds species threshold levels, then additional mitigation measures (e.g. larger exclusion zones or use of alternative construction methods) will be implemented through the relevant Project Management Plan (MEMP, CEMP, DMP). Revised controls will be determined in conjunction with review of behavioural data collected to inform megafauna response to noise. *The observational data from MFO will be reviewed in the context of the underwater noise data to seek additional understanding of behavioural responses to underwater noise. These data will also provide some further context on the presence of marine megafauna within the project area.*

4.3.4 Seagrass and Coral Habitat

Seagrass is a key habitat feature of dugong and marine turtles, providing a direct source of food. As discussed in Section 2.3, the availability and quality of seagrass as a food resource is a key driver of the spatial patterns of distribution and abundance of both Green Turtles and dugong in Cleveland Bay. Cleveland Bay supports a range of reef habitats around Magnetic Island, at Middle Reef and Virago Shoal. Such reefs are likely to be important foraging habitats for a variety of marine turtle species.
As part of the CU Project Seagrass Monitoring Program, Seagrass will be monitored twice annually at a number of sites across the bay, incorporating both impact and control sites. Attributes to be monitored include seagrass biomass, species composition and meadow area.

As part of the CU Project Coral Monitoring Program, coral monitoring will be completed in areas around the project works that potentially may be affected by dredging. The sampling design involves monitoring quarterly at a number of locations in control and impact zones.

The results of seagrass and coral monitoring undertaken for the CU Project will be provided to inform habitat condition and implications to turtle and dugong food resources. Data on the presence, condition and density may provide useful explanatory information for the movement patterns of tagged turtles as well as context for the interpretation of turtle health and marine megafauna stranding data. Results can also be used as an early warning sign for potential impacts to megafauna that rely on seagrass meadows or coral habitats in Cleveland Bay.

Details of the seagrass and coral monitoring review task as they relate to marine megafauna are provided in Table 9.

Table 9: Details of Seagrass/Coral Habitat monitoring

Details of Monitoring Program – Seagrass/Coral Health	Implementation
Objective	Assess the magnitude and extent of changes to turtle and dugong foraging habitats (seagrass and coral) as an indicator of potential impacting processes on turtle and dugong movement and/or health within Cleveland Bay.
Methods	Review the findings of seagrass and coral monitoring completed at key sites. Seagrass and coral health indicators will be compared with baseline surveys and those predicted in the EIS, to describe habitat values for turtles and dugong, as indicators of potential impacts on species behaviour and health.
Baseline	Historical surveys of seagrass have been completed in the region since 2007-8, with more limited surveys for coral. This provides a long-term data set on baseline conditions and natural variability in local seagrass assemblages. Known correlation of spatial patterning between seagrass and Green Turtles and dugongs; and coral habitats supporting other turtle species.
Environmental variable to be monitored and interpretation	Seagrass and coral composition (species present), seagrass biomass, seagrass per cent cover, seagrass canopy height, extent of algae and epiphyte cover; coral percent cover, coral mortality and injury, coral bleaching.

	Changes in habitat values are an indicator of potential change for turtle and dugong behaviour, use of habitats and ultimately health. Results of seagrass and coral monitoring will be collated annually to determine changes to habitat values for dugong and marine turtles, providing greater understanding of the impact of these changes on the marine ecology of Cleveland Bay.
Performance and Limitations	Information to be sourced from these programs will be scientifically robust. Linkages between habitat quality and flow on megafauna impact will be subjective, however this information will provide an early warning identification of potential impacts and context for results from other megafauna monitoring programs (i.e. strandings).
Reporting and Corrective Actions	In the event that a decline in seagrass habitat quality/extent is identified, the implications for marine megafauna will be determined by considering the full suite of results gathered during the implementation of this monitoring plan. While management level responses directly associated with the habitat assessment works will be implemented, further consideration of responses to minimise flow on impacts to marine megafauna will occur to meet the objective of this monitoring plan. This information will support the management measures listed in the relevant management plans (MEMP, CEMP, DMP) and be a part of adaptive management reviews of those plans.

4.3.5 Stranding Program

When marine megafauna are in poor health, or subject to severe injury, they may wash ashore, either alive or dead. Strandings can be a natural event, or the result of anthropogenic influences. The number and types of marine megafauna strandings can provide information on the environmental health of an area and inform the assessment of whether particular modes of impact are being manifested.

For example, if a project with significant vessel movements in narrow channels is undertaken it can result in increased boat strikes on turtles. In which case, an increase in the number of turtle strandings with boat strike injuries may be expected if risks are not adequately controlled. Similarly, if foraging resources such as seagrass habitats are being impacted, then an increase in strandings of emaciated animals in poor condition may be expected. In this context, strandings provide a 'lagging indicator' of the response of marine megafauna populations to relevant environmental stressors.

DES and GBRMPA have been operating a marine animal stranding program in Queensland for a number of decades. Members of the public are encouraged to report marine animal strandings to a central hotline phone number, with responses arranged for live animals or carcasses stranded in public locations. Records of strandings are compiled into a centralised database (known as StrandNet), from which analysis of long term trends can be completed. A summary of stranding records available from DES for the Townsville region for recent years is provided in Table 10 (DES 2019). The recovery protocols to date are reactive and based on availability of DES and GBRMPA staff and volunteers.

Table 10: Summary of stranding records for the Townsville region (DES 2019)

Year	Turtles	Dugong	Humpback whale
2018	27	7	0
2017	42	4	0
2016	29	5	1
2015	51	1	0
2014	68	2	0

The occurrence of marine megafauna strandings is a function of many variables. Strandings can increase well above baseline values in response to major events such as floods. Strandings are more likely to be reported and recorded in locations where large numbers of people are present. In this context, the Port of Townsville, which is adjacent to a major city, is a good location to implement a monitoring program associated with marine megafauna strandings.

Of the strandings that have occurred in the Townsville region previously, few have been subject to detailed examination by an appropriately trained veterinarian familiar with marine fauna anatomy, to determine the cause of death. There is therefore an opportunity to improve understanding of the reasons for marine megafauna strandings in the region, and in particular, assess whether Project-related stressors result in an increase in strandings, and the type of any increases (species affected, nature of impact).

Detailed protocols have been established for the necropsy of dugong and marine turtles (e.g. Eros *et al.* 2007; Flint *et al.* 2009). If undertaken by skilled and trained practitioners, preferably veterinarians or experienced biologists, necropsies can provide valuable information on the cause of death. Such examinations can be supported by the collection of tissues samples for further pathological or toxicological analysis.

Boat strike is a risk for any project where increases in vessel activity will coincide with marine megafauna habitat; this was assessed as a medium level residual risk for the whole PEP. Marine megafauna that are struck by a vessel and subsequently strand often have distinct injuries caused by propellers or blunt force, which can provide insight into the cause of death and the type of vessel involved.

To improve the identification of anthropogenic causes of megafauna mortality, a program of forensic investigations of marine megafauna strandings and carcasses will be established. POTL will proactively work to establish a steering committee for this purpose, with representatives from stakeholders such as DES, GBRMPA, James Cook University Vet School and other research partners in the Townsville region. POTL will fund the work, which will utilise existing systems of notification of strandings through a publicly advertised hotline phone number. The intention will be to have the existing response and carcass retrieval procedures through DES and GBRMPA implemented, with an established veterinarian laboratory identified for accepting the carcasses. Should this response process prove to not be reliable, POTL will have in place a back-up arrangement in the form of a local contractor to coordinate logistical arrangements associated with the assessment, transport and necropsy of suitable carcasses. POTL would look to also work with Traditional Owner Groups as part of knowledge sharing.

Assessments will be completed by independent veterinarians or appropriately trained biologists. Data will be collated through the DES StrandNet system to contribute to state-wide management of marine

megafauna populations. The Project will be actively managed for the life of the CU Project, with the options for other members of the Steering committee being able to continue these works after the CU Project is completed.

Interpretation of the results will involve consideration of historic local and state-wide stranding data, to assess whether occurrences of industry-related strandings and or boat strike have increased since the commencement of construction works and if there are deviations from the trends identified in other regions of Queensland. It is expected that the number of strandings that have been subject to detailed necropsies in the past is relatively limited, making comparisons with historic records difficult. In this context, this monitoring will increase knowledge of the causes of strandings and assist in future management of marine megafauna species.

Forensic examination of physical injuries (i.e. boat strike, predation bites from sharks etc) on dugong, turtle and cetacean carcasses will focus on determining the type of vessel/predator involved where practically able to make such determination. Such investigations do not always provide definitive results, but will be useful in increasing scientific knowledge of potential impacts on the fauna in the Cleveland Bay region, along with linkages to Project impacts where they can be established.

A qualitative assessment of data and the results of necropsies will form the basis of the monitoring task, based upon a weight of evidence assessment approach. Further details of the monitoring task are provided in Table 11.

Table 11: Details of marine megafauna stranding monitoring

Details of Monitoring Program – Strandings	Implementation
Objective	Observe and add to information database on the stranding rate of marine megafauna from the commencement of the Project when compared with pre-project numbers Provide increased understanding of the cause of strandings and deaths (where possible) and assess the potential for project-related mortality. Provide increased understanding on the cause of death through necropsy examinations (where suitable specimens are available), particularly project related causes.
Methods	A steering committee comprising relevant stakeholders will be formed to guide and oversee implementation of this monitoring task. Perform comprehensive necropsy examinations on stranded marine turtles, dugong and other megafauna (where body conditions permit) as per established techniques to determine cause of death, the prevalence of disease, baseline and ongoing contaminant levels in tissues during the four years of monitoring. Appropriately trained veterinarian/biologists will be engaged to undertake necropsies and/or examine live stranded animals for assessment.

	Methods will be applied based upon expertise in forensic necropsies of marine megafauna, using a similar approach to that described by Rommel *et al.* (2007) for manatee; Flint et al (2009) for turtles. The project will link with the existing DES/GBRMPA marine animal stranding program, to maximise value of information collected and the application of findings to future management of projects and megafauna species.
Baseline	Existing DES and GBRMPA stranding records, which date back more than 10 years, show that the historical rate of stranding is on average ~50 for turtles and ~5 for dugongs per annum. There was a spike in 2011 that was associated with large rainfall and flooding events and flow on impact on critical seagrass and habitat food resources.
Environmental variable to be monitored and interpretation	Species, length, tag number, location of stranding, body condition, gross morphological examination, collection of samples for pathological or toxicological analysis. Extent of injuries on carcasses, including length, depth and spacing of cuts and other marks, location of stranding in relation to local currents and commercial vessel routes and schedules. This monitoring task will build on limited existing information on the causes of marine megafauna strandings in the Townsville region and the role of human activities and natural climatic events in contributing to these numbers. POTL will seek to identify underlying health conditions that may have contributed to strandings, while also examining the potential circumstances of blunt trauma injuries. It is generally expected that marine megafauna strandings during the Project will continue at the rates occurring prior to the project.
Performance and Limitations	The information from this program will be subjective, as it is based on injured and dead animals being found and reported with a level of accuracy. The intention will be to support the existing reporting network to improve reporting and retrieval. The value of the necropsy data will be influenced on carcasses being retrieved and in a condition that supports a necropsy being undertaken.
Reporting and Triggers	A necropsy report will be prepared for each individual stranding case, identifying the cause of death (where possible). Data will be entered into the StrandNet database, to build on existing long term data sets. Individual causes of mortality will require veterinary expertise to interpret significance of death and implication as it relates to the Project activities. An increase in strandings above pre-project levels, or the occurrence of strandings linked to Project activities, will result in a review by POTL (involving relevant experts e.g. ITAC, DES) to assess the project influence on the strandings and whether any additional mitigation measures and implementation of additional controls, are necessary. This information will support the management measures listed in the

	relevant management plans (MEMP, CEMP, DMP) and be a part of adaptive management reviews of those plans. Results will be reported annually.

4.3.6 Inshore Dolphin

A separate monitoring plan for inshore dolphins has been prepared to address specific conditions prescribed for the CU Project relating to Inshore Dolphins (Refer to document POT 2154). That monitoring primarily involves vessel-based surveys of dolphins across the study area, and adjacent embayments, using mark / recapture photographic techniques.

During implementation of the inshore dolphin monitoring plan, researchers are likely to make incidental sightings of marine megafauna, which collectively over a long period, may be useful in supplementing data collected under this marine megafauna program. Data from that program will, therefore, be reviewed annually to support use of multiple lines of evidence for interpretation of marine megafauna data.

Details of the inshore dolphin monitoring task as it relates to other marine megafauna monitoring tasks are provided in Table 12. For further details on the Inshore Dolphin Monitoring Plan please refer to document POT 2154 which is also Appendix F of the MEMP.

Table 12: Details of Inshore dolphin monitoring

Details of Monitoring Program – Inshore Dolphin	Implementation
Objective	Utilise incidental sightings and observation data of marine megafauna from the IDMP as supplementary information to assist in the interpretation of other monitoring data.
Methods	The Inshore Dolphin Monitoring Program is being undertaken to monitor the environmental impacts of the construction activities in the marine environment, as well as providing background information prior to the commencement of construction activities. The program will employ boat based surveys (up to six surveys per year) across Cleveland and two adjacent bays during June and July each year, using transect surveying techniques. While the focus is on Dolphin Species, during these surveys information will be recorded on the location, species and behaviour (where collected) of any marine megafauna observed.
Baseline	Baseline information on the distribution and abundance of marine megafauna across the Study Area and beyond is available from a range of published sources.
Environmental variable to be monitored and interpretation	Location, species, behaviour (feeding, migrating, breeding). The data will not provide a complete population survey within the bay however the information will provide supplementary presence

	information to assist with the interpretation of other findings of the MMMP.
Performance and Limitations	Data provided from the Inshore Dolphin program will be adhoc, with the survey design being established for dolphin monitoring only. However, it will provide additional contextual information of sightings in Cleveland Bay.
Reporting	As above, the results of megafauna sightings from the IDMP will not provide a detailed assessment and will not therefore be reported as a stand alone information set. The results from this program will be included in the annual report and assist with the interpretation of other monitoring results.

4.3.7 Marine Fauna Observers

An increase in construction activity in the marine environment associated with reclamation and dredging activities (i.e. piling, dredging, rock placement, vessel traffic) will increase the likelihood (identified as a medium risk in this project) of animal strike, injury or other behavioural change (i.e. avoidance of the work area) by megafauna.

Trained Marine Fauna observers (MFO) will be utilised for key construction activities. A requirement of their role will be to undertake visual observations for marine fauna presence in observation and exclusion zones defined for key activities, notifying of the need to adjust construction activities if fauna approach or enter the exclusion zones. A key aspect of the MFO role will be to record details associated with fauna observations.
To monitor megafauna observations during construction activities, POTL will ensure MFOs are adequately trained to make observations and keep a daily log to identify numbers observed and potential behavioural trends.

Details of the monitoring task as it relates to marine megafauna are provided in Table 13.

Table 13: Details of Marine Fauna Observer monitoring

Details of Monitoring Program – Marine Fauna Observers	Implementation
Objective	Utilise sightings and observation data of marine megafauna from the trained Marine Fauna Observers as supplementary information to assist in the interpretation of other monitoring data.
Methods	The Marine Fauna Observers will be suitably trained observers on key work fronts to undertake observations of marine fauna presence in and around key construction activities (i.e. rockwall construction, piling, dredging). The observers will be used in enforcing exclusion zones for these key activities. In addition, the Marine Fauna Observers will be a structured data recording program, where an agreed recording protocol will be established and all observers will be trained in Fauna identification, behaviour and reporting.

	Key information to be recorded include the location, species and number of individuals, estimated distance from works and movement within key zones and behaviour of any marine megafauna observed during rock placement, piling and dredging activities.
Baseline	Baseline information on the distribution and abundance of marine megafauna across the Study Area and beyond is available from a range of published sources, including the PEP and Townsville Marine Precinct Project EIS documentation.
Environmental variable to be monitored and interpretation	Location, species, weather, number, size/age class of individuals, behaviour (feeding, migrating, breeding), distance from works, movement during observation and entry to established zones. The data collected will not provide an assessment of megafauna within the bay however the characteristic and behaviour data will provide information on megafauna presence and behaviour in the vicinity of the key activities. This information will provide supplementary information to inform the interpretation of other findings of the MMMP.
Performance and Limitations	The use of trained MFOs will provide robust data on species observation and behavioural aspects. However, this data will be collected around specific activities, which may influence megafauna presence and behaviour (including attracting to the area) and will not be a representative or scientifically robust assessment of species presence across the study area.
Reporting	As above, the results of megafauna sightings from the MFOs will not provide a detailed population assessment and will not be reported as a stand alone information set. Periodic review of fauna observer daily log to identify any trends in megafauna presence/absence or behaviours will be undertaken. This information will support the management measures listed in the relevant management plans (MEMP, CEMP, DMP) and be a part of adaptive management reviews of those plans.

4.3.8 Synthesis of Results and Interpretation

The marine megafauna monitoring program involves a diverse range of monitoring tasks and objectives. Some are short-term and are associated with verifying the accuracy of predictions in the EIS (e.g. noise monitoring), to provide observations on the adequacy of mitigation measures (e.g. exclusion zones) and potential trends on behaviour impacts. Other tasks are more focussed on increasing the knowledge of marine megafauna biology and behaviour to allow for improved management in the future (including during future stages of the PEP project).

POTL will coordinate all monitoring data collected during implementation and review regularly against the objectives outlined in this plan. An annual report will be prepared describing the results of monitoring and describing any recommendations in relation to management of the project and its potential environmental impacts. The results of marine megafauna monitoring tasks are likely to provide an important source of supplemental information in the event that an impact from project activities (or natural events) occurs during the four years of the Project's activities. For example, in the event that a

reduction in the area and quality of seagrass occurs, the results of GPS satellite tracking and health studies will provide information to assist in assessing whether this is having an adverse impact on marine turtles.

4.4 Monitoring Locations

The location of monitoring sites varies across the Study Area, depending on the monitoring task objectives and the scale of the potential mode of impact. Details of the location of some monitoring tasks are provided in Figure 2.

4.5 Frequency and Timing

The timing of monitoring tasks varies, according to their objectives and the nature of Project activities. A summary of timing is provided in Table 14.

Table 14: Summary of the timing of key monitoring tasks

Monitoring	Timing
GPS Tracking of Green Turtles	*November to March (Annually for four years)*
Health Assessments	*Annually for four years*
Underwater Noise	*Once during the initial four week period of rock placement activities, piling and dredging activities*
Seagrass Health	*Biannually for four years*
Coral Habitat	*Quarterly for four years*
Stranding Program	*Annual review of stranding data for four years.* *Necropsy triggered when a suitable specimen presents*
Inshore Dolphin	*Annually for four years. Review completed once Inshore dolphin annual report is available (October).*
Fauna Observer	*Daily fauna observer logs to be reviewed monthly during key construction activities with defined observation and exclusion zones.*

4.6 Quality Assurance/Quality Control

POTL will ensure that the Marine Megafauna Monitoring Plan is implemented with a high level of quality, by taking the following steps:

- Engage suitably qualified personnel, including recognised specialists in the management and monitoring of marine megafauna, to coordinate and implement the monitoring plan;
- Require monitoring tasks delivered under this plan (fauna observing, tagging, health assessments etc) to be completed by suitably qualified specialists;
- Require periodic external peer review of the results of the monitoring plan;
- Seek advice and guidance from experts on the ITAC on the design and implementation of monitoring tasks; and

- Ensure that equipment utilised in the collection of data is regularly calibrated (e.g. water quality monitoring devices, hydrophones to measure underwater noise).

Additionally, POTL implements the following recognised procedures:

- ISO 9001:2016 Quality Management Systems;
- ISO 14001:2015 Environmental Management Systems.

POTL contractors undertaking megafauna monitoring will operate under their existing permits including:

- Great Barrier Reef Marine Park Permit;
- Queensland Government Scientific/Marine Parks Permit;
- Relevant scientific purposes permits; and
- Animal Ethics Approvals.

5 PERFORMANCE OBJECTIVES

This monitoring plan will address the performance objectives prescribed for marine megafauna by the MEMP.

The following performance objectives are to be assessed and considered at periods of review under this marine megafauna monitoring plan:

- All monitoring is conducted in a consistent manner as described in this plan, which meets the requirements of the appropriate environmental approvals and any standards; and
- Monitoring results have been interpreted, peer-reviewed and reported at the required frequency;
- Timely delivery of annual and final reports and datasets/spatial layers (where relevant), supplied by agreed milestone dates each year following data analysis;
- Identify trends across the range of parameters and Identify areas of potential concern, which may require management controls or mitigations to be implemented; and
- Establish a temporal and spatial dataset to inform discussions with regulators and provide supporting information for ongoing performance; and
- Any impacts associated with the Project on marine megafauna and their habitats have been assessed and described on the basis of the monitoring results; and
- In the event of an impact on marine megafauna and their habitat being detected, beyond what is approved, then the marine environment management plan and marine megafauna monitoring plan will be amended to provide additional protection to marine megafauna and their habitats.
- Annual review undertaken against the Performance Objectives to review the effectiveness and relevance of the performance indicators.

It is considered that achieving the above performance objectives will ensure compliance with EPBC Act approval conditions.

To support meeting of these objectives, implementation of the monitoring plan will include the use of highly experienced contractors with strong experience with the techniques and species that are a focus of this plan. This will also strengthen linkages to other complimentary monitoring that has, or is, occurring throughout the life of this plan.

A key challenge for this monitoring plan is having the statistical power in the population and other data collected to detect impact. Given the mobility of marine mammals and the expected small populations in the survey area, it is recognised that the monitoring will be limited in its ability to detect impact with any statistical robustness. Further to this limitation, given the complexity of ecological and environmental variability in marine ecosystems, separating the effects of human activities on marine megafauna in the study area from natural ecological and environmental variability will be additionally difficult. Despite this, the monitoring techniques to be employed have been identified through expert review of the potential project impacts and the best mode for detection of change.

While recognising the limitation of the monitoring program to detect change, the program will provide overall scientific benefit to the knowledge and understanding of the listed aspects of the megafauna species in the greater Townsville region. As such, the MMMP will provide an overall contribution to these species in North Queensland.

6 GOVERNANCE AND REVIEW

6.1 Development of MMMP

The Marine Megafauna Monitoring Plan, as a component of the Marine Environment Management Plan, has been developed in consultation with key stakeholders including:

1. Representatives of the Traditional Owners, the Gurambilbarra Wulgurukaba people who are identified as the Native Title claimants of the land covering the Project area;
2. POTL's Community Liaison Group (**CLG**), which comprises a number of community representatives;
3. Environmental consultants;
4. The CU Project Steering Committee, which comprises members of the POTL executive management team; and
5. The Commonwealth Department of Agriculture, Water and the Environment (**DAWE**).

Traditional Owners were consulted in accordance with Condition 25 of EPBC Approval No. 2011/5979 during the development of the MEMP. This consultation involved the following:

- An initial presentation to Traditional Owners on the CU Project on 20 February 2018;
- This draft Monitoring Plan was subsequently presented to a meeting of the nominated Traditional Owners representatives on 30 May 2019. Comments raised were noted during the meeting with the Traditional Owners Working Group asked to provide any further comments on the marine megafauna monitoring plan within a nominated timeframe. All comments received from Traditional Owners were compiled, with the only megafauna related comments raised were part of generic queries on what changes to the hydrology of Ross River Channel will occur and what impact any changes will have on birds and fish, and what opportunities will there be for traditional owners to be trained and employed as marine fauna observers. A copy of all comments made by the Traditional Owners Working Group was provided to the Minister with the MEMP;
- An update regarding the consultation with the Traditional Owners Working Group was then presented to the CU Project Steering Committee, which formally noted that the Traditional Owners Working Group had been consulted in relation to the Monitoring Plan.

6.2 Independent Peer Review of the MMMP

In accordance with Condition 31 of EPBC Approval No. 2011/5979, the Marine Megafauna Monitoring Plan, as a component of the Marine Environment Management Plan, was independently reviewed by the CU project ITAC up to 22 July 2019, before submission to the Minister for approval. A copy of all advice and recommendations made by the independent peer reviewer was provided to the Minister with the draft Marine Megafauna Monitoring Plan.

6.3 Finalisation & Approval of MMMP

This Marine Megafauna Monitoring Plan, as a sub-plan of the MEMP, was submitted on 27 August 2019 for the Commonwealth Minister for the Environment's approval to meet the submission timing requirements of EPBC Approval No. 2011/5979 Condition 24.

7 REPORTING AND RESPONSIBILITY

POTL will take responsibility for coordinating the implementation of this monitoring plan, with the assistance of suitably qualified contractors/consultants.

The results of implementing the marine megafauna monitoring program will be reported through two mechanisms. As soon as data becomes available, it will be analysed and assessed in relation to the objectives of verifying the Project impacts predicted in the EIS. This early utilisation of results will allow the quick identification of any impacts that are above those predicted and approved. A process of adaptive management will be utilised to develop additional controls based on monitoring results.

The second avenue of reporting will be annual reporting documenting the implementation of the monitoring plan and summarising results. This relates primarily with demonstrating progress in implementation and sharing relevant knowledge with the Department and other stakeholders. This reporting will be the preparation of a detailed annual report, which will describe the results and the implications for marine megafauna and their habitats. An evaluation on the need for improvements will also be made, with respect to either the monitoring design or the implementation of Project controls to reduce any observed impacts on marine megafauna.

In the event that the monitoring plan needs to be revised during implementation, then POTL will consult with the Department on the need for amendments and submit a revised plan for approval. Changes of a minor administrative nature will not require approval, in accordance with the Department's policy on management plans.

These annual monitoring reports will be considered by the CU Project team as part of the overall adaptive management of the project. The reports, including any project management responses, will also be presented to the POTL CU Project ITAC for input and comment particularly where there are monitoring results indicating areas of concern or population impacts. The ITAC will consider the results in the context of the project and legislative criteria and evaluate the corrective actions proposed to be implemented. The ITAC advice will further contribute to POTL revision of the relevant management controls and corrective actions to minimise impact on marine megafauna populations.

Where management controls are varied, the relevant Management Plan (CEMP, MEMP, DMP) will be updated and the varied management arrangement incorporated into the on-ground practices. The updating of the plans will occur immediately, or as part of the regular review of the plan depending on the significance of the management action modification. A record of changes made will be kept.

Copies of all report(s) will be kept on-site and will be available for regulatory inspection. If requested by the regulators, all survey data and information related to this Monitoring Plan will be submitted within 30 business days of the request, or within a timeframe agreed by the relevant regulator in writing.

8 CONTINUOUS IMPROVEMENT

The Marine Megafauna Monitoring Plan will be subject to regular review.

This Monitoring Plan is a "living document" which will undergo formal review annually during the construction phase. During delivery, review and amendment will occur as necessary via adaptive management actions to ensure the Program remains relevant and achieves the required program objectives, inclusive of identification and implementation of any new or changing environmental risks and mitigation actions. Recommendations on improvements or amendments will be reported as part of the annual reporting process. This will align with the regular review of the performance of the MEMP as required under the EPBC Act approval conditions.

Changes to the Marine Megafauna Monitoring Plan may be developed and implemented in consultation with relevant regulators and other stakeholders over time. All changes are to maintain the approval conditions and be approved by CU Project Management, before implementation.

Information from this MMMP will be used to assist with improving the control measures in the MEMP and CEMP / DMP where relevant and required.
As noted in section 7, an annual report regarding the Marine Megafauna Monitoring Plan will be produced that will identify the results found and an interpretation of the results in relation to changes to megafauna populations within the study area to identify any impacts from the project where practically able. This information will be reviewed and consider by POTL, in conjunction with the CU Project ITAC, to identify any recommendations on likely causes/stressors to these populations and necessary management actions to be implemented as a result of the survey outcomes.

Where the monitoring identifies the need for revised management actions, this monitoring plan and the associated management plans will be revised to incorporate the adaptive management arrangements. This may include the assessment of any monitoring program modifications.

As per Condition 38 of the EPBC Act Approval (EPBC 2011/5979), any changes to this Monitoring Plan, or any of the Management Plans as a result of the outcomes of the MMMP will be notified to the Department.

Continuous improvement will also be achieved via the *Marine Environmental Management Plan*, to which this monitoring plan is a part of (Appendix G of MEMP). Consideration and review of improvements to the MEMP will be reflected within this Monitoring Plan.

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APPENDIX A

POTL Channel Upgrade Megafauna Workshop Outcomes

DATE: 11 March 2019
TIME: 1000 - 1500
LOCATION: POTL Channel Upgrade Project Meeting Room

Attendees

Helene Marsh	JCU	Marine Megafauna Specialist
Col Limpus	DES	Marine Megafauna Specialist
Andrew Tapsall	Eco Logical	Contractor
Miles Yeates	Eco Logical	Contractor
Christophe Cleguer (Phone)	Murdoch University	Marine Megafauna Specialist
Kerry Neil	GHD	Marine Megafauna Specialist
Kate McLean	POTL	Deputy Project Manager
Spyridon Gerontopoulos	POTL	Project Manager
Melinda Louden	POTL	Manager, Environment (PEP representative)
Tim Smith	POTL	CU Environmental Advisor

Potential Impact pathway:

Activity	Impact	Mitigation	Relevance/ information	Potential/ likelihood	Species affected	Monitoring Tool
Reclamation						
Rock placement	Local noise leading to displacement	Fauna spotters Mitigation measures	Habitat use/ core area	Short term displacement and return Few animals in area Unlikely	Turtle Dugongs Whales	Fauna spotters/observers Due diligence check on noise modelling to ensure it is within the observer zone. If noise is within assessment, accepted. Sat tagging of turtles possibly. PEP consideration for future works?
	Physical damage to fauna	Fauna spotters Daylight hours only	Mortality/ injury	Likely	Turtle	Fauna spotters/observers Strandings program (vet focus on cause of fractures/impacts, measuring wounds)
Habitat loss (direct)	Displacement	Pre-clearance/seagrass survey	Habitat use	Possible Likely Rare	Turtles Dolphins Dugongs	Approved impact. No focused effort.
Entrapment	Capture	Fauna spotter	Mortality/ injury	Likely	Turtles	Fauna Spotter/observers Assessment/protocol to address removal once closed. Sat tagging if captured an option – consideration needed to be prepared for tagging. Stingrays will be key species for being around and impacted

Tailwater discharge	Displacement resulting from reduced WQ Altered behaviour due to discharge/ reclamation	EA conditions reducing impact	Habitat use	Unlikely – will attract Likely to move to adjacent Very unlikely – may be attracted temp difference if discharge water warmer than ambient. Likely – though possibly only localised (bait fish)	Turtles Dugongs Dolphins	Not high risk. Nothing structured. Ad hoc review and assessment – consider static camera positioned on/near discharge area to enable footage for review for aggregation/ attraction etc.
Dredging						
Vessel movement	Vessel strike	DMP Construction vessel plan	Mortality/ Injury	Possible Unlikely Rare	Turtles Dugongs Dolphins	Observers and strandings; inc propeller cuts – length and depths to measure prop size (vets to be notified to ensure collect information on examination/ necropsy); educational component for public engagement

				Unlikely	Whales	Vessel movement/tracking – speed, location etc. For example, barge speed limited to <10 knots in shallow water in other projects; noting speed will be limited by vessel manoeuvrability. Risk area/conditions: Prop driven vessels working in shallow depths Large vessels, high speed, shallow water
	Hydrocarbon spill	DMP Construction vessel pollution plan	Mortality/ Injury	Possible (dep on size of spill)	Turtles Dugongs Dolphins	Emergency procedure Controls. POTL First Strike oil spill response capability HACCAP response
Dredge equipment	Vessel strike	DMP TSHD controls Visual checks for fauna Review management controls for strikes (move from area).	Mortality/ Injury	***Backhoe*** Possible (not high frequency) Unlikely ***TSHD*** Possible Unlikely	Turtles Dugongs/ Dolphins/ whales Turtles Dugongs/ dolphins/ whales	Observers and strandings (propeller cuts – length and depths to measure prop size as noted above) Vessel movement/tracking – speed, location etc. Review of spoil while unloading for noting of entrained/captured animals – consider a protocol for handling/dealing with these animals.
	Noise/displacement from area	DMP Spotters	Habitat use/Range area	Unlikely Unlikely (short term if impact);	Turtles Marine Mammals	Fauna spotters/observers Due diligence check on noise modelling to ensure it is within the observer zone. If noise is within limits predicted by assessment, accepted impact

				dolphins key species		controlled by spotters. TSHD was modelled for noise vs backhoe – backhoe less impact therefore conservative. Sat tagging of turtles resident to the area? PEP consideration for future works?
	Reduced WQ / displacement	DMP Water quality triggers	Habitat use/Range area	Rare	Turtles	Water Quality Monitoring More a perception issue. May attract species if increasing movement of prey
	Contaminants in plume/species uptake	DMP Water quality triggers	Health	Unknown – significance of levels will be difficult to untangle (dependent on age and how far they move)	Turtle Mammals	SAP analysis to inform. Modelling review. Water quality program. Fish study? Crabs also? Strandings and necroscopy / pathology assessments. Vets will need to work with biologists to ensure correct info is collected. Extension of ongoing Cockle Bay turtle health assessments if there is plume impact that far. 5 week program only for TSHD that would extend that far. Function of plume, water quality and dispersion
	Habitat loss/ change	DMP Surveys	Habitat use/Range area	Likely Unlikely depending on survey	Turtle (flatbacks for inverts) Dugong	Sat tracking of turtle movement. Turtles may be attracted to new dredge area and food sources Tagging of species. Flatbacks, ridleys and loggerheads are deep water species. Not easy to capture (option of trawling to capture discussed).

				Likely	Dolphins	Nesting tagging of flatbacks – 10-20 individuals per year on Mag Is. $7000 per tag. Consider extending habitat surveys to include monitoring of invertebrate benthos to assess if prey species for turtles are present.
Piling	Noise displacement	MEMP/DMP Exclusion zones Spotters	Habitat use/Range area	Likely/local and short term Likely (unknown) Likely (unknown)	Turtles Dugongs Dolphins	Acoustics and sound model validation (as noted above). Underwater noise monitoring.

Other comments/notes:

- Need to establish link to Inshore dolphin and exchange information between programs
- Possible use of drone for near field impacts and change, if/where this is deemed necessary to monitor.
- Necropsy/pathology program and response to strandings. Need to organise arrangements via a Workshop with vets, megafauna experts (biologists) and GBRMPA.
- Aerial survey – JCU training in June and November 2019 across Cleveland Bay. Could be an option going forwards.
- While health assessment listed only against Contaminant uptake, noted it could be an indicator of other pressures etc.

Potential Megafauna Monitoring Tools

Monitoring tool	Turtle	Dugong	Other cetaceans	Relevance / Comment
Aerial (person)	Y (not at bay scale) Limited for project	Y (not at bay scale) Limited for project	Y but infrequent visitors so limited	Pop size; relative density; fecundity; area of occupancy; threat exposure More relevant at scale of GBR, not bay scale. Long time periods required. Won't separate project impacts from natural changes. Small turtles not detected, species level detection difficult for turtles and dolphins CASA approval issues and lead time State wide aerial surveys conducted at 5 yearly interval. Last survey 2017. Training for NGBR Survey in Cleveland Bay in June and November 2019.
UAV	N Detector being trained; not at species level.	Y	N Detector being trained; not at species level.	Relative abundance; Pop size; relative density; fecundity; area of occupancy; threat exposure – at local scale. Fine scale habitat use. UAV surveys can be conducted at variable spatial and temporal scales: • large fixed wing, typically used for large scale beyond visual line of sight surveys (area cover - >100km2); • smaller UAVs such as small fixed wing, hybrid VTOLs or multicopters more adapted for local scale surveys (area cover <10s km2). Small UAVs could be used to focus on dredge and dredge area, use of core areas. Potential to detect pop size response, will be dependent on number of individuals detected. Unlikely to be enough individuals except possibly turtles – need trial to determine. High precision positioning of animals in relation to plume or noise and in relation to habitat characteristics possible. Repeatability of survey. Safer than manned aerial surveys. Can register sea snakes, sharks, dolphins, whales, dugongs and turtles (Pilbara experience). All data are archived and can be reused for subsequent analysis.

				Need to determine resolution required for turtle species ID and number of individuals available in channel area. To fulfil CASA's standard requirements the UAVs need to be operated not above 90m and within visual line of sight. Operating beyond these limits require special permits which are likely going to be difficult to obtain in Cleveland Bay given the activity of the TSV airport. Thus, it is recommended to use a method that remains within CASA's standard operating conditions.
Vessel based visual	N	N	N	Not effective for project requirements. Less effective in turbid environments and for dugongs that surface for only a short interval.
Passive underwater visual	N	N	N	Requires clear water, often with bait attraction. Restricted value in turbid environment
Mark Recapture				
Visual/ Photo id	N In development	N	Y	Abundance estimate, movement in and out of area; site fidelity Requires clear water; in turbid env likely need to catch them to ID
Satellite	Y	Y some	N given large range	Home range, habitat use; migratory corridors. Health assessment linkages GPS Satellite telemetry Safety concerns with capturing individuals (mammals). Also movements are individualistic so need sample size of at least 10 to be meaningful. Once individual caught can then do stomach content assessment, blood work etc.
Pit tag (microchip)	Y	Y some	Y some	Life history information. Survivorship, growth etc. Health Assessment linkage Recognise individual through time. Long term value. Flatbacks and Leather backs it is routinely used for. Looking at long timeframe Limited value for mammals given have to catch the animals

				Can have automated readers though have scale issues in bay systems (versus rivers) Safety concerns with capturing individuals (mammals) Once individual caught can then do stomach content assessment, blood work etc.
Flipper tag	Y	Y ?	N	Life history. Survivorship, growth etc. Health assessment linkages. Population performance (trends etc) rather than pop counts/abundance Relevant for broad impacts (flooding etc). Relatively low cost. How to catch – habitat and turbidity factors. Recognise individual through time. Long term value. Flatbacks and Leather backs it is routinely used for. Looking at long timeframe. Once individual turtle caught can then do stomach content assessment, blood work etc. Safety concerns with capturing individuals (mammals)
Molecular tag	N	Y	N	Some pop info. Health indicators. Not viable for turtles, large number of individuals in Bay. Genetic stock info may be viable through these systems (and origins) – turtles and dugongs. Safety concerns with capturing individuals (mammals)
Acoustic tags	Y ?	Y ?	N	Habitat prevalence/preference. Counts only. Need an acoustic array. Very expensive to establish depending on scale and area to be covered. Originally established for sharks and rays in Cleveland Bay, but removed. Array needs to be monitored on a regular basis
Strandings	Y	Y	N	Mortality cause (if possible). Won't give total numbers, but trends. Can do health assessments where not too decomposed.

				For disease issues, need fresh corpse and dedicated approach to respond. Animals in poor health, rather than long term re-hab possibly look at health assessments (for diseased, sick, mal-nutrition animals). Need negotiation with DES for StrandNet program. Potential focus should seagrass degradation from floods occurs – GBRMPA and DES discussion needed on focus on health assessments to defend/demonstrate not port impacts. Perception management. Will need front end work to get all parties ready to respond etc.
Habitat quality (feeding trails)	N	Y	N	Habitat use Not likely to be valuable in this project. Shallow water areas only on Eastern side of Cleveland Bay. Cockle Bay sea grass unlikely to show trails. Difficult to interpret.
Health investigations	Y	N?	N	Pathological investigations On live animals, very valuable for turtles. More difficult for dugongs given turbid water etc. Human safety issues with capture, animal stress concerns.
Beach nesting	N	N	N	Population stats from nesting Inter-nesting movement very important – need satellite tagging. Shows use of deeper water areas (not feeding etc) which is relevant for dredging. 2 week period to make eggs and then nest to lay. Flatback Nov – Jan nesting, Green – 5 mth period. May not be relevant for Cleveland Bay. Academically interesting – sat tag flatbacks on Maggie Is prior to dredging and then monitor during dredging and look for changed behaviour (inter-nesting)
Construction marine observers (structured/qualified)	Y	Y	N	Presence/absence. Injury from activity where observed. Upfront investment in megafauna training and agreed recording protocol (to be developed with megafauna experts) for spotters needed to build strong dataset.

				Questionable in other projects as not designed in a useful way. Need to plan and develop program to ensure valuable data collected. As robust as can be if designed well.
Incidental sightings	Y ?	Y ?	Y ?	Presence/absence. Soft data Unstructured, review of eye on reef in 2017 found quite a significant level of mis-id and spatial location not QA'd. Not clear how good GBRMPA QA is on Eye on the reef. Promote public reporting of strandings so that an expert can id and do health and cause of impact review. Focus should be on reporting and responding by expert.

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