TOWNSVILLE PORT EXPANSION PROJECT

Additional Information to the Environmental Impact Statement

TOWNSVILLE PORT EXPANSION PROJECT

SECTION 8

Marine Ecology

AECOM BMT WBM

8.0 Marine Ecology

8.1 Introduction

Cleveland Bay is a natural embayment located adjacent to Townsville. Despite significant changes to Townsville's coastal zone as a result of urban (Scheltinga and Heydon 2005) and port development (Anderson *et al*. 2002), Cleveland Bay supports a broad range of significant marine ecological values and functions. Particularly notable marine ecological values supported by Cleveland Bay include the following.

- A wide diversity of marine habitat types including intertidal beaches, mangrove forests, saltmarshes, intertidal shoals, subtidal soft sediment habitats, rock walls, coral reefs and rocky shores.
- One of the largest seagrass meadows in the broader region (Rasheed and Taylor 2008).
- Coral communities of high biodiversity significance, particularly those around Magnetic Island.
- Habitats for a wide range of fish and shellfish species of direct economic significance.
- Significant feeding areas for marine turtles, dugongs and dolphins, which are listed as threatened or migratory under Commonwealth and/or state legislation.
- Habitat for a range of other threatened or otherwise listed marine megafauna species, including whales and sharks protected under the *Environment Protection and Biodiversity Act 1999*.

A number of submissions were received in response to the EIS that are relevant to marine ecology. Key matters raised from the submission process include the following:

- adequacy of reef surveys at Cockle Bay
- presence of stromatolites in Geoffrey Bay
- adequacy of marine ecology baseline data and impact assessment
- bioaccumulation of metals in marine fauna
- assessment of impacts to turtles and turtle habitat
- assessment of impacts to marine mega fauna, including dolphins
- adequacy of underwater noise assessment
- assessment of noise impacts to larval fish
- assessment of impacts to marine habitat values at anchorage sites
- assessment of impacts on the Outstanding Universal Value (OUV) of the Great Barrier Reef World Heritage Area (GBRWHA)
- assessment of indirect impacts to Bowling Green Bay Ramsar site
- assessment of impacts from marine pests
- resilience of marine ecosystems
- habitat management plans instead of species management plans.

Submissions received relevant to cumulative impacts and environmental offsets are addressed in Sections 25.0 and 27.0 respectively. Responses to these key matters raised in submissions are provided in the following sections.

8.2 Response to Submissions

8.2.1 Adequacy of reef surveys at Cockle Bay

Five submissions were received regarding the adequacy (spatial coverage) of contemporary reef survey data for Cockle Bay.

Chapter B.6.3.5 of the EIS describes reef benthos community structure along the coast of Magnetic Island, based on existing data and a targeted field survey undertaken in 2012. It was noted that reef communities show great variation over time in response to disturbance and recovery cycles, and that the 2012 survey was undertaken one year after a disturbance event (Cyclone Yasi).

A survey campaign was carried out in September 2014 to provide a contemporary assessment of reef communities in Cockle Bay. The survey was carried out to address specific matters raised in submissions regarding spatial replication of surveys at Cockle Bay, but also to assess whether there was evidence of recovery in coral communities since the 2012 survey. The 2014 survey used the same methodology as adopted in the March 2012, thereby allowing a direct assessment of changes to reef communities over that time period. Additional sites were added to Cockle Bay reef to increase spatial coverage of the survey.

The methodology and findings of the September 2014 sampling campaign are presented in Appendix A1 (Additional Field Studies Report). In summary, the survey found the following.

- There was great spatial variability in habitat characteristics and benthic community structure across the reef.
- Similar to results from 2012, Cockle Bay continued to be numerically dominated by macroalgae, with hard corals typically sub-dominant. At the Cockle Bay site that was surveyed on both occasions (C2), seagrass was recorded in 2014 but not in 2012, suggesting there recovery was occurring. This was consistent with seagrass recovery patterns recorded by James Cook University over this timeframe (see also Section 8.2.3 below).

8.2.2 Stromatolites in Geoffrey Bay

Two submissions were received stating there was no reference to stromatolites purported to exist in Geoffrey Bay.

A review of peer reviewed publications was undertaken to assess the ecology of stromatolites on Magnetic Island reefs. Shiba *et al*. (1991) examined aerobic heterotrophic bacteria taken from a range of biota (including, where possible, stromatolites) at sites throughout Australia. Sampling was carried out at Cape Cleveland and Magnetic Island (Arcadia, Horseshoe and Radical Bays), but no stromatolites were collected for analysis (although aerobic bacteriochloropyll containing bacteria (ABB); a type of bacteria that can form stromatolites, were collected in intertidal algal mats from Magnetic Island). No other specific references to stromatolites in Cleveland Bay were found in the scientific literature.

A survey was carried out in September 2014 at Geoffrey Bay to identify any features (outcrops of rock or coral) bearing any similarity to stromatolites or microbial mats. Dr Jane Mellors from James Cook University was also consulted regarding the status of stromatolites at Geoffrey Bay. Dr Jane Mellors provided information and several photos of structures that are currently the subject of research by James Cook University researchers.

Eight points of interest were recorded on transects at Geoffrey Bay, several of which appeared to be dead coral fragments with microbial/ algal coverings that resembled photos of potential stromatolites supplied by Dr Jane Mellors. While the structures at points 335 and 336 were covered in a thick microbial mat, they differed greatly in morphology to the dome-shaped structures of Shark Bay in Western Australia. Whether these mounds have been created by microbes (true stromatolites), or if they are microbial coverings on dead coral skeletons could not be ascertained during the field trip (by visual survey alone, without destructive sampling).

Information supplied by Dr Jane Mellors suggests that these structures may be low-profile stromatolite mounds, as personally communicated by Professor John Talent (Emeritus Professor of Geology, Macquarie University) in Farabegoli *et al*. (2007). While there is nothing in the primary literature to suggest that the structures are stromatolites, Macquarie University lecture notes by Professor John Talent refer to them, as do interpretive signs located in Cairns.

On this basis, it is concluded stromatolites could be present in Geoffrey Bay, although this will need to be confirmed through further research. There is no information on the tolerances of stromatolites to excess sediment, most likely due to their apparent rarity. For impact assessment purposes (see Section 8.3.4.1 of the AEIS), it has been conservatively assumed that stromatolites (like seagrass and corals) require the maintenance of existing water quality conditions to persist.

8.2.3 Adequacy of marine ecology baseline data and impact assessment

A total of 23 submissions were received regarding the adequacy of baseline data and/or impact assessments relating to marine ecology. The following matters were specifically identified with respect to adequacy of baseline data.

<u>Seagrass Watch data that were not included in the EIS</u> - the Seagrass Watch data provided in the EIS provides a sufficient account of temporal variability in intertidal seagrass cover in Cleveland Bay up to and including 2010. Seagrass Watch monitoring data are now available up to 2013, and show that seagrass meadows declined between 2009-2011, coincident with successive years of wet weather conditions. Seagrass Watch data shows that seagrass cover increased at all Cleveland Bay sites between 2012 and 2014, indicating that meadows were in a recovery phase during this period (Figure 8.1, Figure 8.2). Similarly, meadow monitoring carried out by James Cook University found that seagrass meadow extent had increased between 2011 and 2013, but had not recovered to pre-2009 levels (Davies *et al*. 2013). Seagrass meadows are expected to have low resilience during this recovery phase (Davies *et al*. 2013), particularly those at Magnetic Island which had notably low cover and a limited seed bank (Seagrass Watch 2014).

<u>Benthic habitat mapping -</u>The benthic habitat mapping presented in the EIS provides a spatially comprehensive assessment of subtidal substrate types in Cleveland Bay. Seabed habitats were surveyed using sonar-based methods, and a total of 94 sites were sampled using underwater video. Data were interpolated to generate benthic habitat maps. Furthermore, 152 benthic infauna samples were collected for this assessment (from 38 sites). These

data complements existing work on benthic fauna communities referenced in the EIS (GHD 2009; GHD 2011; Cruz-Motta 2000; Cruz-Motta and Collins 2004; C&R Consulting 2007). It is acknowledged that the species composition and ecology of soft sediment benthic communities on the north Queensland coast are far less studied than some other species and communities (e.g. marine megafauna, seagrass, corals etc.). The available information is considered sufficient to determine the likely composition of benthic communities.

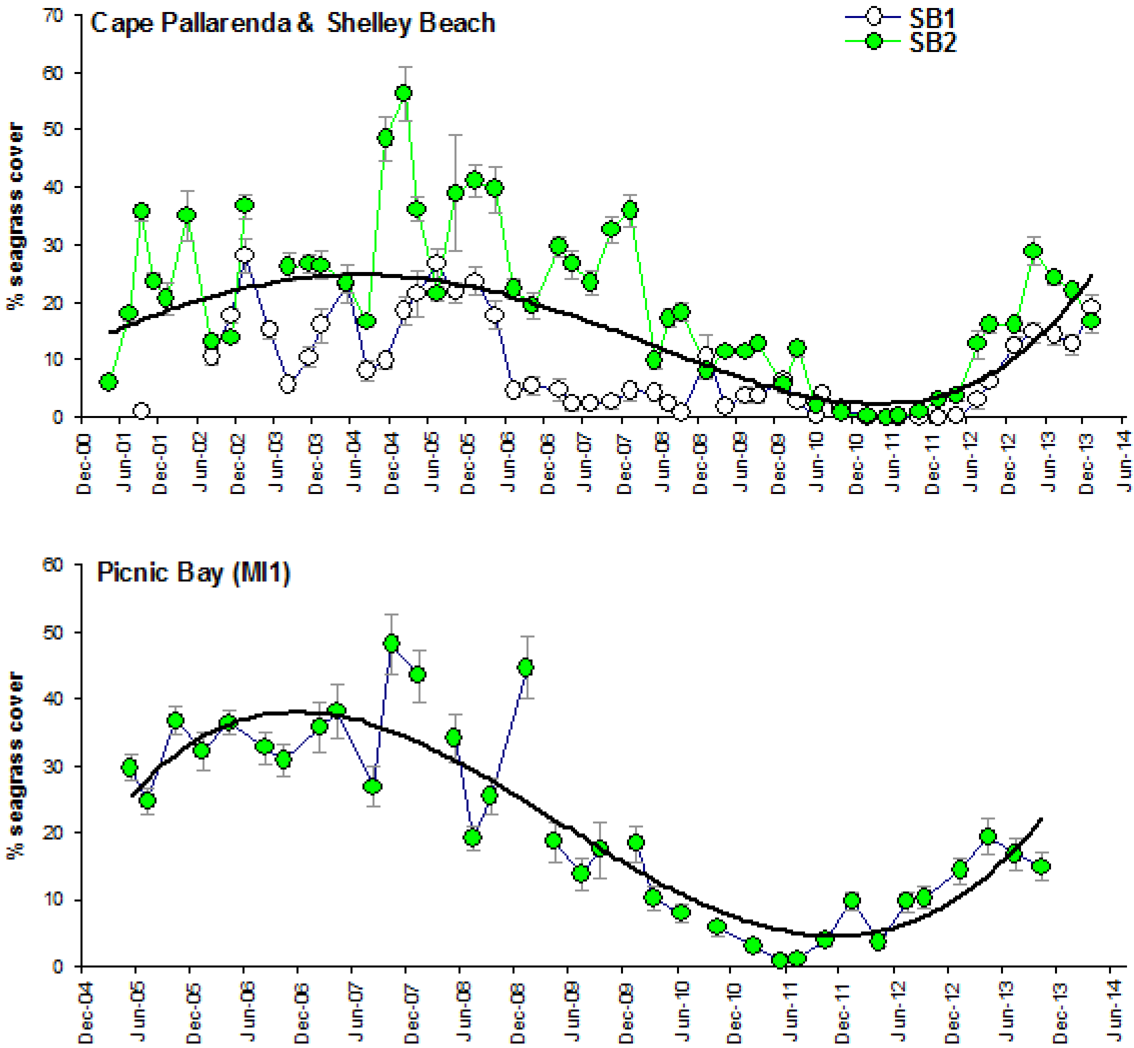

Figure 8.1 Seagrass percent cover at Cape Pallarenda (CP) and Shelley Beach (SB) (mainland coastal intertidal sites), and Picnic Bay (Data from the Reef Rescue Marine Monitoring Program; www.seagrasswatch.org)

Existing marine pest survey data (refer to Chapter B.6.3.8 of the EIS) - As outlined in the EIS, a port wide baseline survey of non-indigenous species was undertaken by James Cook University and the CRC Reef in November 2000 (Neil *et al*. 2001). This study is now out of date and it is acknowledged that although not a regulatory requirement, further surveys are required in this regard.

Marine megafauna species survey data (refer to Chapter B.6.3.7.2 of the EIS -. The EIS describes the relative abundance of key marine megafauna species found in Cleveland Bay, which is based on quantitative sampling methods (i.e. counts per unit sampling effort). A description of the sampling methodology is provided in Appendix K4 of the EIS. No empirical data are available for several very uncommon marine megafauna species that are known or possibly occur in Cleveland Bay.

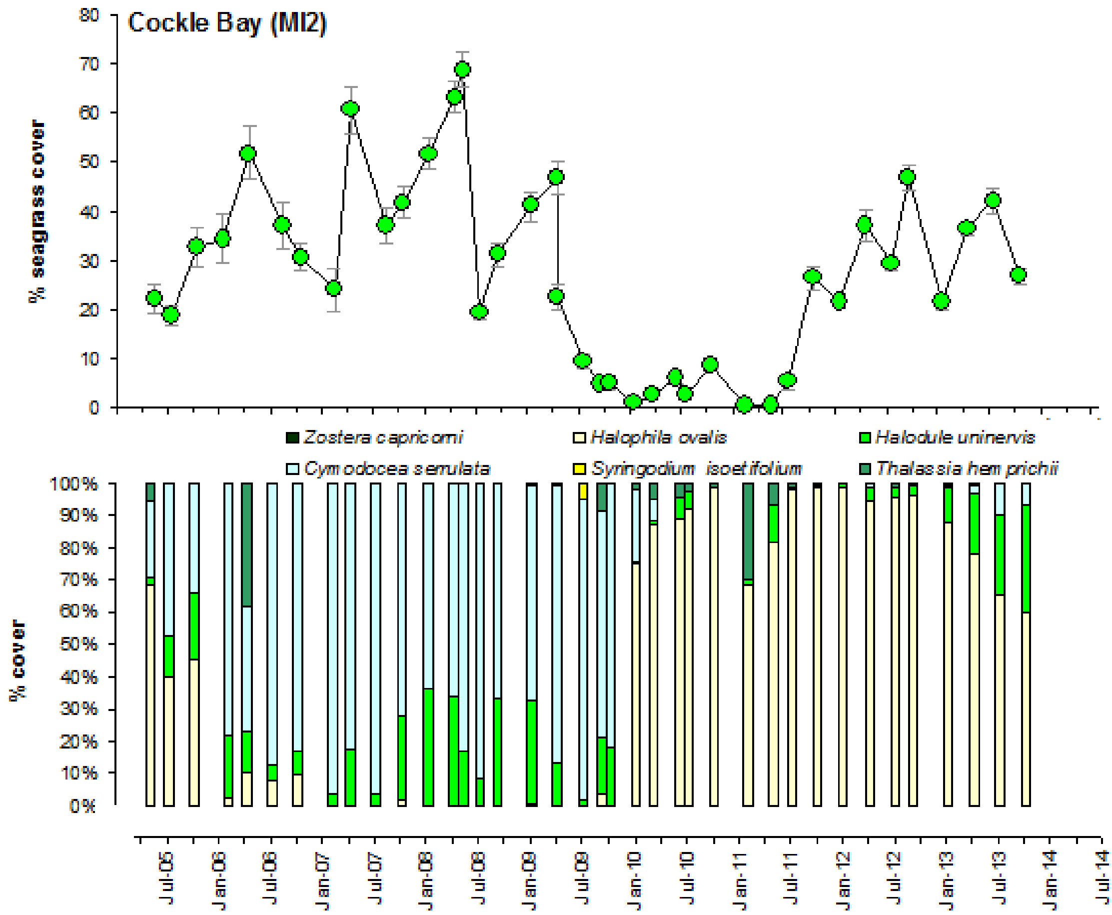

Figure 8.2 Seagrass per cent cover and species composition at Cockle Bay Magnetic Island (Data from the Reef Rescue Marine Monitoring Program; www.seagrasswatch.org)

8.2.4 Bioaccumulation of metals in marine fauna

Five submissions were received regarding the bio-accumulation of mercury in marine biota. Mercury and many other metals found in marine sediments cannot be readily excreted and can accumulate over the life of aquatic organisms. Animals that are high in the food chain (e.g. fish, birds and humans) can accumulate these metals through the consumption of prey, resulting in metal biomagnification. The accumulation of mercury and some other metals can lead to adverse health effects.

Chapter B.5 (Marine Sediment Quality) of the EIS presented existing data on contaminant concentrations in sediments, and did not identify mercury as a contaminant of concern. A Sampling and Analysis Plan for the PEP is required to be developed and implemented prior to commencement of dredging in accordance with requirements set out in the National Assessment Guidelines for Dredging (NAGD). This sampling program will provide an indication of contaminant concentrations in sediments (including mercury).

In addition, the results of the revised assessment have been considered in light of the 2014 Impact Guidelines for OUV of the WHA as outlined in Section 26.0 of the AEIS.

8.2.5 Assessment of impacts on the Outstanding Universal Value of the Great Barrier Reef World Heritage Area

A total of 45 submissions were received regarding the potential impact of the Project on the OUV of the GBRWHA. The submissions typically relate to the impact of sediment released by dredging and disposal on marine features underpinning the OUV of the GBRWHA.

The potential impacts of turbidity and sedimentation on sensitive ecological receptors is discussed in Chapter B.6.4.4 of the EIS. The EIS concluded that impacts to sensitive receptors (corals, seagrass) will likely occur in the absence of appropriate mitigation measures. This finding took into account the existing low levels resilience of seagrass and coral communities, and their sensitivity to further disturbance (both acute and chronic impacts).

The dredging program has been refined and reassessed in this AEIS, which necessitated new modelling assessments. The modelling results for the revised design are documented in Appendix A2 (Modelling Report). The refined Project (as outlined in 2.0 of the AEIS) involves no sea disposal and reduction of dredging by the TSHD.

Additional background water quality data has been collected from a range of sites throughout Cleveland Bay, which together with information on tolerance limits of seagrass, provides a basis for developing thresholds for assessing potential sediment impacts. Appendix A1 (Additional Field Studies Report) presents these additional water quality data and Section 6.0 (Water Quality) of the AEIS describes the thresholds used to identify impact zones. The findings of the re-assessment are discussed in section 8.3.2 below, and specifically consider the potential for impacts to the Outstanding Universal Value of the GBRWHA.

8.2.6 Assessment of impacts to turtles and turtle habitat

12 submissions were received regarding the impacts of the Project on turtles and their habitat.

Chapter B.6.3.7.2 of the EIS describes habitats values of Cleveland Bay and the wider Townsville region for sea turtles. An additional review of existing information was carried out to assess the values of Cockle Bay as a turtle foraging habitat, Magnetic Island as a turtle nesting habitat, and channels as resting areas. The information review suggests the following.

- Cockle Bay is a significant foraging habitat for turtles, particularly green turtles. In their submission of the EIS, DEHP advises that "*Approximately 200 green turtles and 6 hawksbill turtles have now been flipper tagged while foraging in Cleveland Bay. The majority of turtles captured…(were)… found to be using the intertidal seagrass and algal flats found within Cockle Bay. Cockle Bay would be classified as supporting a regionally significant population of foraging green turtles*." Tracking studies undertaken in November 2010 – July 2011 and 2011, demonstrate that juvenile green turtles show significant site fidelity, and only undertook small scale movements around the reef flat (see Appendix K4 of the EIS). As discussed in Chapter B.6.4.5 of the EIS, it is therefore important that dredging does not result in modifications to the availability of food resources for turtles, particularly given the recent local population declines due to successive wet weather years.
- Sandy beaches on Magnetic Island are used by turtles for nesting. Magnetic Island is not classified as a major turtle rookery in a state or national context, but will contribute to the maintenance of turtle populations. Lighting impacts to turtles and mitigation are discussed in Chapter B.6.4.8.1 of the EIS.
- While turtles are typically most abundant around seagrass meadows and reefs, they also traverse navigation channels as they move between feeding areas between Magnetic Island and eastern Cleveland Bay. Turtles may also rest in channel areas, or head to deeper waters (i.e. bottom of the channel) for refuge when disturbed (Pers. Comm. C. Limpus, 14-3-14). This behaviour increases their susceptibility to vessel strike by ships. Stranding data show that vessel strike is a common cause of turtle mortality on the Queensland coast, however there are too few data to determine the relative importance of ships versus fast-moving small craft to total mortality. Vessel strike impacts are considered in Chapters B.6.4.6 and B.6.4.9 of the EIS.

In addition to the residual low risk of impacts posed to turtles, the selected dredge window for dredging by the TSHD noted in Section 8.3.4.2 (avoiding spring/summer months, primarily for the benefit of seagrass and corals) will provide the further advantage of minimising potential disruptions to turtle nesting.

The construction of off-channel turtle resting habitats was considered as a potential mitigation measure. This would consist of dredging small cul-de-sacs off the navigation channel that are filled with logs. The suggested mitigation measure has the potential to be a significant navigation hazard as well as a threat to life. Further if the logs broke free, these could catastrophically impact either a large ship, ferry or recreational vessel in the wider waterspace as waterlogged logs typically sit just below the waterline. Townsville is exposed to cyclonic activity and the suggested mitigation is not feasible. This had been confirmed with the regional harbour master.

8.2.7 Assessment of impacts to marine mega fauna, including dolphins

Since the submission of the EIS, the conservation status of the Australian snubfin dolphin *Orcaella heinsohni* (formerly *Orcaella brevirostris*) and the Australian humpback dolphin *Sousa sahulensis* (formerly *Sousa chinensis*) has been revised. Both species are now classified as Vulnerable species (previously Near Threatened) under the Queensland *Nature Conservation Act 1992*. Their status under the *Environment Protection and Biodiversity Conservation Act 1999* remains unchanged, being Listed Migratory and Cetacean species. Given the listing now as threatened species, further background on these species is provided below for completeness, noting that much of this information was previously provided in the EIS.

Australian Snubfin Dolphin distribution and abundance

Australian Snubfin Dolphin *Orcaella heinsohni* has a geographic distribution that is restricted to tropical and subtropical zones of Australia, and southern New Guinea (Beasley *et al*. 2005). It is an uncommon nearshore coastal species in most areas, and is often found in small groups (Parra 2005; 2006a).

This species inhabits riverine, estuarine and coastal waters. This species generally occurs in waters less than 15 m deep, within 10 km of the coast and within 20 km of a river mouth (Parra, Corkeron, & Marsh, 2004). They appear to favour shallow waters (1-2 m deep) where seagrass is present and waters near river/creek mouths (GHD 2011).

The species has an opportunistic generalist diet, feeding on fish and cephalopods (octopus, squid etc.) from coastal, estuarine and nearshore reef habitats (Parra, 2006; Parra & Jedensjö, 2009). Australian snubfin dolphins commonly occur in the vicinity of the Port of Townsville, with the Ross River and Creek mouths, and adjacent seabeds, considered to represent foraging habitat for the species in this area. Snubfin dolphins are frequently observed in waters adjacent to the port, typically in association with bait fish food resources (GHD 2012). The targeted monitoring undertaken by GHD (2012) emphasises the importance of waters near the Ross Creek and Ross River mouths, as well as near the creeks along eastern Cleveland Bay, as nearshore dolphin habitat (Figure 8.1). Incidental sightings showed snubfin dolphins also commonly occurred close to the harbour and shipping channel (Figure 8.2, GHD 2012).

The estimate for the Australian snubfin dolphin ‘sub-population’ in 2002 in Cleveland Bay was 63 individuals (95% confidence interval = 51-88) (Parra, Corkeron, & Marsh, 2006; Parra, Schick, & Corkeron, 2006). Of this number 51 were observed in more than one calendar year between 1999 and 2002 and certain individuals repeatedly came back to specific areas in the broader Cleveland Bay area. Note that researchers from James Cook University are presently undertaking research to update these (10^{+} year old) population estimates in the Townsville region, for both Australian snubfin and Australian humpback dolphins, but that the outcomes of this research are not yet available.

Looking at the broader Townsville region, Parra (2006) found two core use areas for this species: one west of Cape Pallarenda, around the mouth of the Black and Bohle Rivers; the other around the Port of Townsville, including around highly modified habitats such as breakwaters (see Figure 8.3). The study did not indicate the presence of two distinct sub-populations, with photographic evidence suggesting that individuals travel between the two core areas. Further, while some snubfin dolphins may be permanent residents of the Cleveland Bay area, most tend to have short residence times, typically leaving the bay after 3 to 30 days (Para *et al*. 2006). They will usually spend periods of over a month away before entering the bay again (Parra 2006) and likely have large home ranges extending to 100’s km.

GHD (2011a) concluded that the recurrent use of Cleveland Bay by adult and calf snubfin and Australian humpback dolphins for foraging, indicates that this area, particularly around the mouth of Ross Creek and River, is an important feeding area at a local scale. There is limited information on the reproductive ecology of this species, although in Cleveland Bay Australian snubfin dolphins calves have been observed year- round (Parra, 2006; Parra, Corkeron, & Marsh, 2006).

Australian Humpback Dolphin distribution and abundance

Similar to *Orcaella heinsohni*, the geographic distribution of the Australian humpback dolphin *Sousa sahulensis* (formerly with *S. chinensis*) encompasses the tropical and subtropical east and west coasts of northern Australia and southern New Guinea. *Sousa sahulensis* occurs in a broad range of coastal habitats including coastal lagoons, enclosed bays, estuaries and open coastal waters (Jefferson and Karczmarski 2001).

Also like the Australian snubfin dolphin, Australian humpback dolphin generally occurs in waters less than 15 m deep, within 10 km of the coast and within 20 km of a river mouth (Parra, Corkeron, & Marsh, 2004). Australian Humpback Dolphins do not display any preference for turbid or clear-waters, and have been recorded from a broad range of coastal habitats including coastal lagoons, enclosed bays, and open coastal waters (Jefferson & Karczmarski, 2001). The species is also an opportunistic generalist predator, with a diet consisting of fish and crustaceans (Parra, 2006; Parra, Schick, & Corkeron, 2006).

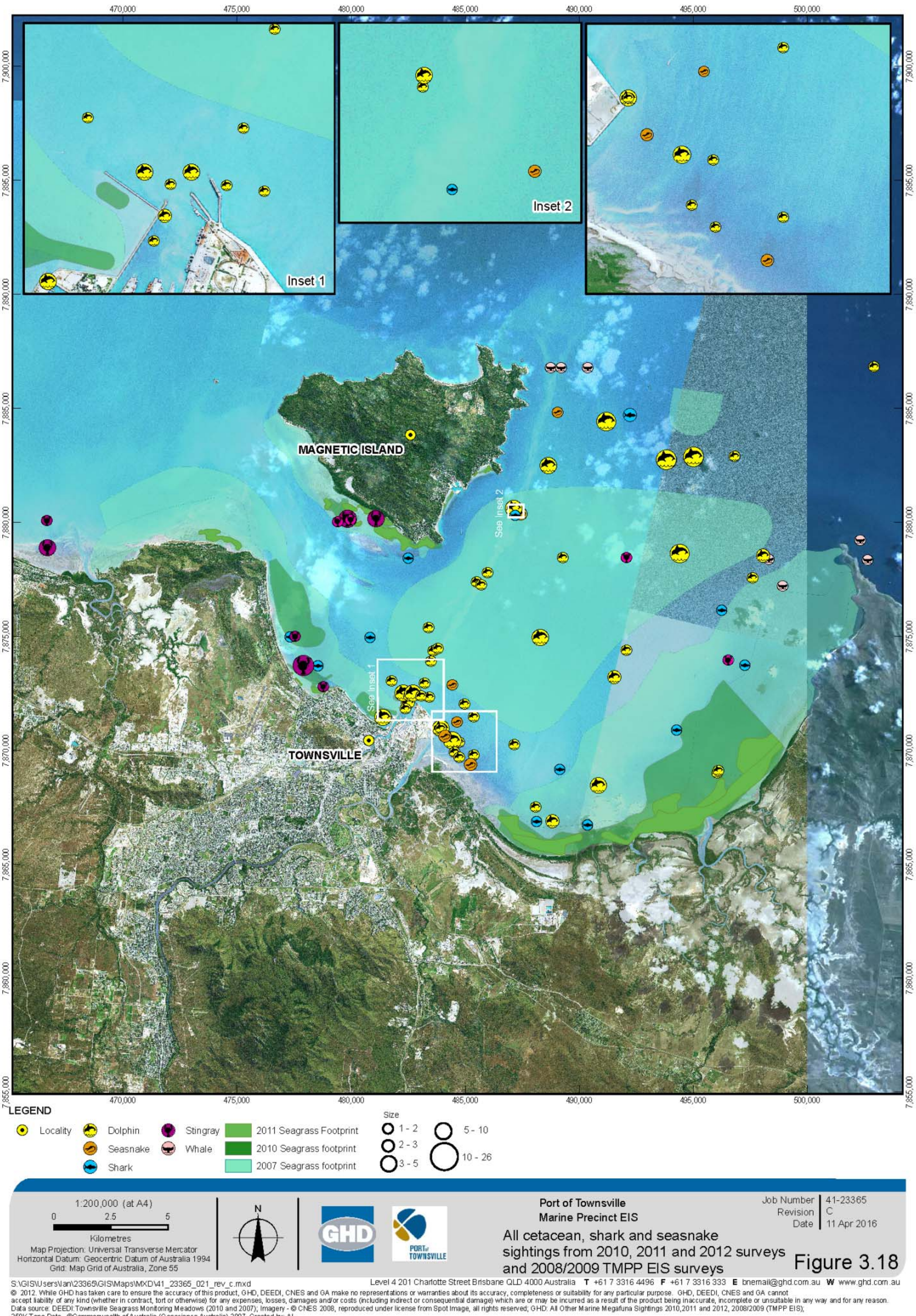

Figure 8.1 Nearshore dolphin (and other megafauna) sightings from multiple surveys, 2008 to 2012 (GHD 2012)

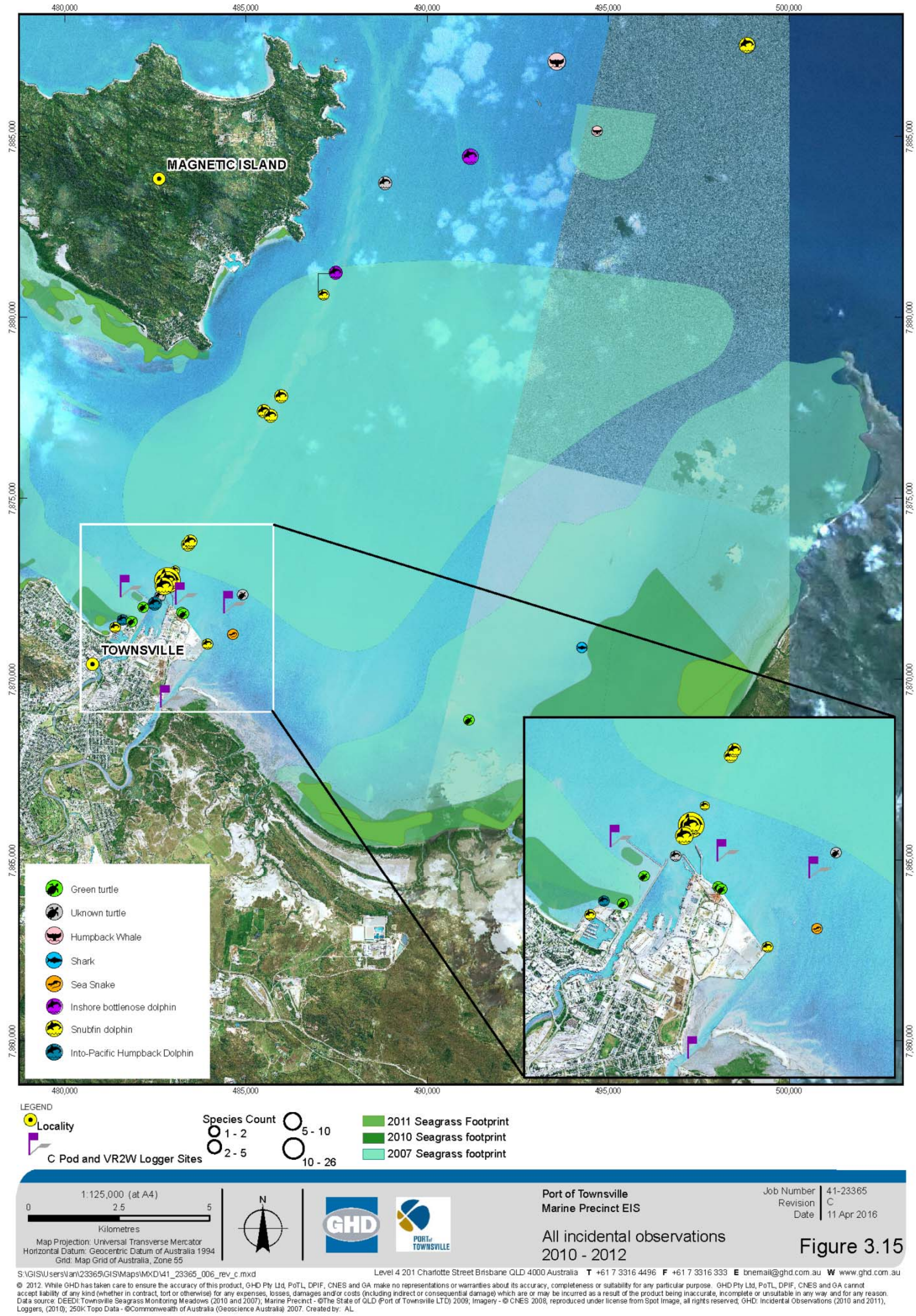

Figure 8.2 Incidental nearshore dolphin sightings

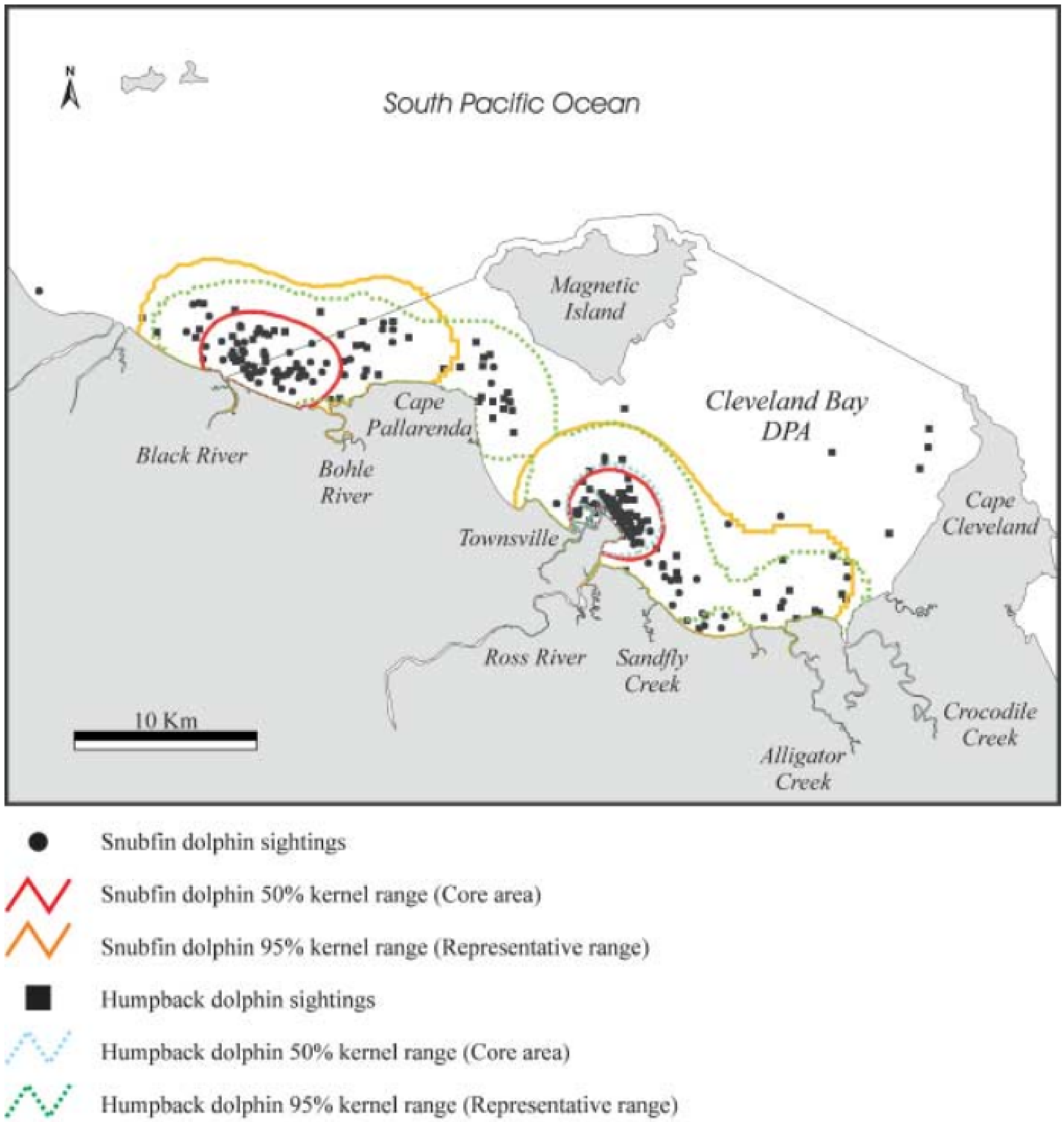

Figure 8.3 Core areas and representative ranges of Australian snubfin and Australian humpback dolphins in the Townsville region (figure from Parra 2006)

In the Townsville region, the representative range for this species extended throughout nearshore waters from Cape Cleveland to Black River. Their core area was located 17 km^2 area around the Port of Townsville (Parra 2006, Figure 8.3), including highly modified habitats in this area such as breakwaters, the harbour and dredged channels. In this locale, the Ross River and Ross Creek mouths and adjacent seabeds are considered to represent feeding habitat for Australian humpback dolphin.

Parra *et al.* (2006) estimated that the Australian humpback dolphin sub-population in Cleveland Bay during 2002 was 54 (95% confidence limit = 38 to 77). Of this number 32 were observed in more than one calendar year between 1999 and 2002. This species, like Australian snubfin dolphin, has a wide home-range (up to 395 km^2; Hung in DSEWPC 2012) and undertakes regular movements in and out of Cleveland Bay. While some Australian humpback dolphins may be permanent residents of the Cleveland Bay area, most tend to have short to moderate residence times, typically leaving the bay after 10 to 140 days (Parra *et al*. 2006). In terms of habitat usage, this species has mainly been observed to be foraging in the area, including foraging behind trawlers (Parra, 2006).

Biodiversity values and habitat significance for threatened nearshore dolphins

The occurrence of migratory species, and their habitat utilisation when present, needs to be considered in the context of the broader population, and their wider distribution and habitat availability. In this regard it is necessary to establish whether the area affected by the Project is an 'important habitat' for impact assessment purposes. The Matters of National Environmental Significance Significant Impact Guidelines 1.1 (Department of the Environment 2013) provides guidance by defining important habitat for migratory species as:

- *habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species, and/or*

- *habitat that is of critical importance to the species at particular life-cycle stages, and/or*
- *habitat utilised by a migratory species which is at the limit of the species range, and/or*
- *habitat within an area where the species is declining.*

In the context of the above:

- ecologically significant proportion of population:
  - Both species have been recorded in the PEP area in low numbers (GHD 2011, 2012), feeding and/or moving between feeding areas at the mouths of the tidal creeks/rivers within (i.e. Ross Creek and River mouth) and near Cleveland Bay (e.g. core usage area recognised west of Cape Pallarenda).
  - While a total population estimate is not available for Australian snubfin dolphin, Parra (2006b) estimated that the east Queensland coast population was likely in the thousands rather than 10's of thousands. It is estimated that the total number of mature Australian snubfin dolphin is fewer than 10,000 (DoE SPRAT database 2016). The Cleveland Bay sub-population of Australian snubfin dolphin recorded by Parra *et al*. (2002a) was 64-76 individuals. The home ranges of this species can extend 100's km outside Cleveland Bay, and individuals typically had a residence time of up to a month before emigrating outside Cleveland Bay. There is emerging evidence from case-studies in north-western Australia (Brown *et al*. 2014) and central-southern Queensland (Cagnazzi *et al*. 2011) that this species may exist as metapopulations of small, semi-isolated sub-populations.
  - The Australian humpback dolphin is more widely distributed than Australian snubfin dolphin, extending from Exmouth Gulf in the west, to the QLD/NSW border region in the east. The Australian humpback dolphin population in Australia is thought to number in the 1000's rather than 10,000's (Parra *et al*. 2002). Similar to Australian snubfin dolphin, Australian humpback dolphins are not permanent residents, with individuals regularly immigrating and emigrating outside Cleveland Bay.
- No formal critical habitat assessment has been undertaken for these species in Queensland or Australia. Within Cleveland Bay, the abundance of both species is highest at Ross River and Ross Creek mouths, and also appears to favour seagrass meadows and Cape Pallarenda. The low abundance of both species within the Project area does not suggest that this represents a particularly high value habitat. Like other nearshore environments throughout Cleveland Bay (and elsewhere), the Project area is expected to provide potential foraging habitat for individuals when they are residing in Cleveland Bay.
- As outlined above, the Project area is not at the limit of the species' range.
- There is presently no empirical evidence available to suggest that the species are declining in the Townsville region, and no other major marine projects of this scale planned for the area in the near future. The lack of long term empirical survey data does however limit the ability to detect long-term changes in population size (Parra *et al*. 2006). Key threats to the species are outlined in the following section.

Resistance/resilience of threatened near-shore dolphins

The resistance and resilience of these threatened nearshore dolphins to the development are primarily dependent on: the biological, physiological and ecological traits of the species; the resilience of their habitats and resources; and the magnitude, extent and timing/frequency of Project disturbances (in the context of other natural and/or anthropogenic disturbances). Here we outline the key resilience characteristics of these species relevant to the Project, namely:

- feeding behaviour (and sensitivity to turbidity)
- dietary requirements
- site fidelity
- capacity to reproduce
- overall population size
- key threats to species.

These are considered in relation to the Project in the impact assessment (Section 8.3.4).

Within their core use area at the Port of Townsville, both species appear to utilise highly modified habitat such as dredged channels and waters in close proximity to breakwaters. While the nearby river mouths and seagrass beds likely remain their preferred habitat, their common occurrence around the ports indicates some capacity to adapt to, and coexist with, such developments. More broadly, the preferred nearshore habitat of both of these dolphin species represents a highly dynamic environment. These nearshore environments are highly turbid, subject to periodic physical disturbance (storms, cyclones, floods) have characteristically highly temporally variable water quality conditions. As a result, invertebrate and fish food resources in the nearshore areas will be reasonably robust and typically comprised of species that are capable of rapid recovery.

This has important implications in terms of resistance of near-shore dolphin species to changes in environmental conditions. In this regard, near-shore dolphins have the following biological characteristics that allow them to cope with altered environmental conditions.

- Feeding behaviour and turbidity. Nearshore dolphin species are capable of successfully foraging in turbid waters. Dolphins often stir up bed sediments when foraging for benthic prey, resulting in limited to no visibility for prey detection. It is thought that dolphins detect prey using echolocation rather than visual cues (Mustoe, 2006; Mustoe, 2008). On this basis, nearshore dolphins therefore have adaptations that allow them to feed in high turbidity waters (Parra & Jedensjö, 2009).
- Opportunistic diet. Both nearshore dolphin species are considered to be 'opportunistic-generalist feeders' (Parra & Jedensjö, 2009). Gut contents analysis performed on dolphins captured along the Queensland coast (Parra & Jedensjö, 2009) found that both dolphins primarily fed on a range of demersal and pelagic fish species commonly found in estuarine and shallow nearshore habitats. In addition to fish, snubfin dolphins were found to feed on squid and cuttlefish, which typically occur in the water column. The opportunistic, generalist diet of these species reduces their susceptibility to changes in availability of particular prey types.
- Both dolphin species have home ranges extending at least 100's km outside Cleveland Bay and can, therefore, temporarily move from habitats that have sub-optimal environmental conditions.

Despite possessing a range of adaptations that allow a degree of resistance to short-term changes in environmental conditions, both nearshore dolphin species are considered to have low capacity to recover from population declines, as:

- Both are long-lived species with low reproductive rate. While the reproductive ecology of these species has not been well studied, most Delphinids bear one calf every two to three years (DSEWPC, 2012e; DSEWPC, 2012d). Consequently, these species will have slow rates of population recovery.
- Both species have small overall population sizes, and also have small local sub-population sizes. A substantial decline in dolphin numbers will be expected where the viability of local sub-populations is substantially reduced.
- Both species are under increasing threat from human activities. In this regard, both species have narrow habitat requirements, being restricted to near-shore habitats (often around river mouths and seagrass meadows). These environments are subject to the high levels of anthropogenic pressures. Key threats include habitat loss and degradation, entanglement in gill nets and shark nets, pollution (both direct and indirect impacts) and vessel strike from fast-moving watercraft (Parra, Corkeron, & Marsh, 2004; DSEWPC, 2012d; DSEWPC, 2012e).

Submission responses

26 submissions were received regarding the impacts of the Project on megafauna (including dolphins) and their habitat.

Chapter B.6.6 of the EIS discusses cumulative impacts on dolphins, and concludes: *"measurable adverse impacts to marine biodiversity values at localised (nearshore Cleveland Bay) spatial scales are expected. In particular, proposed future port projects could reduce available foraging area for nearshore dolphin species, possibly resulting in reduced numbers of dolphins visiting the local area"*. POTL has undertaken a range of investigations to assess habitat usage patterns of marine megafauna in the port area and wider Cleveland Bay (e.g. GHD 2011, 2012), which will continue to be considered in future port planning and environmental impact assessment studies.

Further detail and explanation is provided in the revised impact assessment presented in Section 8.3.4.

8.2.8 Adequacy of underwater noise assessment

Four submissions were received regarding noise impacts to megafauna. Chapter B.6.4.7 of the EIS considers impacts of noise on marine fauna, which is based on previous work undertaken by GHD for Port of Townsville Limited. This also considers mitigation measures, which includes a commitment to develop a Marine Megafauna Management Plan to manage noise impacts to fauna. Mitigation measures include:

- shut down / stop work procedures if marine megafauna are observed within defined exclusion zones
- water-based noise activities (pile driving in particular) will be commenced gradually to provide warning to nearby marine megafauna (i.e. ramp-up / soft-start procedure)
- noise mitigation measures to attenuate underwater noise such that the identified hazard level can be reduced as far as practicable, including:
  - use of a resilient pad (dolly) will be used where feasible between the pile and hammer head
  - air curtains to attenuate noise levels where practicable
  - dredge staging to manage piling noise attenuation.

The plan will be developed in conjunction with an appropriately qualified underwater noise consultant, and will include the implementation of contemporary management measures.

8.2.9 Noise impacts to larval fish

Acoustic cues are used by larval fish to detect suitable habitat for settlement (Holles *et al*. 2013; Slabbekoorn *et al*. 2010). Anthropogenic noise can have multiple effects including (Slabbekoorn *et al*. 2010): (i) stress and avoidance behaviour; (ii) masking of natural acoustic cues that facilitate detection of suitable settlement sites (e.g. waves crashing on reefs). Project activities during the construction phase (e.g. vessel traffic movements, piling, dredging) could therefore interfere with larval fish settlement behaviour.

The timing of spawning and settlement varies greatly among species. Unlike broadcast spawning corals, there is no distinct breeding season in all reef fish species, although many commercially significant reef fish tend to spawn during spring and summer months (e.g. Russell 2001). The use of generic 'seasonal windows' to mitigate impacts from construction activities may therefore protect some but not all species. On this basis there are no practical measures that can mitigate this impact.

Two fish species listed as threatened have the potential to occur in Cleveland Bay: green sawfish *Pristis zijsron* and whale shark *Rhincodon typus*. Based on available (limited) reproduction data for these species:

- *Pristis zijsron* – this species return seasonally (wet season) to inshore coastal waters adjacent to the northern Australian region to breed and pup (Peverell 2005). This species does not have a larval stage as it is a live-bearer. Therefore, the above mentioned acoustic noise issues discussed above are not relevant to this species.
- *Rhincodon typus* – this species is also a live bearer. This species is not known to pup in Australian waters (SPRAT database 2016).

8.2.10 Assessment of impacts to marine habitat values at anchorage sites

The Magnetic Island Nature Care Association (MINCA) submission raised the impacts of anchorages on habitat. Any anchoring that does occur will result in disturbance of benthic habitat at the anchor site. This could have cumulative impacts if anchoring frequency greatly increases and anchorages are inappropriately managed. Marine anchorage areas for commercial vessels are currently being investigated by the Regional Harbour Master and relevant agencies. The preferred anchorage locations are areas that have been previously disturbed by historical trawling and support relatively simplified soft sediment habitats and epibenthic communities that are representative (i.e. not unique) of habitats found nearby. The increase in vessel and anchoring requirements as a result of PEP are being considered as part of this process.

8.2.11 Assessment of cumulative impacts on the Outstanding Universal Value of the Great Barrier Reef World Heritage Area

212 submissions (includes form letter submissions) raised the assessment of cumulative impacts on the OUV of the GBRWHA. The EIS considered cumulative impacts to the OUV of the GBRWHA. Guidelines have now been released by the Australian government to assist in the assessment of potential impacts to the OUV of the WHA. Refer to Section 8.3.4 and Section 25.0 (Cumulative Impacts) for an assessment of impacts of the revised design which adopts the new guidelines.

8.2.12 Assessment of indirect impacts to Bowling Green Bay Ramsar site

Two submissions were received regarding the levels of impacts (both direct and indirect) of the Project on the Bowling Green Bay Ramsar site. Chapter B.6.4.14.5 of the EIS considers both direct and indirect impacts to the Ramsar site. It is concluded that "*It is…highly unlikely that the proposal will adversely impact on Bowling Green Bay Ramsar site or its supporting values",* based on the path and direction of modelled plumes and re-suspended sediments. This conclusion remains current.

8.2.13 Assessment of impacts from marine pests

Two submissions were received regarding potential impacts of marine pests. Chapter B.6.4.10 of the EIS considers potential impacts associated with introduced marine pests, and defines the risk level as low to medium. As outlined in this section, a construction stage marine pest management plan will be developed to minimise risk of marine pest introductions. This plan will be developed in accordance with DAF and other regulatory agency requirements. Marine pest management strategies will be developed during operational phase by port customers, in accordance with agency requirements.

8.2.14 Resilience of marine ecosystems

12 submissions were received regarding the impacts of the proposal on marine ecosystems that currently have low resilience. The current poor condition and low resilience of coastal ecosystems in Cleveland Bay and the wider Great Barrier Reef region is extensively described and considered in the Chapter B.6 (Marine Ecology) of the EIS. Furthermore, the potential impacts of the revised design on marine ecosystems (see Section 8.3.4) is considered to be conservative, recognising the existing low resilience levels.

As per Appendix B1 (Dredge Management Plan), the condition of marine ecosystems will be evaluated prior to commencement of dredging, with trigger values developed and approved by a scientific panel of experts (Technical Advisory Committee).

8.2.15 Habitat management plans instead of species management plans

The NQ Dry Tropics submission suggested that species management plans should be replaced by habitat management plans. Marine fauna management plans are required to minimise the risk of direct, construction related impacts to marine megafauna. Habitat or ecosystem management plans are not fit for purpose in this regard.

Notwithstanding this, the need for managing potential impacts of the PEP at the habitat level is acknowledged in the EIS. Habitat protection management actions form core components of the Dredge Management Plan (see Section C2.1), and offset commitments (see Section B23.3), and implicitly consider key existing stressors on marine ecosystems within Cleveland Bay.

The Dredge Management Plan (DMP) (Appendix B1) outlines management actions relating to construction phase impacts. Specifically, the DMP identifies measures designed to minimise the potential for dredging generated plumes to impact on sensitive habitats (particularly seagrass meadows and reefs). The timing and staging of dredging also takes into account critical life-cycle periods of corals and seagrasses, particularly recognising the current low levels of resilience of benthic primary producer habitats.

Section 27.0 (offsets) of the AEIS outlines commitments to better protect and enhance marine habitats in Cleveland Bay, or to better understand the land and water ecosystems, thereby providing a means for formulating management actions. This includes:

- an extension to Cleveland Bay Fish Habitat Area (additional 1,240 ha)
- improving water quality entering the GBRWHA through funding of the NQ Dry Tropics Sustainable Agriculture Program
- funding of research that seeks to identify the source of sediments within grazed properties and within Cleveland Bay, thereby improving the ability to better manage catchment pollutant impacts on marine habitats
- development of a Long Term Ecosystem Health Assessment in Cleveland Bay
- funding research into better understanding marine megafauna distribution and abundance and baitfish schooling triggers in Cleveland Bay.

8.3 Revised Environmental Impact Assessment

8.3.1 Legislation and policy

There are no major legislation or policy changes since submission of the EIS relevant to the assessment of marine ecology. The EIS omitted discussion regarding State marine parks declared under the *Marine Parks Act 2004*. The Great Barrier Reef Coast Marine Park is a State Marine Park that runs the length of Commonwealth GBRMP, and encompasses tidal waters up to highest astronomical tide. The Great Barrier Reef Coast Marine Park is managed under the *Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004* as a multiple use marine park. The PEP footprint falls only within the port exclusion zone and outside of the GBRMP.

The two inshore dolphin species (Australian snubfin dolphin *Orcaella heinsohni* and Australian humpback dolphin *Sousa sahulensis*) have had their conservation status upgraded from Near Threatened to Vulnerable species under the Queensland *Nature Conservation Act 1992*. Their conservation status under the *Environment Protection and Biodiversity Act 1999* remains unchanged.

8.3.2 Design refinement

The revised design includes widening of the channel, the removal of the offshore marine disposal of capital dredge material, and an increase in the size of the reclamation area. These changes will affect marine ecological receptors due to changes in turbid plumes and habitat loss from reclamation. These impacts are assessed in Section 8.3.4.

The PEP revised design components relevant to the marine ecology assessment include the following:

- the size of the reclamation will be increased from approximately 100 to approximately 150 ha to accommodate more dredge material (including breakwaters)
- the channel will be widened and only partially deepened (previous design included deepening and targeted widening).

8.3.3 Supporting studies

Additional field studies (Appendix A1), water quality assessment (Section 6.3.4.1) and Technical Modelling Report (Appendix A2).

8.3.4 Revised assessment

8.3.4.1 Impact assessment

Table 8.1 is a summary of the predicted extent of habitat loss or modifications as a result of various port construction and operation activities for the revised design case. Figure 8.4 and Figure 8.5 shows the extent of habitat loss or modification due to these activities.

Direct modifications associated with dredging and reclamation

Construction of the port facilities and associated reclamation will result in the direct loss of 152 ha of soft-sediment habitat (compared to approximately 100 ha in the original design). A total of 264 ha of soft sediment habitat will also be disturbed by dredging activities (inclusive of the existing dredged channel, which will be deepened).

Figure 8.4 Cumulative disturbance footprint for the outer harbour Project area and nearshore sections of the navigation channel

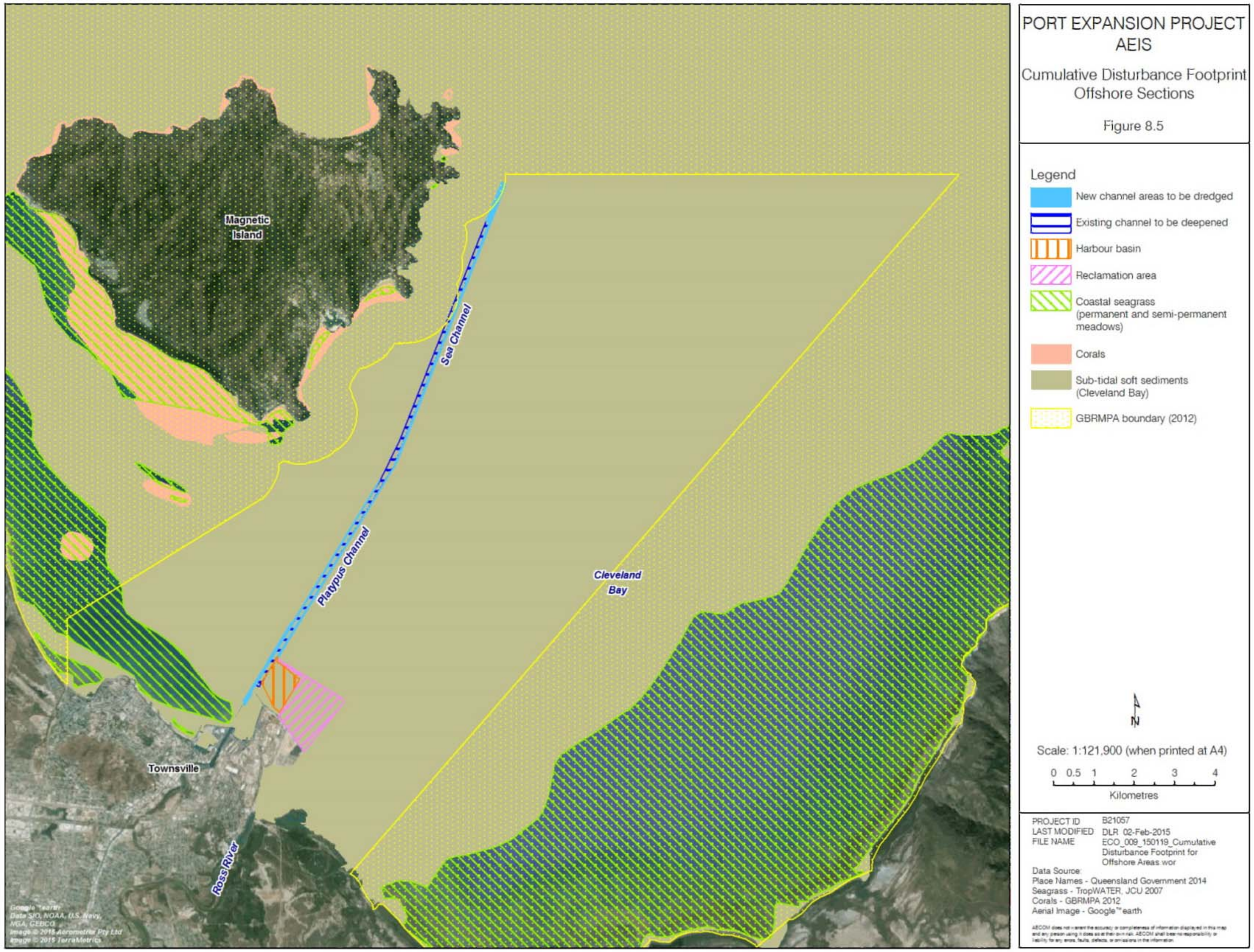

Figure 8.5 Cumulative disturbance footprint for the offshore sections of the navigation channel

Table 8.1 Area of disturbance within each impact location

Phase	Activity	Impact Type	Habitat	Area (ha)
Direct Irreversible Losses and Gains				
Construction, Operation	Reclamation	Loss of soft sediment habitat	Sub-tidal soft sediments	152 ha
Construction, Operation	Reclamation	Increase in rock wall habitat	Rock wall habitat	12.6 ha (net gain)
		Increase in rock wall habitat (including Western Breakwater)	Rock wall habitat	15.6 ha (net gain)
Direct Habitat Disturbance Associated with Dredging				
Construction, Operation	Dredging and deepening of harbour basin (outside reclamation footprint)	Habitat modification - Increase in depth; ongoing disturbance by maintenance dredging	Sub-tidal soft sediments	65 ha
Construction, Operation	Deepening of the existing navigation channel	Habitat modification - Increase in depth; ongoing disturbance by maintenance dredging	Sub-tidal soft sediments	123 ha
Construction, Operation	Deepening, widening and/or lengthening of navigation channel in previously undredged areas	Habitat modification - Increase in depth; ongoing disturbance by maintenance dredging	Sub-tidal soft sediments	76 ha
Indirect Temporary Changes due to Turbidity/Sedimentation *				
Construction	Dredging of port area and navigation channels	Turbid plume – Zone of Low, Moderate or High Impact (i.e. potential detectable effects)	Coastal seagrass (maximum recorded extent)	0 ha
			Reefs	0 ha
Construction – Worse Case	Dredging of port area and navigation channels	Turbid plume – Zone of Low Impact (Sub-lethal effects, medium term recovery) *(Nb: Zone of Moderate or High Impact not predicted to align with location of seagrass or reef)*	Coastal seagrass (maximum recorded extent)	8.8 ha
			Reefs	66.8 ha (widening) – Stage 1 77.6 ha (deepening) – Stage 3
Construction – Expected Case	Dredging of port area and navigation channels	Turbid plume – Zone of Low Impact	Coastal seagrass (maximum recorded extent)	0 ha
			Reefs	0 ha

Note: Areas of coastal seagrass based on maximum recorded extent (i.e. 2007). No seagrass or corals occur in zones of impact for expected case

As discussed in Appendix A1 (Additional Field Studies Report), the soft sediment habitat to be lost or disturbed is well represented within the nearshore environments of Cleveland Bay, and benthic communities here are neither rich nor abundant compared to other parts of Cleveland Bay. It is expected that dredging of the navigation channel will create benthic habitat conditions that are similar to those found within the existing navigation channel. As discussed in Appendix A1 (Additional Field Studies Report), existing benthic habitats and macroinvertebrate assemblages within the navigation channels are highly simplified and have low diversity compared to adjacent undredged areas. These navigation channels are subject to ongoing disturbance as a result of maintenance dredging and propeller wash. While in a modified condition, it will be expected benthic habitats and communities within the navigation channel will continue to support similar benthic communities and ecological functions as found in the existing channels.

The greatest biodiversity values supported in areas to be lost or disturbed is the provision of habitat for the two state listed Vulnerable nearshore dolphins (*Orcaella heinsohni* and *Sousa sahulensis)*. As outlined in Chapter B.6.4.5.2 of the EIS, waters surrounding the Port of Townsville, as well as the mouths of Ross Creek and Ross River, represent locally important feeding areas for both species. These species also forage throughout Cleveland Bay and have another core use area west of Cape Pallarenda. As outlined in the EIS, reclamation will result in the localised loss of soft-sediment subtidal habitat and foraging areas for the two nearshore dolphin species, resulting in displacement of dolphins foraging in the proposed development footprint. During construction, these species will be more reliant on habitats elsewhere in Cleveland Bay, west of Cape Pallarenda and elsewhere in the broader home range (i.e. outside the Townsville region). Following rock wall construction, based on current usage patterns in the Port, it is expected they will continue to occur around the new rock wall (i.e. reclamation boundary).

As discussed in the EIS, both species are opportunistic foragers and have wide home ranges. While the Project is unlikely to cause a significant impact to the population status of these species, there is a clear need for further research to fill knowledge gaps regarding broad and local-scale movement patterns of these dolphin species, and the relative importance of different habitat patches at both local (i.e. within Cleveland Bay) and regional spatial scales. As outlined in the EIS, POTL has undertaken a range of investigations to assess habitat usage patterns of marine megafauna in the port area and wider Cleveland Bay, which will need to be considered in future port planning and environmental impact assessment studies. The protection of tidal habitats within the Fish Habitat Area extension as proposed as an offset to the PEP will further enhance marine habitats in Cleveland Bay used by these dolphin species.

Incursion of sea channel into GBRMP

The revised design has reduced the length of the Sea Channel by about 1.7 km since the EIS design. As shown in Figure 8.5, this has avoided a direct impact into the Great Barrier Reef Marine Park General Use Zone.

Habitat fragmentation and effects to hydrodynamics

As for the design adopted in the EIS, the refined project design has been developed to avoid forming a barrier to tidal currents and fluvial flows from the Ross Creek. The Project will not create a barrier to the movement patterns of mobile fauna between Ross Creek and Cleveland Bay. Furthermore, the Port Expansion Project will not form a barrier between the eastern and western sections of the outer harbour Project area, although marine fauna will need to travel a greater distance to move around the reclamation area. Such changes are expected to result in highly localised changes to marine fauna movement patterns (impacts measured in 100s of metres of the final structure), however such changes are not expected to result in detectable changes to the habitat, biodiversity or fisheries values of Cleveland Bay, or populations status of resident marine fauna.

Based on modelling results presented in the Appendix A2 (Modelling Report):

- The reclamation and increased water depths resulting from dredging will result in minor changes to local hydrodynamics, being confined to changes (± 0.2-0.3 m/s) in velocity magnitude in the immediate vicinity of the proposed breakwaters and reclamation area. Minor, localised effects to benthic communities are expected in these areas.
- The increased water depth and changes to hydrodynamics in the harbour area will result in the same localised changes to benthic communities as predicted in the EIS. In this regard, an increase in fine sediments is likely to favour species that prefer fine sediments (e.g. some suspension-feeders).
- The predicted minor changes to sediment transport processes in Cleveland Bay are not expected to result in significant changes to benthic fauna or seagrass assemblages.

Turbidity and sedimentation impacts due to dredging

Impact Thresholds

Section 6.0 provides a detailed description of the methodology and findings of the potential impacts of dredge-generated turbid plumes on water quality, and sediment deposition. The methodology and impact thresholds adopted in Section 6.0 consider tolerances of marine ecological receptors, and are therefore applicable to this marine ecology impact assessment. As outlined in Section 6.0, four zones of impact were defined based on severity of potential impact to marine ecological receptors.

Potential impacts

In summary, based on the expected case (impact zones figures are presented in Section 6.0):

- For both channel deepening and widening, reefs occur in the predicted zone of influence for both TSS (Figure 6.10 and Figure 6.14) and sediment deposition (Figure 6.16 and Figure 6.18), but not in any of the impact zones (Table 8.1). For both deepening and widening, all reefs along eastern Magnetic Island from Gowrie Bay to the eastern margin of Cockle Bay Reef are located in the predicted zone of influence. The closest reef to any of the potential impact zones is the northern end of Geoffrey Bay, which occurs directly adjacent to the channel. As reefs do not fall into any impact zones, significant impacts to corals are not predicted for the expected case, including Cockle Bay.
- For both channel deepening and widening, Magnetic Island coastal seagrass meadows occur in the predicted zone of influence for both TSS and sediment deposition, but not in any of the impact zones (Table 8.1). Seagrass assemblages within the zone of influence are located on the east and south-east coast of Magnetic Island, and are comprised of *Halodule uninervis*, *Halophila spinulosa, H. ovalis, Cymodocea serrulata* and (in some years), *Thalassia hemprichii* (Davies *et al.* 2015). In 2014 these seagrass meadows were rated as being in Very Good (Geoffrey Bay and Nelly Bay) and Good (southern Magnetic Island) condition, following a three year recovery period after extreme weather and climate related losses leading up to 2011 (Davies *et al.* 2015). Davies *et al*. (2015) suggest that the present day good condition of seagrass will have at least partially restored meadow resilience compared with the recent past. Assuming seagrasses remain in a similar, or better, condition at the time of dredging, together with the predicted low sediment concentrations, significant impacts to seagrasses are

not expected for the expected case. Impacts may be worse than predicted if seagrass condition drastically declines between now and the Project commencement.

- For both channel deepening and widening, coastal seagrass meadows from Cape Pallarenda to the Strand occur in the predicted zone of influence for both TSS and sediment deposition, but not in any of the impact zones (Table 8.1). Seagrass assemblages within this area are comprised of *Halodule uninervis*, *Halophila ovalis,* and *Cymodocea serrulata* (Davies *et al.* 2015). In 2014 these seagrass meadows were rated as being in Good condition, following a three year recovery period after extreme weather and climate related losses leading up to 2011 (Davies *et al.* 2015). Assuming seagrasses remain in a similar, or better, condition at the time of dredging, significant impacts to seagrasses in this area are not predicted to occur for the expected case. Impacts may be worse than predicted if seagrass condition drastically declines between now and the Project commencement

In summary, based on the worse case (impact zones figures are presented in Section 6.0):

- For both channel deepening and widening, reefs occur in the predicted zone of influence for both TSS (Figure 6.11 and Figure 6.15) and sediment deposition (Figure 6.17 and Figure 6.19), and the zone of low impact for TSS (Table 8.1). For both deepening and widening, all reefs along eastern and southern Magnetic Island from the eastern headland of Horseshoe Bay to the western margin of Cockle Bay Reef are located in the predicted zone of influence. Reefs from Florence Bay south to Nelly Bay (including Geoffrey Bay) occur in the zone of low impact for TSS. It is possible that stress could occur to corals in the zone of low impact, especially if dredging were to be undertaken during and following unfavourable climatic periods when coral resilience is low. The most recent published coral monitoring data for the Burdekin region (Thompson *et al*. 2014) shows that reefs (including Magnetic Island and Middle Reef) are in poor condition, reducing their resilience to further stress. It is therefore important that mitigation measures are put in place to ensure that any stress to corals does not manifest as injuries or mortality.
- For both channel deepening and widening, Magnetic Island coastal seagrass meadows occur in the predicted zone of influence for both TSS and sediment deposition, and zone of low impact (Table 8.1). Seagrass assemblages within the zone of low impact occur at Geoffrey Bay and Nelly Bay on the eastern coastline of Magnetic Island. Stress to seagrass meadows could occur to seagrass in this zone. While these meadows are currently in good condition, mitigation measures should be implemented to minimise the risk of impacts, especially if climatic processes leading up to dredging result in declines to seagrass meadow condition. Impacts may be worse than predicted if seagrass condition drastically declines (e.g. due to a major cyclonic disturbance etc.) between now and the Project commencement.
- For both channel deepening and widening, coastal seagrass meadows from Saunders Beach to the Strand (including Cape Pallarenda) occur in the predicted zone of influence for both TSS and sediment deposition, but not in any of the impact zones (Table 8.1). Significant impacts to seagrasses in this area are not predicted to occur for the worse case.

Note that deepwater ephemeral seagrass has been previously recorded in Cleveland Bay on one occasion (in 2007), following successive years of drought conditions. Should seagrass re-establish in this area it is possible that some impacts (not necessarily mortality) could occur, primarily limited to seabed areas near the channel where this coincides with the Zone of High Impact.

Monitoring and other measures outlined in Section 8.3.4.2 below will be critical to mitigating such effects and ensuring that impacts are managed within acceptable limits (as listed under mitigation in Section 8.3.4.2). Ongoing monitoring of coastal seagrass and reef community condition will form a key component of the Reactive Monitoring Program that will be undertaken during dredging.

In the unlikely event that seagrass mortality occurs as a result of increased turbidity, recovery could occur through a number of mechanisms, which are discussed in Section 6.1.5.4 of the EIS. These include the following:

- Seagrass species found in the study area can reproduce both sexually and asexually, providing multiple mechanisms for relatively rapid recovery (Coles *et al*. 2004).
- Where vegetative growth is not possible (e.g. extensive plant mortality), recovery will be dependent on germination of seeds stored in the seed bank at that location. Seeds may be able to survive in a dormant condition for two to three years and still remain viable (Campbell and MacKenzie 2004, Orth *et al*. 2006). A poor seedbank was recorded in Magnetic Island meadows in 2013, but those at mainland sites (Cape Pallarenda) were in better condition.
- Mainland seagrass meadows at Cape Pallarenda and Cape Cleveland are not expected to be affected, thereby providing potential propagule sources for potentially affected areas at Magnetic Island. Hydrodynamic modelling shows that during ebbing tides (prevailing winds), currents flow between mainland meadows at Cape Pallarenda and Cape Cleveland to southern and eastern Magnetic Island, forming a potential linkage for seagrass propagules between these areas.

As discussed in the EIS, the rate of recovery will be dependent on factors such as the location, magnitude and extent of disturbance, seed bank and meadow condition, as well as the season and environmental conditions during the recovery period. Rapid recovery (measured in months to 10s of months) will expected in the event that impacts were low magnitude and seagrass had high resilience, but longer recovery timeframes (measured in years) will expected if mitigation measures are not in place, and seagrass was in poor condition.

As discussed in the EIS, the tolerance of corals to low light conditions varies greatly between species. While coral species in Cleveland Bay have adaptations to cope with periodic high sedimentation and turbidity levels (e.g. heterotrophic feeding, mucous secretions), levels outside the range of natural variability generally cannot be tolerated in the medium to long term.

The potential for impacts to reef communities (particularly corals), like seagrass, also depends on ambient conditions at the time of dredging, as well as other disturbances (e.g. a major cyclone could occur and impact seagrass or coral communities prior to Project commencement). Turbidity levels are largely driven by variations in the wind-wave climate and rainfall, as discussed in Chapter B.4 (Marine Water Quality) of the EIS. It is therefore expected that corals may be closer to their critical light limits and sedimentation tolerance limits during wet periods with high winds than lower wind, dry periods. It is notable however that patterns in turbidity can show a high degree of variability across a range of other temporal scales, and that other factors can lead to stress in corals (e.g. high water temperature, disease, predation etc.).

Assuming environmental conditions are poor leading up to and during dredging (i.e. high water temperature, low salinity, high nutrients and sediments), there is a greater potential for excess sediment created by dredging to affect corals and possibly other reef species (including macroalgae, soft corals, other filter feeders and possibly stromatolites). This is particularly the case given the existing poor condition of coral communities around Magnetic Island following successive years of extreme weather-related disturbances. It is therefore important that mitigation measures are put in place to manage potential impacts to corals and other reef species.

As discussed in Sections 6.3.4.2 and 8.3.4.2, mitigation strategies will be developed and implemented to minimise the risk of impacts to sensitive ecological receptors. Modelling presented in Section 6.3.4.2 demonstrates that dredge plumes could extend to reefs and seagrass meadows along the coast of Magnetic Island. However, overall, the residual risk rating for seagrass and corals is classified as Low (for areas in Zone of Influence) to Low-Medium (for areas in Zone of Low Impact). It is therefore not expected that dredge plumes will have a significant impact on key feeding habitats used by marine megafauna, including the important turtle foraging habitats at Cockle Bay and elsewhere along Magnetic Island.

8.3.4.2 Mitigation measures

Mitigation measures will be required to minimise the potential for turbid plumes to impact seagrass and coral assemblages along eastern and southern Magnetic Island. A hierarchy of controls will be followed as follows, as outlined in the DMP:

- Avoidance of late spring and summer months by the TSHD, noting that (see the EIS for details):
  - corals and seagrass may be under stress from (i) high temperatures; (ii) high turbidity and low salinity associated with floods
  - the spring and early summer period (together with other less extreme summer periods) may represent key periods for seagrass growth and resilience building
  - mass coral spawning occurs during November, with recruitment of broadcast spawners occurring thereafter
  - summer represents a key turtle nesting period.
- Minimisation Using Monitoring Controls - Development and implementation of a reactive water quality and coral monitoring program (RMP). Dredging activities will be modified or suspended in the event that monitoring detects exceedance/s of trigger values. The trigger values are based on both sub-lethal effects guidelines (i.e. changes in turbidity relative to background) and direct impact response guidelines (i.e. coral bleaching and/or mortality), which will illicit different management responses. An advisory body will be established that oversees the development and implementation of the reactive monitoring program.

Other mitigation commitments outlined in the EIS will also be applied.

With respect to offset requirements, the relevant MNES and MSES significant impact criteria were consulted for the threatened species of key concern in the context of this Project (i.e. nearshore dolphins, *Orcaella heinsohni* and *Sousa sahulensis*). For determining significant impacts to these species as MNES, the criteria for Listed Migratory Species are recommended under the Matters of National Environmental Significance Significant Impact Guidelines 1.1 (Department of the Environment 2013). These criteria are listed under MNES in Table 8.2. Note that no specific guidelines are provided for Listed Cetaceans in the MNES guidelines.

Under the State Significant Residual Impact Guidelines (DEHP 2014), criteria for threatened species are listed under ‘Protected Wildlife Habitat’, including any area of habitat (e.g. foraging, nesting, roosting or breeding habitat) for an animal that is endangered, vulnerable or a special least concern animal. Criteria for threatened wildlife and their essential habitat are as listed under MSES in Table 8.2.

As detailed in Table 8.3 below:

- Both dolphin species use sound for navigation, feeding and avoiding predators (through echo location) and also for communication. Construction works are expected to generate noise that will compromise the ability of dolphins to communicate, navigate and echo locate by sound. During the construction period, nearshore dolphins will likely avoid the reclamation construction footprint at times when noisy, or otherwise disturbing, construction activities are underway. This will lead to the displacement of these species in waters directly adjacent to the construction area during the construction phase. Noise disturbance will be temporary and intermittent throughout the construction period.
- The locally important dolphin feeding habitats at the mouths of the Ross Creek and Ross River will not be directly affected by the PEP.
- The proposed reclamation would result in the permanent loss of habitat used by nearshore dolphins. The habitat types (sediment types, hydrodynamics, depths, water quality) and benthic communities present in the proposed reclamation area are similar throughout the nearshore environments of the wider port area, and are not known or likely to contain unique feeding resources or functional values.
- Based on observations of dolphins within and adjacent to existing berth and breakwater areas (GHD 2011), it is expected that the dolphins will use waters in the vicinity of the new breakwater (i.e. PEP reclamation boundary) in the same manner.
- Dolphins will need to swim a slightly greater distance around the Port Expansion Project area to move between the feeding areas at the Ross River and Ross Creek mouths. No significant impacts to broad-scale movements are expected (i.e. to and from the wider Cleveland Bay, seagrass meadows, or core area west of Cape Pallarenda). The proposal will not fragment the local populations of these species, nor pose ecologically significant impediments.

Table 8.2 MNES and MSES Significant Impact Guidelines and Relevant PEP Impact Assessment for threatened nearshore dolphins

	Impacting Process	Timescales
MNES (Listed Migratory Species)		
An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:		
1. *substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species;*	Direct Permanent loss of habitat in proposed reclamation area (i.e. highly localised), but no direct impacts to the locally important foraging habitats at mouths of Ross River and Ross Creek, or to seagrass meadows	Permanent – Construction and operational phases
	Indirect No significant modifications to habitats outside the reclamation footprint, noting no major changes to hydrodynamics, water quality, sediment quality or benthic communities Dolphins currently forage adjacent to the existing seawall and port facilities, and this is expected to continue post construction of the new seawall	Temporary - Construction phase
2. *result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or*	The action is unlikely to result in the invasive pests (or cause disease) causing serious impacts to habitat values for nearshore dolphins	Construction and operational phases
3. *seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour of an ecologically significant proportion of the population of a migratory species.*	Possible temporary displacement of both species from waters near the construction zone during construction phase (noise, boat traffic)	Temporary and intermittently during construction phase
	See 1.	See 1.
MSES *(Protected Wildlife Habitat, including any area of habitat - e.g. foraging, nesting, roosting or breeding habitat - for an animal that is endangered, vulnerable or a special least concern animal):*		
An action is likely to have a significant impact on endangered and vulnerable wildlife if the impact on the habitat is likely to:		
4. *lead to a long term decrease in the size of a local population; or*	See 1 and 3 Significant impacts to important habitat near the river mouths (and seagrass) not expected	See 1 and 3
5. *reduce the extent of occurrence of the species; or*	See 4	See 4
6. *fragment an existing population; or*	See 4	See 4
7. *result in genetically distinct populations forming as a result of habitat isolation; or*	See 4	See 4
8. *result in invasive species that are harmful to an endangered or vulnerable species becoming established in the endangered or vulnerable species' habitat; or*	See 2	See 2
9. *introduce disease that may cause the population to decline; or*	Not applicable	Not applicable
10. *interfere with the recovery of the species; or*	See 4 Current population trend unknown, no confirmation that population is in a state of decline or recovery	See 4
11. *cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species.*	See 3	See 3

Table 8.3 Rationale advising no significant impact to nearshore dolphins with respect to key significant impact criteria

MNES (Migratory Species): Will the action substantially modify, destroy, isolate an area of important habitat for a migratory species? MSES (Endangered and Vulnerable Wildlife): Will the action cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species?		
Impact Matter	Significant Residual Impact?	Rationale
Will the development impact on the species during construction?	No	There is likely to be a temporary impact during construction as the animals are displaced from the reclamation footprint. However the intensity, scale, magnitude and duration of the impact are not expected to preclude use and transit of the area during construction periods and will not preclude use of the habitat (direct reclamation footprint excluded) in the future once works are completed (see below). Mitigation measures are set out in the CEMP/DMP to avoid or otherwise minimise adverse impacts from piling and to reduce incidence of adverse vessel interaction. Contingency and response measures will be implemented for any harmful interaction in accordance with government guidance, noting it is considered highly unlikely works will cause a significant injury or mortality to an individual given the highly mobile nature of the species. Accordingly, this temporary impact of displacement is not considered to be a significant residual impact to the species.
Destruction of an important habitat leading to potential impacts to the population of the species	No	The reclamation will result in the loss of 152 ha of habitat that is currently used as feeding habitat by the species. There is not any practical design or mitigation measures that could be implemented by the PEP to further minimise this impact other than to not proceed with the Project (e.g. not reclaim the land). The size of the reclamation responds to the commercial and operational needs for port expansion but also the requirements of the Commonwealth and State government to beneficially re-use capital dredge material and prohibition on the placement of such material at sea. The feeding habitat in the Project area is part of a broader sub-regional habitat for the species as defined in Parra (2006). For the sub-population frequenting Cleveland Bay, this includes their representative range from Black River to eastern Cleveland Bay and contains similar habitats to Ross River/Ross Creek at the mouths of the Black and Bohle Rivers, and Sandfly, Alligator and Crocodile Creeks. The area lost to reclamation makes up <1% of this overall sub regional unit. The individuals of the species likely transit and forage for food across all suitable habitats within this sub regional unit. The habitat range of these species extends well beyond this sub-regional unit. These species are known to be highly mobile with home ranges extending outside Cleveland Bay, and individuals typically have a short (snubfin) to moderate (humpback) residence time in the bay, often spending periods of a month or more away before returning (Para *et al*. 2006). It is considered likely that they use areas to the south (Bowling Green Bay) and further north (Halifax Bay to Luncinda) as well as around Magnetic Island. There is no data or evidence to suggest that the individuals present in the sub-region display any genetic distinctiveness or specifies specific behavioural patterns but this remains a knowledge gap. Once construction is completed, it is considered likely that the dolphins will continue to use the remaining undisturbed habitat areas immediately adjacent to the reclamation based on documented observations of dolphin numbers following completion of both the Eastern Reclaim and Marine Precinct projects (see below). In this context, the Project does not propose any significant residual impacts on undisturbed habitats (e.g. no permanent changes to hydrodynamics, water quality and sediment quality). The habitat affected is soft bottom feeding habitat which is part of broader habitat range used by the species. The habitat affected is not at the limit of the species range. The habitat is not within an area where the species is known to be declining. On this basis, the loss of habitat from the reclamation is not considered to be a significant residual impact on the species.

MNES (Migratory Species): Will the action substantially modify, destroy, isolate an area of important habitat for a migratory species? **MSES (Endangered and Vulnerable Wildlife):** Will the action cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species?		
Once completed, will the new reclamation impact on how the dolphins use or transit the area?	No	Based on the monitoring data and observations undertaken by GHD and the Port (GHD 2011, 2012), the species appear to be able to successfully co-exist with the existing port and to accommodate the impacts of major expansion projects including the Eastern Reclamation, TPIX and Marine Precinct. The PEP reclamation is not expected to affect migratory patterns or limit transit of the animals any more than the existing reclamation will. The reclamation will not cause any notable or significant change to hydrodynamics of the adjacent undisturbed soft bottom benthic environment used by the dolphins. As evidenced by the cetacean studies and monitoring undertaken to date, it will be expected that following the initial period of displacement (as above), once the works are completed, the species will continue to use the undisturbed areas of the Project area as feeding habitat. To this end, there is anecdotal information that the dolphins will also preferentially use the artificial rock wall habitat from time to time to augment their feeding habitat and will also seek respite/resting opportunities in the more confined waters within the breakwaters or dredged channels. On this basis, the loss of habitat from the reclamation is not considered to be a significant residual impact on the species.

8.3.5 Summary

Table 8.4 is a summary of key impacts to marine ecology, and revised risk ratings based on the revised design.

Table 8.4 Revised Impact Assessment Summary – Marine Ecology

<table>
<tr><th rowspan="2">Element</th><th rowspan="2">Primary Impacting Process</th><th colspan="3">Updated Risk Rating</th><th rowspan="2">Mitigation Measures</th><th rowspan="2">Mitigated Risk Rating</th></tr>
<tr><th>Magnitude</th><th>Likelihood of impact</th><th>Risk Rating</th></tr>
<tr><td rowspan="2">1) Impacts on seagrass</td><td rowspan="2">1a. Turbid plumes and sedimentation resulting from dredging leading to the temporary loss or stress to coastal seagrass meadows in areas along eastern and southern Magnetic Island</td><td>Worse case scenario: Minor to Moderate (Zone of Low Impact)</td><td>Possible</td><td>Medium</td><td rowspan="2">See Section 8.3.4.2.
Implement standard mitigation measures as per the DMP.
Implement additional mitigation measures, including:
▪ Avoidance of dredging using TSHD late spring and summer months to minimise potential impacts to key life-history functions
▪ Develop and implement a Reactive Monitoring Program with appropriate triggers and corrective actions.</td><td>Low (Unlikely)</td></tr>
<tr><td>Expected Case scenario: Minor (Zone of Influence only)</td><td>Possible</td><td>Low</td><td>Negligible (Highly Unlikely)</td></tr>
<tr><td rowspan="2">2) Impacts on corals</td><td rowspan="2">2a. Turbid plumes and sedimentation resulting from dredging leading to coral stress and/or mortality</td><td>Worse case scenario: Minor to Moderate (Zone of Low Impact)</td><td>Possible</td><td>Medium</td><td rowspan="2">As for 1a</td><td>Low (Unlikely)</td></tr>
<tr><td>Expected Case scenario: Minor (Zone of Influence only)</td><td>Possible</td><td>Low</td><td>Negligible (Highly Unlikely)</td></tr>
<tr><td rowspan="3">3) Impacts on soft sediment habitats and invertebrate communities</td><td>3a. Turbid plumes and sedimentation resulting from dredging channels, berths and harbour basin leading to the temporary effects to benthos</td><td>Minor</td><td>Likely</td><td>Medium</td><td>As for 1a</td><td>Medium (Likely)</td></tr>
<tr><td>3b. Removal of habitat and fauna through reclamation (irreversible) and capital dredging (temporary) resulting in detectable impacts to soft sediment communities in the wider Cleveland Bay area and/or significant effects to GBRWHA values</td><td>High</td><td>Highly Unlikely</td><td>Medium</td><td>Nil
(Potential opportunities for offsetting impacts will be examined)</td><td>Medium (Highly Unlikely)</td></tr>
<tr><td>3c. General disturbance and degradation of benthic communities in the harbour basin through day to day port operations (maintenance dredging, stormwater discharges, spills etc.)</td><td>Minor</td><td>Likely</td><td>Medium</td><td>Implementation of stormwater and waste management measures</td><td>Medium (Likely)</td></tr>
</table>

Element	Primary Impacting Process	Updated Risk Rating			Mitigation Measures	Mitigated Risk Rating
		Magnitude	Likelihood of impact	Risk Rating		
	3d. Changes to hydrodynamics and morphology due to operation of new harbour facilities and channels leading to changes in benthic communities within the direct footprint	Minor	Likely	Medium	Nil	Medium (Likely)
4) Impacts of hard substrate habitat on reef-associated species	4a. Loss of existing rock wall due to reclamation 4b. Expansion of rock wall habitat associated with the new harbour facilities	Potential beneficial (local scale, some reef associated species only)	Almost certain	Positive benefit (local scale, some reef associated species only)	N/A	Positive benefit (local scale, some reef associated species only)
5) Impacts to marine megafauna	5a. Light spill from construction plant and port facilities leading to disorientation of hatchlings or nesting adults	Moderate	Unlikely	Low	Light management procedures to minimise light spill to the marine environment to the greatest extent possible noting navigational and WHS safety requirements.	Low (Unlikely)
	5b. Increase in rubbish production increasing the risk of entanglement and/or ingestion of marine debris by turtles and marine mammals	Moderate	Possible	Medium	Waste management procedures implemented by construction contractors and operator	Low (Rare)
	5c. Increase in noise during construction leading to marine fauna temporarily avoiding affected area (displacement)	Moderate	Likely	Medium	Construction phase megafauna management plan Visual checks for megafauna, and implement strategies to avoid interactions	Medium (Possible)
	5d. Injury/mortality to marine megafauna resulting from the use of dredge plant or noise generated by construction activities	Moderate	Possible	Medium	Construction phase megafauna management plan Tickler chains on TSHD dredge head Ensure suction on TSHD is ceased prior to hoisting the dredge head Visual checks for megafauna, and implement strategies to avoid interactions	Low (Highly Unlikely)
	5e. Loss of food resources and habitat as a result of construction and port facility operation leading to displacement of marine megafauna	Moderate	Likely	Medium	Refer to 1a for turbidity/ sedimentation impacts Refer to 3b for offsets	Medium (Likely)

Element	Primary Impacting Process	Updated Risk Rating			Mitigation Measures	Mitigated Risk Rating
		Magnitude	Likelihood of impact	Risk Rating		
	5f. Increased potential for hydrocarbon or other contaminant spill from vessels or on-site facilities, potentially leading to direct effects to marine megafauna or their prey (construction, operation)	High	Unlikely	Medium	Develop hazardous material handling procedures Implement emergency response procedures in general accordance with the *Queensland Coastal Contingency Action Plan* Spill response training for staff	Medium (Unlikely)
	5g. Increase in vessel traffic during construction phase potentially leading to an increase in vessel strike risk or habitat disturbance due to prop wash	High	Possible	Medium	As for 5c Go slow zones for construction vessels	Medium
	5h. Increase in vessel traffic during operational phase potentially leading to an increase in vessel strike risk or habitat disturbance due to prop wash	High	Possible	Medium	Nil	Medium
6) Impacts on fisheries production	6a. Loss of fisheries habitat associated with reclamation (irreversible) and dredging activities (temporary)	Moderate	Likely	Medium	Refer to 3b for offsets Monitoring to assess recovery of benthos and seagrass following dredging activities	Medium (Likely)
	6b. Displacement of economic species due to construction related disturbance	Moderate	Unlikely (at Cleveland Bay wide scale)	Low	Nil	Medium (Local) Low (Regional)
	6c. Increased potential for hydrocarbon or other contaminant spill from vessels or on-site facilities, potentially leading to direct effects to economic species or their prey (construction, operation)	High	Unlikely	Medium	As for 5f	Medium (Unlikely)
7) Marine pests	7a. Increased potential marine pest introductions	High	Possible	Medium	Implement State and Commonwealth biofouling and ballast management requirements	Medium (Possible)
8) Impacts to GBRMP	8a. Deepening of the portion of the Sea Channel within the GBRMP leading to changes to benthic habitats and communities	N/A (No longer part of the design)	N/A (No longer part of the design)	N/A (No longer part of the design)	N/A (No longer part of the design)	N/A (No longer part of the design)
	8b. Dredge plume impacts to marine ecology	Minor to Moderate (Zone Moderate Impact) – Worse case only Minor (Zone of Influence) – Expected Case	Possible Possible	Medium Low	As for 1a	Low (Unlikely) Negligible (Highly Unlikely)

Element	Primary Impacting Process	Updated Risk Rating			Mitigation Measures	Mitigated Risk Rating
		Magnitude	Likelihood of impact	Risk Rating		
9) Impacts to FHA	9a. Dredge plumes leading to loss of seagrass, and subsequent reduction in the abundance of economic species supported by the FHA	Moderate	High Unlikely	Low	Refer to 1a.	Low (Rare)
10) Impacts to GBRWHA values (marine ecology)	10a . The key impacts relate to the irreversible loss of soft sediment habitat due to reclamation, and ongoing impacts associated with day to day operations of the port facility. Temporary impacts to corals, seagrass and benthic fauna could occur as result of dredge plumes, and noise generated by dredging, piling and construction activities is also likely to result in the temporary avoidance of construction areas by megafauna and fish. Potential changes to natural values supporting the OUV of the GBRWHA.	High	Unlikely	Medium	Refer to 1 – 9 above Impacts to benthos to be offset	Medium
11) Impacts on Ramsar site	11a. Dredge plumes leading to loss of seagrass, and subsequent reduction in the abundance of marine megafauna supported by the site	Worse case/expected case scenario: Minor (No impact)	Highly Unlikely	Low	Refer to 1a.	Low

8.4 Conclusion

Key findings from the revised impact assessment include the following.

- The design refinement in the outer harbour will not create additional impacting processes to those considered and reported in the EIS. While the reclamation area for the design refinement is larger than reported in the EIS, the impact risk levels remain the same as reported previously.
- Dredge plume modelling was undertaken for the design refinement. If unmitigated dredge plumes are expected to extend to coastal environments along Magnetic Island, which support sensitive ecological receptors (reefs and seagrass meadows). However, given the magnitude and frequency of plumes in relation to background conditions, the residual risk rating for seagrass and corals is classified as Low.
- Mitigation measures are proposed to minimise the potential for turbid plumes to impact seagrass and coral assemblages along eastern and southern Magnetic Island. To ensure that potential impacts can be contained to acceptable levels, a hierarchy of controls will be followed as follows:
    - avoidance of late spring and summer months (see the EIS for details) during TSHD dredging
    - development and implementation of a Reactive Monitoring Program (including water quality and coral monitoring program).
    - significant impacts to the OUV of the GBRWHA are not expected (refer to OUV section in Cumulative Impact Section 25.0).