As reef communities are not listed species under the provisions of the EPBC Act and/or the NC Act, an assessment of potential Project impacts with respect to their potential contribution to species threatening processes is not relevant for this value. No reef communities are listed as a MNES under the provisions of the EPBC Act or are listed MSES under the provisions of the *Environmental Offsets Regulation 2014*. As such, a significant residual adverse impact assessment has not been conducted for reef communities.

9.12 Fish and marine reptiles (excluding marine turtles) – existing environment

9.12.1 Background

9.12.1.1 Fish

The Port Curtis region contains a range of high value natural habitat types important to fish and fisheries species, including seagrasses meadows, reefs, hard and soft benthic substrates, through to shallow inshore areas including tidal mudflats, mangrove forests and mangrove lined creeks and estuaries (Lucas et al. 1997). The region supports a variety of marine species, many of which are significant for their Indigenous, recreational and commercial value. The region also contains three FHAs declared under the provisions of the Fisheries Act.

Fisheries values presented in this section include a variety of non-fish species, including nektobenthic invertebrates which refer to larger benthic invertebrates capable of moving in water independent of currents (e.g. crabs, prawns, cuttlefish).

Fish assemblages can vary depending on marine, coastal, estuarine and freshwater habitats. For example, coral reef habitats, mangroves and estuarine areas typically contain a high diversity of fish and nektonic invertebrates while seagrass meadows and inter-reef areas generally exhibit lower levels (Lucas et al. 1997). Fish assemblages in Port Curtis have historically shown spatial and temporal variability (i.e. Wesche et al. 2013; DAF 2018; Sawynok et al. 2014).

A Project EIS baseline monitoring program was undertaken by VE (2015a) to provide baseline information on fish and fisheries values at potential impact (i.e. areas to be dredged and the WBE reclamation area) and reference sites (refer Figure 9.40).

Analysis of QFish datasets (DAF 2012) for the S30 Commercial Fishery, 30 minute Reporting Grid (referred to as the fishing activity area), for the 2007 to 2018 period was undertaken to determine trends associated with species diversity, abundance and yields. The fishing activity area is shown in Figure 9.41.

The methodology implemented to describe fish and fisheries values is provided in Appendix I1 (Section 9.2).

9.12.1.2 Other marine reptiles

There are two species of crocodiles in Australia, the Freshwater crocodile (*Crocodylus johnstoni*) and the Saltwater crocodile (*Crocodylus porosus*). Both are listed as marine under the EPBC Act and the Saltwater crocodile is also listed as migratory under the EPBC Act and vulnerable under the NC Act. Freshwater crocodiles occur in inland rivers and wetlands in the Gulf of Carpentaria and as far south as the Ross River, which flows into the Coral Sea at Townsville (i.e. outside of the Project impact areas). Saltwater crocodiles are known to occur from the Gulf of Carpentaria and Cape York Peninsula to as far south as Gladstone (DoEE 2019a). The primary habitat for Saltwater crocodiles is within swamps, and the tidal reaches of rivers, however Saltwater crocodiles are known to move out of rivers and along the coast or to islands within the GBRWHA, particularly following heavy rainfall (Lucas et al. 1997).

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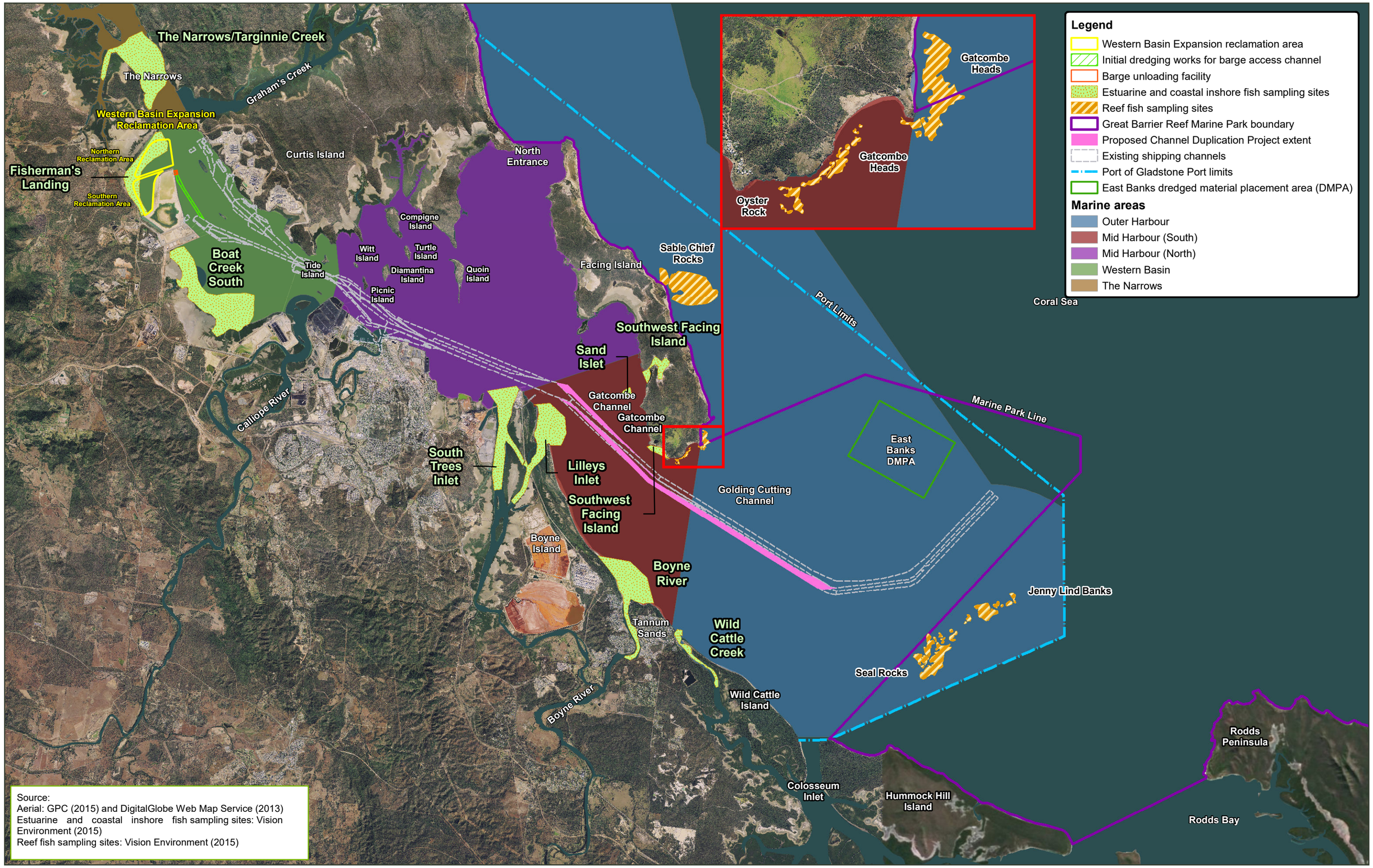

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Figure 9.40: Project fish and nekton sampling sites

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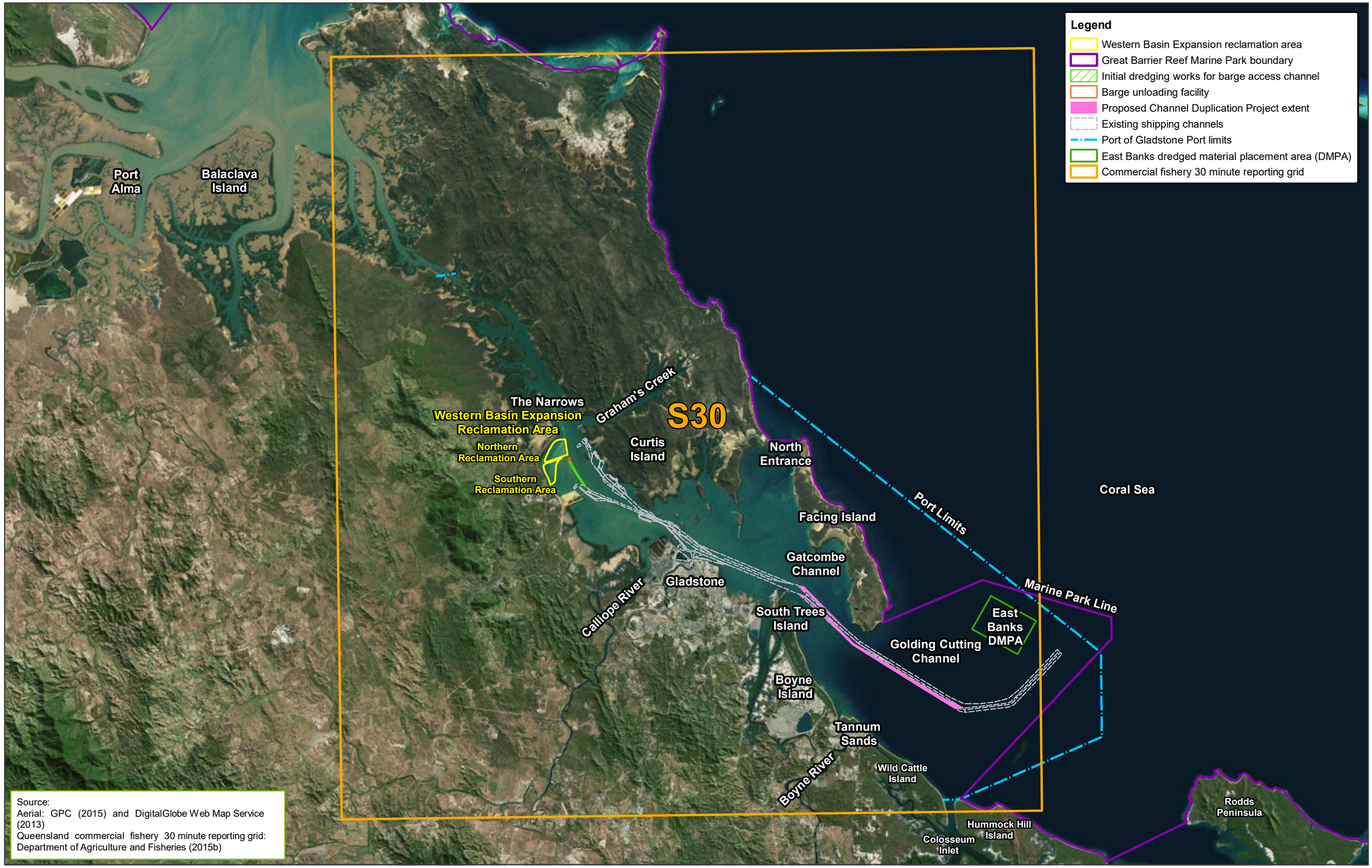

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Figure 9.41: Commercial and recreational fishing activity area

Sea snakes in Australia comprise of true sea snakes (Genus *Hydrophiidae*) and sea kraits (Genus *Laticauda*). True sea snakes are entirely marine based and never voluntarily leave the water, whereas the sea kraits venture onto land regularly to rest, hide and breed. True sea snakes have a distribution generally extending from southern Queensland northward, around to the central coast of Western Australia (GBRMPA 2012c). There are approximately 32 species of true sea snakes in Australian waters, with 14 species maintaining permanent breeding populations in the Great Barrier Reef (GBRMPA 2012c). Breeding populations of sea kraits are not thought to occur within the Great Barrier Reef (GBRMPA 2012c). There are no species of sea snake or sea krait currently listed as having conservation significance under Queensland or Commonwealth legislation.

The methodology implemented to describe other marine reptile values is provided in Appendix I1 (Section 10.2).

9.12.2 Fish and marine reptile values (excluding marine turtles)

9.12.2.1 Species of conservation significance

Fish species

Database records for Port Curtis and the Gladstone region list 42 fish species under the EPBC Act as either migratory (8) or listed marine (34) species (refer Appendix I1 (Section 9.3.1)). The migratory species are all sharks and rays, while the listed marine species are all sygnathids (i.e. seahorse, pipehorse and pipefish).

Based on the results of database searches, there are five fish species of conservation significance, which have the potential to occur within the Project impact areas (i.e. low and moderate likelihood only) (refer Table 9.45).

Table 9.45 Listed marine fish species identified from database searches of the Port Curtis region

Scientific name	Common name	NC Act status	EPBC Act status	Likelihood of occurrence in the Project impact areas
Dasyatis fluviorum	Estuary stingray	Near threatened	Not listed	Moderate
Carcharodon carcharias	Great white shark	Least concern	Vulnerable/Migratory (Bonn Convention)	Moderate
Rhincodon typus	Whale shark	Least concern	Vulnerable/Migratory (Bonn Convention)	Moderate
Pristis zijsron	Green sawfish	Least concern	Vulnerable/Migratory (Bonn Convention)	Low
Manta alfredi	Reef manta ray	Vulnerable	Migratory (Bonn Convention)	Moderate

Source: Ecology Technical Report (refer Appendix I1 (Appendix B)).

Fish and other nekton included on the Fitzroy NRM BoT species prioritisation framework are listed in Appendix I1 (Appendix K (Table 2)), including fish species historically found in the Port Curtis region such as the Green sawfish and the Grey nurse shark (*Carcharias taurus*) (east coast population) (Alquezar 2011; Currie and Connolly 2004; Graham et al. 2007).

The Green sawfish inhabits muddy bottom habitats and enters estuaries (DERM 2010). It has been recorded in inshore marine waters, estuaries, river mouths, embankments and along sandy and muddy beaches. The Green sawfish has not been recorded in Port Curtis since the late 1960s.

While Great white sharks can travel large distances offshore, they can also frequent inshore marine environments around rocky reefs, surf beaches and shallow coastal bays (DERM 2010), all of which can be found in the Port Curtis region.

The Grey nurse shark, listed as critically endangered under the provisions of the EPBC Act, has the potential to occur in waters to the south of Rodds Peninsula (DoEE 2019a). However, the closest record to the Project impact areas included in the Atlas of Living Australia is situated off the coast of Byron Bay, New South Wales, approximately 600km southeast of Port Curtis.

Other marine reptiles

Analysis of environmental databases indicates that 13 sea snake species are known, or are predicted to occur, within Port Curtis and adjoining waters (refer Appendix I1 (Section 10.3.2)). However, none of these sea snake species are listed as having conservation significance under the provisions of the NC Act or the EPBC Act.

Analysis of environmental databases indicates that one crocodile species, the Saltwater crocodile, is known, or is predicted to occur within Port Curtis and adjoining waters. The Saltwater crocodile is a species of conservation significance, listed as migratory (Bonn Convention) under the EPBC Act, and vulnerable under the provisions of the NC Act. This species is included with intertidal fauna species in Sections 9.6 and 9.7, as it is likely to utilise a wide range of habitats (i.e. not strictly a marine species), and are therefore not further discussed in this section or in Section 9.7 (discussion of potential impacts on fish and marine reptiles (excluding marine turtles)).

9.12.2.2 Fish Habitat Areas

FHAs are declared under provisions of the Fisheries Act and afford a level of protection to high value natural fish habitats in coastal areas. Rodds Harbour (i.e. Rodds Bay), Colosseum Inlet and the Dē-răl-lĭ (Calliope River), located south of the proposed Project impact areas (refer Figure 9.42), are declared FHAs.

FHAs are considered to be an important resource to support local commercially and recreationally important fisheries. FHAs seek to protect natural fish habitats by limiting coastal development and associated physical disturbance within and adjacent to a declared FHA, while still allowing for continued community use and access.

Table 9.46 provides a summary of the key values of the FHA within Port Curtis and defines the distance from the Project impact areas to each FHA. The nearest FHA is approximately 15km from the Project areas to be dredged (i.e. Dē-răl-lĭ FHA).

Table 9.46 Summary of the key values of the Fish Habitat Areas in proximity to the Project impact areas

Declared Fish Habitat Area	Key values and location in relation to the Project impact areas
Rodds Harbour FHA (FHA-036)	▪ Covers an area of 11,619ha, and comprises Rodds Bay, Turkey Beach/Tannum Sands, Pancake Creek, Middle Creek and Jenny Lind Creek ▪ Contains important juvenile fish and prawn habitat, and is an important Mud crab recruitment area (NPSR 2016). The area is characterised by extensive habitat values, including mangrove zones bordering estuaries, samphire and claypan areas, seagrass meadows, island banks, bar zones, channels and deltaic areas ▪ Supports commercial, recreational and Indigenous fisheries values for a broad range of species ▪ 40km southeast of Gladstone and southeast of the Project areas to be dredged

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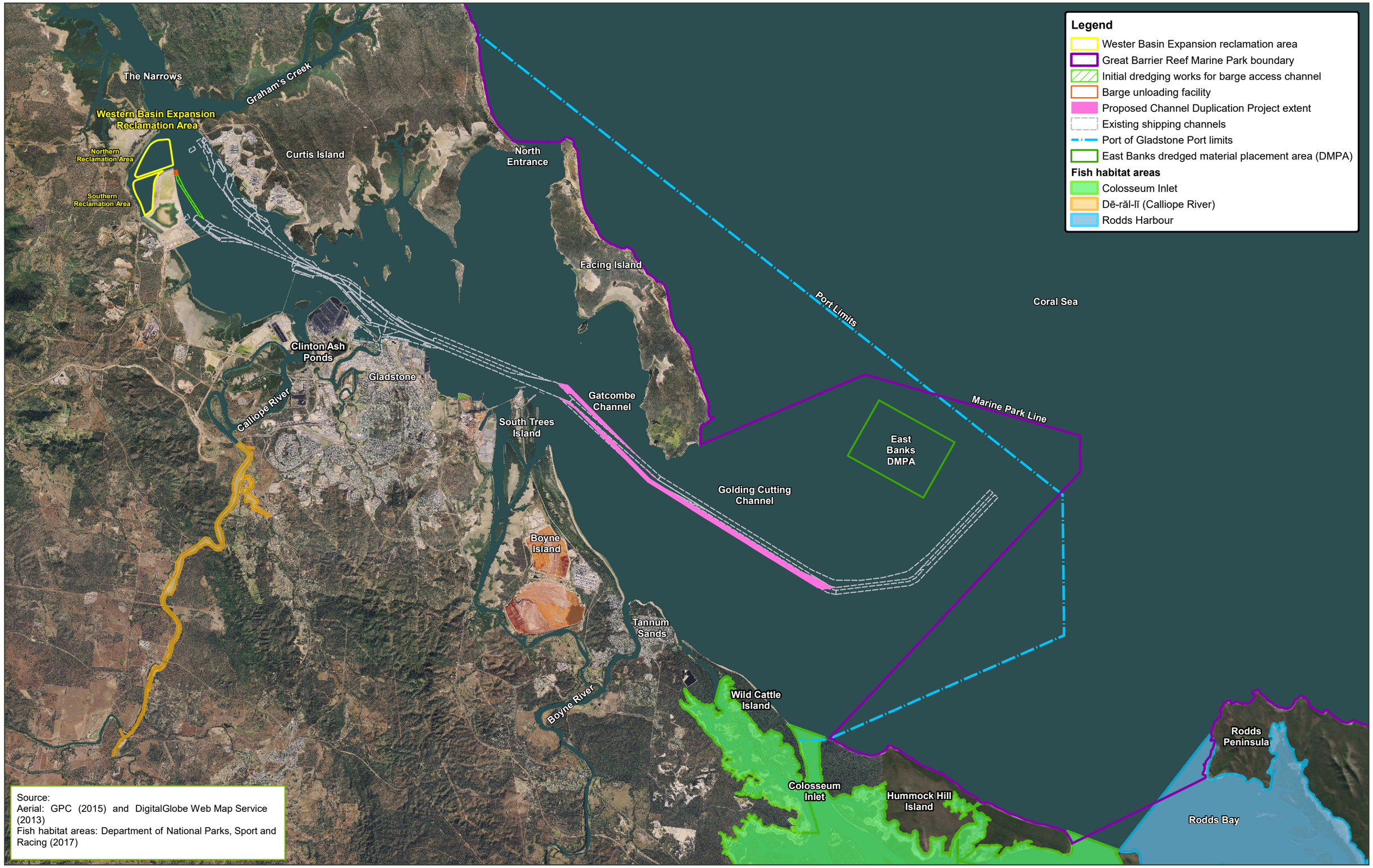

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Fish habitat areas: Department of National Parks, Sport and Racing (2017)

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Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.42: Declared fish habitat areas in relation to the extent of the Project

Declared Fish Habitat Area	Key values and location in relation to the Project impact areas
Colosseum Inlet FHA (FHA-037)	▪ Covers an area of 11,816ha, and comprises the Colosseum Inlet, Wild Cattle Creek and Seven Mile Creek area ▪ Provides important fish and juvenile prawn habitat (NPSR 2012). Characterised by extensive habitat values, including mangroves, bar zones, island banks, silty sand, channels, deltaic islands, samphire and clay pan areas, small coral community and seagrass meadows towards Tannum Sands ▪ Supports commercial, recreational and Indigenous fisheries values for a broad range of species ▪ 24km southeast of Gladstone and south of the Project areas to be dredged
Dē-răl-lĭ (Calliope River) FHA (FHA-075)	▪ Covers an area of 314ha within the Calliope River between the Moura Short Railway Line and the North Coast Line ▪ Supports a valuable commercial fishery, providing habitats that are essential for the productive crab, beam trawl and net fisheries operating adjacent to the river ▪ Significant to recreational fisheries due to accessibility to the river and high catch rates ▪ 15km east of the Project areas to be dredged

Source: Adapted from NPSR (2012; 2014a; 2016)

9.12.2.3 Estuarine and coastal fish communities

The following provides a summary of the detailed description of estuarine and coastal fish communities provided in Appendix I1 (Section 9.3.2).

Habitat values

Estuaries and coasts are complex environments that support a wide range of flora and fauna, and can comprise a number of subtidal and intertidal habitats, including seagrass meadows, mangrove forests, saltmarshes, soft muddy and sandy flats, sandy beaches and rocky outcrops (Faunce and Serafy 2006; Meynecke 2009; Sheaves et al. 2007). Fish communities can vary widely among these habitats.

Seagrass meadows have important economic value in terms of providing nursery and feeding habitats for commercial and recreational fisheries species (Watson et al. 1993; Unsworth and Cullen 2010), particularly inshore and offshore prawn fisheries with the Tiger prawn (e.g. *Penaeus esculentus, Penaeus monodon*), Endeavour prawn (*Metapenaeus endeavouri*), Banana prawn (*Fenneropenaeus merguiensis*) and Rainbow prawn (*Parapenaeopsis sculptilis*), with all of these species relying on the region's seagrass communities at some stage of their lifecycle (Lee Long et al. 1992; GPC 2015). While seagrass meadows are extensively used by juvenile fishes, studies have also shown that large predatory fish inhabit seagrass beds at night (Alquezar 2011). Seagrass meadows are also recognised as important ecosystems for the maintenance of sea bed stability, water quality and biodiversity (NPRSR 2014).

Mangrove environments are critical for creating an ecosystem to support fish and prawn species (including commercially and recreationally important species) as they rely on these environments during vulnerable stages of their lifecycle (Hutchinson et al. 2014). Mangroves provide an ideal protective environment, food and shelter, juvenile nursery grounds, and a place for estuarine and freshwater spawning fish (Alquezar 2011; Hutchinson et al. 2014).

Although fish utilisation of saltmarshes in the Port Curtis region is not well studied, investigations of saltmarsh-dependent organisms and adjacent mangrove habitats by GBRMPA found abundance and diversity of fish species increases with connection between habitat types. In the Great Barrier Reef region, saltmarshes have been found to play a valuable role in the lifecycles of Red emperor (*Lutjanus sebae*), sharks, rays and other fish species (Goudkamp and Chin 2006; GPC 2015).

Estuaries, creeks and rivers act as highways for fish and other nekton that commute from one system to another, especially along coastal beaches and fringing rocky reefs during tidal movements, concentrating fish numbers in search for food and shelter (Jones and West 2005; Meynecke et al. 2008a; Meynecke et al. 2008b; Neira and Potter 1992; Rolls 2011; Sousa and Dangremond 2011 in VE 2015a). These estuarine environments are essential to the lifecycle of many recreational, Indigenous and commercially targeted fish species, including Mud crab, Barramundi (*Lates calcarifer*), Flathead, Prawn species (Penaeidae), Mullet, and Bull shark (*Carcharhinus leucas*) (Walker 1997; Wesche 2013). Some local species such as Mangrove jack (*Lutjanus argentimaculatus*) use estuaries as juveniles and then move to offshore reefs as they mature (Sawynock et al. 2014).

Freshwater inputs in Port Curtis come from two major rivers, the Boyne River and the Calliope River, and the numerous creeks and tributaries that discharge into the Port and surrounding waters. The mean spring tidal range for the Port is 3.24m, the mean neap tidal range is 1.54m and the maximum tidal range is 4.69m (BMT WBM 2019). Due to the large tidal storage areas of the Port of Gladstone and the amplification effect on water levels, good tidal flushing and high tidal velocities generally exist within the main channels of Port Curtis (BMT WBM 2019).The importance of freshwater flows in Port Curtis on the productivity of the region has been shown through previous studies where years of large flows tend to result in higher benthic invertebrate productivity, resulting in higher growth rates in fish such as Whiting, which are then caught earlier in their life cycle than would otherwise occur (Connelly et al. 2006).

Species assemblages

Targeted cast net surveys conducted for the Project EIS recorded a total of 2,936 individuals representing 34 species of which 2 species (Blue swimmer crab (Portunis armatus*)* and Banana prawn) were invertebrates and the remaining species were fish (refer Appendix I1 (Section 9.3.2.2)). The most commonly observed species were Southern herring (38.7%), Estuary glassfish (*Ambassis marianus*) (21.3%) and Spottyface anchovy (14.3%), although Banana prawn were also frequently encountered (7.4%) (VE 2015a).

Significant differences in fish density, species richness, diversity and evenness were encountered among the locations sampled (refer Figure 9.43), with highest numbers of fish encountered at Lilleys Inlet, South Trees Inlet, Calliope River mouth and The Narrows/Targinnie Creek sites. Lowest numbers were encountered at Sand Islet and Southwest Facing Island sites (VE 2015a). Species richness was also significantly lower at Sand Islet, Fisherman’s Landing and Wild Cattle Creek relative to all other sites (VE 2015a). In general, there were no significant differences in the biodiversity of the fish and other nekton encountered between the dry season and the wet season (VE 2015a). However, significant interactions among season and location were observed, suggesting that differences in biodiversity were encountered between seasons for some locations but not others (refer Figure 9.43) (VE 2015a).

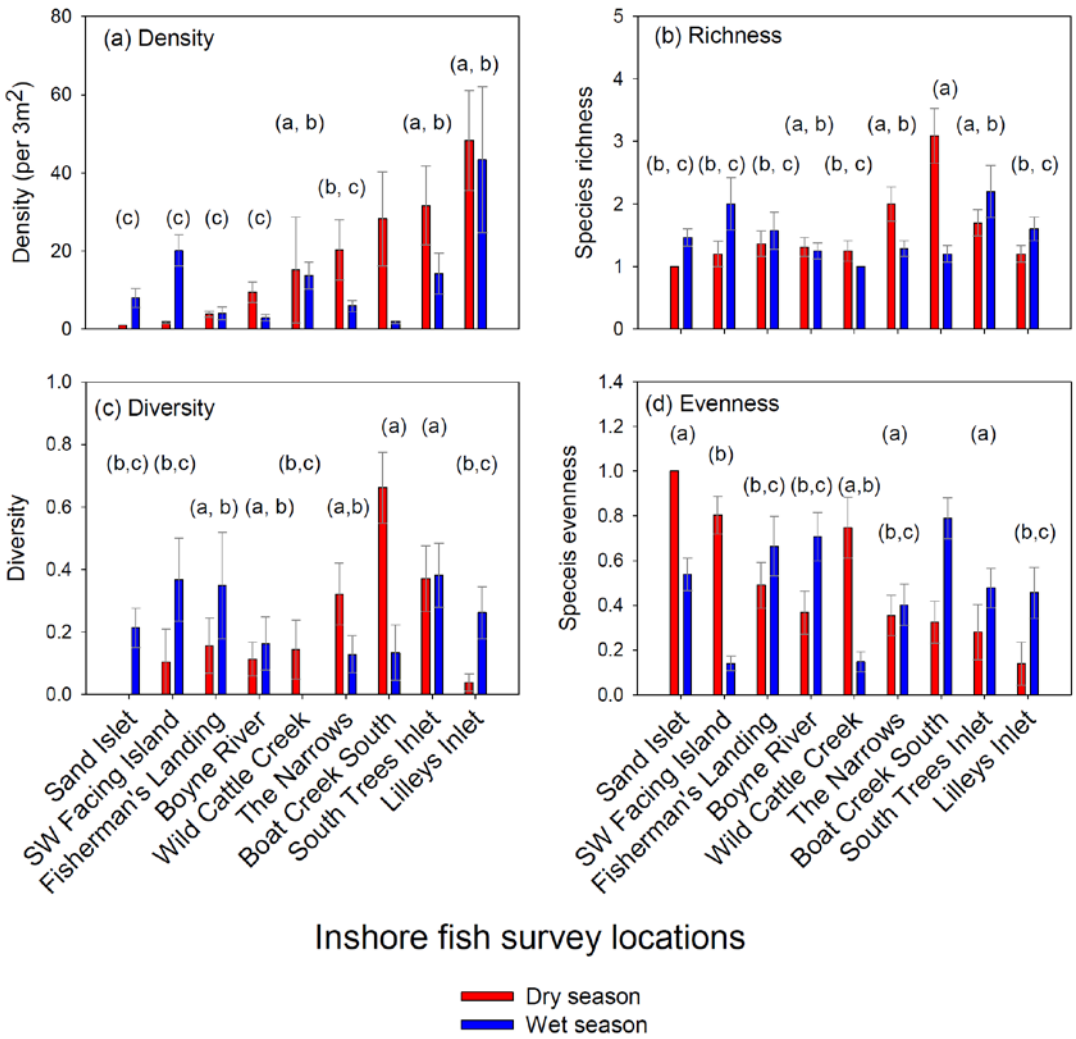

Figure 9.43 **Mean fish density (a), species richness (b), diversity (c), and species evenness (d) at nine estuarine and coastal inshore cast net sampling locations**

Source: VE (2015a)

Similar to biodiversity, fish community assemblages were also significantly dissimilar among locations, irrespective of season (refer Figure 9.43), with the largest differences observed between the South Trees Inlet and Sand Islet, in addition to Sand Islet and Lilleys Inlet (VE 2015a). Fish communities were similar in composition between Fisherman's Landing and The Narrows/Targinnie Creek, Wild Cattle Creek and Boyne River, and South Trees Inlet and Boyne River (refer Figure 9.44). There were no significant differences in fish communities recorded at each location during different seasons (refer Figure 9.44).

Differences in fish communities among locations can be attributed to a number of factors, including differences in habitat features (e.g. vegetated versus non-vegetated). In addition, physicochemical parameters, including turbidity and natural tidal flow, have been demonstrated to influence abundance of new recruits within Port Curtis and other locations around Queensland (Currie and Connolly 2004; Currie and Small 2005). Given the difference in the habitats surveyed as part of the EIS investigations, the observed variation in estuarine and coastal inshore fish communities is not unexpected.

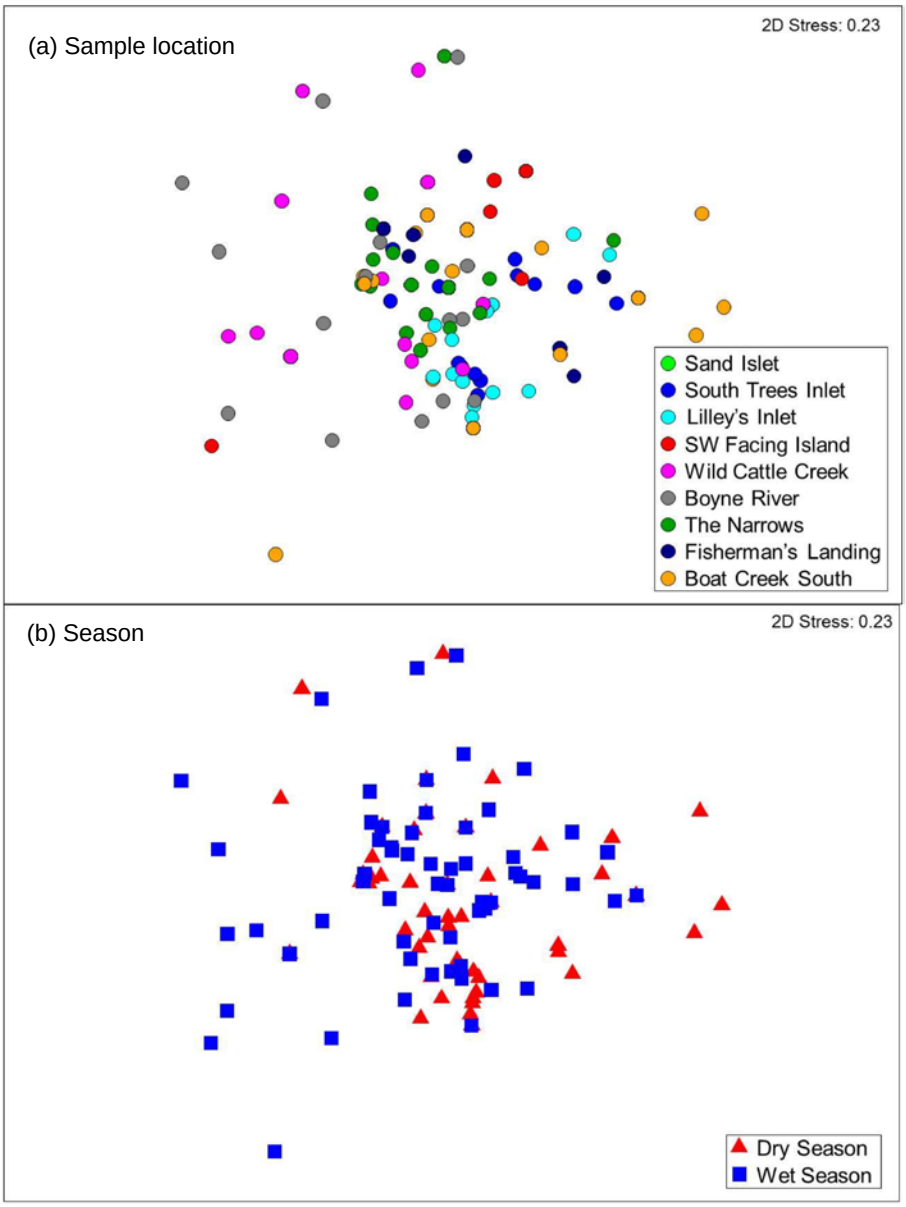

Figure 9.44 **Non-metric Multidimensional Scaling (nMDS) ordination plot (Bray-Curtis similarity) of fish community assemblages utilising shallow complex habitats among (a) locations, and (b) seasons**

Source: VE (2015a)

A total of 44 species of fish were identified during gill net sampling during the 2014 dry season and the 2015 wet season (VE 2015a). The most commonly caught species was the Giant queenfish (27%), Blue threadfin (11%), Beach salmon (11%), and Mud crab (11%). Highest numbers of fish and other nekton caught in gill nets, irrespective of season, were encountered at Fisherman's Landing (12 individuals), followed by the Boyne River (10 individuals) and Lilleys Inlet (8 individuals). No fish or other nekton were collected by gill nets at Wild Cattle Creek or The Narrows/Targinnie Creek during both dry and wet season campaigns (VE 2015a). Species richness was also highest at Fisherman's Landing and Lilleys Inlet (VE 2015a).

9.12.2.4 Reef associated fish communities

The following provides a summary of the more detailed description of reef fish communities provided in Appendix I1 (Section 9.3.3).

Habitat values

Reef associated fish are important components of shallow water habitats, in that they form complex ecosystem functions. While fish are more mobile and can cover great distances compared to nektonic invertebrates, some fish such as Reef damselfish (*Pomacentrus* spp.) and Baitfish have restricted homing ranges (Alquezar 2011). For example, some reef associated fish species are obligate corallivores (species that feed primarily on coral), whereas other fish species are grazers, which rely on different types of algal growth thus preventing overgrowth of macroalgal habitats. It is suggested that up to 75% of fish found within a coral reef rely on live corals for food, shelter or settlement (Pratchett et al. 2011). Hence, there is a strong positive relationship between coral and other live substrate cover, and reef associated fish assemblages.

Coral reef communities in Port Curtis are typical of fringing coral reefs on the southern inshore Great Barrier Reef. When compared to reefs in the northern Great Barrier Reef region, or at mid-shelf or outer-shelf areas, reefs in the Port Curtis are generally lower in coral species richness and tend to be made up of corals along with other benthic organisms (e.g. algae, sponges) growing on rocks or boulders (Ayling et al. 2012; GBRMPA 2007; DeVantier et al. 2006). Section 9.10 provides a detailed overview of reef communities in the Port Curtis region.

Anecdotal evidence from online fishing forums and recreational fishing websites provide some indication of reef associated species found in Port Curtis. Information suggests that several reef associated species such as Tuskfish (*Choerodon* spp.), Grass emperor (Sweetlip) (*Lethrinus laticaudis*), and Estuary cod (*Epinephelus coioides*) inhabit rocky outcroppings such as those located in the Inner Harbour zone at the southern end of Curtis Island and surrounding islands (e.g. Diamantina Island, Witt Island, Turtle Island, Picnic Island) (BMT WBM 2014a). Further south around Seal Rocks and Gatcombe Head, species such as Grass emperor, Coral cod (*Cephalopholis miniata*), Coral trout (*Plectropomus leopardus*), Silver bream (*Rhabdosargus sarba*) and Yellowfin bream have been reported.

Species assemblages

During the Project EIS baseline surveys, a total of 6,037 fish from 59 species were encountered throughout the four monitoring locations for the 2014 dry season (37% of individuals recorded) and the 2015 wet season (63% of individuals recorded) (VE 2015a) (refer Appendix I1 (Section 9.3.3)). The most common fish species observed was the Yellowtail demoiselle (*Neopomacentrus azysron*) (41%), followed by the Spotted-tail wrasse (*Coris caudimacula*) (11%), and Wards damsel (*Pomacentrus wardi*) (10%). The most common fish families throughout the monitoring program included Pomacentridae (Damsel fish) (73%), followed by Labridae (Wrasse) (21%), and Apogonidae (Cardinal fishes) (2%) (VE 2015a).

Significant differences in fish density, species richness, diversity and evenness were observed among sampling locations, with the highest quantities of fish and diversity of species encountered at Sable Chief Rocks and Jenny Lind Banks (refer Figure 9.45). Lowest numbers and species diversity were encountered at Seal Rocks and Gatcombe Heads. No significant differences were observed in fish biodiversity between seasons.

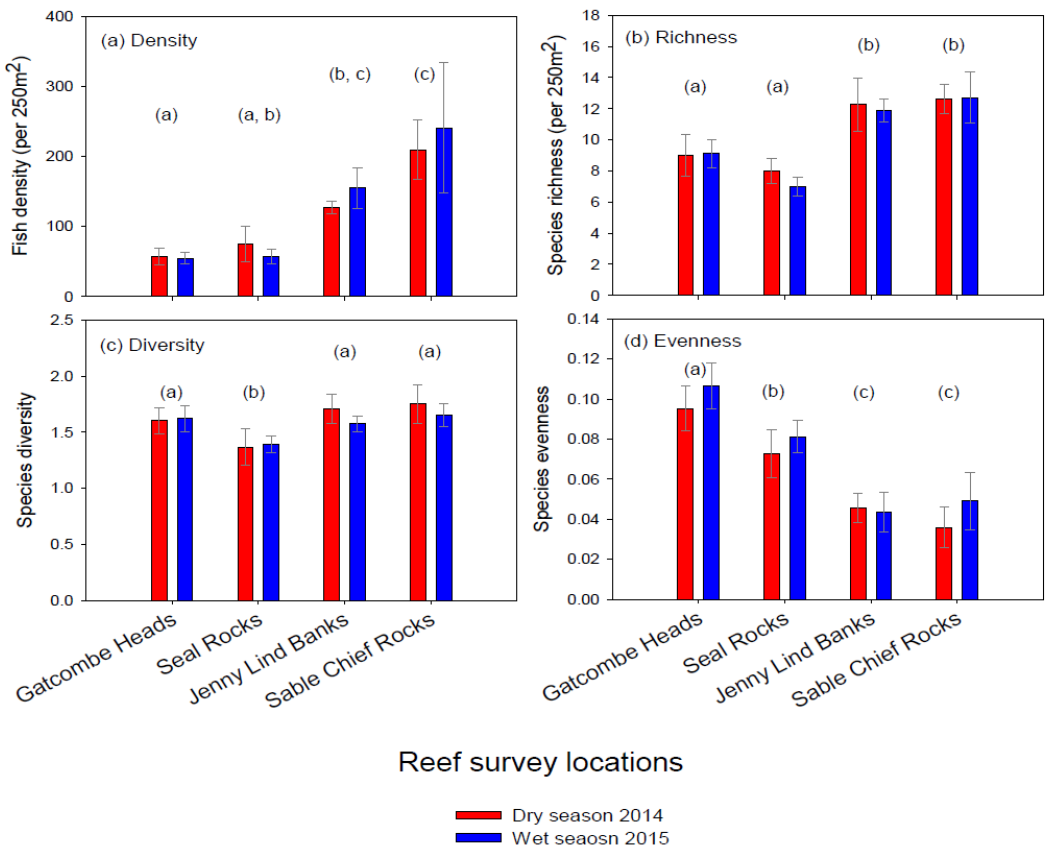

Figure 9.45 **Mean fish density (a), species richness (b), diversity (c), and species evenness (d) at four reef locations sampled**

Source: VE (2015a)

Reef obligate and associated fish communities tend to be territorial or have very limited homing ranges, hence they do not move large distances throughout their lifetime (VE 2015a). This is likely to explain why there were no differences in biodiversity observed between seasons (VE 2015a).

Significantly dissimilar reef associated fish assemblages were observed among locations, and season, with the highest differences in fish community structure encountered between Gatcombe Heads, Sable Chief Rocks and Seal Rocks (refer Figure 9.45). However, fish communities were similar between Jenny Lind Banks and Sable Chief Rocks, as well as Gatcombe Heads and Seal Rocks.

Minor correlations between substrate community matrices and fish assemblages were encountered, with hard coral substrate being the best fitting correlation to explain fish community assemblages among locations (refer Figure 9.46). However, reef macroalgae was highly correlated with fish assemblages between the wet and dry seasons. The results suggest that different fish communities may be governed by the type of reef structure present. Hence, a change in substrate type is likely to lead to a change in fish communities. Hard corals represented 16% of the total variation in the total data and macroalgae contributed to 45% of the total variation (refer Figure 9.46).

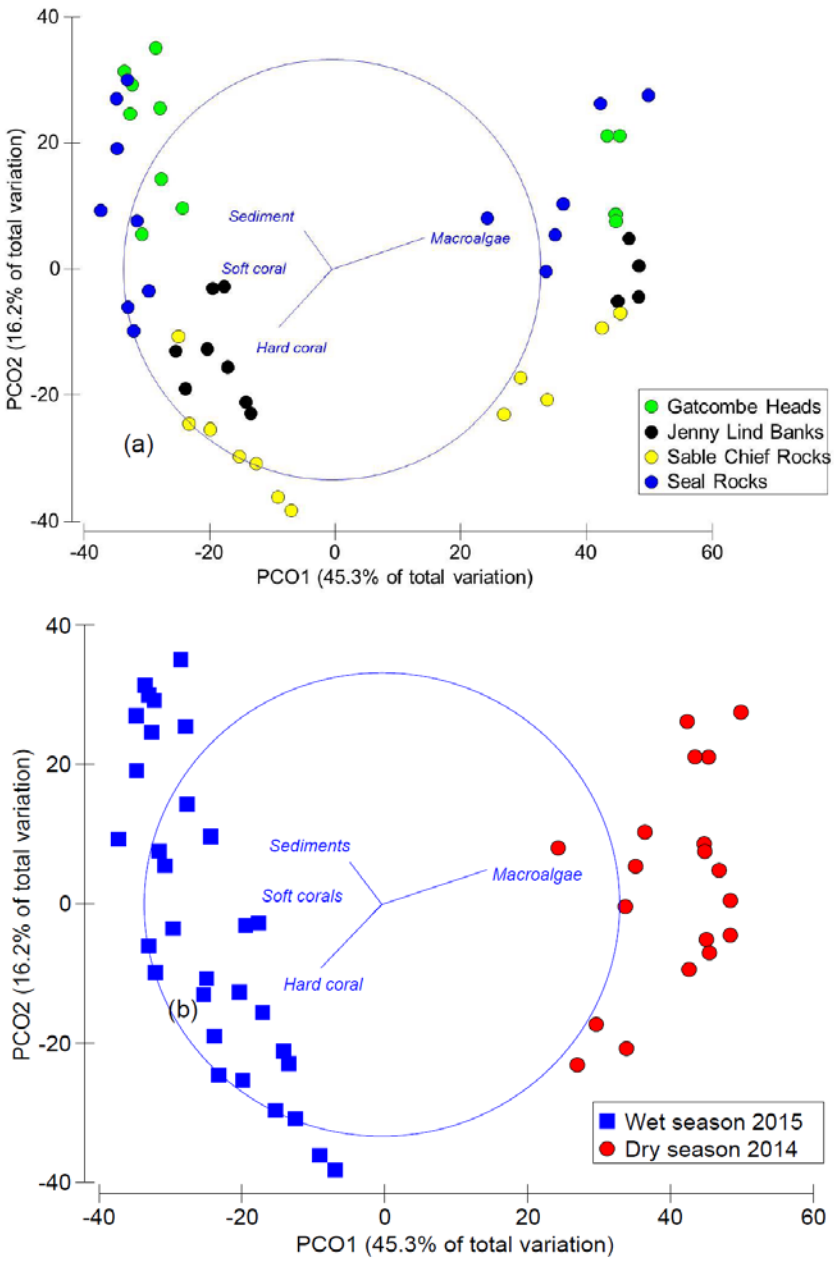

Figure 9.46 Principle Coordinates Ordination of reef associated k=fish and other nekton among locations (a) and season (b)

Source: VE (2015a)

Analysis of baited remote underwater video stations (BRUVS) data collected in 2014 indicated that the highest number of occurrences of fish in a one hour block was at Gatcombe Heads, followed by Jenny Lind Banks and Sable Chief Rocks, suggesting that fish resided in the vicinity of the BRUVS longer at Gatcombe Heads compared to other locations (VE 2015a). There were also significantly higher numbers of fish observed per frame at Gatcombe Heads compared to Jenny Lind Banks and Sable Chief Rocks, however there were no significant differences in species richness among locations (VE 2015a). The highest numbers of species were recorded at Jenny Lind Banks (VE 2015a).

9.12.2.5 Commercial, recreational and traditional fisheries values

Commercial and recreational fish catch data spatial distribution

The reported and documented catch rates of species within the Port of Gladstone and the associated intertidal and upstream environments have been consolidated within a database created by Infofish Australia (2018). For the purpose of the Project EIS, fish catch data was obtained for the period between 2014 and 2018. The Infofish Australia fish catch data has been derived from two sources:

- Suntaggers (2018)
- GHHP (2017) recruitment survey data.

The consolidated Infofish Australia fish catch data has been used to show the spatial distribution of various fish catch species within the Port of Gladstone and its associated tributaries.

The data identifies that of the 32 fish species recorded, 18 were predominantly confined to being caught within the coastal bays, inlets and waterways. These species include Sand whiting, Banana prawns, Mangrove jack, Threadfin salmon, Coastal whiting and Flattail mullet. The remaining 14 species were recorded to be caught throughout the greater Port of Gladstone area and included fish species such as Yellowfin bream, Pikey bream, Barramundi, Gold-spotted rock cod and Dusky flathead (refer Appendix L (Figures L1 to L32) in Appendix I1 (Ecology Technical Report)).

The data obtained from Infofish Australia (2018) shows only two species, Gold-spotted rock cod and Barred javelin, being caught in proximity to the proposed channel duplication area to be dredged. Other fish species were recorded in the bays on the southwestern side of Facing Island.

The Infofish Australia (2018) data has been spatially summarised into general habitat types utilised by the fish species caught and recorded, including:

- Soft benthic habitat species (refer Figure 9.47)
- Intertidal/estuary habitat species (refer Figure 9.48)
- Reef associated habitat species (refer Figure 9.49)
- Sandy habitat species (refer Figure 9.50).

The data indicates that fish species utilising soft benthic habitats, intertidal/estuary habitat and reef associated habitat were primarily caught, identified and recorded in those areas to the north of the channel duplication area to be dredged and in the Port estuaries and bays to the east.

There was no clear differentiation observed between habitats utilised by certain species and their distribution within the Port of Gladstone area and surrounding waterways. Sandy habitat species were mostly confined to those sandy areas associated with bays and inlets, and not the larger expanses of open water associated with the Port.

Commercial fisheries

At a State-wide scale, Port Curtis and the associated intertidal areas and upstream rivers and creeks represent an important resource for Queensland's commercial fisheries. Both inshore and offshore fisheries operate out of Port Curtis with commercial fishing activities in the area consisting of crabbing, trawling, net fishing, line fishing and tourist charters. Target species for commercial fisheries include a variety of fish and macroinvertebrates, including Barramundi, Mullet, Banana prawn, Mud crab, Bull shark and Queenfish. Inshore and offshore fisheries operate out of Gladstone harbour (NPSR 2014). The existing WB reclamation area is known as a breeding ground for crab, shark, Blue salmon (*Eleutheronema tetradactylum*), prawns and estuary fish and is a common area to catch crabs (pers. comm. M McMillan et al. 2018).

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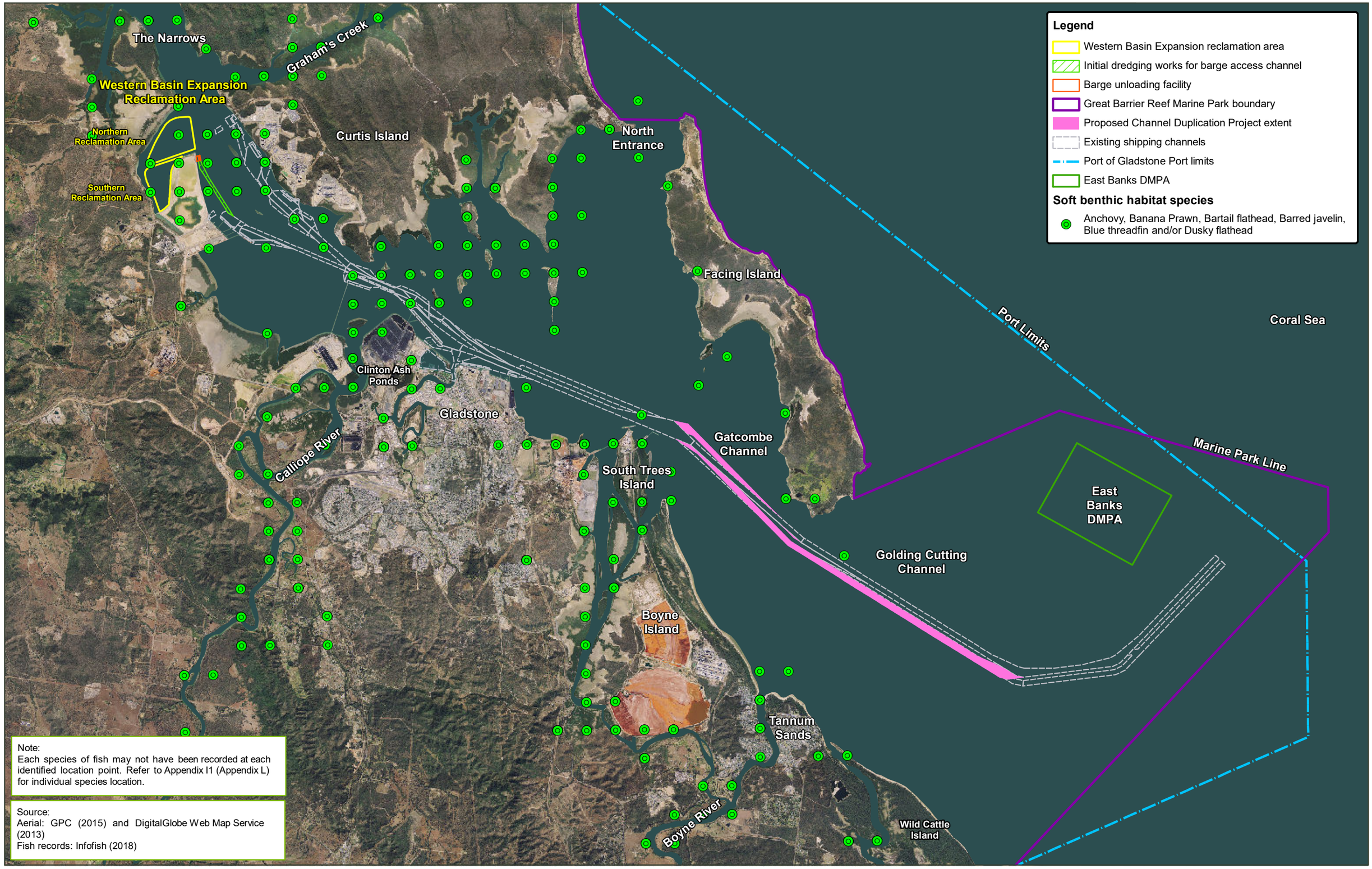


Note:
Each species of fish may not have been recorded at each identified location point. Refer to Appendix I1 (Appendix L) for individual species location.

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Fish records: Infofish (2018)

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_358.mxd 07/02/2019 15:30

0 1,550 3,100 Metres

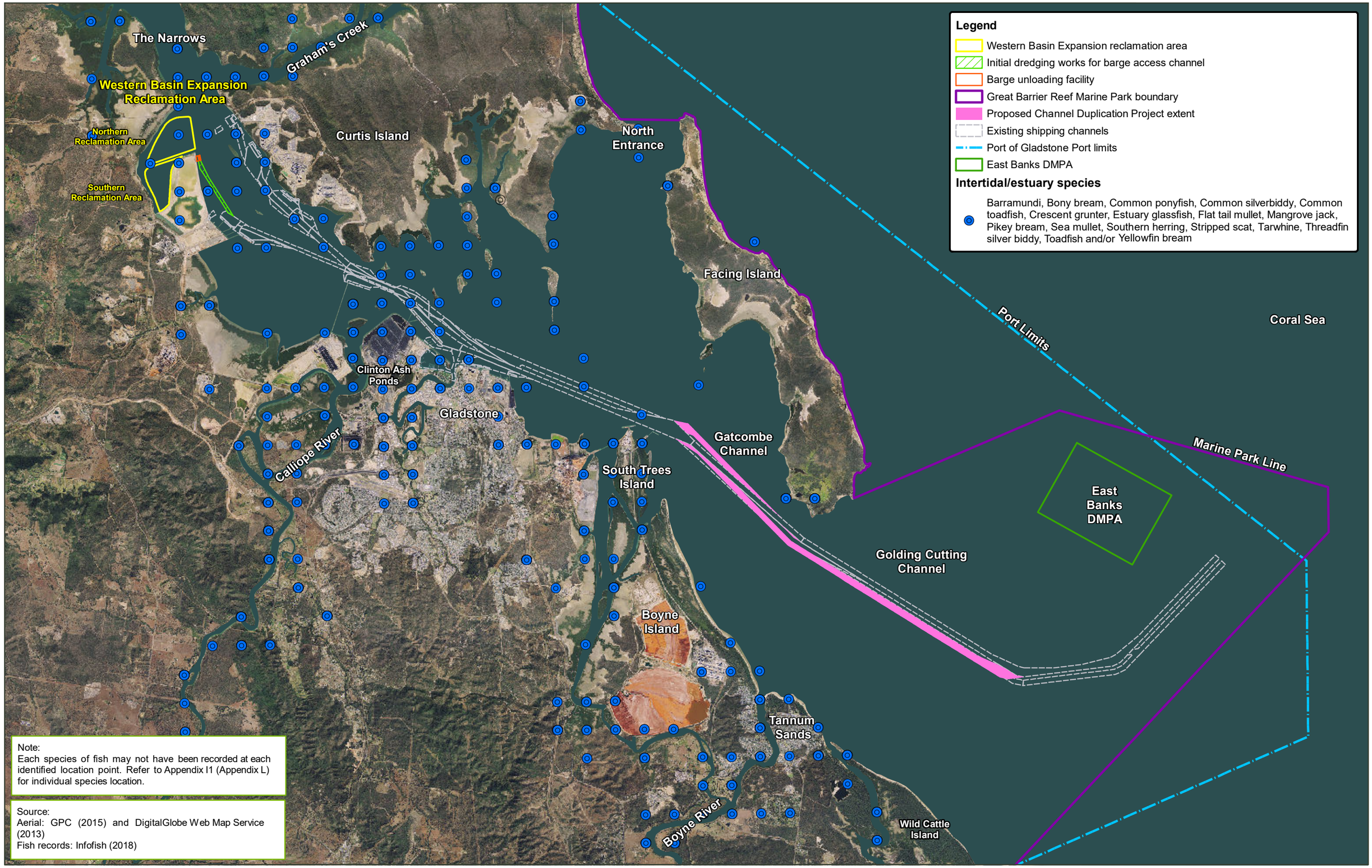
Date: 07/02/2019 Version: 0 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.47: Recorded fish species for soft benthic habitat species

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon



Note:
Each species of fish may not have been recorded at each identified location point. Refer to Appendix I1 (Appendix L) for individual species location.

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Fish records: Infofish (2018)

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Date: 07/02/2019 Version: 0 Job No: 237374

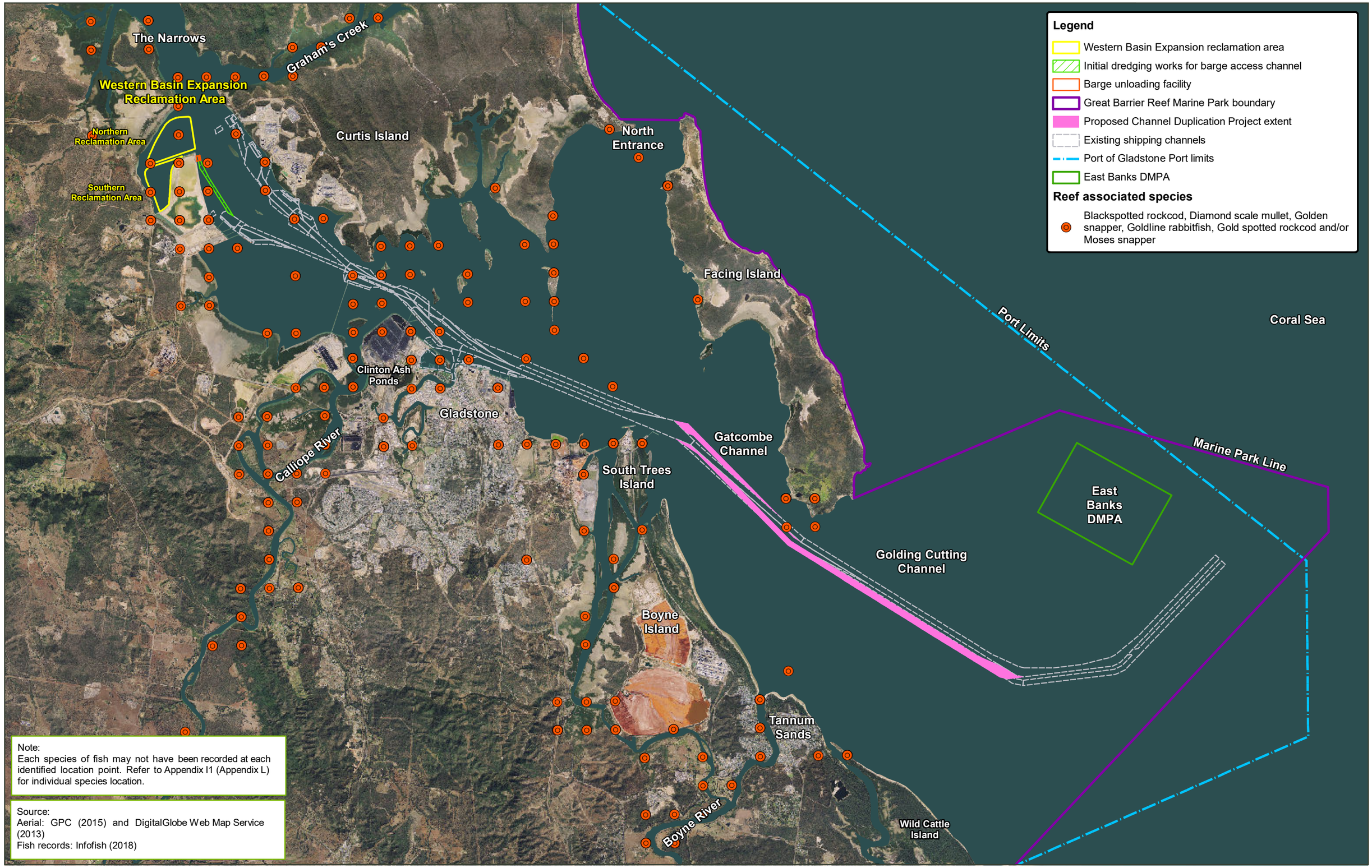
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.48: Recorded fish species for Intertidal/estuary species

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon



Note:
Each species of fish may not have been recorded at each identified location point. Refer to Appendix I1 (Appendix L) for individual species location.

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Fish records: Infofish (2018)

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0 1,500 3,000 Metres

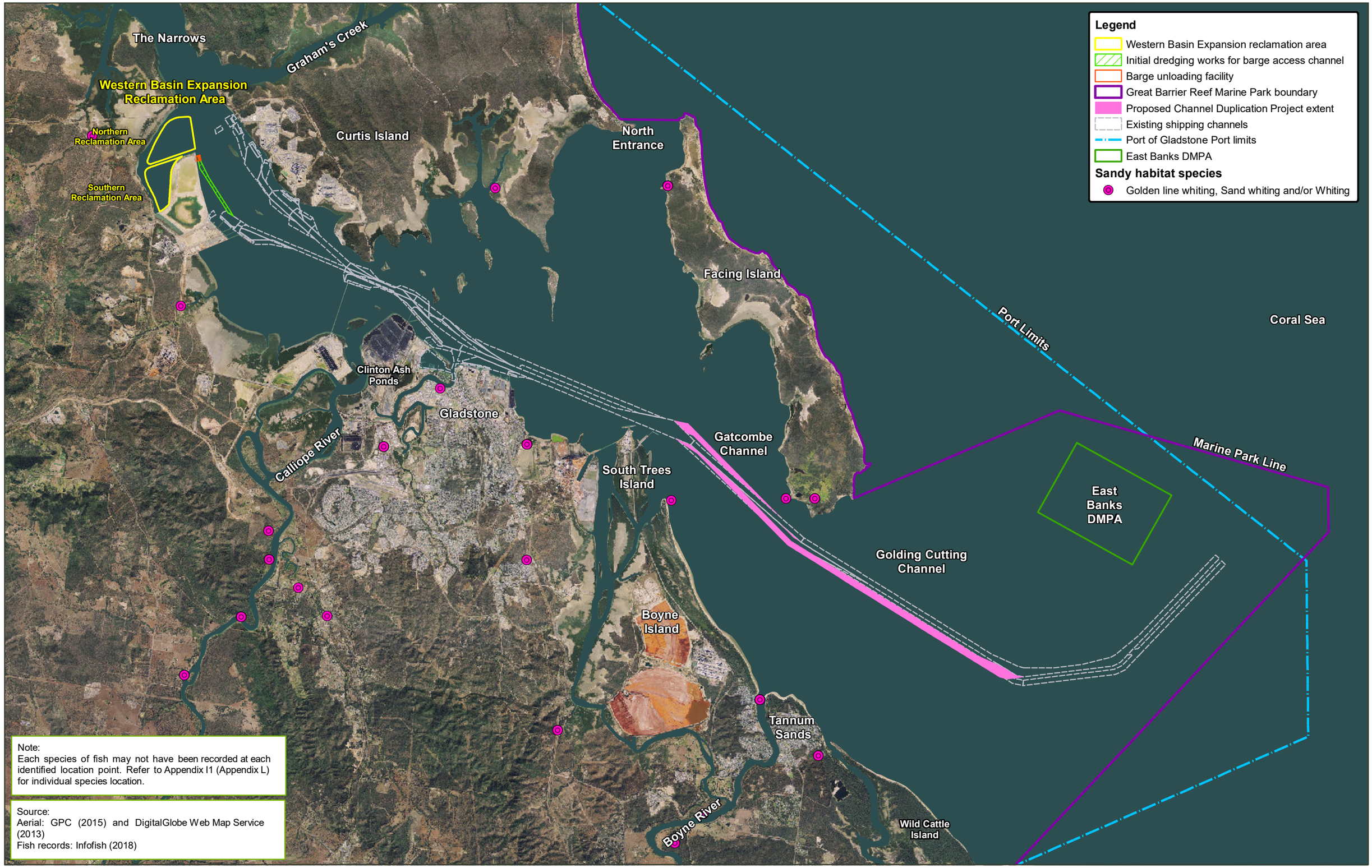
Date: 07/02/2019 Version: 0 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.49: Recorded fish species for reef associated species

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon



Note:
Each species of fish may not have been recorded at each identified location point. Refer to Appendix I1 (Appendix L) for individual species location.

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Fish records: Infofish (2018)

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Date: 07/02/2019 Version: 0 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.50: Recorded fish species for sandy habitat species

Figure 9.51 outlines the commercially harvested species in tonnes from the S30 grid fishing activity area (refer Figure 9.41 for S30 grid area). This figure shows mud crabs are the principal target species for the Port Curtis region (DAF 2018; NPRSR 2014). Commercial operators set crab pots in estuaries or near-shore areas such as in the Calliope River, adjacent to Fisherman's Landing, The Narrows, Graham's Creek and South Trees Inlet (NPRSR 2014; GPC 2012a; Wesche et al. 2013). Most Mud crabs are caught between December and June.

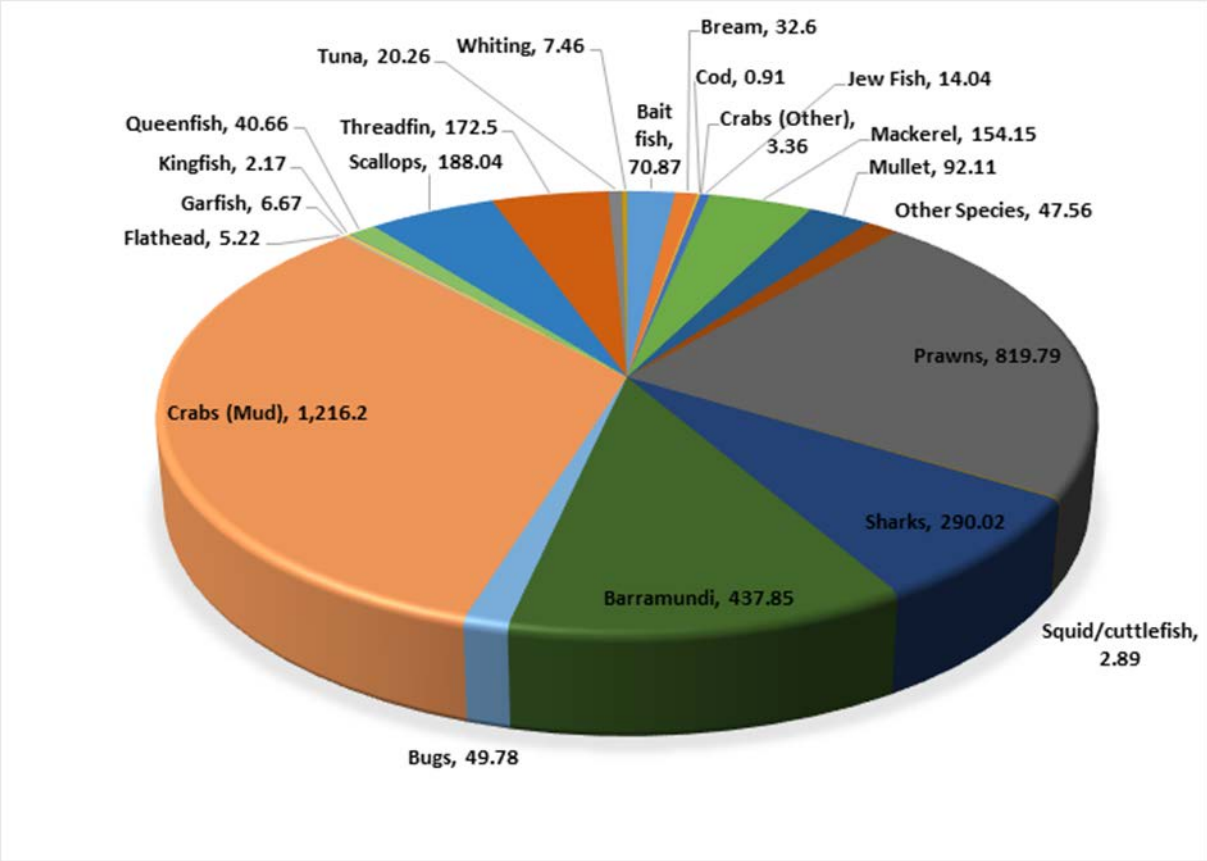

Figure 9.51 Commercially harvested species (in tonnes) within the fishing activity area (S30) (2008/2009 to 2017/2018)

Source: DAF (2018)

There are two licenced Queensland trawl fisheries that operate in the Port Curtis region: the East Coast Otter Trawl Fishery and the River and Inshore Beam Trawl Fishery (NPRSR 2014). Trawlers are restricted from operating in specific areas of Port Curtis, such as the Inner Harbour and Western Basin zones.

Banana prawns are the main target species for trawler fisheries that operate in the Port Curtis region. Mangrove lined creeks provide nursery habitat for juvenile Banana prawns before moving into coastal waters as they mature. Banana prawn numbers are significantly influenced by rainfall and freshwater flows with increased catches positively correlated with high rainfall years (DAF 2013). Prawn species such as Endeavour, Tiger and coral species are also caught by trawlers, however catch totals are very low and these species have not been recorded since 2005 (DAF 2013). The amount of commercially harvested prawns within the fishing activity area from 2008/2009 to 2017/2018 was 819.79 tonnes (t) (refer Figure 9.51) (DAF 2018).

Figure 9.52 shows the proportion of the catch by weight (and commercial licenses and fishing days) that the S30 grid fishing activity area contributes to the total catch for the Queensland commercial fishing industry.

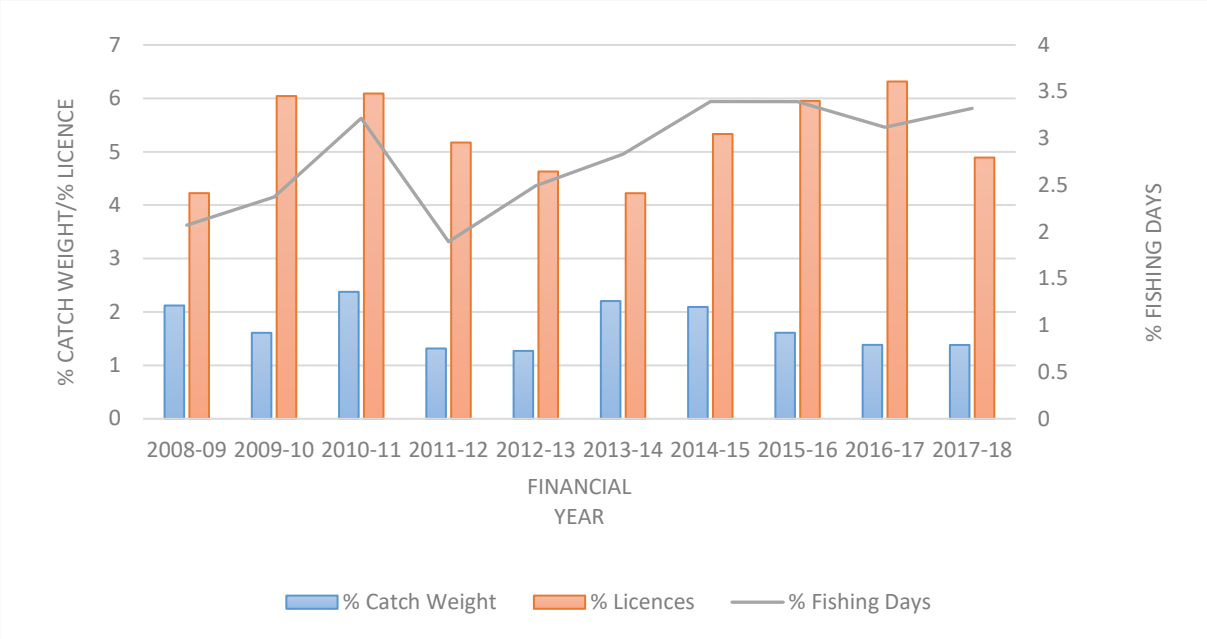

Figure 9.52 **Percentage of the Queensland commercial fishing industry that is provided by the fishing activity area (S30) (2008/2009 to 2017/2018)**

Source: DAF (2018)

Over the 10 year period assessed, on average, the fishing activity area yielded approximately 376.88t of commercial catch, utilised approximately 74 licences and encompassed approximately 4,407 fishing days per year (refer Figure 9.53) (DAF 2018). When assessed at the State level (refer Table 9.47 and Figure 9.52), the fishing activity area contributed approximately 1.7% of the commercial catch, utilised approximately 4.9% of the licences, and encompassed approximately 2.8% of the fishing days per year of Queensland's commercial fishing industry (DAF 2018).

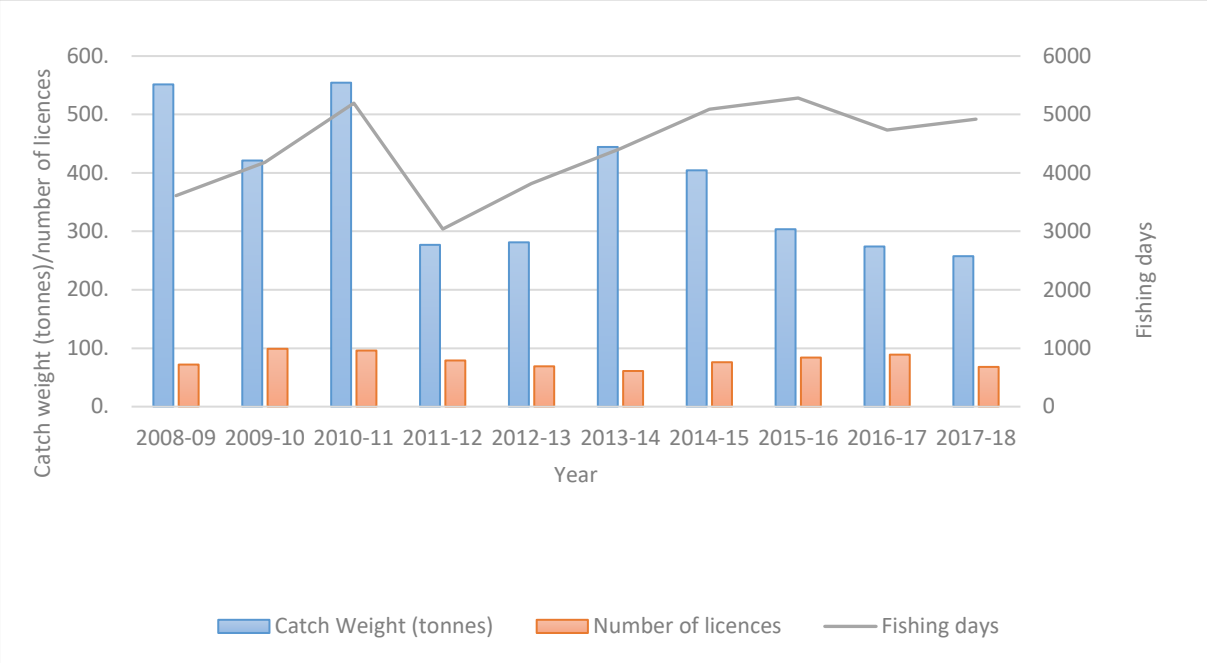

Figure 9.53 **Annual commercial catches for all commercial fishing activities in the fishing activity area (S30) (2008/2009 to 2017/2018)**

Source: DAF (2018)

Table 9.47 Annual commercial catches for all commercial fishing activities in the fishing activity area (S30)

Year ending June	S30 commercial fish yield (t)	% of Queensland yield	S30 commercial fishing licences	% of Queensland licences	S30 commercial fishing days	% of Queensland fishing days
2018	257.5091	1.38%	64	4.60%	4,894	3.31%
2017	274.10034	1.38%	82	5.82%	4,697	3.10%
2016	303.63538	1.61%	78	5.53%	5,264	3.38%
2015	404.46232	2.09%	72	5.05%	5,087	3.39%
2014	444.4323	2.20%	56	3.88%	4,399	2.82%
2013	281.20963	1.27%	67	4.50%	3,807	2.48%
2012	276.90113	1.32%	74	4.85%	3,017	1.88%
2011	554.41838	2.38%	90	5.71%	5,174	3.20%
2010	421.2483	1.61%	88	5.37%	4,145	2.35%
2009	550.95934	2.12%	69	4.05%	3,589	2.06%
Average over 10 years	376.88762	1.7%	74	4.9%	4,407	2.8%

Source: DAF (2018)

In the context of Queensland's commercial fishing industry, the fishing activity area provided yields of Mud crab and Shark that were greater than 5.0% of the State's reported commercial catch (refer Figure 9.54). All other species contributed less than 5% to Queensland's commercial fishing industry during the 2008/2009 to 2017/2018 period (refer Figure 9.54).

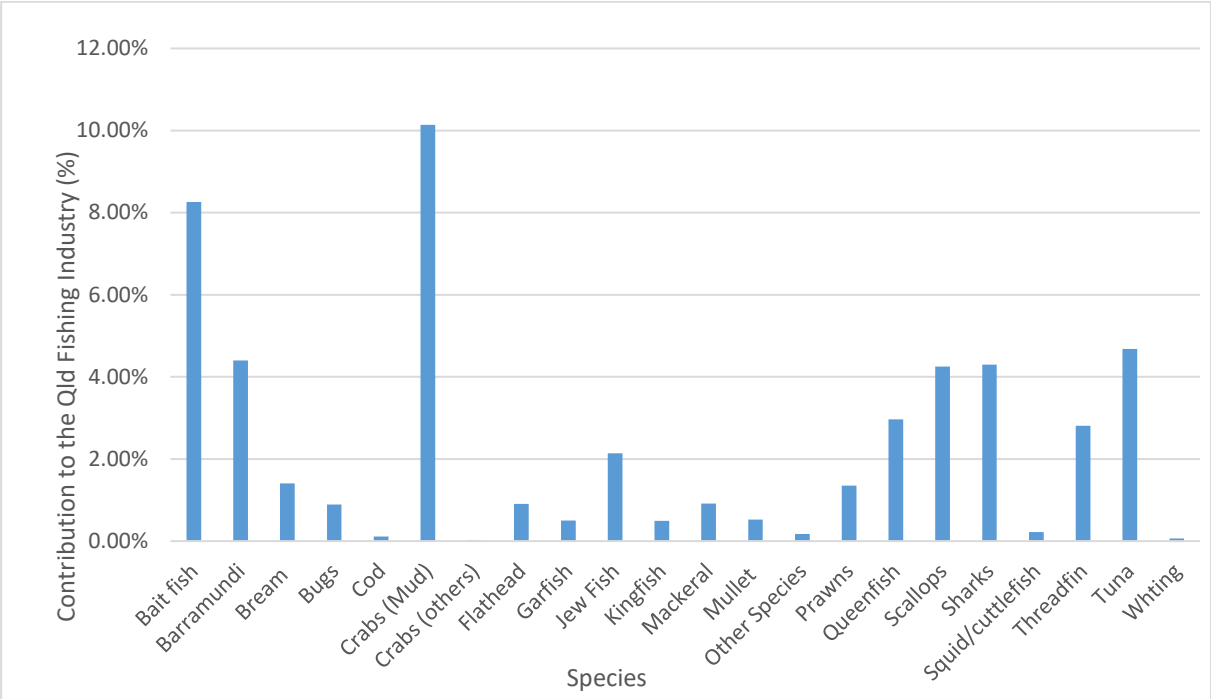

Figure 9.54 Contribution of commercially harvested species within the fishing activity area (S30) to the Queensland commercial fishing industry (2008/2009 to 2017/2018)

Source: DAF (2018)

Recreational fisheries

Port Curtis supports a very popular recreational fishing industry which is a key component of the region's tourism industry. Fishing activities predominantly include line fishing, crabbing and prawning. The majority of fishing is done by boat with a significant increase (36.1%) in boat registrations in the GRC area recorded over the period of 2006 to 2014 from 5,396t to 7,342t (Sawynok et al. 2014). Generally, the main species caught within Gladstone Harbour include Bream, Barramundi, Cod, Flathead, Salmon and Mangrove jack (pers. comms. B Thomson 2018).

Based on an analysis of recreational fishing activities within Port Curtis and adjoining waterways from 2006 to 2014 the most commonly kept species (i.e. highest percent of species caught and retained) within the Gladstone region were Mud crab (20.7% (underestimated)), Seabream (Yellowfin bream and Pikey bream) (20.3%) and Barramundi (2.2%) (refer Figure 9.55) (Sawynok et al. 2014).

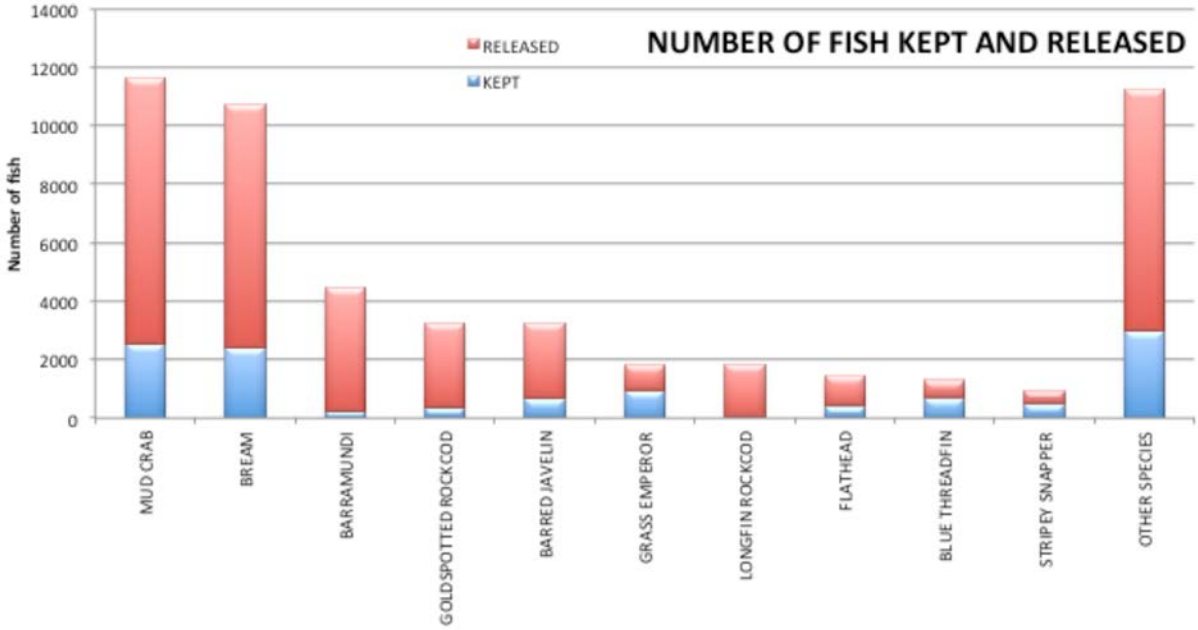

Figure 9.55 Numbers of key species caught and kept from recreational fishing catches within Port Curtis (2006 to 2014)

Source: Sawynok et al. (2014)

The most popular locations for recreational crabbing trips from summer 2012/2013 to spring 2013 were the estuarine and inlet areas of Calliope River followed by Gladstone Harbour, South Trees Inlet and the Boyne River. For locations fished, Gladstone Harbour, Boyne River and Calliope River were the most popular locations in 2014 with an increase in fishing in the Harbour from 2012. Species such as Seabream, Barramundi and Threadfin are targeted in these areas. Graham's Creek and The Narrows are popular locations for recreational fishing, crabbing and prawning (depending on season) (GPC 2012a).

Anecdotal sources suggest popular beach fishing locations in the region are Lillie's Beach, Yellow Patch on the eastern side of Curtis Island, Turkey Beach at Rodds Bay and Farmer's Point on the northwest side of Facing Island (Battersby 2014; Tourism and Events Queensland 2016). Popular reef fishing locations include the southern end of Curtis Island and surrounding islands, Seal Rocks and Gatcombe Heads (Tourism and Events Queensland 2016; BMT WBM 2013).

The number of small boat registrations is often used as an indicator of the size of recreational fishing activities in an area. Figure 9.56 depicts the trends in vessel registration (up to 8m, no sails) in Gladstone from 2006 to 2014. Between 2006 and 2014 the number of boat registrations rose from 5,396 to 7,342, representing a 36.1% increase during that time. Between 2013 and 2014, boat registrations increased by 1.9% (Sawynok et al. 2014). This increasing trend in registration is indicative of the increasing popularity of recreational fishing in the Gladstone area.

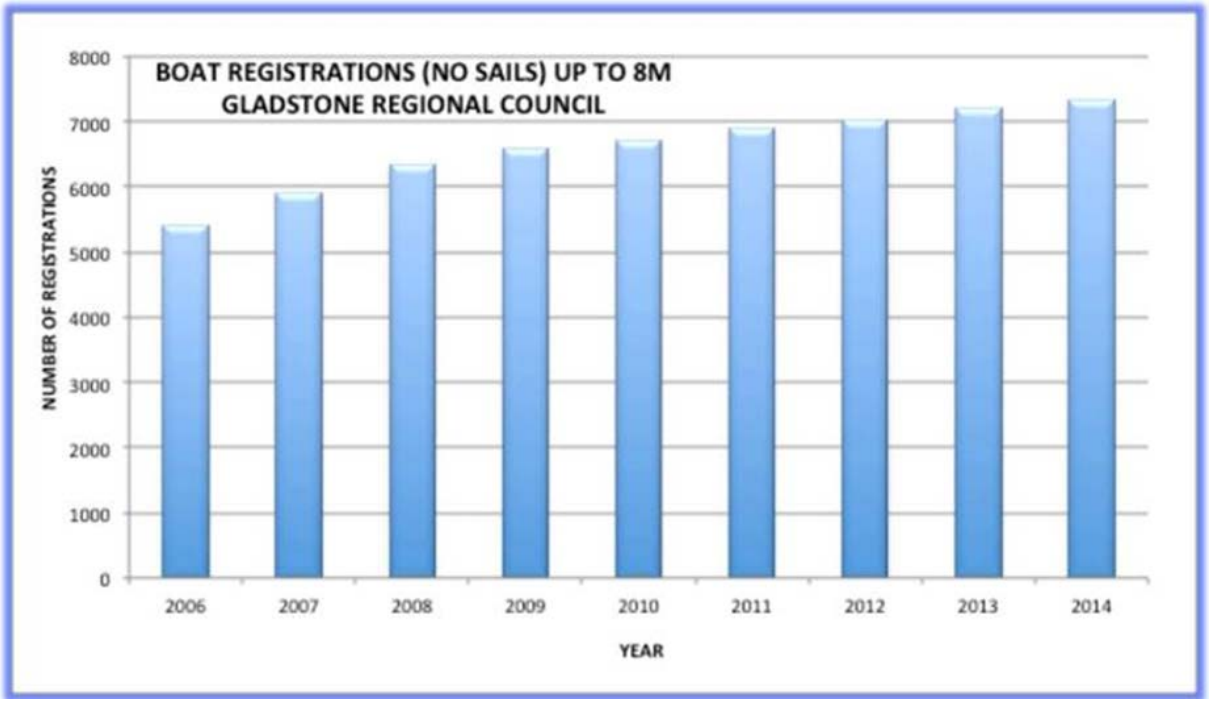

Figure 9.56 **Number of registered motorboats (up to 8m, no sails) in the Gladstone Local Government Area from 2006 to 2014**

Source: Sawynok et al. (2014)

Traditional fisheries

Traditional Use of Marine Resources Agreements (TUMRA) are developed by Traditional Owner groups in partnership with the Commonwealth and Queensland Governments, and describe how Traditional Owners intend to manage their take of natural marine resources (including protected species) within the GBRMP. The Port Curtis Coral Coast TUMRA is the largest agreement of its kind and covers an area of 26,386km^2 extending from Burrum Heads, south of Bundaberg, to the northern end of Curtis Island and the Fitzroy River mouth. Accredited in August 2011, the agreement represents the Gooreng Gooreng, Gurang, Bailai and Tarebilang Bunda Traditional Owners (NPRSR 2014). Chapter 16 (Aboriginal cultural heritage) provides further information on the Port Curtis Coral Coast TUMRA.

9.12.2.6 Other marine reptile habitat values

As previously outlined, Saltwater crocodiles have been sighted within Port Curtis at Fisherman's Landing, the Calliope River, The Narrows and in Pacific Creek on the northeastern corner of Curtis Island (GPC 2012a).

Limited information is available on sea snakes and their specific habitat requirements within Port Curtis, although they have been identified in a variety of areas from clear reef waters to turbid inshore estuaries, depending on the species (GPC 2012a).

Opportunistic sightings of sea snakes within Port Curtis have been recorded in various investigations. During Project field investigations, an Olive sea snake (*Aipysurus laevis*) was encountered within a coral reef, though the specific location is not identified within the report (VE 2015a).

Aerial and boat-based surveys conducted by GHD (2011a; 2011b) within the Gladstone region recorded five sea snakes during the summer 2011 survey (one in Port Alma, one east of Curtis Island and four in The Narrows), and six sea snakes during the autumn 2011 survey (two in Port Alma and three in The Narrows); however the identity of these species was not determined. In addition, a sea snake (possibly an Olive sea snake) was observed within the Western Basin zone during a benthic marine ecology survey undertaken in June 2009 (GHD 2009c).

9.13 Fish and marine reptiles (excluding marine turtles) – potential impacts and risk assessment

9.13.1 Background

9.13.1.1 Section content

This section identifies the potential impacts and provides a risk assessment for fish, fisheries values and some marine reptiles (i.e. marine sea snakes and kraits contained within the family Elapidae) as a result of Project activities. Table 9.48 summarises the Project activities and the relevant section containing the impact assessment discussion.

Table 9.48 Summary of Project activities and section addressed (fish and marine reptiles (excluding marine turtles))

Project activity	Section
Establishment of the WBE reclamation area and BUF, including: ▪ Site preparation ▪ Establishment of the site compound, offices and temporary areas ▪ Source and transport of reclamation bund wall material ▪ Placement of core and armour material, and geotextile fabric ▪ Sheet piling (or similar earth retaining structure) and fill placement for the BUF	Section 9.13.2
Dredging activities, including: ▪ Initial dredging works for the barge access channel ▪ Dredging to duplicate the Gatcombe and Golding Cutting shipping channels ▪ Dredging vessel movements ▪ Unloading and placement of dredged material in the WB and WBE reclamation areas	Section 9.13.3
Removal and installation of navigational aids	Section 9.13.4
Stabilisation and maintenance activities on the WBE reclamation area	Section 9.13.5

Operation of the duplicated shipping channels and maintenance dredging activities are discussed in Sections 9.23 and 9.24, respectively.

It is important to note that this section focuses on fish species and fish values, as well as other marine reptiles, which are commonly associated with marine habitats. The Project potential impact and risk assessment for other marine turtles and marine mammals are in included in Section 9.20 and Section 9.21, respectively. The Project potential impact and risk assessments for reef communities, seagrass meadows and epibenthic macroalgae, and intertidal flora, which provide areas of fish habitat and resources, are provided in Sections 9.11, 9.9 and 9.5, respectively.

The sections below provide a potential impact and risk assessment for fish and fisheries values described in Appendix I1 (Section 9) and other marine reptiles described in Appendix I1 (Section 10).

9.13.1.2 Sensitivity ratings

The sensitivity criteria and ratings associated with magnitude, likelihood, consequence and risk which are used to assess the consequence of potential impacts on ecological receptors are defined in Appendix I2 (refer Table 3.1 for the criteria used to define sensitivity ratings). The sensitivity ratings for each of the significant environmental receptors associated with fish, nekton, marine reptiles and fisheries values are discussed below.

Fish species of conservation significance and/or migratory fish species

There are eight fish of conservation significance and/or migratory species that are considered to have a moderate likelihood of occurring within and/or adjacent to the Project impact areas. Their sensitivity ratings are provided in Table 9.49.

Table 9.49 Fish species of conservation significance and migratory fish species identified as being likely to occur within the Port Curtis region

Fauna value and species	Conservation status under the EPBC Act and/or NC Act	Likelihood of occurrence within Project impact areas	Sensitivity rating
Estuary stingray (*Dasyatis fluviorum*)	Near-threatened (NC Act)	Moderate	High
Whale shark (*Rhincodon typus*)	Vulnerable, Migratory (EPBC Act)	Moderate	High
Great white shark (*Carcharodon carcharias*)	Vulnerable, Migratory (EPBC Act)	Moderate	High
Shortfin mako shark (*Isurus oxyrnchus*)	Migratory (EPBC Act)	Moderate	High
Longfin mako shark (*Isurus paucus*)	Migratory (EPBC Act)	Moderate	High
Porbeagle (*Lamna nasus*)	Migratory (EPBC Act)	Moderate	High
Reef manta ray (*Manta alfredi*)	Migratory (EPBC Act)	Moderate	High
Giant manta ray (*Manta birostris*)	Migratory (EPBC Act)	Moderate	High

For the purposes of the Project potential impacts and risk assessment, fish species of conservation significance and migratory fish within and/or adjacent to the Project impact areas are considered to have a sensitivity rating of high.

Other marine reptiles (sea snakes and kraits)

Thirteen species of marine snake/krait (family: Elapidae) are known, or are predicted to occur, within Port Curtis and adjoining areas (refer Table 9.50).

Table 9.50 Sea snake species known or predicted to occur within the Port Curtis region

Scientific name	Common name	Conservation status		Sensitivity rating
		EPBC Act	NC Act	
Acalyptophis peronii	Horned sea snake	Marine	Least concern	Low
Aipysurus duboisii	Dubois' sea snake	Marine	Least concern	Low
Aipysurus eydouxii	Spine-tailed sea snake	Marine	Least concern	Low
Aipysurus laevis	Olive sea snake	Marine	Least concern	Low
Astrotia stokesii	Stokes' sea snake	Marine	Least concern	Low
Disteira kingie	Spectacled sea snake	Marine	Least concern	Low
Disteira major	Olive-headed sea snake	Marine	Least concern	Low
Emydocephalus annulatus	Turtle-headed sea snake	Marine	Least concern	Low
Hydrophis elegans	Elegant sea snake	Marine	Least concern	Low
Lapemis hardwickii	Spine-bellied sea snake	Marine	Least concern	Low
Laticauda colubrina	Yellow-lipped sea krait	Marine	Least concern	Low
Laticauda laticaudata	Blue-lipped sea krait	Marine	Least concern	Low
Pelamis platurus	Yellow-bellied sea snake	Marine	Least concern	Low

Source: GPC (2012a)

Limited information is available on sea snakes and kraits, and their specific habitat requirements within Port Curtis. However, they have been identified in a variety of areas from clear reef waters to turbid inshore estuaries, depending on the specific habitat requirements of the species (GPC 2012a).

For the purposes of the potential impacts and risk assessment, the species listed in Table 9.50 are considered to have a sensitivity rating of low.

Estuarine and coastal fish communities

Estuaries and coasts are complex environments that support a wide range of flora and fauna species. These areas contain both subtidal and intertidal habitats, including seagrass meadows, mangrove forests, saltmarshes, soft muddy and sandy flats, sandy beaches and rocky outcrops (Faunce and Serafy 2006; Meynecke 2009; Sheaves et al. 2007). Many of these areas have important economic values in terms of providing spawning, nursery and feeding habitats for commercially and recreationally important fish species (Seitz et al. 2013; Hutchinson et al. 2014). In addition to fish, commercially harvestable invertebrates such as prawns often depend upon estuarine and coastal habitat such as seagrass meadows, and these environments have been recognised as important for the maintenance of seabed stability, water quality and biodiversity (NPRSR 2014).

Fish diversity and abundance within the coastal and estuarine habitats of the Port Curtis area are considered to be relatively high with 2,936 individuals representing 34 species being captured during cast-net surveys, and 44 different species being captured during gill net surveys associated with the Project EIS (refer Appendix I1 (Section 9) and Appendix J).

For the purposes of the potential impacts and risk assessment, estuarine and coastal fish communities (i.e. where not listed as having conservation significance and/or migratory) within and/or adjacent to the Project area are considered to have a sensitivity rating of moderate.

Reef communities

Reef associated fish are important components of shallow water habitats, in that they form part of a complex functioning ecosystem. While fish are more mobile and can cover great distances compared to nektonic invertebrates, some fish such as Reef damselfish (*Pomacentrus* spp.) and Baitfish have restricted homing ranges (Alquezar 2011). Based on mapping from GBRMPA (2009), Port Curtis contains 19 reefs made up of predominantly rocky shores or shallow subtidal reefs, although existing mapping is thought to significantly underestimate the extent of subtidal reefs in this area (BMT WBM 2014a). Coral reef communities in Port Curtis are typical of fringing coral reefs on the southern inshore Great Barrier Reef (e.g. similar hard coral cover) (BMT WBM 2013).

In total, 59 fish species have been encountered within reef habitats within Port Gladstone based on data collected during the Project EIS surveys. The greatest occurrences of fish have been identified at Gatcombe Heads, followed by Jenny Lind Banks and Sable Chief Rocks (refer Appendix I1 (Section 9)).

For the purposes of the potential impacts and risk assessment, reef fish communities within and/or adjacent to the Project area are considered to have a sensitivity rating of high.

Commercial fisheries

At a state-wide scale, Port Curtis and the associated intertidal areas, upstream rivers and creeks represent important resources for Queensland's commercial fisheries (NPRSR 2014). Both inshore and offshore fisheries operate out of Port Curtis. Fishing activities predominantly include, line and beam trawling, netting, and use of pots.

Known areas of the Port Curtis region of value to commercial fisheries include:

- Mangrove areas in The Narrows and estuarine inlets
- Seagrass meadows and intertidal wetlands in coastal areas (e.g. Western Basin area)

- Cape Capricorn on the north-eastern headland of Curtis Island (wider area)
- Capricorn Bunker Group of offshore reefs (wider area).

For the purposes of the potential impacts and risk assessment, commercial fisheries within and/or adjacent to the Project impact areas are considered to have a sensitivity rating of high.

Recreational fisheries

Port Curtis supports a popular recreational fishing industry, which is a key component of the region's tourism industry. Fishing activities predominantly include line fishing, crabbing and prawning. The majority of fishing within the region is undertaken by boat (Sawynok et al. 2014).

From a recreational viewpoint, the most popular locations for recreational crabbing trips are the estuarine and inlet areas of Calliope River as well as Graham's Creek and The Narrows, followed by the Boyne River and South Trees Inlet (Gladstone Region 2018). For locations fished, the following areas are considered popular locations (Gladstone Region 2018):

- Barney Beach: Flathead, Salmon, Barramundi, Grunter and pelagic species
- Auckland Creek: Flathead, Barramundi, Fingermark (*Lutjanus johnii*), Mangrove jack, Salmon, Bream and Grunter
- Calliope River: Barramundi, Queen fish, Trevally, Salmon, Mangrove jack, Bream and Grunter
- Estuarine and inlet areas of Calliope River: Mud crabs, Barramundi, Mangrove jack, Bream, Fingermark, Salmon, Triple tail, Cod and Mulloway (*Argyrosomus japonicus*)
- Boyne River and South Trees Inlet: Barramundi, Flathead, Mud crabs, Whiting, Bream, Grunter, Diamond trevally (*Aclectus indica*) and Queen fish
- Gatcombe Head: Mackerel, Squire, Coral trout, Grass emperor (sweetlip), Redthroat emperor (sweetlip emperor) (*Lethrinus miniatus*), Parrot fish and Black spotted tusk fish
- Colosseum Inlet: Mud crabs, Mangrove jack, Bream, Whiting, Mackerel, Salmon and Barramundi.

For the purposes of the potential impacts and risk assessment, recreational fisheries within and/or adjacent to the Project area are considered to have a sensitivity rating of moderate.

Declared Fish Habitat Areas

FHAs are considered to be an important resource to support local commercial and recreational fisheries, and have been established to protect natural fish habitats by limiting coastal development and associated physical disturbance within and adjacent to a declared FHA, while still allowing for continued community use and access (NPSR 2017).

FHAs are declared under the provisions of the Fisheries Act and have the purpose to afford a level of protection to high value natural fish habitats in coastal areas. Rodds Harbour (i.e. Rodds Bay) and Colosseum Inlet, located south of the proposed Project activities (refer Appendix I1 (Figure 9.16)), are declared FHAs. In addition, Dē-răl-lĭ (Calliope River) FHA was declared on the 30 September 2016 and includes the upper sections of the Calliope River. This area is also regulated under the Fisheries Act.

For the purposes of the potential impacts and risk assessment, declared FHAs within and/or adjacent to the Project area are considered to have a sensitivity rating of high.

9.13.2 Establishment of the dredged material placement area and barge unloading facility

9.13.2.1 Permanent loss and alteration of habitat

Context of impact

The establishment of the WBE reclamation area and BUF will result in the loss of intertidal and subtidal habitat, with the southern area encompassing an area of 111.12ha, 164.98ha for the northern area and 1.89ha for the BUF. These intertidal and subtidal habitats provide potential habitat for a range of fish species, other marine reptiles, and fisheries values. This impact relates to the potential for impacts to species/values as a result of the loss of potential habitat, and not the actual loss of the potential habitat (this impact is assessed in other sections of this chapter, such as in Section 9.9.2 (seagrass) and Section 9.15.2 (soft sediment habitats and benthic macroinvertebrates)).

The WBE reclamation area and BUF are not located within or directly adjacent to a declared FHA or reefs, and therefore the risk of potential impacts on FHAs and reef fish communities as a result of this activity are considered negligible.

Of the Chondrichthyan fish species that have conservation significance and/or are migratory fish species with a moderate likelihood of occurring within the Project areas, the WBE reclamation area has the potential to be utilised by the Estuary stingray. The Estuary stingray is typically associated with shallow coastal waters, where the species inhabits mangrove-fringed rivers, estuaries and submerged mudflats. It is considered unlikely that establishment of the WBE reclamation area would adversely impact other Chondrichthyan fish species of conservation significance, as the area is unlikely to represent important habitat.

Other marine reptiles which have the potential to occur within the WBE reclamation area consist of marine snakes (sea snakes (12 species)) and kraits (1 species). Given that relatively little is known regarding the specific habitat requirements of sea snakes and kraits within the Port Curtis region, the habit assumptions related to areas of habitat have been assessed using broader literature. Whilst most of the 12 species of sea snakes identified as having a moderate potential to occur within the Project impact areas typically associated with reef and fringing reef environments, several species (e.g. *Aipysurus eydouxii*, *Astrotia stokesii* and *Lapemis hardwickii*) typically associate with shallow turbid waters (Wilson and Swan 2008) which occur at the WBE reclamation area. Whilst the krait (*Laticauda laticaudata*) specialises in hunting in reef environments, this is an amphibious species which returns to land following successful hunting and for reproduction (i.e. egg laying) (Wilson and Swan 2008). As such, this krait is often associated with shallow turbid coastal waters. The WBE reclamation area represents potential habitat for sea snakes and kraits occurring within Port Curtis.

The WBE reclamation area habitats include soft sediments and seagrass meadows, and are adjacent to mangrove and saltmarsh communities (i.e. outside of the Projects direct impact areas). Seagrass meadows and mangroves are important habitats for many species of fish and prawns (Seitz et al. 2013; Hutchinson et al. 2014), and mangroves are also a known habitat utilised by estuarine and freshwater fish species for spawning (Alquezar 2011). Saltmarsh areas within the Gladstone region are known to provide habitat to a host of species, including Seabream, Whiting and Mullet, although these areas generally have lower species richness than other inshore habitats such as mangroves and seagrass (Thomas and Connolly 2001; Sheaves et al. 2007).

Exposed mud and sand banks are the most common intertidal habitat within Port Curtis. While generally thought to be unproductive environments for fish compared to seagrass meadows or mangroves, high proportions of economically important fish species in subtidal flats have been observed within these areas (Small 1997; NPRSR 2014). Furthermore, these habitats harbour high productivity and nutrient values with high diversity and biomass of benthic invertebrates and algae which provide a direct food source for commercially and recreationally important fish species (QCG 2009; Long and McKinnon 2002). Impacts on seagrass meadows are discussed in Section 9.9.

In relation to fisheries, seagrass meadows have an important economic value as they provide nursery and feeding habitats for commercial and recreational species (Watson et al. 1993; Unsworth and Cullen 2010), particularly inshore and offshore prawn fisheries with the Tiger prawn (e.g. *Penaeus esculentus, Penaeus plebejus, Penaeus semisulcatus*), Endeavour prawn (*Metapenaeus endeavouri*) and Western king prawn (*Panaeus latisulcatus*) all relying on Port Curtis seagrass communities at some stage of their lifecycle (Lee Long et al. 1992). In addition, mangrove environments are considered important in relation to their provision of nursery and feeding areas for many commercially harvestable fish species (Alquezar 2011).

Marine species of conservation significance

The establishment of the WBE reclamation area has the potential to impact habitat that may be utilised by the Estuary stingray. However, there is substantial areas of suitable potential habitat in adjacent areas, and this is not likely to be critical or key habitat for this species. The loss of this potential habitat will be permanent and irreversible and restricted to a contained area, therefore moderate in magnitude.

Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of habitat loss at the WBE reclamation area (refer Section 9.27). Other relevant Project mitigation measures are provided in Section 9.27 and the Project EMP (Appendix Q2).

The post mitigation risk rating associated with a permanent and irreversible loss of intertidal and subtidal habitat for migratory fish and/or species of conservation significance during the establishment of the WBE reclamation area is medium. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Other marine reptiles

The establishment of the WBE reclamation area has the potential to impact habitat that may be utilised by sea snakes and kraits occurring within Port Curtis. The habitat within the reclamation area is not considered to be critical or key habitat for this species, and similar habitat is located in adjacent areas. This permanent loss of this potential habitat and impact will be permanent and irreversible and restricted to a contained area, therefore moderate in magnitude.

Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of habitat loss at the WBE reclamation area (refer Section 9.27). Other Project mitigation measures are provided in Section 9.27 and the Project EMP (Appendix Q2).

The post mitigation risk rating for kraits and other marine reptiles associated with a permanent and irreversible loss of intertidal and subtidal habitat during the establishment of the WBE reclamation area is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Estuarine and coastal fish communities

Estuarine and fish communities are likely to utilise habitat within the WBE reclamation area and BUF, and adjacent areas. Adjacent areas of mangroves and saltmarsh communities are not located in the direct impact areas and will not be directly impacted as a result of this activity. The loss of this habitat within the reclamation area will be permanent and restricted to a contained area, and is therefore moderate in magnitude.

Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of habitat loss at the WBE reclamation area (refer Section 9.27). Other relevant Project mitigation measures are provided in Section 9.27 and the Project EMP (Appendix Q2).

The post mitigation risk rating for the permanent and irreversible loss of potential estuarine and coastal fish species habitat during the establishment of the WBE reclamation area and BUF is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Fisheries

Seagrass meadows (i.e. important habitat for commercially harvested species) are present in both the northern and southern areas associated with the WBE reclamation area (refer Sections 9.6 and 9.9). Direct loss of mangrove and intertidal communities will not occur as part of the WBE reclamation area (refer Figure 9.10). Whist the direct loss of inshore habitat has the potential to impact on fisheries values, it is unlikely that this will result in significant adverse impacts on fisheries given the extent of these habitats in adjacent areas (e.g. The Narrows, Graham's Creek).

Whilst the direct loss of inshore habitat from the establishment of the WBE reclamation area has the potential to impact on fisheries values, due to the extent of other Port Curtis seagrass meadows, mangrove communities and other inshore areas identified as having fisheries importance, this Project direct loss of inshore habitat will not result in any adverse impacts on Port Curtis fisheries.

Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of potential habitat loss at the WBE reclamation area (refer Section 9.27). Project design will reduce, where practical, the permanent loss of habitat within WBE reclamation area direct disturbance area. Other Project mitigation measures are provided further in Section 9.27 and the Project EMP (Appendix Q2).

This Project activity and the potential impacts to fisheries values (particularly the loss of potential habitat), will be permanent and irreversible and restricted to a contained area, therefore moderate in magnitude.

The post mitigation risk ratings associated with the permanent loss of potential fisheries values associated with the establishment of the WBE reclamation area and BUF are low for recreational fisheries, and medium for commercial fisheries. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.13.2.2 Potential noise and vibration impacts

Increased underwater noise and vibration has the potential to be generated during the construction of the bund walls at the WBE reclamation area and sheet piling (or similar earth retaining works) at the BUF. Fish are sensitive to high sound pressures, which can affect auditory structures of fish (soft tissue and otoliths) and swim bladders. Noise management criteria for the avoidance of damage to fish tissue (Popper et al. 2006) are shown in Table 9.51. However, relatively little is known about the auditory sensitivity of sharks, however behavioural responses to pulsed low frequency sounds (up to around 1 kHz) have been recorded. GHD (2011a; 2011b) suggested that the criterion for fish > 2g is applicable to sharks.

Excessive levels of underwater noise have the potential to impact a variety of marine species through:

- Trauma to hearing (temporary or permanent)
- Trauma to non-hearing tissue (barotraumas)
- Alteration of behaviour (e.g. avoidance of predators, interfering with the acquisition of prey or mates, displacement from essential habitat areas, selection of appropriate nesting sites).

Marine fauna species vary in their response to underwater noise with ear anatomy, frequency range and amplitude playing a role is species sensitivities (Ketten 1998; Popper et al. 2006).

Table 9.51 Criteria for fish avoidance of underwater noise impacts

Fish size	Unit of measure		Single or multiple pulse noise	Non-pulse noise
	SEL	Peak sound pressure		
All fish	$1\mu Pa^2 .sec$	$1\mu Pa_{peak}$	206dB	206dB
Fish > 2g	$1\mu Pa^2 .sec$	$1\mu Pa_{peak}$	187dB	187dB
Fish < 2g	$1\mu Pa^2 .sec$	$1\mu Pa_{peak}$	183dB	183dB

Table note:

SEL = sound exposure level
dB = decibel

Source: Adapted from Popper et al. (2006), GHD (2011a) and GHD (2011b)

An assessment of the underwater noise and vibration to be generated as a result of Project activities was undertaken (refer Chapter 13 (noise and vibration)). Impacts to fish species are expressed as:

- Mortality and potential mortal injury
- Recoverable injury
- Temporary Threshold Shift (TTS), describing the potential for temporary hearing loss
- Avoidance
- Behavioural changes.

The primary sources of noise and vibration from the establishment of the WBE reclamation area are predicted to occur during the placement of core material into marine waters, primarily the dumping of rocks from trucks during bund wall construction. The criteria modelled as part of this assessment included:

- Range of SEL levels for rock dumping events
- Noise generating mechanism of rock tumbling and grinding
- Modelled point source depth 'near seafloor'
- Non-pulses, transient noise types.

When modelled for a variety of hertz values across the one-third octave band central frequency, underwater noise generated during rock dumping events was calculated not to exceed a SEL of approximately 182dB re 1µPa^2·S at 1m from the rock dumping area.

An assessment of the potential underwater noise and vibration impacts during rock dumping indicates that it is unlikely that animals would be at risk of peak acoustic pressure damage from underwater rock dumping until they are within the range of direct physical impact from the dumping of rock material. Given the mobile nature of the cartilaginous fish species of conservation significance and migratory fish species, common fish species, sea snakes and kraits as well as other vertebrate species that have been identified as potentially occurring within the WBE reclamation area and the relatively low noise emissions emitted from the activity, it is unlikely that they would remain within proximity to the rock dumping locations to be significantly impacted or alter behavioural responses.

Analysis of potential noise masking indicates that there is no possibility of a behavioural displacement response during foraging and communication as a result of the proposed activities for Project for fish species (refer Section 13.6).

Potential impacts of increased noise and vibration to estuarine and coastal fish communities associated with the WBE reclamation area has the potential to result in alteration of behaviour (e.g. avoidance of the area) during peak noise production. However, controlled experiments conducted off the coast of West Scotland, using playback indicate that fish exhibit avoidance behaviour to loud noise associated with anthropogenic construction activities within a natural setting (Mueller-Blenkle et al. 2010).

Non-pulse development activities such as vibratory sheet piling (for BUF construction) are not expected to result in significant adverse noise impacts to fish species due to the relatively low noise emissions from these activities.

Further information on the zones of impact are provided in Section 13.6.2 and Appendix K2.

This Project activity and the potential exposure of fish and marine reptile species to these impacts will be temporary within a contained extent, resulting in a low level of magnitude. Impacts on FHAs and reef fish communities are not expected to occur as they are not in proximity to the WBE reclamation area and BUF.

Mitigation measures to reduce the impacts of underwater noise on estuarine and coastal fish communities during establishment of the WBE reclamation area and BUF are included in Section 9.27 and the Project EMP (refer Appendix Q2).

During the establishment of the WBE reclamation area and BUF, the post mitigation risk ratings associated with increased noise and vibration on fish and fisheries values are medium for species of conservation significance or migratory species, medium for commercial fisheries values, and low for all other values. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.13.2.3 Short term decline in water quality in the marine environment

Establishment of the WBE reclamation area (northern and southern areas) and BUF will be undertaken over a three year period and will involve the placement of core material directly over existing sediments, followed by armour material being placed along the seaward exposed face. The construction activities associated with the establishment of the WBE reclamation area and BUF have the potential to impact the water quality in adjacent marine environments (i.e. enclosed coastal waters of Port Curtis) and impact upon the fish, fisheries values and other marine reptiles either directly (e.g. exposure to contaminants, increased turbidity) or indirectly (e.g. lead to the decline of important habitat). The potential impacts to water quality as a result of Project activities are provided in Chapter 8 (water quality) and Appendix H1.

Suspended sediments in the water column can increase light attenuation and reduce the amount of benthic light reaching key areas of fish habitat contained within coastal and estuarine areas such as seagrass meadows (Erftemeijer and Lewis 2006; Sofonia and Unsworth 2010). Sediment deposition can also smother sessile benthic organisms and promote epiphytic growth placing further pressure on seagrass meadows (Erftemeijer and Lewis 2006).

The waters of the Port Curtis estuary are naturally turbid with higher turbidity levels experienced during the wet season (Commonwealth of Australia 2013; Herzfeld et al. 2004) and during spring and neap tidal cycles. Despite this the Port of Gladstone supports a diversity of resident fish species and a viable fisheries industry and many areas that are considered to be important for the maintenance of fish populations that are located within this area.

Water quality, and the presence of contaminants in water, are known to have a direct impact upon fish communities, however, these were not identified as a proximate cause of fish illness, injury and death in the Gladstone Harbour and associated waterways (EHP 2013).

In relation to turbidity that is generated as part of the WBE reclamation area and BUF establishment, it is likely that more mobile species (e.g. sharks and larger fish) will actively avoid turbid waters generated by Project activities.

Contaminants (e.g. hydrocarbons) and sediment-laden runoff have the potential to be released during the Project placement of core and armour material at the WBE reclamation area and BUF or via spills from vehicles and/or onsite storage facilities. However, the volume of contaminants to be stored onsite will be relatively low.

This Project activity and potential exposure of marine species to these impacts will be within the medium term and restricted to a contained area, and therefore moderate in magnitude. However, there are no reef communities or declared FHAs within proximity of the WBE reclamation area and BUF, therefore impacts on these values is expected to be negligible for this Project activity.

Mitigation measures to minimise marine water quality being impacted during the WBE reclamation area and BUF establishment and adversely impacting fish, fisheries values and other marine reptiles are included in Section 9.27 the Project EMP (refer Appendix Q2).

During the establishment of either of the WBE reclamation area and BUF, the post mitigation risk ratings associated with the short term decline in water quality in the marine environment on fish and fisheries values are medium for species of conservation significance or migratory species, medium for commercial fisheries values, and low for all other values. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.13.2.4 Entrapment and direct contact with construction plant

Construction equipment required for the establishment of the reclamation bund walls includes trucks and a small number of excavators and/or dozers required to assist in the placement of material. Core material will be placed directly over the existing sediments and bund material will then be shaped by bulldozer, grader or long arm excavator depending on location and required bund profile. Armour material will then be placed along the seaward exposed face. Construction of the bund walls is to be undertaken over a three year period, and has the potential to entrap marine fauna species.

There is potential for fish and marine reptiles to be entrapped within the bund wall during construction. This is not expected to impact on the fish and marine reptiles until the dredging activities commence. Therefore, this impact is addressed under dredging activities in Section 9.13.3.3.

9.13.2.5 Potential increase in waste material and marine debris

Construction activities associated with the establishment of the WBE reclamation area and BUF will involve the generation of some waste material which has the potential to enter the marine environment (i.e. potential marine debris). Injury and fatality to vertebrate marine life as a result of ingestion, or entanglement in, harmful marine debris is listed as a key threatening process under the EPBC Act (DoEE 2016). Direct impacts to fish and marine reptiles from entanglement of anthropogenic debris is a well-documented source of injury and death (NOAAMDP 2014; Hardesty and Wilcox 2013).

Harmful marine debris is commonly associated with discarded fishing gear, but it may also include solid non-biodegradable floating materials and plastic garbage washed or blown from the land or vessels into the sea. This can include (but not limited to) plastic bags, bottles, food packaging, strapping bands, sheeting and synthetic ropes.

This Project activity, and the potential exposure of fish and marine reptiles to these impacts, will be within the short term and restricted to a contained area, therefore low in magnitude. There are no reef communities or declared FHAs within proximity of the WBE reclamation area and BUF, therefore impacts on these values is expected to be negligible for this Project activity.

Mitigation measures to minimise and avoid waste materials entering the marine environment during the WBE reclamation area and BUF establishment are included in Section 9.27 and the Project EMP (refer Appendix Q2).

During establishment of the WBE reclamation area and BUF, the post mitigation risk ratings associated with the potential increase in anthropogenic waste material and marine debris on fish and marine reptiles is low, and impacts on commercial and recreational fishing is expected to be negligible. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.13.2.6 Increase in hard substrate

The establishment of the WBE reclamation area will involve the construction of outer reclamation area bund walls, and internal bund walls for the management of dredging decant water. Part of the BUF outer wall will also be constructed of the same rock material. The construction of rock walls within the marine environment provides three dimensional artificial habitats in intertidal and subtidal areas which have the potential to promote species settlement such as algae, fish and sessile fauna such as corals. While it is expected to take several years for assemblages to reach high levels of diversity to sustain a significant ecological community, there is the potential for the proposed bund walls to provide a range of functional ecological values for a variety of reef and inshore associated fish and invertebrate species.

The creation of new rock wall habitat has the potential to lead to a localised increase in habitat and food availability for fish and marine reptile species and therefore adverse impacts on fish, fisheries values or other marine reptiles are not expected.

9.13.3 Dredging activities

9.13.3.1 Short term decline in water quality in the marine environment

The potential impacts to water quality as a result of dredging projects have been widely studied and water quality, in particular the presence of contaminants in water has been identified as a source of marine species illness, injury and death (refer Appendix I1 (Section 9)).

A detailed assessment of the potential impacts to water quality as a result of Project dredging activities is provided in Chapter 8 (water quality) and Appendix H1. This includes an assessment of the risk of dredging activities resulting in a decline in water quality, predominantly through increased turbidity, including:

- Dredging (i.e. turbidity generated at the dredger head, overflow and propwash)
- Dredging vessel movements
- Dredged material unloading and placement (e.g. potential bund wall seepage)
- Licenced discharge of dredging decant water from the WB and WBE reclamation areas.

Areas that provide important habitat to fish (i.e. outer reefs, seagrass) are sensitive to declines in water quality. In particular, the presence of elevated turbidly levels, limits photosynthetic process in both plants and the symbiotic algae contained within the tissue of corals by attenuating light reaching these organisms. In addition, sediments that settle upon living structures (i.e. living coral and sea grass) has the capacity to lead to anoxic conditions which negatively impact the living structure (McCook et al. 2015). However, despite this, the sensitivity of many important fish habitats vary widely, with inshore coral species being considered to be more tolerant of increasingly turbid conditions than their outer-reef cousins. In addition, certain species of seagrass are capable of surviving in light concentrations that are below that which is required for net photosynthetic gain for many weeks, using physiological and morphological adjustments to cope with the reduced light conditions (Chartrand et al. 2012; Mulligan 2009).

Other areas of fish habitat, such as mudflats, mangroves and seafloor habitats are generally considered to be relatively resilient to impacts associated with declines in water quality (McCook et al. 2015). Most inshore habitats have high levels of naturally occurring accumulated loose sediment which are considered important for sediment-dwelling infauna. However, whist many of these species are filter feeders and may benefit from low levels of supplementary suspended organic matter, higher levels may overwhelm their feeding strategies and may result in negative impacts (McCook et al. 2015). This may result in impacts to higher trophic levels with chronic exposure in the long term and subsequent species displacement/avoidance of the area.

In relation to fish, elevated turbidly may have the following direct impacts (McCook et al. 2015):

- Clogging of gills (at high levels)
- Degradation of pelagic habitat for those species that require clear water or feed upon plankton
- Prey advantages (cephalopods) or disadvantaged (fish) depending on their visual systems
- Predator/prey dynamic altered
- Planktivore feeding inhibited
- Changes in fish biomass.

In addition, the following indirect impacts associated with elevated turbidly may occur:

- Inhibition of visual predators
- Food limitation and decreased carrying capacity for planktivores
- Alteration of migration routes for clear water species
- Reduction in the numbers of herbivorous fish species
- Reduced ecosystem resilience.

Fish populations within areas impacted by a short term decline in water quality are unlikely to be physically harmed directly by the elevated turbidity generated by dredging activities. Evidence from other areas suggests that levels high enough to directly impact fish physiology will be limited to the immediate vicinity of the dredging and disposal operations (reviewed in McCook et al. 2015) and fish are known to demonstrate avoidance or escape responses at extreme turbidity levels which are likely to result in their physical harm.

Whilst direct impacts upon fish as a result of a short term decline in water quality are unlikely to result in a significant, long term impact, areas of important fish habitat such as seagrass meadows and reef systems are less likely to be as resilient. However, it is important to note that limited areas of deep water seagrass meadows were recorded in and around the areas to be dredged in 2002 (refer Sections 9.6 and 9.9). While some deep water seagrass meadows were recorded in the areas to be dredged in 2002, subsequent baseline seagrass surveys (i.e. 2009, 2013 and 2014) have not recorded seagrass in this area. In addition, reef systems have not currently been documented as occurring within either the Golding Cutting Channel or the Gatcombe Channel which will be subject to dredging activities (refer Sections 9.10 and 9.11).

Hydrodynamic modelling results for the Project are presented in Section 7.4, Section 8.6.2 and Appendix G, which provide an understanding of the spatial and temporal patterns of the dredging sediment plume and represent modelled turbidity, bed sedimentation (gross and net) and impacts to benthic light at sensitive receptors. The zone of moderate impact is a delineated geographical area in which continuous levels of turbidity, sedimentation or sediment deposition are such that they are likely to cause sub-lethal impacts to benthic primary producers and corals present in this area. The zone of low impact and zone of influence is a delineated geographical area in which continuous levels of turbidity or sediment deposition are such that they are likely to cause changes which will not result in detectable impacts to photosynthetic benthos (including corals) present in this area. It should be noted that declared FHAs (i.e. Del-ral-li (Calliope River), Rodds Harbour and Colosseum Inlet) are located outside of the predicted zone of influence.

Dredging activities that effect water quality will likely be contained to certain areas at any given time (i.e. only one dredger will be working at particular points within the areas to be dredged at any given time). The Dredging EMP will be implemented during dredging activities which will minimise and mitigate potential impacts to water quality from dredging activities. These plans include adaptive and reactive management measures to be adopted during dredging activities which will focus on minimising impacts at key FHAs, such as seagrass meadows (e.g. by focussing on benthic light thresholds) (refer Section 9.27). Mitigation measures to minimise water quality impacts are provided in Section 8.7, Section 9.27 and Appendix Q1.

Although Gladstone harbour is known to contain trace metals, metalloids and other contaminants (reviewed in McCook et al. 2015), sediment data associated with Gladstone dredging activities over the past 20 years indicate that significantly elevated levels of contaminants are not present within sediments throughout the Port of Gladstone. Therefore, exposure or disturbance of these sediments during dredging operations is not expected to result in toxicological impacts to fish (McCook et al. 2015).

Desktop and field geochemical investigations undertaken for the Project concluded that the marine sediments to be removed from the areas to be dredged are considered 'clean' as per NAGD (2009) and the potential for contaminants to be mobilised into the water column during dredging activities is considered to be low (refer Section 6.5 and Appendices E4 and E6). Based on these results the potential for fish, fisheries values and other marine reptiles to be impacted by contaminants from sediment to be dredged is also considered low.

Adaptive design measures will be implemented during the Project detailed design phase to reduce the potential impacts to water quality (refer Section 9.27). Project design of the WBE reclamation area will incorporate geotextile material to be placed within the inner face of the seaward bund wall in order to minimise the migration of dredged material fines through the bund wall to the marine waters of Port Curtis.

Furthermore, the location of the reclamation area licenced dewatering discharge point will be placed at a location where seagrass is not present (or have the potential to grow), to avoid potential impacts to important fish habitat through scouring of the seabed. The release of dredging decant waters will be controlled by a licenced discharge point and weir box with conditions which will dictate the water quality criteria to be met prior to discharge.

Mitigation measures to minimise the impact of short term declines in water quality during dredging activities on fish and marine reptiles are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

During dredging activities, the post mitigation risk ratings associated with impacts to fish and marine reptile values as a result of short term decline in water quality are medium for species of conservation significance or migratory species, medium for commercial fisheries values, low for recreational fishing and species not listed as having conservation significance, and negligible for all other fisheries values. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.13.3.2 Permanent loss and alteration of habitat

Approximately 12.6Mm^3 of seabed material will be removed from the channel duplication area to be dredged during dredging activities for the Project and approximately 0.25Mm^3 of material to be dredged for the barge access channel (refer Section 2.4).

The dredging activities will result in an unavoidable permanent loss of benthic substrate at the areas to be dredged as well as at the barge access channel. Significant areas of habitat for fish species of conservation significance or migratory marine fish species have not been identified within the direct impact areas.

There are no FHAs located within the Project's direct impact areas associated with dredging activities (refer Figure 9.41).

The direct disturbance areas for dredging activities include potential habitat for fish and marine reptile species, however, it is important to note that the deep water seagrass meadows mapped within the channel duplication area were last recorded there in 2002 (refer Sections 9.6 and 9.9). The areas to be dredged are not located in intertidal areas, and will therefore not directly impact on mangroves, and intertidal wetlands which are important fisheries habitats. Furthermore, no hard structure reef habitat is situated within the areas to be dredged (refer Section 9.11.3).

These potential impacts are expected to be temporary and will be within the local area, and are therefore negligible to low in magnitude.

Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of habitat loss at the areas to be dredged (refer Section 9.27). Project design will reduce, where practical, the permanent loss of fish and marine reptile values from the areas to be dredged.

During dredging activities, the post mitigation risk ratings associated with the direct loss and alteration of fish and marine reptile habitat are negligible for reef fish communities and low for all other fish and fisheries values. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.13.3.3 Entrapment and direct contact with construction plant

There is potential for fish and marine reptiles to be entrapped within the bund wall during construction (refer Section 9.13.2). This is not expected to impact on the fish and marine reptiles until the dredging activities commence. Once the dredging activities commence there is potential for any entrapped fish and marine reptile species to be injured (including mortal injuries) as a result of the placement of dredged material into the reclamation area, or due to the dewatering process (i.e. via asphyxiation of fish).

Mitigation measures to avoid injury or death to fish and marine reptiles occurring as a result of direct contact with construction plant or entrapment within a reclamation area are included in Section 9.27 and the Project EMP (refer Appendix Q2).

These potential impacts are expected to be temporary and are expected to be contained in extent, and are therefore low in magnitude.

The post mitigation risk ratings associated with the potential impact associated with entrapment of fish and marine reptile species during the construction of the WBE reclamation area is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.13.3.4 Potential noise and vibration impacts

Dredging activities will generate underwater noise at the areas to be dredged. This will form a persistent source of underwater noise and vibration, and will continue intermittently during dredging activities (though the vibration impacts are not considered to be substantial, and are not further assessed) (refer Chapter 13 and Appendix K2).

Increased underwater noise has the potential to be generated during dredging activities. Excessive levels of underwater noise have the potential to impact a variety of marine fauna, including fish and marine reptiles through:

- Trauma to hearing (temporary or permanent)
- Trauma to non-hearing tissue (barotraumas)
- Alteration of behaviour (e.g. avoidance of predators, interfering with the acquisition of prey or mates, and displacement from essential habitat areas)
- Masking of biologically significant sounds (BOEM 2014; McCarthy 2004; Slade and Dunlop 2014).

Popper et al. (2014) identifies several categories of fish for the purpose of analysing the potential effects of sound, including:

- Fish with no swim bladder or other gas chamber – these species only detect particle motion, not sound pressure, and are less susceptible to barotrauma than other categories of fish
- Fish with swim bladders in which hearing does not involve the swim bladder – these species are susceptible to barotrauma, even though their hearing involves only particle motion, not sound pressure

- Fish in which hearing involves a swim bladder or other gas volume – these species are susceptible to barotrauma, and can detect sound pressure as well as particle motion
- Fish eggs and larve.

Marine animals vary in their sensitivities to underwater noise with ear anatomy, frequency range and amplitude sensitivity each playing a role (Ketten 1998). A detailed review of underwater sound propagation, natural and anthropogenic sources of marine noise, and the potential vulnerabilities of receptors (i.e. marine fauna) of interest is provided in Chapter 13 and Appendix K2.

Baseline underwater noise modelling undertaken (refer Chapter 13 and Appendix K2) estimates underwater noise generated by dredging activities is above ambient underwater noise sources (e.g. shipping, waves). At distances less than approximately 500m from dredging activities, it is possible that elevated levels of dredger noise greater than ambient underwater noise (waves, shipping) may result in impairment to communication and/or bio-sonar function and associated behavioural displacement. Given the mobile nature of fish and marine reptiles, it is unlikely that they would remain stationary near dredging operations to be affected by TTS.

The risk of underwater noise generated through dredging activities causing acute damage to fish and marine reptiles is considered low. Intermittent cumulative increases to ambient underwater noise is also considered to be low. Potential impacts associated with increased underwater noise during dredging activities may occur over the short term and are expected to be contained in extent, and are therefore low in magnitude. These impacts are not expected to have an impact on the FHAs as they are situated outside of the areas to be dredged.

Mitigation measures to reduce the impacts of underwater noise on fish, fisheries values and other marine reptiles during dredging activities are included in the Dredging EMP (refer Appendix Q1).

During dredging activities, the post mitigation risk ratings associated with noise and vibration impacts on fish and marine reptiles are low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.13.3.5 Potential vessel strike impacts

Within eastern Australian waters, boat strikes are responsible for injuries and death marine species, including sharks to differing degrees (DoE 2007). As such, vessel movements associated with dredging activities within Port Curtis pose a potential risk to the fish species of conservation significance and migratory species (i.e. sharks and rays).

The Port of Gladstone currently experiences a high volume of commercial and recreational vessel traffic. The nature, scale and volume of Project vessel movements are considered minor compared to the existing Port vessel movements. It should be noted that vessel numbers required to complete the Project will be considerably lower than those required for the LNG developments on Curtis Island and the associated Western Basin capital dredging. Dredging vessel movements include TSHD, CSD, barges, pushbusters, tugs and other support vessels.

Studies regarding marine mammals suggest that the risk of boat strike is considerably reduced when vessel speeds are below 10 knots, allowing sufficient time for both marine species and vessel operators to avoid collision (SKM 2014; Hazel et al. 2007). Larger vessels such as dredgers, pushbusters with barges and work boats are slow-moving and are not likely to present a significant threat to species in the area, while smaller work boats capable of travelling at faster speeds may present a higher risk.

These potential impacts may occur over the short term and are expected to be contained in extent, and are therefore low in magnitude.

Mitigation measures to reduce the risk of vessel strike on fish and marine reptiles during dredging activities are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

The post mitigation risk ratings associated with impacts to fish species of conservation significance, migratory species, common fish species and other marine reptile species as a result of vessel strike during dredging activities are low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.13.3.6 Direct contact with dredging equipment

The risk of fish and marine reptile species coming in direct contact with dredging equipment is likely to depend on the type of dredging plant being used and mitigation measures implemented. A TSHD poses a greater risk to marine animals, often resulting in injury or death, as TSHDs are slow-moving, quiet and have strong suction power at the draghead (Goldberg et al. 2015).

Despite the risk of dredging activities to many marine species, the *Vulnerability Assessment for the Great Barrier Reef* (GBRMPA 2012d; GBRMPA 2013) does not list dredging activities *per se* as a concern for sharks and rays (i.e. species of conservation significance and migratory species).

This Project activity and potential exposure of fish and marine reptiles to these impacts will be temporary and within a contained extent and therefore low in magnitude.

Mitigation measures to reduce the risk of injury or death to marine fish and marine reptiles occurring as a result of direct contact with dredging equipment, or entrainment during dredging activities are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

During dredging activities, the post mitigation risk ratings associated with impacts to species of conservation significance, migratory fish and marine reptiles, as well as common fish species and marine reptiles, due to direct contact with dredging equipment are low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.13.3.7 Potential artificial lighting impacts

Artificial lighting will be required for safety and navigation during night time hours on dredgers and work boats for dredging activities and at the BUF and reclamation areas during night time unloading and placement operations which will generate minor light spillage into the marine environment.

Phototaxis in marine fish and invertebrates has been well documented, however the direction of response can be specific to species and life stage (McConnell et al. 2010). Artificial illumination at night has been shown to result in an increased presence of invertebrates, fish larvae and juvenile fish. Importantly primary prey species of many fish (e.g. larvae of the mollusc groups Gastropoda and Bivalveia) have been documented as having a positive phototaxis responses (McConnell et al. 2010).

Due to the low levels of light spill into the marine environment, and the short term nature of potential impacts, dredging activities are expected to pose negligible risk to fish and marine reptiles.

Mitigation measures to minimise the potential impacts associated with artificial light sources from the dredging activities are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

9.13.3.8 Increase in waste material and marine debris

Project dredging activities have the potential for some waste material (e.g. marine debris) to enter the marine environment. Direct impacts to fish and marine reptiles from entanglement of marine debris is a well-documented source of injury and death (NOAAMDP 2014).

This Project activity and potential exposure of fish and marine reptiles to these impacts will be within the short term and restricted to a contained area, therefore low in magnitude. These impacts are not expected to have an impact on the FHAs as they are situated outside of the areas to be dredged and the reclamation area.

Mitigation measures to minimise and avoid waste materials entering the marine environment during the dredging are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

During the dredging activities, the post mitigation risk ratings associated with a potential increase in waste material and marine debris on fish and marine reptile values are low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.13.4 Removal and installation of navigational aids

9.13.4.1 Potential noise and vibration impacts

The installation of navigational aids will involve use of a hydraulic piling hammer that is anticipated to generate the highest levels of underwater noise, approximately 204dB for the impact piling and 168dB for the piling barge, during the Project activities (refer Chapter 13 and Appendix K2). As stated in Section 9.13.2.2, excessive levels of underwater noise have the potential to impact a variety of marine species, including fish and marine reptiles. The specific size of the Junttan hydraulic hammer is expected to be in the range of 124dB. Two existing navigational aids will be removed and five existing navigational aids will be removed and reinstalled using a barge and pile extractor.

The installation of new navigational aids (i.e. piling) is estimated to take two to three days per pile. Installation is anticipated to be undertaken during daylight hours over a period of two to three months with hammering undertaken intermittently. An assessment of underwater noise and vibration baseline levels along with predicted noise and vibration impacts from installation of the navigational aids were modelled (refer Chapter 13 and Appendix K2). The following criteria were modelled as part of this assessment:

- Range of SEL levels for impact piling and operation of the piling barge
- Noise sources, including Junttan hydraulic impact hammer use and piling barge operation supporting navigational aid installation
- Noise generating mechanisms of impact piling and propeller/thruster use
- Modelled point source depths of ‘mid water column’ and ‘near surface’
- Multiple pulses, non-pulses and continuous noise types.

Estimates of the underwater noise generated from the installation of navigational aids range from 15dB (RMS SPL parameter) and 28dB (peak SPL parameter) for distances closer than 2km to the source, whilst for distances further than 10km away an estimation of 10dB is derived.

Noise emitted from a single piling strike associated with the removal and installation of the navigational aids is expected to cause injury for fish species within a distance of 35m from source location. Avoidance of source location is predicted to occur from distances up to 3.4km and behavioural changes for distances up to 5.5km is expected (refer Section 13).

Fish species zone of impact for cumulative SEL levels are up to a distance of 80m for injuries with exposure duration of 10 minutes, 1 hour exposure duration will require a distance greater than 270m to avoid potential mortal injury and up to 500m for recoverable injuries for the same exposure duration (SLR 2019b). TTS-onset threshold for fish species is much lower than physical injury with exposure duration of 10 minutes having a potential zone of impact up to a distance of 1.8km and 1 hour exposure duration up to a distance of 4.2km from source location (SLR 2019b) (refer Section 13).

However, as noted in Section 9.13.3.3, controlled experiments conducted overseas using playback, indicate that fish exhibit avoidance behaviour to loud noise associated with anthropogenic construction activities within in a natural setting (Mueller-Blenkle et al. 2010) and are therefore, likely to move away from the areas of noise generation before they are subject to physical harm. It is important to note that there has been minimal research undertaken within Australian waters related to the impacts of noise and vibration upon marine fish within a natural setting.

This Project activity and potential exposure to fish and marine reptiles to these impacts will be temporary and with the local area, therefore low in magnitude.

Mitigation measures to minimise potential impacts associated with noise and vibration during the removal and installation of navigational aids are included in Section 9.27 and the Project EMP (refer Appendix Q2).

The post mitigation risk ratings associated with an increase in potential noise and vibration impacts during dredging activities on fish and marine reptile values are medium for species of conservation significance or migratory species, medium for commercial fisheries values, medium for reef fish communities, and low for other fish and fisheries values.

Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.13.4.2 Direct contact with construction plant

Vessel activity associated with the removal and installation of navigational aids has the potential to pose a risk to marine fish and marine reptiles in Port Curtis. The potential impacts to fish and marine reptiles as a result of vessel strike and direct contact with construction plant are discussed in Sections 9.13.3.5 and 9.13.3.6, respectively. The sources of potential impact and the resultant impacts on fish and marine reptiles are consistent with the discussion in these sections; however, due to the temporary nature of this activity it is expected that the potential risk to fish and marine reptiles will be negligible.

Port Curtis currently experiences a high volume of commercial and recreational vessel traffic and the addition of the Project vessels will not significantly increase the risk of vessel strike to marine fish and marine reptiles the overall existing risk that exists in Port Curtis and is therefore considered negligible as a result of the Project activities.

9.13.4.3 Potential artificial lighting impacts

Artificial lighting on the Project navigational aid vessels will be required for safety and navigation. The removal and installation of navigational aids is not proposed to occur outside of daylight hours. The artificial lighting risk to marine fish and marine reptiles during this Project activity is therefore negligible.

9.13.5 Stabilisation and maintenance activities

9.13.5.1 Short term decline water quality in the marine environment

Release of contaminants

The use of vehicles during surface stabilisation and maintenance works at the WB and WBE reclamation areas has the potential to result in the release of contaminants (e.g. hydrocarbons). The release of contaminants may lead to the degradation of intertidal or subtidal habitats in adjacent marine environments and potential impacts on marine life, including fish and marine reptiles via direct contact with contaminants or the ingestion of contaminated food. Potential impacts on fish and marine reptiles as a result short term declines in water quality in the marine environment associated with the establishment of the WBE reclamation area are discussed in Section 9.13.2.3, and similar impacts are expected to occur as a result of stabilisation and maintenance activities.

This Project activity and potential exposure of fish and marine reptiles to these impacts will be within the short term and within a contained extent, and therefore low in magnitude.

Mitigation measures to avoid contaminant releases impacting fish and marine reptiles and their associated habitat during surface stabilisation and maintenance works at the WB and WBE reclamation areas are included in Section 9.27 and the Project EMP (refer Appendix Q2).

The post mitigation risk ratings associated with the release of contaminants on conservation and migratory, common fish, and marine reptile species are low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Soil erosion and sedimentation

Soil erosion of the final Project landform and possible sedimentation have the potential to have an impact on the quality of adjacent intertidal and subtidal habitats that are considered important resources for fish. Potential impacts on fish and marine reptiles as a result short term declines in water quality in the marine environment associated with the establishment of the WBE reclamation area are discussed in Section 9.13.2.3, and similar impacts are expected to occur as a result of stabilisation and maintenance activities

This Project activity and potential exposure to fish and marine reptiles to these impacts will be within the short term and within a contained extent, and therefore low in magnitude.

Mitigation measures to reduce the potential impacts of soil erosion and runoff on fish and marine reptiles (and their associated habitat) during surface stabilisation and maintenance works at the WB and WBE reclamation areas are included in Section 9.27 and the Project EMP (refer Appendix Q2).

The post mitigation risk ratings associated with potential impacts of a release of sediment laden runoff to marine waters on fish and marine reptiles during maintenance activities on the final Project landform are low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.13.5.2 Potential artificial lighting impacts

Artificial lighting on the stabilisation and final Project landform will be required for safety. The maintenance activities on the final Project landform works are not proposed to occur outside of daylight hours. The artificial lighting risk to fish and marine reptile species during this Project activity is therefore negligible.

9.13.6 Threatening processes for species of conservation significance and migratory species

Threatening processes which may lead to the progressive loss of species of conservation significance or migratory species, including ecologically significant habitat, have been assessed with regards to the potential Project impacts. Threatening processes for species of conservation significance or migratory fish or other marine reptiles (excluding marine turtles) which have been confirmed to occur, or are considered to have a high or moderate likelihood of occurrence within the Project impact areas (refer Appendix I1 (Appendix B)), have been identified from the relevant species recovery plan, conservation listing advice and/or threat abatement plan.

The potential Project impacts which have been provided in Sections 9.13.2 to 9.13.5 have been assessed with regard to their potential contribution to the species threatening processes (refer Appendix I3).

Residual impacts on a threatening process have the potential to result where an impact has a high or very high risk rating. Fish or other marine reptile (excluding marine turtle) species for which potential Project impacts are considered to have a residual impact on a threatening process which may lead to the progressive loss of the species or ecologically significant habitat (refer Appendix I3), will be subject to a significant residual adverse impact assessment. The significant residual adverse impact assessment is provided below.

9.13.7 Significant residual adverse impact assessment

A significant residual adverse impact assessment has been conducted to identify if the Project will, or is considered likely to have, a significant residual adverse impact on any fish or other marine reptile (excluding marine turtle) value which is defined as a MNES or MSES. The significant residual adverse impact assessment included in this section has been conducted in accordance with the *Matters of National Environmental Significance Significant Impact Guidelines, Version 1.1* (DoE 2013) and the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (EHP 2014a).

A significant residual adverse impact assessment has been conducted for fish or other marine reptile (excluding marine turtle) species which are considered to have a moderate or high likelihood of occurrence within the Project impact areas (refer Appendix I1 (Appendix B)).

This assessment of significant residual adverse impacts considers the significance of potential Project impacts after the implementation of the Project mitigation measures included in Section 9.27, the Dredging EMP and Project EMP (refer Appendices Q1 and Q2, respectively).

Section 9.13.1.2 includes the fish or other marine reptile (excluding marine turtle) species which are subject to this significant residual adverse impact assessment, due to Project impacts having the potential to result in:

- Very high or high risk (post mitigation measures) on a species (refer Sections 9.13.2 to 9.13.5), and/or
- A residual impact to a key threatening process (refer Appendix I3 (Item 2.0)).

The MNES significant impact assessment criteria for listed and migratory species (DoE 2013) and the significant impact assessment criteria for protected wildlife habitat (EHP 2014a) has been used for the significant residual adverse impact assessment (refer Table 9.52). For the purposes of the significant residual adverse impact assessment, the species listed in Section 9.13.1.2 have been considered together as 'Chondrichthyan species', as all species are all contained within this broader scientific classification (i.e. class containing cartilaginous fish).

The significant residual adverse impact assessment concluded that the proposed Project activities will not have a significant residual adverse impact on fish or other marine reptile (excluding marine turtle) species.

Table 9.52 Significant residual adverse impact assessment – Fish and marine reptiles (excluding marine turtles) species

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ▪ Lead to a long term decrease in the size of a population of a species ▪ Reduce the area of occupancy of the species ▪ Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline ▪ Adversely affect habitat critical to the survival of a species ▪ Substantially modify (including by fragmentation, altering fire regimes, alerting nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species **MSES significant impact assessment criteria – Protected wildlife habitat:** ▪ Lead to a long term decrease in the size of a local population ▪ Reduce the extent of occurrence of the species ▪ Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
Unlikely to have a significant impact The Chondrichthyan species subject to this assessment are pelagic, mobile species which are widely distributed in Australian waters. The inshore region of Port Curtis provides potential habitat for juvenile, sub-adult and adult Chondrichthyan species in the form of nursery grounds and foraging habitat. The construction of the WBE reclamation area will result in the direct and permanent loss of potential habitat for the Estuary stingray, though is unlikely to be potential habitat for other Chondrichthyan species known or likely to occur in the Project impact areas. Dredging activities will result in the temporary loss of potential habitat for Chondrichthyan species associated with the shipping channels and the barge access channel. This temporary loss is not expected to result in significant impacts on these species as the areas to be dredged are not known to be ecologically significant or important habitat. The Project activities may also result in underwater noise impacts and short term declines in water quality, however, with the implementation of the Dredging EMP (refer Appendix Q1) and the Project EMP (refer Appendix Q2), these potential impacts are not likely to impact on the size of a population, area of occupancy or important habitat for Chondrichthyan species. The primary foraging resources for the Chondrichthyan species included in this assessment are defined by common and widespread species, including zooplankton, benthic macroinvertebrates, crustaceans and fish. The Project will have a potential impact on intertidal foraging resources within the WBE reclamation area and BUF, however with respect to the non-specific nature of the foraging resources, the mobility of the Chondrichthyan species subject to this assessment and that the works will not isolate species movement, the Project is not anticipated to have a significant impact on the foraging resources for the species. It is important to note that no part of Port Cutis is listed as an area of identified habitat critical to the survival of the Chondrichthyan species included in this assessment, as per any applicable recovery plans or conservation advice documents. Proposed works within the Project impact areas are not anticipated to cause disruption to ecologically significant locations for the Chondrichthyan species included in this assessment. Consequently, the removal of potential species habitat is not considered likely to reduce the viability of local species assemblages, impacting on their extent of occurrence or leading to a long term population decrease in the local region.
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ▪ Fragment an existing population into two or more populations **MSES significant impact assessment criteria – Protected wildlife habitat:** ▪ Fragment an existing population ▪ Result in genetically distinct populations forming as a result of habitat isolation
Unlikely to have a significant impact Chondrichthyan species are considered to be highly mobile species which do not require the provision of specific shelter or microhabitat resources to facilitate movement across the landscape. The Project is considered unlikely to create a significant barrier to species movement through the marine environment or fragment cartilaginous fish populations. The Project activities are not anticipated to result in genetically distinct populations forming as a result of habitat isolation.
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ▪ Disrupt the breeding cycle of a population ▪ Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species
Unlikely to have a significant impact The Chondrichthyan fish species included in this assessment are pelagic and mobile species which give birth to live young. As such, the species do not require specific microhabitat features to facilitate breeding activities. The proposed works within the Project impact areas are not considered to result in a significant impact on areas critical to species breeding. As such, the Project is not anticipated to have a significant impact on the breeding cycle of species populations.

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
The establishment of the WBE reclamation area and BUF and Project dredging activities have the potential to result in underwater noise impacts. These potential noise impacts may alter the behaviour patterns of fish and result in modification of fish behaviour, however, these impacts will be temporary to short term in nature and within a contained extent. Given the mobile nature of these species, and the absence of ecologically significant or important habitat within the Project impact areas, it is expected that Chondrichthyan fish species will temporarily avoid the Project impact areas during periods of peak underwater noise production. Underwater noise impacts will be managed with the implementation of the appropriate mitigation measures contained in the Dredging EMP (refer Appendix Q1) and the Project EMP (refer Appendix Q2). As such, potential impacts are unlikely to have a significant impact on Chondrichthyan fish species.
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ▪ Result in invasive species that are harmful to an endangered, vulnerable or migratory species becoming established in the species' habitat **MSES significant impact assessment criteria – Protected wildlife habitat:** ▪ Result in invasive species that are harmful to an endangered or vulnerable species becoming established in the endangered or vulnerable species' habitat
Unlikely to have a significant impact Invasive species have not been identified as a key threatening process for the Chondrichthyan species subject to this assessment (DES 2017; DSEWPC 2013; GBRMPA 2012d; GBRMPA 2013). However, the introduction and/or spread of invasive species have the potential to adversely impact Chondrichthyan species via increased competition for resources or predation pressures. With the implementation of the mitigation measures included in the Dredging EMP (refer Appendix Q1) and the Project EMP (refer Appendix Q2), it is unlikely that Project activities will result in the introduction or spread of invasive species harmful to Chondrichthyan species.
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ▪ Introduce disease that may cause the species to decline **MSES significant impact assessment criteria – Protected wildlife habitat:** ▪ Introduce disease that may cause the species to decline
Unlikely to have a significant impact The nature of the Project activities is considered unlikely to introduce disease that may cause species decline. The Dredging EMP (refer Appendix Q1) and Project EMP (refer Appendix Q2) will be implemented to minimise the potential introduction of disease to the area which have the potential to cause species decline.
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ▪ Interfere with the recovery of the species **MSES significant impact assessment criteria – Protected wildlife habitat:** ▪ Interfere with the recovery of the species
Unlikely to have a significant impact Following review of the relevant conservation advices, recovery plans and threat abatement plans for the Chondrichthyan species subject to this assessment, injury and mortality as a result of bycatch in recreational and commercial fishing operations has been identified as a key threatening process to the species (DES 2017; DSEWPC 2013c; GBRMPA 2012d). The Project will not contribute to this threatening process. Declining water quality is another key threatening process common to the Chondrichthyan species subject to this impact assessment (DES 2017; DSEWPAC 2013; GBRMPA 2012d; GBRMPA 2013). Short term declines in water quality are likely to occur as a result of Project activities. These potential impacts will be minimised through the implementation of mitigation measures on the Dredging EMP (refer Appendix Q1) and Project EMP (refer Appendix Q2). Therefore, potential impacts as a result of declines in water quality are not likely to interfere with the recovery of Chondrichthyan species subject to this assessment.

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
Desktop and field geochemical investigations undertaken for the Project concluded that the marine sediments to be removed from the areas to be dredged are considered 'clean' as per NAGD (2009) and the potential for contaminants to be mobilised into the water column during dredging activities is considered to be low (refer Section 6.5 and Appendices E4 and E6). Adaptive design measures will be implemented during the Project detailed design phase to reduce the potential impacts to water quality (refer Section 9.27). Project design of the WBE reclamation area and BUF will incorporate geotextile material to be placed within the inner face of the seaward bund wall reclamation area in order to minimise the migration of dredged material fines through the bund wall to the marine waters of Port Curtis. The release of dredging decant waters will be controlled by a licenced discharge point and weir box with conditions which will dictate the water quality criteria to be met prior to discharge.

9.13.8 Assessment summary

To describe the fish and marine reptile assemblages and key habitat values within the Project impact areas, a review of Government databases, scientific literature and recent ecological surveys was conducted. The Project impact areas, include intertidal and subtidal environments which provide potential habitat for species of conservation significance, including Chondrichthyan fish species (e.g. sharks and rays) as well as significant fisheries resources (e.g. nursery grounds, foraging resources and a variety of fish habitats).

Port Curtis is important in terms of its commercial and recreational fisheries, and contains ecologically important fisheries habitats including the declared FHAs located at Colosseum Inlet, Rodds Harbour, and the upper reaches of the Calliope Creek. In addition, areas of significant inshore fish habitat in the form of seagrass meadows, mangrove communities, estuaries and coral reef communities are present within the Port.

The FHAs are not located in the Project direct impact areas, and are not expected to be significantly impacted as a result of the Project activities. The nearest FHA to the Project impact areas is the Dē-răl-lĭ (Calliope River) FHA which is situated approximately 15km to the east of the areas to be dredged for the barge access channel.

The Port Curtis region provides habitat for commercial and recreationally valuable fish, prawns and other marine reptiles, including species of conservation significance such as the Estuary stingray. These species rely on these habitats within Port Curtis for fish nurseries, maintenance of biodiversity and conservation of fisheries stock (Seitz et al. 2013; Hutchinson et al. 2014; NPRSR 2014a). Whilst the direct loss of inshore habitat from the establishment of the WBE reclamation area has the potential to impact on fisheries values, due to the extent of other Port Curtis seagrass meadows, mangrove communities and other inshore areas identified as having fisheries importance, this Project direct loss of inshore habitat will not result in any significant adverse impacts on Port Curtis fisheries.

The establishment of the WBE reclamation area and BUF will result in the direct and permanent loss of 278ha of intertidal and subtidal habitat. This represents potential habitat for the Estuary stingray which is of conservation significance and is listed under the provisions of the NC Act. The WBE reclamation area and BUF is not likely to be habitat for other species of conservation significance and/or migratory species. Given the availability of similar intertidal and subtidal habitats within adjacent areas (i.e. The Narrows, Graham's Creek) and the broader Port Curtis region, it is unlikely that this loss of potential habitat will have a significant impact on species of conservation significance and/or migratory fish species.

During dredging activities a short term decline in water quality is expected to occur in the form of increased turbidity caused by sediment resuspension predominately concentrated in and around the areas to be dredged (referred to as the ‘zone of high impact’ and ‘zone of moderate impact’). Increased turbidity has the potential to impact upon fish, fisheries values and other marine reptiles either directly, through exposure to contaminants or indirectly, through habitat loss. Given the location of the zones of high or moderate impact, the temporary nature of the dredge plume, and the highly mobile nature of fish species, it is not expected that the water quality impacts will have a significant or long term impact on fish, other marine reptiles and fisheries values.

Other water quality impacts also have the potential to occur as a result of WBE reclamation area and BUF construction through suspended sediments in the water column increasing light attenuation and reducing benthic light reaching key habitats within coastal and estuarine areas. Smothering of sessile benthic organisms causing epiphytic growth through sediment deposition will also impact habitats such as seagrass meadows (Erftemeijer and Lewis 2006; Sofonia and Unsworth 2010). However, with the implementation of mitigation measures outlined in the Dredging EMP (refer Appendix Q1) and the Project EMP (refer Appendix Q2), these impacts are expected to occur within a contained extent and are likely to be temporary in nature.

An increase to underwater noise and vibration (above background levels) has the potential to occur through Project activities, including construction of the WBE reclamation area and BUF (i.e. rock dumping), piling associated with the BUF construction, dredging activities, and piling of new piles for navigational aids. It is unlikely that temporary or permanent hearing trauma will result from these activities although an alteration in behaviour (e.g. avoidance) is possible for fish and marine reptiles.

Other unmitigated Project activities have the potential to result in the injury or death to fish and marine reptiles through an increase of waste materials entering the marine environment (i.e. ingestion or entanglement marine debris), vessel strike or direct contact with construction plant or entrapment in reclamation areas.

The Project will implement mitigation measures outlined in the Dredging EMP and Project EMP (refer Appendices Q1 and Q2, respectively), and associated management plans, to reduce the likelihood and magnitude of potential Project impacts on fish and marine reptiles. The implementation of mitigation measures contained in these EMPs will reduce residual Project impacts on fish and marine reptiles.

The potential for a Project impact to have a residual impact and contribution to a fish and marine reptiles species threatening process has been assessed for species of conservation significance and/or migratory fish species which have been confirmed to occur, or are considered to have a high or moderate likelihood of occurrence within the Project impact areas. A significant residual adverse impact assessment was conducted for the species where the Project has the potential to result in a residual impact on a species of conservation significance (leading to the progressive loss of the species or areas of ecologically significant habitat).

The significant residual adverse impact assessment concluded that the proposed Project activities are unlikely to result in a significant residual adverse impact on fish and marine reptile species in the area.

9.14 Soft sediment habitats and benthic macroinvertebrates – existing environment

9.14.1 Background

Macroinvertebrates are animals without backbones that can be observed by the naked eye (> 500 micrometres (µm)). Benthic macroinvertebrate communities within a marine estuary are made up of those organisms dwelling on the sediment surface (i.e. epifauna) and those which are buried within the sediment (i.e. infauna), which utilise the surface and subsurface sediment area for feeding and habitat. These communities encompass a diverse range of fauna comprising several types of feeding groups such as deposit-feeders, filter-feeders, grazers and predators, and include crustaceans (e.g. crabs; shrimp); gastropods (e.g. molluscs; clams); polychaetes (e.g. bristle worms); echinoderms (e.g. sea stars); ascidians (e.g. sea squirts); anemones (e.g. corals; sea pens); sponges; and bryozoans.

Benthic macroinvertebrate communities are an essential component of all estuarine ecosystems and play an important role in ecological processes such as nutrient recycling (enhancing nitrification and denitrification) and maintaining water quality (Currie and Small 2005). They also serve as an important food source for higher trophic levels such as shorebirds and fish species (Currie and Small 2006).

The distribution of benthic macroinvertebrate species is controlled by a number of environmental variables, including sediment particle size, contaminant concentrations, water quality and biological factors such as competition and predation (Peeters et al. 2004). The dynamics of benthic fauna reflect the impacts of abiotic, biotic and anthropogenic influences (Currie and Small, 2005; 2006), therefore macroinvertebrate communities are commonly used in studies as biological indicators of ecological change (Stewart et al. 2000).

The methodology implemented to describe the soft sediment habitats and benthic macroinvertebrates values is provided in Appendix I1 (Section 11.2).

9.14.2 Soft sediment and macroinvertebrate values

9.14.2.1 General context

Soft sediment benthic habitats in Port Curtis are well studied both temporally and spatially. Surveys undertaken as part of the long term Port Curtis Macrobenthic Monitoring Program between 1995 and 2005 (Alquezar, Small and Stratford 2006) for the Port of Gladstone and Queensland Energy Resources Limited (QERL), collected a total of 12,113 organisms from 418 taxa throughout the Port (Alquezar, Small and Stratford 2006).

In 2002, Port Curtis and Rodds Bay seagrass and benthic macroinvertebrate community baseline surveys (Rasheed et al. 2003) commenced, including surveys of areas extending into coastal waters out to Port limits. The baseline survey found that there was an obvious distinction in the density and diversity of benthic macroinvertebrate communities between the inner Port area (inside Facing Island) and the Outer Harbour zone and coastal waters (refer Figure 9.57).

The most complex and diverse benthic macroinvertebrate communities occurred in the inner Port area around the maintained shipping channels. The Western Basin zone of the Port consisted of medium to high density macroinvertebrate communities comprising rubble reefs with a high abundance of bivalves, ascidians, bryozoans and hard corals. The maintained shipping channels from Targinie Channel up to Clinton Channel contained some of the highest density communities containing scallop and rubble reefs with a high abundance of bivalves and mixed reef taxa (e.g. sponges, soft coral, hard coral, hydroids, bryozoans and gorgonians).

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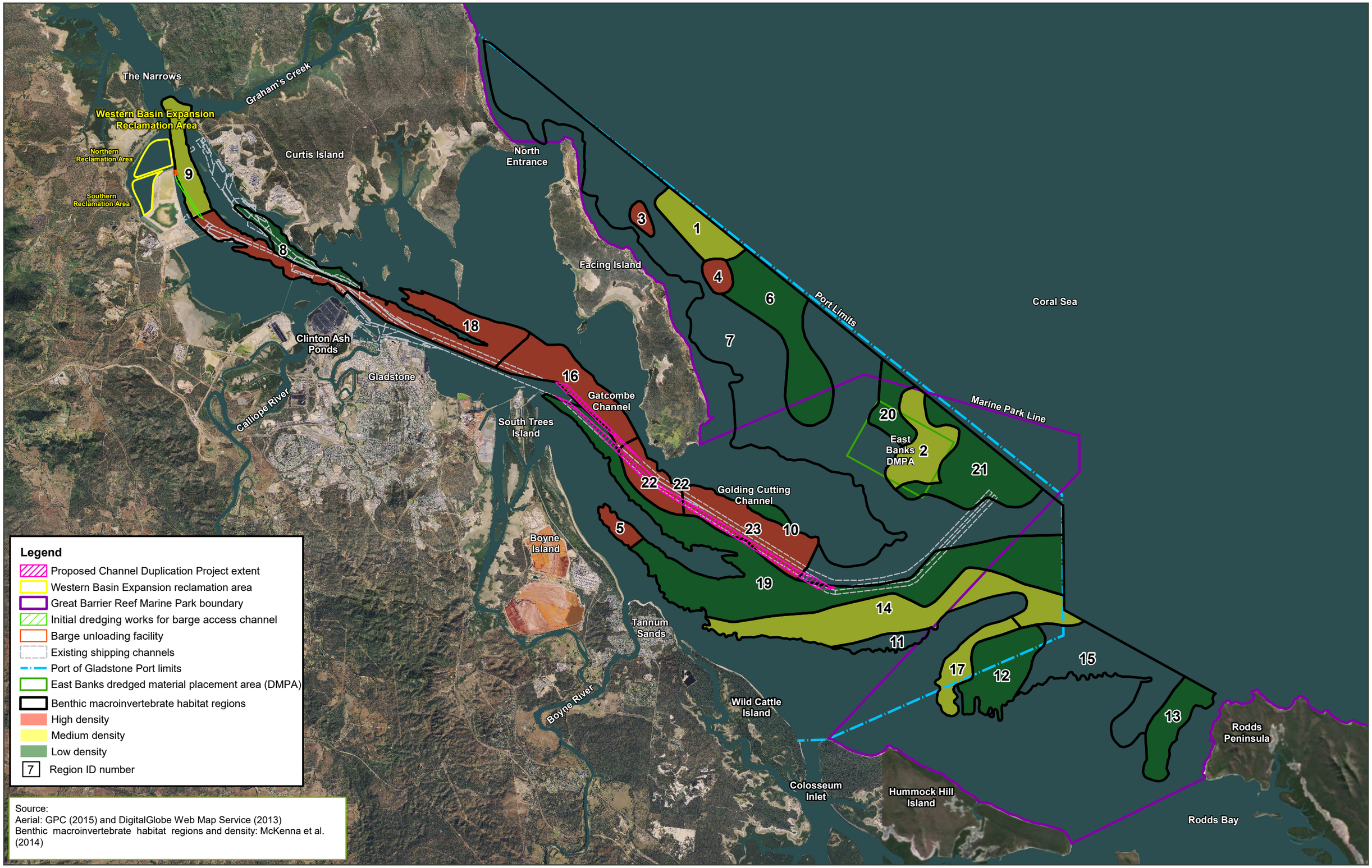

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Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.57: Location, density and distribution of benthic macroinvertebrates (November 2002)

The higher diversity of benthic life in the shipping channels of the inner Port at the time of the 2002 study was attributed to the high currents flowing through these channels, compared with the open substrate areas outside of Facing Island. The benthic communities in these inner Port areas were dominated by filter feeding species such as sponges, gorgonians and bivalves, taxa which tend to thrive in high current environments (Rasheed et al. 2003).

Benthic habitat surveys conducted for Port Curtis by McKenna et al. (2013) (refer Appendix I2 (Appendix D)) identified approximately 90,692ha of deep water benthic macroinvertebrate habitat within Port Curtis (i.e. in areas ≥ 6m). The Project direct impact areas (WBE reclamation area, BUF, barge access channel and channel duplication area) cover approximately 681.58ha of potential soft sediment and benthic macroinvertebrate habitat, representing approximately 0.75% of the available soft sediment habitat resource in Port Curtis (note that this is a conservative estimate as this value is based on areas of deep water benthic macroinvertebrate habitat only).

9.14.2.2 Summary of results from the Project EIS baseline assessment and transect data

The Port Curtis region benthic macroinvertebrate baseline assessment undertaken in November 2013 found that the region supports a diverse range of benthic community types that are typical of communities found in offshore and near shore subtidal areas elsewhere in Queensland such as Hay Point (Thomas and Rasheed 2011), Abbot Point (McKenna et al. 2013a) and Cairns (McKenna et al. 2013b). The area surveyed is shown in Figure 9.58.

Typically, the majority of these areas are dominated by open substrate with a low to medium density of benthic communities, which differed from the 2002 survey. The diversity and density of benthic macroinvertebrates was similar between the inner Port area (inside Facing Island) and the outer Port (outside Facing Island) (McKenna et al. 2014).

Medium densities of habitat-forming benthos and benthic invertebrates were also found in the area to be dredged. Macroinvertebrates tended to be concentrated around habitat-forming ‘live’ and dead rock/rubble and reef. This association tended to be the driver behind the patches of higher biodiversity and density observed in the 2013 survey area.

The benthic macroinvertebrate communities in the 2013 survey area were dominated by filter feeding and suspension feeding species such as polychaetes, bryozoans, hydroids and bivalves. Elevated suspended material can result in the death of benthic fauna through congestion of feeding mechanisms and smothering, especially in filter-feeding organisms that occurred in the 2013 survey such as polychaetes, bivalves and bryozoans (Cruz-Motta and Collins 2004; Erftemeijer and Lewis 2006). Some species tend to be more sensitive than others to burial and increases in turbidity (Cruz-Motta and Collins 2004).

Although only low to medium density regions of benthic macroinvertebrates occurred in the 2013 survey area, which differed from the 2002 survey, the value of these communities in supporting fisheries and biodiversity values should still be considered. Benthic fauna are a source of food for many marine consumers (Miller et al. 2003). Benthic fauna also forms a link between habitat substrata, detritus-based food chains and larger carnivores (Posey et al. 1997).

During investigations undertaken by VE (2015b) for the Project EIS, a total of 5,043 macroinvertebrate infauna were collected at all locations sampled. Sampled macroinvertebrates represented 162 different families and 18 phyla, 40% of which were identified during the dry season survey and 60% of which were identified during the wet season survey. The most common taxa sampled included the Polychaete (*Maldane sarsi*) (11%), the Brittle star (*Ophiuroidea* sp.) (6%), the Unsegmented marine worm (*Sipuncula* sp.) (6%) the Ascidian ball (*Ascidiacea*) (5%), and the Polychaete worm (*Syllidae* sp.) (5%) (refer Photograph 9.8).

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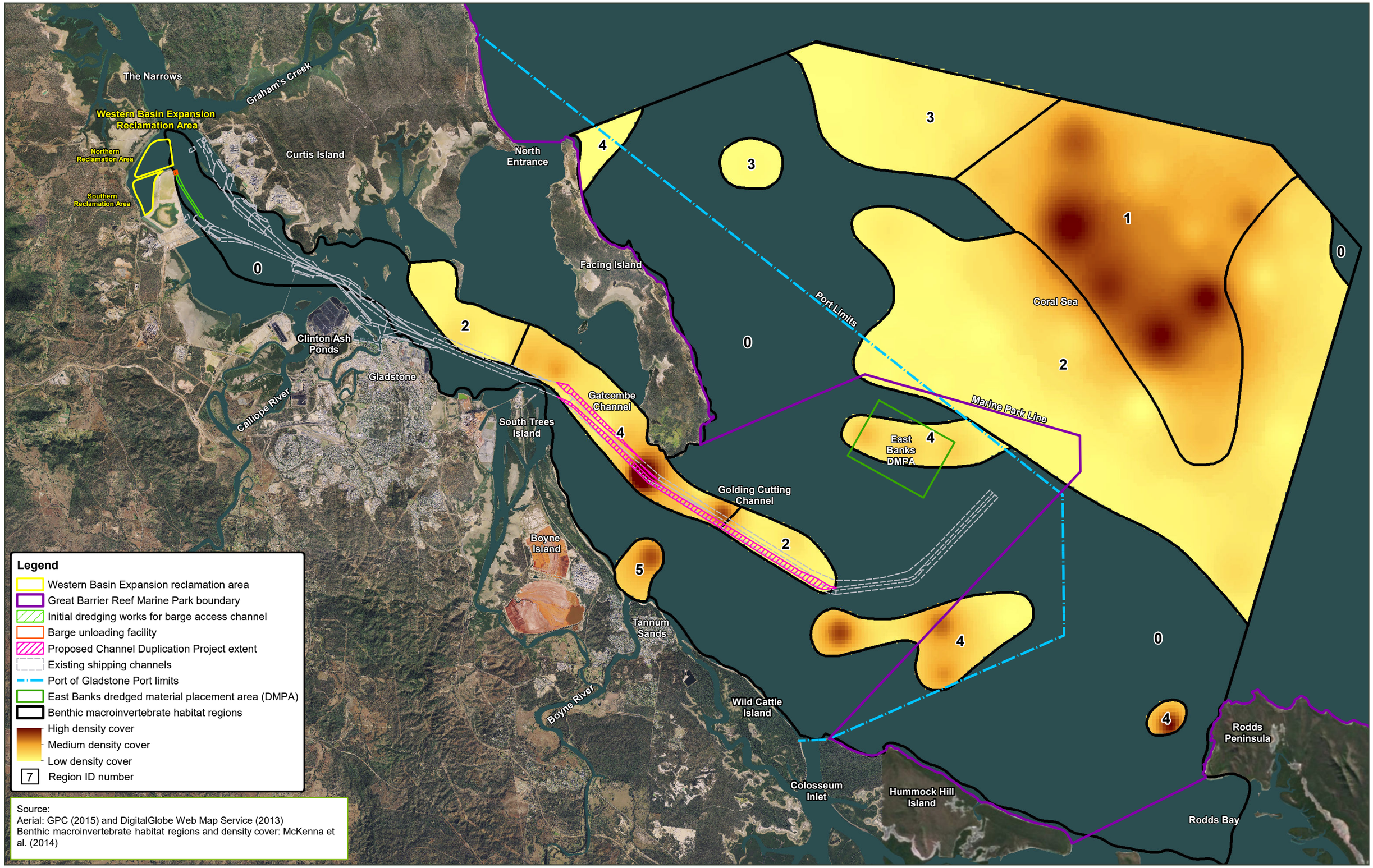

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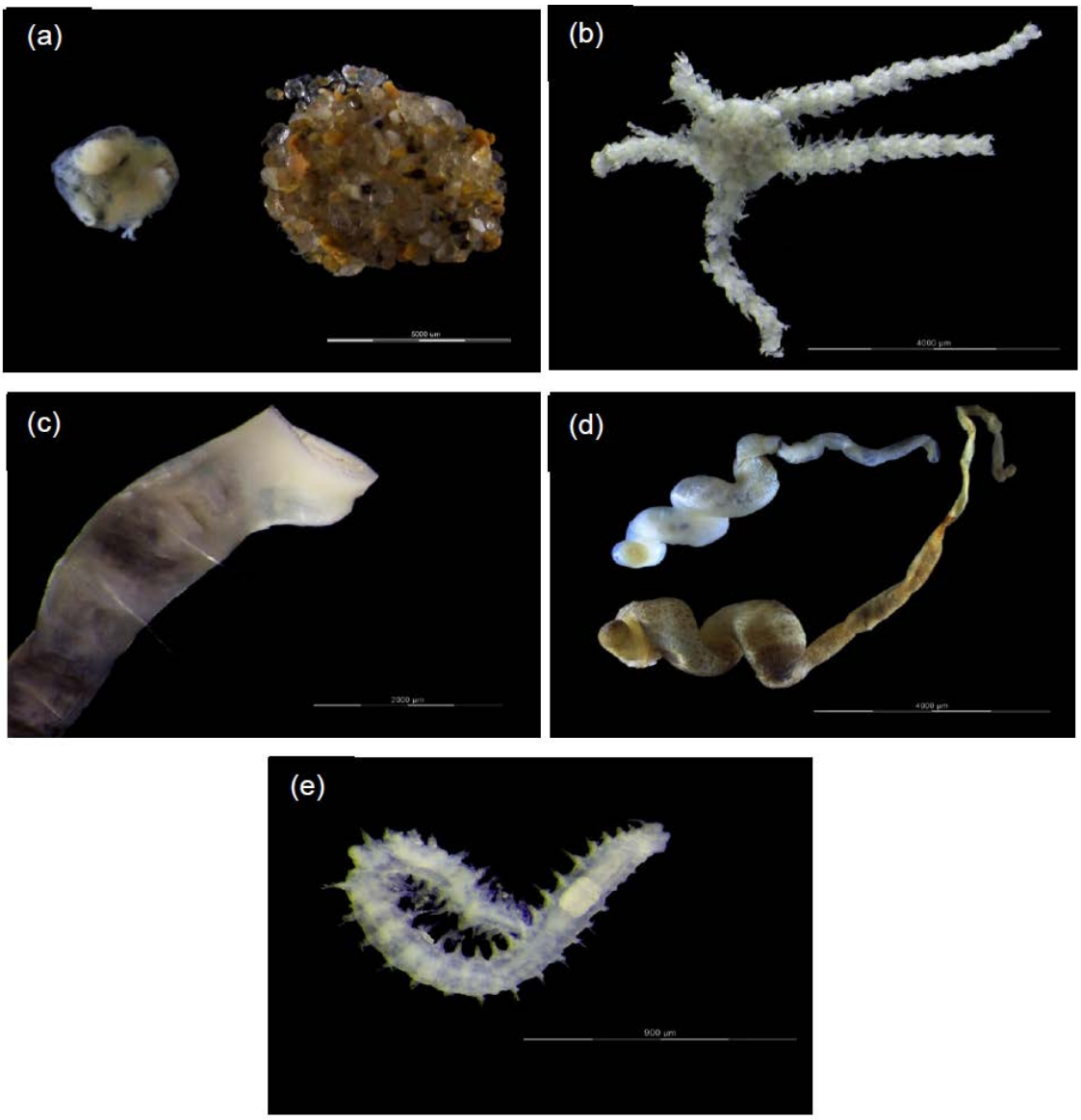
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.58: Location, density and distribution of benthic macroinvertebrates (November 2013)



Photograph 9.8 Five most common macroinvertebrate species observed at all sites: (a) Ascidiacea, (b) *Ophiuroidea* sp., (c) *Maldane sarsi*, (d) *Sipuncula* sp., and (e) *Syllidae* sp.

Source: VE (2015b)

VE (2015b) noted that seasonal differences existed in macroinvertebrate abundance, richness and diversity. The wet season had significantly higher abundance, richness and diversity compared to the dry season, irrespective of sites. However, as there was no significant seasonal difference in evenness, the abundance spread among the taxa remained consistent across the baseline data collection period. These surveys included sample sites within the area to be dredged for the duplication of the channels and sample sites adjacent to the WBE reclamation area. A summary of the results collected from the dredging footprint impact zone and near field zone are provided in Appendix I2 (Appendix M) and are summarised below.

- Impact transects for the dredging footprint recorded significantly higher taxa abundance during the dry season compared to samples collected in the wet season. Abundance scores recorded at the dredging footprint impact transects were highest in areas associated with high moderate to course sand (0.5 to 2mm) and gravel (> 2mm). Sediment in these areas were of silt/clays content (< 63µm) and TOC, suggesting that macroinvertebrate assemblages potentially favour sandy environments.
- Higher taxa richness was recorded at the dredging footprint impact transects during the wet season compared to samples collected in the dry season. Richness recorded at the dredging footprint impact transects was highest in areas associated with high moderate to course sand (0.5 to 2mm), gravel (> 2mm) and silt/clay content.

- The dredging footprint impact transects recorded immediate taxa diversity when compared to other sample locations collected during monitoring program. Taxa diversity did not vary between samples collected in the wet season and the dry season.
- Evenness across taxa did not vary significantly between samples collected in the wet season and dry season sampling periods at the Western Basin impact transects. Taxa evenness values did not vary significantly between samples locations collected across the Project impact transects.

Consistent with the observations of Rasheed et al. (2003) and McKenna et al. (2014), VE (2015b) noted that significant differences in macroinvertebrate abundance, richness, and diversity occurred at different locations within Port Curtis. Highest abundance overall was evident in the Inner Harbour zone, and in the Western Basin zone adjacent Fisherman's Landing (8.7 to 64.5 organisms/0.008m^3) all of which contained intermediate or high levels of TOC and fine sediment particle sizes. Lowest abundance was evident at the edge of the Mid Harbour/Outer Harbour zones (0.6 to 3.3 organisms/0.008m^3) which contained some of the lowest sediment TOC concentrations, in addition to low silt/clay content (VE 2015b).

Further detailed information from these Project EIS baseline assessments is provided in Appendix I1 (Section 11).

9.14.2.3 Species diversity

Results from sampling sites at Fisherman's Landing, The Narrows and Flying Fox Creek, indicated that the most abundant groups were molluscs, crustaceans and chordates which accounted for more than 97% of the individuals collected (Alquezar, Small and Stratford 2006). Other taxa collected in the surveys included echinoderms, cnidarians, sipunculids, nemerteans, branchiopods and pycnogonids (Alquezar, Small and Stratford 2006). Benthic communities were found to have higher species abundances, richness and diversity in the pre-wet season (November) compared to post-wet season (April) for all sites surveyed (Alquezar and Small 2006).

Surveys undertaken by the CQU Centre for Environmental Management in 2010 to 2011 (Alquezar 2011) recorded 551 macroinvertebrate organisms from 124 species and from 7 different phyla from survey sites in The Narrows zone, Western Basin zone, and the Calliope River mouth. The most common phyla included polychaete worms (38%), molluscs (31%) and crustaceans (28%) with nemerteans and pycnogonids being the least common (< 1%). At each site, molluscs (*Mactra abbreviate*), crustaceans (*Corophium cf. Acutum* and *Ogyrides delli*) and annelid worms (*Glycera* sp. and *Eunice vittata*) were the most abundant of all species. Diversity was observed to be higher at intertidal areas than subtidal areas and the highest species richness and diversity was observed in The Narrows (Alquezar 2011).

Surveys conducted over a 15 month period in 2011 (to examine the potential impacts of placement of dredged material at the existing East Banks DMPA) collected a total of 483 morpho-species comprising 182 families, 76 orders, 28 classes and 16 phyla. At all sampling locations, the most abundant phyla consisted of crustaceans, annelids and molluscs, although chordates (*Amphioxus* spp.) and echinoderms were also relatively abundant (BMT WBM 2012). Richness and abundance were higher during winter and spring, and lower in summer and autumn indicating a strong seasonal pattern. Lower abundance was particularly noticeable in the sampling event following the 2010/2011 Queensland flood event.

The most recent macroinvertebrate and sediment monitoring undertaken at the East Banks DMPA in the 2016/2017 wet season and 2017 dry season recorded a total of 1,228 macroinvertebrates in the wet season and 1,044 species in the dry season, representing 158 taxa in total (VE 2017).

When compared to the surveys undertaken in the Outer Harbour zone in 2011 (BMT WBM 2012), the macroinvertebrate abundance, species richness and diversity values observed were lower in 2016/2017, however the results were not significantly different (i.e. no statistical significance was identified during analyses). This is reported as likely to be the result of regional environmental influences and differences in the depths of grab samples collected and analysed (i.e. VE 2017 samples were up to a depth of 89mm, whereas BMT WBM 2012 samples were to a depth of 120mm detecting species that burrow deeper into benthic sediments).

9.14.2.4 Spatial and temporal trends

Long term trends observed by Currie and Small (2005; 2006) throughout a six year study of benthic communities between The Narrows and the Inner Harbour zone, found that the distribution and abundance of soft sediment benthos was closely linked to water depth and sediment particle size, with species abundance and richness being lowest in the fine muddy substrates of the intertidal areas, and highest in the coarse, sandy sediments associated with the areas of the deeper channels (Currie and Small 2005). This ecological gradient was observed throughout seasonal and interannular changes in species dominance (Currie and Small 2005; 2006).

Currie and Small (2005; 2006) found temporal trends in abundance and richness were related to environmental variables with species richness and abundance positively correlated to influxes of freshwater and associated turbidity from runoff (Currie and Small 2005). High levels of turbidity appeared to indirectly promote recruitment and/or survival of benthic fauna in Port Curtis, indicating that long term declines and subsequent recovery of benthic communities could be attributed to long term climatic cycles, including El Nino southern oscillation events.

Surveys in 2011 to examine the potential impacts of the placement of dredged material at the existing East Banks DMPA (BMT WBM 2012) resulted in substantially different species diversity when compared to previous results for this area (i.e. study periods 2003 to 2005, and 2006), with macroinvertebrate communities appearing to be highly variable over time.

Specifically, the most prevalent taxa collected in the 2010 to 2011 survey (BMT WBM 2012) differed substantially to those identified in 2006 with only three of the ten most prevalent taxa recorded in 2006 (elphidiid foramniferans, *Leptochela* sp. (comb shrimp), mysid shrimp, lumberinid polychaetes, microporid bryozoans, anemones, maldanid polychaetes, phoxocephalid amphipods, venerid bivalves and ampeliscid amphipods) recorded again in the 2011 survey (BMT WBM 2006; 2012). Similarly, foraminiferans, bryozoans and sea anemones were the numerically dominant taxa in 2006 surveys, but were rather absent in the 2003 to 2005, and 2010 to 2011 surveys (BMT WBM 2012).

9.15 Soft sediment habitats and benthic macroinvertebrates – potential impacts and risk assessment

9.15.1 Background

9.15.1.1 Section content

This section identifies the potential impacts and risk assessment for soft sediment habitats and benthic macroinvertebrate values as a result of the Project activities. Table 9.53 summarises the Project activities and the relevant section containing the impact assessment discussion.

Table 9.53 Summary of Project activities and Section addressed (soft sediment habitats and benthic macroinvertebrates)

Project activity	Section
Establishment of the WBE reclamation area and BUF, including: ▪ Site preparation ▪ Establishment of the site compound, offices and temporary areas ▪ Source and transport of reclamation bund wall material ▪ Placement of core and armour material, and geotextile fabric ▪ Sheet piling (or similar earth retaining structure) and fill placement for the BUF	Section 9.15.2
Dredging activities, including: ▪ Initial dredging works for the barge access channel ▪ Dredging to duplicate the Gatcombe and Golding Cutting shipping channels ▪ Dredging vessel movements ▪ Unloading and placement of dredged material in the WB and WBE reclamation areas	Section 9.15.3
Removal and installation of navigational aids	Section 9.15.4
Stabilisation and maintenance activities on the WBE reclamation area	Section 9.15.5

Operation of the duplicated shipping channels and maintenance dredging activities are discussed in Sections 9.23 and 9.24, respectively.

It is important to note that this section focuses on soft sediment habitats and benthic macroinvertebrates. Potential impact and risk assessment for other ecological values that depend on soft sediment habitats and benthic macroinvertebrates (for habitat and foraging resources) are provided in the following sections:

- Seagrass meadows (refer Section 9.9)
- Fish and marine reptiles (excluding marine turtles) (refer Section 9.13)
- Migratory birds (refer Section 9.17)
- Intertidal fauna (refer Section 9.7)
- Marine turtles (refer Section 9.19))
- Marine mammals (refer Section 9.21).

9.15.1.2 Sensitivity ratings

The sensitivity criteria and ratings which are used to assess the impact consequence and risk of potential impacts on ecological receptors are included in Appendix I2. Soft sediment habitats and benthic macroinvertebrates contribute to the ecological processes of the marine environment, including nutrient remineralisation and cycling in sediments and the provision of foraging resources for many native marine and intertidal fauna species (Currie and Small 2005).

The distribution of benthic macroinvertebrate species in soft sediment habitats is controlled by a number of environmental variables, including sediment physical parameters (e.g. sediment structure, particle size, carbon content), contaminant concentrations, water parameters, and biological factors such as competition and predation (Peeters et al. 2004). Sediment particle size composition of soft sediment habitats can be attributed to many factors, including wave action, currents and discharge from local point sources. Large tidal currents within Port Curtis allow for a vertically well-mixed water column, and resuspension of finer sediment particles (VE 2015).

Baseline benthic macroinvertebrate studies were conducted for the Project EIS and included studies conducted by VE (2015a) (refer Appendix I1 (Appendix N)) and Davies et al. (2015) (refer Appendix I1 (Appendix O)). Baseline benthic macroinvertebrate studies conducted for the Project EIS also included an updated baseline survey of Port Curtis benthic communities, undertaken in November 2013 by McKenna et al. (2014). McKenna et al. (2014) found that the Port Curtis region supports a diverse range of benthic community types that are typical of communities found in offshore and near shore subtidal areas elsewhere in Queensland. The dominant habitat feature which was identified during the survey was open substrate with a low to medium density of benthic macroinvertebrate community life. There were no benthic macroinvertebrate communities identified during the survey which were classified as 'high density' (McKenna et al. 2014).

Currie and Small (2005) undertook a comprehensive assessment of the benthic macroinvertebrate assemblage of Port Curtis over a six year period. The study found that the species richness of the benthic macroinvertebrate assemblage surveyed in Port Curtis was generally lower than in higher latitude embayments elsewhere in Australia.

The soft sediment habitats and benthic macroinvertebrate communities of Port Curtis are not considered to be unique or rare to the region, and are considered to be representative of those present in similar environments across Queensland (Currie and Small 2005). The soft sediment habitats and benthic macroinvertebrate communities of Port Curtis are considered to be an abundant and widely distributed value based on the findings of the baseline macroinvertebrate studies undertaken within Port Curtis (VE 2015a; Davies et al. 2015; McKenna et al. 2014).

Soft sediment habitats and benthic macroinvertebrates are not listed on a recognised or statutory state, national or international register as being of conservation significance (i.e. EPBC Act, NC Act and Fisheries Act).

For the purposes of the Project potential impacts and risk assessment, soft sediment habitats and benthic macroinvertebrates within and/or adjacent to the Project impact areas are considered to have a sensitivity rating of low.

9.15.2 Establishment of the dredged material placement area and barge unloading facility

9.15.2.1 Permanent loss and alteration of habitat

The WBE reclamation area (northern and southern areas) and BUF cover approximately 278ha of intertidal and subtidal habitat adjacent to the Fisherman's Landing and the existing WB reclamation area. Construction of the external and internal bund walls for the WBE reclamation area and BUF will result in the permanent loss of soft sediment habitat and benthic macroinvertebrates, through smothering and being disconnected from the marine environment.

The establishment of the WBE reclamation area and BUF will result in the replacement of subtidal soft sediment habitat with intertidal and subtidal, hard substrate habitat. Soft sediment habitats and benthic macroinvertebrates will be smothered through the placement of dredged material, representing a zone of high impact (i.e. permanent impacts).

The baseline macroinvertebrate survey which was conducted for the Project impact areas (VE 2015, refer Appendix I1 (Appendix N)) included a sample site within the WBE reclamation area direct impact area (impact zone) and a sample site adjacent to the reclamation area (near field zone) (refer Figure 11.2 in Appendix I1). A summary of the results collected from the WBE reclamation area impact zone and near field zone are provided below. The full results of the baseline benthic macroinvertebrate survey conducted for the Project are included in Appendix I1 (Appendix N).

- Western Basin impact transects (refer Figure 11.2 in Appendix I1) were defined by intermediate to high levels of total organic carbon (TOC) and fine sediment particle sizes. Transects recorded high abundance when compared to other sample locations collected during monitoring program. Significant higher taxa abundance was recorded during the wet season compared to samples collected in the dry season.
- Higher taxa richness was recorded at the Western Basin impact transects during the wet season compared to samples collected in the dry season. Transects recorded high taxa richness when compared to other sample locations collected during the monitoring program.
- The Western Basin impact transects recorded the highest taxa diversity when compared to other sample locations collected during the monitoring program
- Evenness across taxa did not vary significantly between samples collected in the wet season and dry season sampling periods at the Western Basin impact transects. Taxa evenness values did not vary significantly between samples locations collected across the Project impact area transects.

The soft sediment habitats and benthic macroinvertebrate species which have been recorded within the WBE reclamation area are not considered to be unique to the WBE reclamation area, and are representative of those species which have been recorded in the wider Port Curtis area. Based on habitat assessments and benthic macroinvertebrate community surveys, the WBE reclamation area and BUF is not considered to support unique benthic macroinvertebrate or benthic habitats, nor are the benthic macroinvertebrate communities present considered to be particularly diverse or abundant compared to adjacent areas.

Benthic habitat surveys conducted for Port Curtis by McKenna et al. (2013) (refer Appendix I1 (Appendix D)) identified approximately 90,692ha of deep water benthic macroinvertebrate habitat within Port Curtis (i.e. in waters ≥ 6m deep). The WBE reclamation area and BUF covers approximately 278ha of potential soft sediment and benthic macroinvertebrate habitat, representing approximately 0.30% of the available soft sediment habitat resource in Port Curtis (note that this is a conservative estimate as this value is based on areas of deep water benthic macroinvertebrate habitat only).

The loss of inshore habitat associated with this Project activity, will be permanent and irreversible, and restricted to a contained area, therefore moderate in magnitude.

Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of habitat loss at the WBE reclamation area (refer Section 9.27). Project design will reduce, where practical, the area of direct disturbance associated with the WBE reclamation area. Project mitigation measures are provided further in Section 9.27.

During the establishment of the WBE reclamation area and BUF, the post mitigation risk rating associated with habitat loss and alteration of soft sediment habitats and benthic macroinvertebrates is medium. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.15.2.2 Short term decline in water quality in the marine environment

The establishment of the WBE reclamation area and BUF will be undertaken over a three year period and will involve the placement of core material directly over existing sediments to establish the bund walls and the placement of armour material along the seaward exposed face. The construction activities associated with the establishment of the WBE reclamation area and BUF have the potential to impact the water quality of the receiving environment and impact soft sediment habitats and benthic macroinvertebrates through:

- Release of contaminants during site establishment works at the WBE reclamation area and BUF
- Increased turbidity and sediment deposition on soft sediment habitats and benthic macroinvertebrates due to the release of sediment during site establishment works at the WBE reclamation area and BUF

The potential impacts to water quality as a result of Project activities are further detailed in Chapter 8 and Appendix H1.

Potential impact on soft sediment habitats and benthic macroinvertebrates due to contaminant releases

Soft sediment habitats and benthic macroinvertebrate assemblages adjacent to the WBE reclamation area, BUF and barge access channel may be adversely impacted by contaminant releases during the establishment of the reclamation area. Contaminants also have the potential to be released into the environment during works associated with the site compound. Contaminants may be potentially released during the placement of core and armour material at the reclamation area or via spills from onsite storage facilities. Truck movements associated with the transport of bund wall rock material and the use of machinery during works at the reclamation area have the potential to result in the release of contaminants such as hydrocarbons and waste materials.

The release of contaminants may lead to the degradation of soft sediment habitats situated downstream of, or adjacent to, the Project impact areas and may result in harm to benthic macroinvertebrate assemblages. Contamination of water and sediments have the potential to result in direct acute toxicity in benthic macroinvertebrates. Direct acute toxicity has the potential to result in death or chronic impacts in benthic macroinvertebrates, including alterations in genetic structure which may result in deformities and impacts on larvae development (Chin 2003; Reynoldson 1987).

Benthic macroinvertebrates have the potential to transfer contaminants to other components of the aquatic system, including via bioaccumulation, trophic transfer, migration biodegradation, bioturbation and biodeposition (Reynoldson 1987). Contamination of benthic macroinvertebrate assemblages has the potential to threaten the prey base and subsequent prey availability for native fauna species, increasing competition pressures for food resources and increasing native species susceptibility to pressures associated with exotic species.

Contaminants to water may temporally increase toxicity (depending on the properties of the chemical and rate of processes such as biodegradation) in the vicinity of the source and downstream as the plume disperses, however some toxins may accumulate in the environment over time (e.g. in soft sediment substrates).

The potential impacts to water quality and soft sediment habitats and benthic macroinvertebrate assemblages through a release of contaminants will be generally restricted to a contained area and within the medium term, therefore moderate in magnitude.

Mitigation measures to minimise potential impacts to water quality at receiving environments during the WBE reclamation area and BUF establishment which have the potential to adversely impact soft sediment habitats and benthic macroinvertebrate assemblages are included in Section 9.27 and the Project EMP (refer Appendix Q2).

During the establishment of the WBE reclamation area and BUF, the post mitigation risk rating associated with the potential impacts to soft sediment habitats and benthic macroinvertebrates due to contaminant releases is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Increased turbidity and sediment deposition

Soft sediment habitats and benthic macroinvertebrate assemblages adjacent to the WBE reclamation area, BUF and barge access channel may be adversely impacted by sediment releases during the establishment of the WBE reclamation area and BUF.

Sediment has the potential to be released into environment during the establishment of the WBE reclamation area, BUF and the site compound. Sediment may also be potentially released during the placement of core and armour material at the WBE reclamation area and BUF or via spills from onsite storage facilities.

High rates of sedimentation can result in the burial of sessile benthic species and stress to filter feeding species, potentially leading to changes in the community structure of benthic macroinvertebrate assemblages. Sessile benthic fauna have the potential to be smothered in areas experiencing high levels of sedimentation which has the potential to result in stress and eventually mortality of benthic fauna. Suspended sediments in high concentrations have the potential to lead to the interference or blocking of respiratory and feeding structures of filter-feeding benthic macroinvertebrate taxa.

As the seabed is exposed to tidal currents and mobile sand waves, benthic macroinvertebrate species persist in a highly variable environment which is subject to constant sediment movement and deposition. The mean spring tidal range for the Port is 3.24m, the mean neap tidal range is 1.54m and the maximum tidal range is 4.69m (BMT WBM 2019). Due to the large tidal storage areas of the Port of Gladstone and the amplification effect on water levels, good tidal flushing and high tidal velocities generally exist within the main channels of Port Curtis (BMT WBM 2019). The importance of freshwater flows in Port Curtis on the productivity of the region has been shown through previous studies where years of large flows tend to result in higher benthic invertebrate productivity, resulting in higher growth rates in fish (Connelly et al. 2006). The waters of the Port Curtis estuary are generally turbid with higher turbidity levels experienced during the wet season (Commonwealth of Australia 2013).

Currie and Small (2005) investigated the Port Curtis macrobenthic community response to long term environmental changes. Benthic macroinvertebrate taxa richness and abundance were found to be positively correlated with turbidity levels, suggesting that high levels of turbidity levels promote recruitment and growth of benthic macroinvertebrates in Port Curtis (Currie and Small 2005). Positive responses of benthic macroinvertebrate taxa to elevated turbidity levels could be attributed to increased concentrations of waterborne food sources (i.e. derived from mangroves in periods of high rainfall) or reduced predation pressure on benthic macroinvertebrates by benthic predators (i.e. fish) due to restricted movement of benthic predators during periods of elevated turbidity (Currie and Small 2005).

Some benthic fauna species (i.e. polychaete worms, crabs and prawns) are capable of vertical migration, burrowing into sediments with capacity to return to the sediment surface (Ports Australia 2014). The ability of vertical migration provides a response strategy for some benthic fauna species to persist in environments with variable rates of sediment deposition.

Project releases of sediment are anticipated to be minor and not result in significant deposition rates within adjacent soft sediment environments. The risks to soft sediment habitats and macroinvertebrate communities associated with increased turbidity and sedimentation will be contained in extent and medium term in duration, and are therefore moderate in magnitude

Mitigation measures to minimise potential impacts to sediments during the WBE reclamation area and BUF establishment which have the potential to adversely impact soft sediment habitats and benthic macroinvertebrate assemblages are included in Section 9.27 and the Project EMP (refer Appendix Q2).

The post mitigation risk rating associated with the potential impacts to soft sediment habitats and benthic macroinvertebrates due to sediment releases associated with the establishment of the WBE reclamation area and BUF is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.15.2.3 Increase in hard substrate

The establishment of the WBE reclamation area will involve the construction of outer reclamation area bund walls, and an internal bund wall for the management of dredging decant water. Part of the BUF outer wall will also be constructed of the same rock material. The construction of rock walls within the marine environment provides three dimensional artificial habitats in intertidal and subtidal areas which have the potential to promote species settlement such as algae, fish and sessile fauna. While it is expected to take several years for assemblages to reach high levels of diversity to sustain a significant ecological community, there is the potential for the proposed bund walls to provide a range of functional ecological values for a variety of reef associated species.

The creation of new rock wall habitat has the potential to lead to a localised increase in food resource availability for some marine species.

9.15.3 Dredging activities

9.15.3.1 Permanent loss of soft sediment habitats and alteration of benthic macroinvertebrate communities

Approximately 12.6Mm^3 of seabed material will be removed from the channel duplication area to be dredged during dredging activities for the Project and approximately 0.25Mm^3 of material to be dredged for the barge access channel (refer Section 2.4).

The dredging activities will result in an unavoidable permanent loss of soft sediment habitats and benthic macroinvertebrates at the areas to be dredged.

Dredging activities will result in a temporary loss and mobilisation of benthic macroinvertebrates from within the dredging footprint, with benthic macroinvertebrates anticipated to recolonise the new dredging footprint. The soft sediment habitats and benthic macroinvertebrate species which have been recorded within the dredging footprint are not considered to be unique, and are representative of the taxa diversity and abundance which have been recorded in the wider Port Curtis area.

Dredging activities also have the potential to alter the composition and structure of the benthic macroinvertebrate assemblages which recolonise the area as the dredging footprint will be regularly subject to disturbance via ongoing maintenance dredging activities. It is anticipated that the dredging activities will create benthic habitat conditions which are reflective of those which are currently present within the existing navigational channels of the Port of Gladstone.

Benthic macroinvertebrates have the ability to recolonise the dredging footprint via the following process:

- Passive recolonisation, involving the passive settlement of entrained or otherwise resuspended organisms. This may occur immediately after dredging activities have ceased.
- Larval settlement by planktonic organisms from the water column. This may occur within hours or days, following passive recolonisation.

- Post-colonisation invasion of the dredging footprint by benthic macroinvertebrate organisms present within the local vicinity. This may occur via vertical migration of buried individuals through dredged material or horizontal immigration of post larval individuals from the surrounding community (Ports Australia 2014).

As the dredging footprint will be subject to continued disturbance via the maintenance dredging program, the benthic macroinvertebrate assemblages within the dredging footprint are not considered likely to 'functionally recover' (i.e. benthic macroinvertebrate assemblages are not anticipated to return to the pre-disturbance level of species diversity or individuals present). As such, maintenance dredging will effectively keep the benthic macroinvertebrate communities in a state of flux. The dredging footprint is in a current shipping channel and subject to continual maintenance dredging. The ability of benthic macroinvertebrate communities to persist in the current environment suggest that the local assemblages are robust and have a strong recovery potential in areas adjacent to the dredging footprint.

The loss of these habitats as a result of dredging activities will be permanent and will occur in the local area, and are therefore, high in magnitude. Project design will minimise where practical the area of direct disturbance associated with the dredging footprint area (refer Section 2.10).

The post mitigation risk rating for the potential impact on soft sediment habitats and benthic macroinvertebrates due to the direct loss and alteration of habitat associated with dredging activities is high. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.15.3.2 Short term decline in water quality in the marine environment

Context of impact

Dredging activities may result in a decline in water quality, predominantly through increased turbidity, associated with:

- Dredging (i.e. turbidity generated at the dredger head, overflow and propwash)
- Dredging vessel movements
- Dredged material unloading and placement (e.g. potential bund wall seepage)
- Licence discharge of dredging decant water from the WB and WBE reclamation areas.

Potential Project impacts which have the potential to result in a decline in marine water quality and have an impact on soft sediment habitats and benthic macroinvertebrates include:

- Release of contaminants during dredging activities
- Release of contaminants and sediments due to bund wall failure or seepage
- Increased turbidity and sediment deposition on soft sediment habitats and benthic macroinvertebrates during dredging activities.

A detailed assessment of the potential impacts to water quality as a result of Project dredging activities is provided in Section 8.6.

Potential impact on soft sediment habitats and benthic macroinvertebrates due to contaminant releases

Contaminants such as hydrocarbons and waste materials have the potential to be released from the dredging vessels and degrade soft sediment habitats adjacent to the areas to be dredged, the WBE reclamation area, BUF and the barge access channel. Contaminant releases and potential impacts on soft sediment habitats and macroinvertebrates are discussed in Section 9.15.2.2 for the establishment of the reclamation area. The potential impact sources and receptors discussed in Section 9.15.2.2 also apply to dredging activities.

The release of contaminants has the potential to harm benthic macroinvertebrates due to physical trauma caused by interaction with contaminant. Prey availability for native fauna species have the potential to be impacted by the potential contamination of benthic macroinvertebrates.

The release of contaminants to water may temporarily increase toxicity (depending on the properties of the chemical and rate of processes such as biodegradation) in the vicinity of the source and as the plume disperses, however some toxins may accumulate in the environment over time (e.g. substrate, vegetation).

Dredging activities have the potential to disturb contaminated sediments. Desktop and field geochemical investigations undertaken for the Project concluded that the marine sediments to be removed from the areas to be dredged are considered 'clean' as per NAGD (2009) and the potential for contaminants to be mobilised into the water column during dredging activities is considered to be low (refer Section 6.5 and Appendices E4 and E6). Based on these results, the potential for soft sediment habitats and benthic macroinvertebrates to be impacted by contaminants from sediment to be dredged is considered low.

Mitigation measures to minimise the impact of chemical releases during dredging activities on soft sediment habitats and benthic macroinvertebrates are included in the Project EMP and Dredging EMP (refer Appendices Q2 and Q1, respectively).

This Project activity and potential exposure of soft sediment habitats and benthic macroinvertebrates to these impacts will be within the temporary and within a local area, and therefore low in magnitude.

The post mitigation risk rating for the potential impact on soft sediment habitats and benthic macroinvertebrates due to contaminant releases during dredging activities is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Increased turbidity and sediment deposition during dredging activities

The potential impacts associated on soft sediment habitats and macroinvertebrates associated with increased turbidity and sedimentation are discussed in Section 9.15.2.2 for the establishment of the reclamation area. The potential impact sources and receptors discussed in Section 9.15.2.2 also pertain to dredging activities.

As the seabed is exposed to tidal currents and mobile sand waves, benthic macroinvertebrate species persist in a highly variable environment which is subject to constant sediment movement and deposition. Some benthic macroinvertebrate species (i.e. polychaete worms, crabs and prawns) are capable of vertical migration, burrowing into sediments with capacity to return to the sediment surface (Ports Australia 2014). The ability of vertical migration provides a response strategy for some benthic macroinvertebrate species to persist in environments with variable rates of sediment deposition.

Hydrodynamic modelling results for the Project are presented in the Project Coastal Processes and Hydrodynamic Report (refer Appendix G) and the Project Water Quality Technical Report (refer Appendix H1). The results of the hydrodynamic modelling provide an understanding of the spatial and temporal patterns of the dredging sediment plume and represent modelled turbidity, bed sedimentation (gross and net) and impacts to benthic light at sensitive receptors.

Based on the turbidity thresholds applied to the modelling outputs, the zone of high impact is within the immediate vicinity of the dredged channels and extends approximately 1km in a northwest direction of the Gatcombe Channel and approximately 2km south east from the Golding Cutting Channel. The zone of high impact also extends 6-7km in both east and west directions from the Golding Cutting channel. The zone of low impact extends northwards along the coastline of Facing Island and into the Narrows. The largest impact is expected to occur immediately within and adjacent to the Gatcombe and Golding Cutting Channels.

It is important to note that there are large areas of comparable soft sediment habitat and benthic macroinvertebrate assemblages within the Port Curtis region that are not expected to experience a temporary decline in water quality from dredging activities.

Dredging activities that have the potential to impact on water quality are likely be contained to certain areas at any given time (i.e. only two dredgers will be working at particular points within the Project area at any given time). The Project Dredging EMP (refer Appendix Q1) will be implemented during dredging activities to minimise and mitigate potential impacts to water quality from dredging activities. The Dredging EMP include adaptive and reactive mitigation measures to be adopted during dredging activities.

Any potential indirect impacts to soft sediment habitats and benthic macroinvertebrates as a result of dredging activities are expected to be temporary. Sediment plumes from dredging at the channels are unlikely to be continuous at any particular site due to changes in the dredger location within the channel and dredging rates. Natural influences, such as wind and tidal conditions, will also vary the spatial extent of the turbidity plume generated by dredging activities.

The main areas of short term increased sediment deposition rates are predicted to occur within the immediate vicinity of the dredged channels and the WBE reclamation area and BUF. Minor sustained, but temporary, increases in sediment deposition are noted within the shipping channel.

Adaptive design measures will be implemented during the Project detailed design phase to reduce the potential impacts to water quality (refer Section 9.27). Project design of the WBE reclamation area and BUF will incorporate geotextile material to be placed within the inner face of the outer bund wall in order to minimise the migration of dredged material fines through the bund wall to the marine waters of Port Curtis. The release of dredging decant waters will be controlled by a licenced discharge point and weir box with conditions which will dictate the water quality criteria to be met prior to discharge.

Mitigation measures to minimise the impact of turbidity and sedimentation during dredging activities on soft sediment habitat and benthic macroinvertebrates are included in Section 9.27 and the Dredging EMP (refer Appendix Q1). The potential impacts associated with short term declines in water quality during dredging activities will be short term and within the local area, and therefore moderate in magnitude.

The post mitigation risk rating associated with the potential impacts to soft sediment habitats and benthic macroinvertebrates due to sediment deposition during dredging activities is medium. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.15.3.3 Displacement of macroinvertebrates due to the introduction and spread of invasive species

Invasive species have the potential to be introduced into the marine environment during dredging activities via the movement of dredging equipment and vessels. Invasive species may be introduced to the marine environment via attachment to marine vessels (i.e. attachment to boat hulls, anchor chains and internal boat compartments) or via transport in the seawater system of a vessel (i.e. in pipes or bilge and ballast water) (National Introduced Marine Pest Information System (NIMPIS) 2014).

Marine pest species may compromise the integrity of soft sediment habitats and compete with native benthic macroinvertebrate assemblages for resources. Marine pest species such as the European fan worm (*Sabella spallanzanii*) can smother soft sediment habitats and compete with native species for prey resources and habitat. The NIMPIS database does not identified any introduced marine pests which are known to have established in the Port Curtis area (NIMPIS 2014).

Potential impacts on macroinvertebrate communities are expected to be short term and contained in extent, and therefore low in magnitude.

Mitigation measures to minimise the risk of introduction or spread of invasive marine species which have the potential to have an adverse impact on soft sediment habitats and benthic macroinvertebrates during Project dredging activities are included in Section 9.27 and the Project Dredging EMP (refer Appendix Q1).

The post mitigation risk rating for the potential impacts of invasive species on soft sediment habitats and macroinvertebrates during dredging activities is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.15.4 Removal and installation of navigational aids

9.15.4.1 Permanent loss and alteration of habitat

The removal and installation of navigational aids has the potential to result in a permanent small scale disturbance to the seafloor. The potential impacts from the removal and installation of navigational aids on soft sediment habitats and benthic macroinvertebrates in Port Curtis is expected to be negligible given the very localised and small scale nature of the Project activities associated with the removal and installation of navigational aids.

Adaptive design measures will be implemented during the Project detailed design phase to reduce the soft sediment habitats and benthic macroinvertebrates during removal and installation of navigational aids (refer Section 9.27).

The post mitigation risk rating associated with the permanent loss soft sediment habitat and benthic macroinvertebrates due to the removal and installation of navigational aids is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.15.4.2 Short term decline in water quality in the marine environment due to contaminant releases

The removal and installation of navigational aids has the potential to result in the release of contaminants from vessels and/or the pile driving barge. Contaminants which may be released include hydrocarbons and waste materials.

Mitigation measures to avoid contaminant releases impacting soft sediment habitat and benthic macroinvertebrates during removal of navigation aids are included in Section 9.27 the Project EMP (refer Appendix Q2).

The post mitigation risk rating for the potential impact on soft sediment habitats and benthic macroinvertebrates due to contaminant releases during removal and installation of navigational aids is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.15.5 Stabilisation and maintenance activities

9.15.5.1 Short term decline in water quality in the marine environment

Release of contaminants

The use of vehicles during surface stabilisation and maintenance works at the WB and WBE reclamation areas has the potential to result in the release of contaminants (e.g. hydrocarbons). The release of contaminants may lead to the degradation of soft sediment habitats located downstream of, or adjacent to, the final Project landform and result in impacts to benthic macroinvertebrates via contact with contaminants.

The potential impacts on soft sediment habitats and macroinvertebrates as a result of the release of contaminants into the marine environment during stabilisation and maintenance activities are expected to be short term and contained in extent. The magnitude of these potential impacts is therefore low.

Mitigation measures to avoid contaminant releases impacting soft sediment habitats and benthic macroinvertebrates during surface stabilisation and maintenance works at the WB and WBE reclamation areas are included in Section 9.27 and the Project EMP (refer Appendix Q2).

The post mitigation risk rating associated with the potential contaminant releases during surface stabilisation and maintenance works impacting soft sediment habitats and benthic macroinvertebrates is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Soil erosion and sedimentation

The potential for erosion of the final WB and WBE reclamation areas landforms, and subsequent downstream sedimentation, have the potential to have an impact on the integrity of downstream soft sediment habitats and benthic macroinvertebrates. Erosion and sediment runoff can result in decreased water quality and result in the burial of sessile benthic species and stress to filter feeding species. This may potentially lead to changes in the community structure of benthic macroinvertebrate assemblages.

The potential impacts on soft sediment habitats and macroinvertebrates as a result of soil erosion and sedimentation during stabilisation and maintenance activities are expected to be short term and contained in extent. The magnitude of these potential impacts is therefore low.

Mitigation measures to avoid and/or minimise the potential for soil erosion and sediment runoff impacting soft sediment habitats and benthic macroinvertebrates during surface stabilisation and maintenance works at the final WB and WBE reclamation areas landforms are included in Section 9.27 and the Project EMP (refer Appendix Q2).

The post mitigation risk rating associated with the potential erosion and sediment runoff during surface stabilisation and maintenance works impacting soft sediment habitats and benthic macroinvertebrates is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.15.6 Threatening processes for species of conservation significance

Soft sediment habitats and benthic macroinvertebrates are not listed as having conservation significance under the provisions of the EPBC Act or the NC Act. As such, an assessment of potential Project impacts with regards to their potential contribution to species threatening processes is not relevant for this chapter.

9.15.7 Significant residual adverse impact assessment

No soft sediment habitats or benthic macroinvertebrate species are listed as a MNES under the provisions of the EPBC Act or are listed MSES under the provisions of the *Environmental Offsets Regulation 2014*. As such, a significant residual adverse impact assessment has not been conducted for the value.

Soft sediment habitats and benthic macroinvertebrates do provide potential habitat value and foraging resources for a number of MNES and MSES listed species. The significance of potential Project impacts on soft sediment habitats and benthic macroinvertebrates with respect to potential significant impacts on MNES and MSES listed species, has been assessed for the relevant species in the species respective impact assessment section.

9.15.8 Assessment summary

The Port Curtis region supports a diverse range of benthic community types that are typical of communities found in offshore and near shore subtidal areas across Queensland. The soft sediment habitats and benthic macroinvertebrate communities of Port Curtis are not considered to be unique or rare to the region, with the communities' considered representative of those present in similar environments across Queensland.

A benthic macroinvertebrate baseline assessment for the Port Curtis region which was undertaken in November 2013 (McKenna et al. 2014) identified 'open substrate with a low to medium density of benthic macroinvertebrate community life' as the dominant benthic habitat type within Port Curtis. During the November 2013 baseline survey, there were no benthic macroinvertebrate communities identified which were classified as 'high density'.

Baseline benthic macroinvertebrate studies were conducted for the Project EIS and included studies conducted by McKenna et al. (2014), Davies et al. (2015) and VE (2015). VE (2015) recorded a total of 5,043 macroinvertebrates across the monitoring period, representing 162 families and 18 phyla. Significant differences in macroinvertebrate abundance, richness, and diversity were observed across survey sites and between seasons. The wet season survey recorded significantly higher abundance, richness and diversity of benthic macroinvertebrate taxa compared to the dry season, irrespective of the survey site location.

Macroinvertebrate samples collected at the WBE reclamation area were of high abundance when compared to the other sample locations collected during monitoring program. Diversity in macroinvertebrate taxa recorded at the WBE reclamation area during the wet and dry season sampling programs were the highest diversity values recorded during the monitoring program. Macroinvertebrate samples collected from within the dredging footprint during the wet season were of lower abundance when compared to the other sample locations collected during monitoring program.

The establishment of the WBE reclamation area and BUF will result in the permanent loss of soft sediment habitat and benthic macroinvertebrate assemblages due to the placement of dredged material. Dredging activities will result in the direct removal of soft sediment habitats, with approximately 12.6Mm^3 of seabed material to be removed from the channel duplication area to be dredged. Dredging activities will result in a temporary loss and mobilisation of benthic macroinvertebrates from within the dredging footprint, with benthic macroinvertebrates anticipated to recolonise the dredging footprint.

Project activities have the potential to have an indirect impact on soft sediment habitats and benthic macroinvertebrates due to the potential release of contaminants and increased turbidity levels and sedimentation.

The release of contaminants may lead to the degradation of soft sediment habitats situated adjacent to the Project impact areas, and result in harm to benthic macroinvertebrate assemblages due to physical trauma caused by interaction with the contaminant.

High rates of sedimentation have the potential to result in the burial of sessile benthic species and stress to filter feeding species, potentially leading to changes in the community structure of benthic macroinvertebrate assemblages. The main areas of short term increased sediment deposition rates are predicted to occur within the immediate vicinity of the dredged channels and the WBE reclamation area and BUF. Minor sustained, but temporary, increased in sediment deposition are noted within the shipping channel.

Invasive species have the potential to be introduced into the marine environment during dredging activities via the movement of dredging equipment and vessels. Marine pest species may compromise the integrity of soft sediment habitats and compete with native benthic macroinvertebrate assemblages for resources.

The Project will implement mitigation measures outlined in the Dredging EMP (refer Appendix Q1) and the Project EMP (refer Appendix Q2), and associated management plans, to reduce the likelihood and magnitude of potential Project impacts on soft sediment habitats and benthic macroinvertebrate assemblages. The implementation of mitigation measures contained in these management plans will reduce residual Project impacts on soft sediment habitats and benthic macroinvertebrate assemblages.

With regards to potential impacts on soft sediment habitats and benthic macroinvertebrate assemblages, the WBE reclamation area supports a high richness and diversity of macroinvertebrate taxa. The establishment of the WBE reclamation area and BUF will result in the removal of approximately 0.30% of the total soft sediment and benthic macroinvertebrate habitat present within Port Curtis.

9.16 Migratory birds – existing environment

9.16.1 Background

In Australia, migratory species are those animals that migrate to Australia and its external territories, or pass through, or over, Australian waters during their annual migrations. Migratory species include some species of birds (e.g. petrels, albatrosses), marine mammals (e.g. dugongs, whales and dolphins) and reptiles (e.g. marine turtles, crocodiles).

There are a number of global conventions and agreements which have been established for the international coordination of conservation efforts for migratory species, including:

- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)
- China-Australia Migratory Bird Agreement
- Japan-Australia Migratory Bird Agreement
- Republic of Korea-Australia Migratory Bird Agreement

The EPBC Act lists migratory species as MNES, including species that are protected under the international conventions and agreements listed above. Actions likely to impact on migratory species are required to be assessed under the *Significant Impact Guidelines 1.1* (DoE 2013).

This section primarily focuses on migratory shorebird species for two reasons:

- The majority of the existing data from studies and reports is relevant to migratory shorebird species
- Project activities have greater potential to impact on migratory shorebirds and their habitat, due to the location of Project impact areas (direct and potential indirect impact areas).

It is noted, however, that other groupings of migratory birds are discussed where information is available.

The Project EIS migratory bird survey locations are shown in Figure 9.59.

The methodology implemented to describe migratory bird values is provided in Appendix I1 (Section 12.2).

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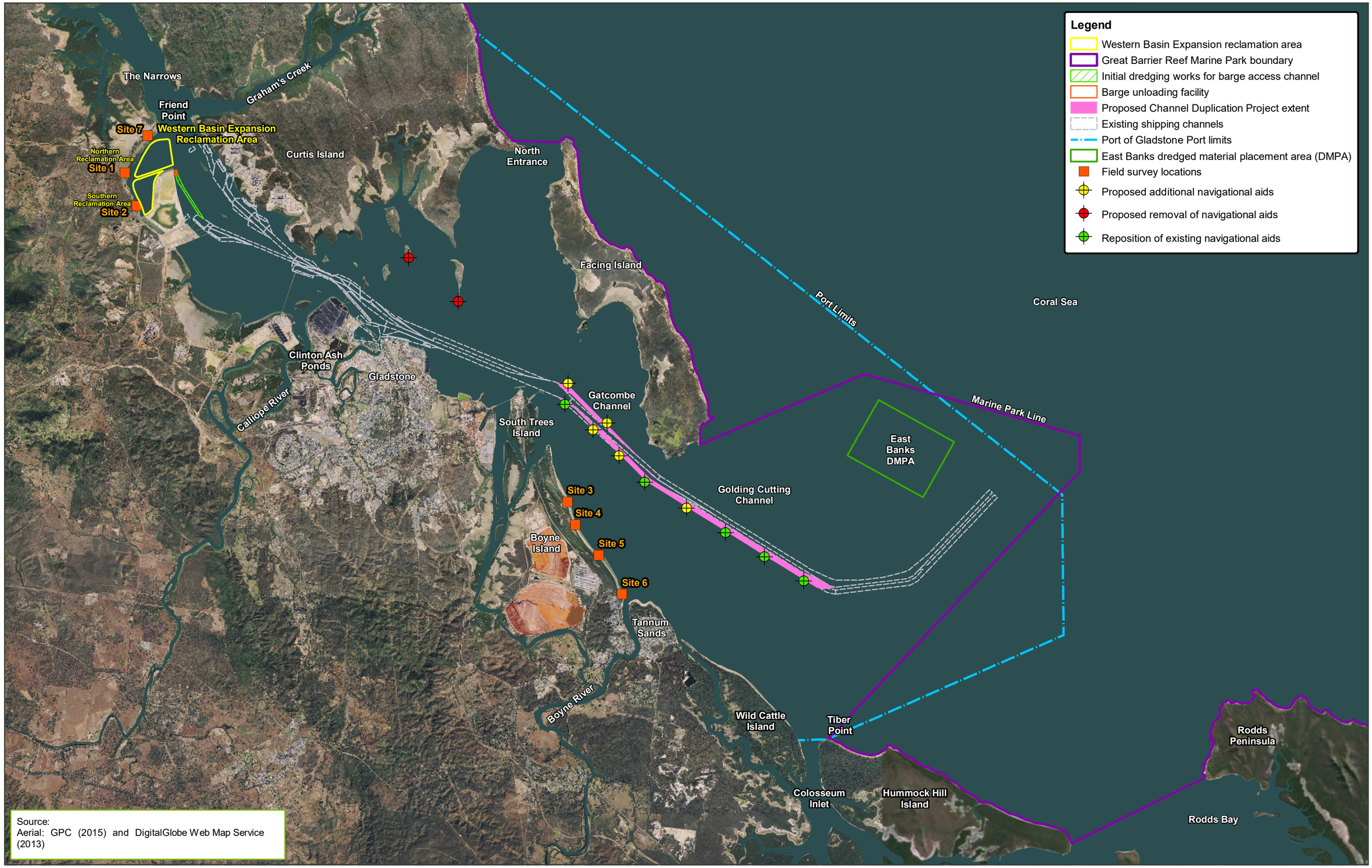

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Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.59: Migratory bird species survey locations

9.16.2 Migratory bird values

9.16.2.1 General context

The Curtis Coast region, including the Gladstone sub zone, contributes approximately 8% of the total population of migratory shorebirds in Queensland with an average population size during monitoring events in excess of 29,500 birds (population size calculated as a sum of the average counts over time for each species) (IMEMS 2013). Earlier estimates (Driscoll 1997) report a lower contribution for the Curtis Coast region of approximately 2.5% of the migratory shorebird population in Queensland; however at that time, the abundance of migratory shorebirds within the Fitzroy Delta and North Curtis Island had not yet been quantified.

The Gladstone sub zone contributes approximately 6% of the total population of migratory shorebirds in Queensland, with an average population size during monitoring events in excess of 22,500 birds (IMEMS 2013).

Table 9.54 presents a summary of the species that occur within the Gladstone sub zone and contribute to more than 10% of the Queensland population for each specific species (IMEMS 2013).

Table 9.54 Migratory shorebird species present in the Gladstone sub zone that contribute more than 10% of the total species numbers to the Queensland population

Migratory shorebird species	Percentage of State population within Gladstone sub zone
Common greenshank	10.3%
Curlew sandpiper	15.6%
Lesser sand plover	10.9%
Red-necked stint	11.0%
Ruddy turnstone	12.4%
Terek sandpiper	13.7%

Source: Adapted from IMEMS (2013)

9.16.2.2 Habitat values

Important migratory shorebird habitat

One roost site within the Port Curtis region on North Curtis Island (Yellow Patch Estuary, approximately 29km north of the WBE reclamation area) has been recorded to host more than 1% of the flyway population of Whimbrels and is therefore considered internationally important habitat based on the above definition. This roost site will not be directly impacted by the Project activities.

Within 5km of the Project areas to be dredged, six locally important roost sites were identified, including two on Facing Island; one on Boyne Island; one at the entrance to the Colosseum Inlet; one at Six Mile Island; and one at Friend Point (refer Figure 9.60 and Table 9.55).

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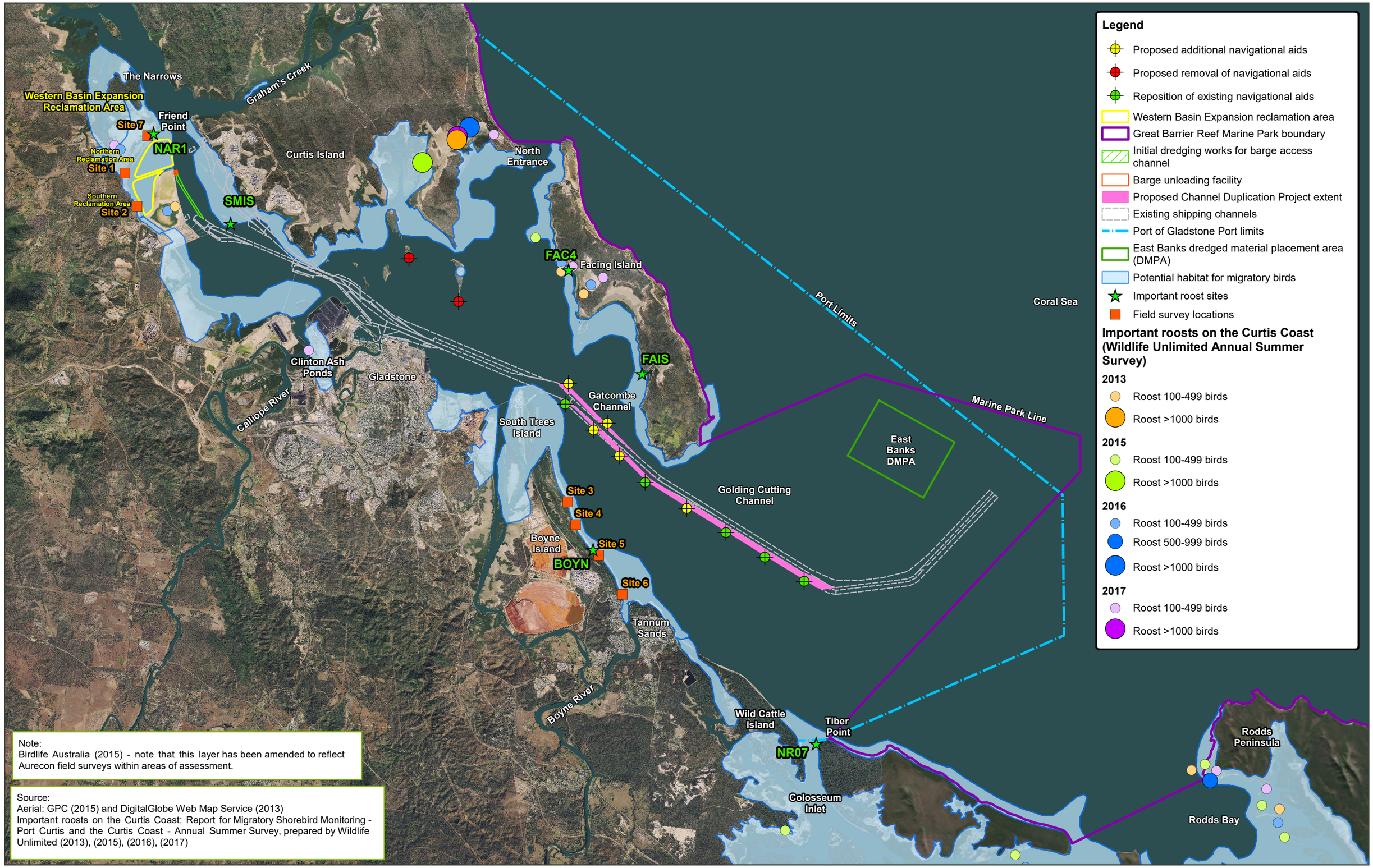

Note:
Birdlife Australia (2015) - note that this layer has been amended to reflect Aurecon field surveys within areas of assessment.

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Important roosts on the Curtis Coast: Report for Migratory Shorebird Monitoring - Port Curtis and the Curtis Coast - Annual Summer Survey, prepared by Wildlife Unlimited (2013), (2015), (2016), (2017)

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Figure 9.60: Potential habitat for migratory bird species (Overview)

Table 9.55 Locally important roost sites within proximity to Project impact areas as identified in IMEMS (2013) that contain at least 0.1% of a flyway population for one or more shorebird species

Location of important local roost sites with > 0.1% of a flyway population	Species for which counts of birds on least one occasion exceed > 0.1% of the flyway population	Nearest Project impact area
▪ **NAR1** (1% to 2%)	▪ Eastern curlew	WBE reclamation area
▪ **SMIS** (1% to 2%)	▪ Eastern curlew	
▪ **FAC4** (7% to 10%)	▪ Eastern curlew ▪ Grey-tailed tattler ▪ Lesser sand plover ▪ Terek sandpiper	Areas to be dredged and the location of new navigational aids
▪ **FAIS** (1% to 2%)	▪ Terek sandpiper	
▪ **BOYN** (1% to 2%)	▪ Lesser sand plover	
▪ **NR07**(1% to 2%)	▪ Ruddy turnstone	

Two locations within proximity to the WBE reclamation area and BUF (i.e. NAR1 and Six Mile Island Roost Site (SMIS)) were identified as important roost sites for the Eastern curlew, with the NAR1 site situated approximately 400m north of the reclamation area at Friend Point on Kangaroo Island (refer Figure 9.60 and Figure 9.61).

No additional roost sites of local importance (based on the 0.1% flyway population threshold) were identified during annual shorebird surveys undertaken for GPC for the Port Curtis region in 2014 and 2015, 2016, 2017 and 2018 (Wildlife Unlimited 2014; 2015; 2016; 2017; 2018) compared to those identified in Table 9.55. However, the 2015 annual monitoring report indicates that the roost sites at Friend Point on Kangaroo Island may constitute 'critical migratory shorebird habitat' in the upper harbour area (Wildlife Unlimited 2015), which is located approximately 400m from the WBE reclamation area.

The IMEMS (2013) report identifies the NAR1 roost site on the shoreline at Friend Point as being locally important; and Wildlife Unlimited (2015) noted that previous survey work suggests that while migratory shorebirds will preferentially utilise the Friend Point shoreline roost, they have been recorded to move further inland to the claypan areas when the tide inundates the shoreline roost (Wildlife Unlimited 2015). Previous survey counts of the shoreline and claypan roost sites at Friend Point demonstrate the combined capacity of these sites is in excess of 150 birds (Wildlife Unlimited 2014). In 2018 Whimbrels were observed roosting for the first time on the bund wall of the WBRA (Wildlife Unlimited 2018).

Habitat for migratory pelagic birds

Potentially suitable foraging habitat exists for migratory pelagic bird species in the open waters in the Project impact areas.

Habitat for terrestrial migratory birds

Predictive habitat mapping was prepared for terrestrial migratory species which were considered to have a moderate likelihood of occurrence within the Project impact area. The potential habitat maps for terrestrial migratory bird species are provided in Appendix I1 (Section 12.3.7), with a summary of the mapping results provided in Table 9.56.

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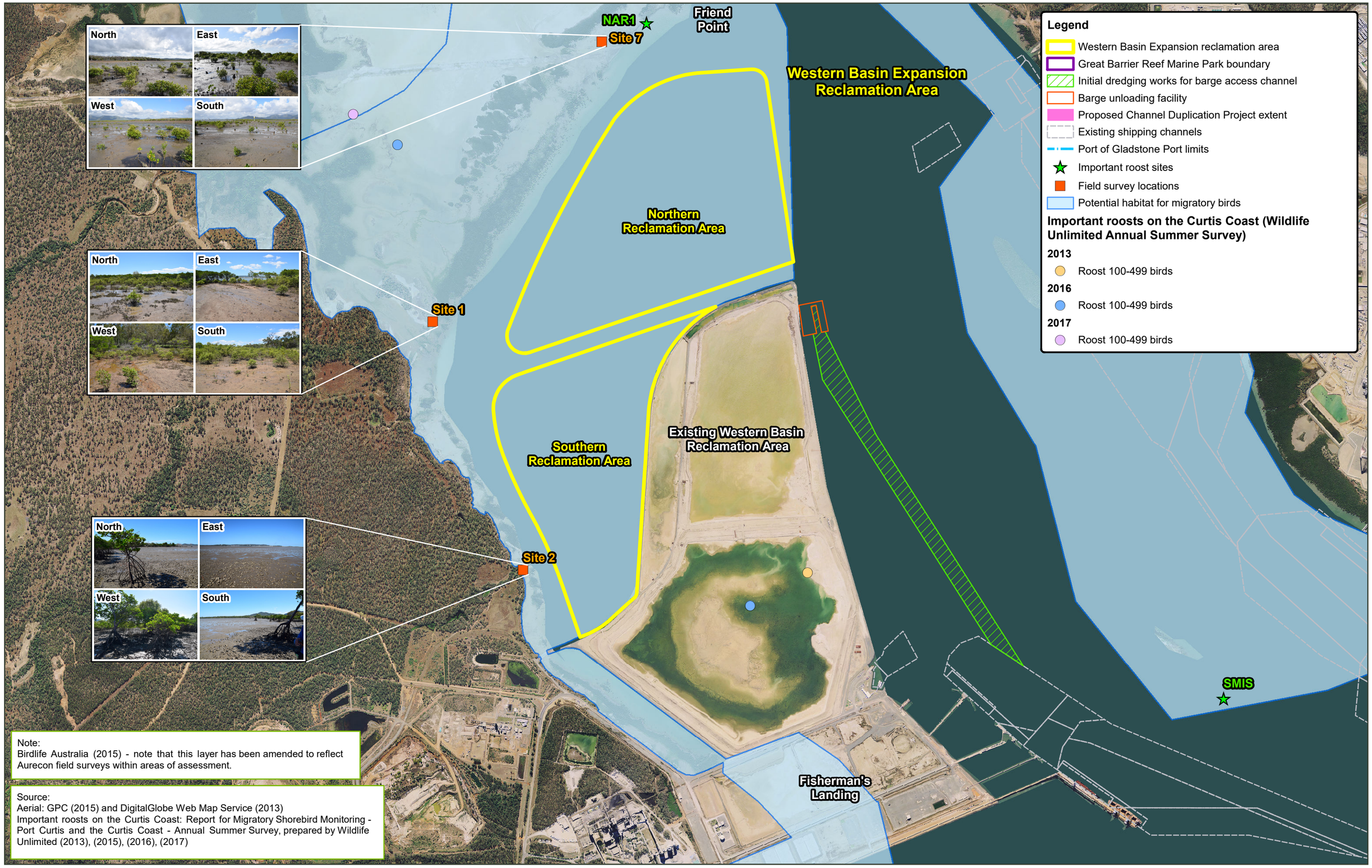

Note:
Birdlife Australia (2015) - note that this layer has been amended to reflect Aurecon field surveys within areas of assessment.

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Important roosts on the Curtis Coast: Report for Migratory Shorebird Monitoring - Port Curtis and the Curtis Coast - Annual Summer Survey, prepared by Wildlife Unlimited (2013), (2015), (2016), (2017)

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Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.61: Potential habitat for migratory bird species (Western Basin Expansion reclamation area)

Table 9.56 Migratory terrestrial birds for which potential habitat areas were modelled using available GIS layers

Species name	Likelihood of occurrence within Project impact areas	Results of potential habitat mapping
Black-faced monarch (*Monarcha melanopsis*)	Moderate	The WBE reclamation area is located approximately 230m east of the mapped potential habitat for this species
Oriental cuckoo (*Cuculus optatus*)	Moderate	The WBE reclamation area is located approximately 230m east of the mapped potential habitat for this species
Rufous fantail (*Rhipidura rufifrons*)	Moderate	The WBE reclamation area is located approximately 115m east of the mapped potential habitat for this species
Satin flycatcher (*Myiagra cyanoleuca*)	Moderate	The WBE reclamation area is located approximately 105m east of the mapped potential habitat for this species

Air spaces above all of the Project impact areas are considered to provide habitat for the aerial migratory species (i.e. Fork-tailed swift (*Apus pacificus*) and White-throated needletail (*Hirundapus caudacutus*)).

9.16.2.3 Species of conservation significance

The desktop review of information identified a total of 70 migratory bird species as having the potential to occur within the Project database search area (refer Figure 9.1). Of these species, 64 were identified as having been previously confirmed within the Project database search area, or having a moderate likelihood of occurrence (based on the presence of suitable habitat and records of the species from nearby localities) (refer Appendix I1 (Section 12.3.5)).

These 66 species can be grouped into four broad categories due to similar habitat requirements and general ecology:

- Shorebirds which utilise habitats along the shoreline
- Pelagic species which utilise open oceans for foraging and sub-Antarctic islands for roosting
- Aerial species which forage aerially
- Terrestrial species which utilise terrestrial habitats.

Of these 66 species, 20 are listed as species of conservation significance under the provisions of the EPBC Act (refer Table 9.57). Eight of the species listed in Table 9.57 have been previously recorded within Port Curtis, including four species that are critically endangered under the provisions of the EPBC Act, namely, Curlew sandpiper, Great knot, Northern Siberian bar-tailed godwit and the Eastern curlew.

Table 9.57 Migratory birds of conservation significance identified from the desktop review as potentially occurring within the Project impact areas

Scientific name	Common name	EPBC Act status	NC Act status	Likelihood of occurrence in the Project impact areas
Shorebirds				
Charadrius mongolus	Lesser sand plover	Endangered, Migratory/Marine	Endangered	Confirmed
Charadrius leschenaultii	Greater sand plover	Vulnerable, Migratory/Marine	Vulnerable	Confirmed
Calidris canutus	Red knot	Endangered, Migratory/Marine	Endangered	Confirmed
Calidris ferruginea	Curlew sandpiper	Critically endangered, Migratory/Marine	Endangered	Confirmed

Scientific name	Common name	EPBC Act status	NC Act status	Likelihood of occurrence in the Project impact areas
Calidris tenuirostris	Great knot	Critically endangered, Migratory/Marine	Endangered	Confirmed
Limosa lapponica baueri	Bar-tailed godwit	Vulnerable, Migratory/Marine[1]	Vulnerable	Confirmed
Limosa lapponica menzbieri	Northern Siberian bar-tailed godwit	Critically endangered, Migratory/Marine[1]	Endangered	Confirmed
Numenius madagascariensis	Eastern curlew	Critically endangered, Migratory/Marine	Endangered	Confirmed
Pelagic species				
Ardenna pacifica	Wedge-tailed shearwater	Migratory/Marine	Vulnerable	Moderate
Phoebetria fusca	Sooty albatross	Vulnerable, Migratory/Marine	Vulnerable	Moderate
Thalassarche cauta cauta	Shy albatross	Vulnerable, Migratory/Marine	Vulnerable	Moderate
Thalassarche impavida	Campbell albatross	Vulnerable, Migratory/Marine	Not listed	Moderate
Thalassarche salvini	Salvin's albatross	Vulnerable, Migratory/Marine	Not listed	Moderate
Thalassarche cauta steadi	White-capped albatross	Vulnerable, Migratory/Marine	Vulnerable	Moderate
Thalassarche eremita	Chatham albatross	Endangered, Migratory/Marine	Not listed	Moderate
Thalassarche melanophris	Black-browed albatross	Vulnerable, Migratory/Marine	Not listed	Moderate
Macronectes giganteus	Southern giant petrel	Endangered, Migratory/Marine	Endangered	Moderate
Pterodroma neglecta neglecta	Kermadec petrel (western)	Vulnerable, Marine[2]	Not listed	Moderate
Fregetta grallaria grallaria	White-bellied storm-petrel	Vulnerable, Marine[3]	Not listed	Moderate
Pachyptila turtur subantarctica	Fairy prion (southern)	Vulnerable, Marine[4]	Not listed	Low

Source: Refer Appendix I1 (Appendix B)

Table notes:

1 Listed as migratory and marine species at the species level listing for *Limosa lapponica*
2 Listed as a marine species at the species level listing for *Pterodroma neglecta*
3 Listed as a marine species at the species level listing for *Fregetta grallaria*
4 Listed as a marine species at the species level listing for *Pachyptila turtur.*

9.16.2.4 Population trends

Global population trends

Four shorebird species known to occur within the Port Curtis region and which have recently been listed under the EPBC Act as critically endangered, are the Eastern curlew, Curlew sandpiper, Great knot, and the Northern Siberian Bar-tailed Godwit. Garnett et al. (2011) identified in *The Action Plan for Australian Birds 2010* that the populations for these species had undergone recent and ongoing declines of up to 79% in the past three generations of these species (refer Table 9.58).

For the Eastern curlew, observed declines in numbers across Australia are reported to stem from ongoing loss of intertidal mudflat habitat at key migration staging sites in the Yellow Sea (TSSC 2015a). Curlew sandpipers are threatened by wetland degradation in East Asia at stopovers during their migration, with recorded threats to habitat, including environmental pollution, reduced river flow, sea level rise, human disturbance and reclamation for industrial uses (TSSC 2015b). Threats for migratory shorebirds are also occurring in Australia, including coastal development, land reclamation, alteration to surface and groundwater levels, recreational activities and impacts on food availability due to change in water quality (TSSC 2015a; 2015b).

Table 9.58 Population trends reported in the Action Plan for Australian Birds 2010 for species confirmed within the Project impact areas

Species	Population trends reported in *Action Plan for Australian Birds 2010*
Eastern curlew	Past, recent and ongoing declines of 30% to 49% in three generations (30 years) based on survey data and habitat loss
Grey-tailed tattler	Declines of 20% to 29% over three generations (25 years) based on survey data
Lesser sand plover	Past, current and anticipated declines of 50% to 79% over periods of three generations (24 years) based on survey data and habitat loss
Ruddy turnstone	Past decline in flyway estimated at 30% to 49% in three generations (25 years) based on survey data. However non-declining populations in other flyways are not phenotypically differentiated, suggesting genetic interchange, so downgraded to near threatened
Curlew sandpiper	Past, recent and ongoing declines of 50% to 79% in three generations (23 years) based on survey data and habitat loss
Great knot	Data not available
Northern Siberian bar-tailed godwit	Data not available

Source: Garnett et al. (2011)

Shorebird populations in the Curtis Coast region

The population dynamics and abundance of shorebirds within the Curtis Coast region are not understood well enough to draw statistically valid conclusions regarding trends in populations or abundance.

Wildlife Unlimited (2016) found a reduction in the total abundance in shorebirds compared to the previous year, which was mostly due to a 42% reduction in the number of Red-necked stints recorded. Other species that returned a reduction in abundance compared to 2015 were Greater sand plover, Bar-tailed godwit, Great knot, Terek sandpiper and Grey plover. These decreases were offset by increases in the abundance of Grey-tailed tattlers and a number of the species which are relatively rare on the Curtis Island (Wildlife Unlimited 2016).

Wildlife Unlimited (2017) found a 21% increase of migratory shorebirds from February 2016, and 14% more than the summer average calculated from nine surveys conducted in January and February from 2011 to 2017. The increase in total abundance of migratory shorebirds was mostly due to the 229% increase in the number of Terek sandpipers (Wildlife Unlimited 2017). Other species that returned an increase in abundance compared to 2016 were Sand plover species, Red-necked stint and Whimbrel. The distribution of migratory shorebird was skewed to the north with the three highest abundance roosts all located there.

The survey conducted in 2017 found that the total abundance of migratory shorebirds was only slightly less than the previous year and it was concluded that the overall trend of migratory shorebird abundance on the Curtis Coast does not appear to be declining (Wildlife Unlimited 2016; 2017; 2018).

9.17 Migratory birds – potential impacts and risk assessment

9.17.1 Background

9.17.1.1 Section content

This section identifies the potential impacts on, and risk assessment for migratory shorebirds, and migratory pelagic birds (herein referred to as migratory seabirds), and their habitat, as a result of the Project activities. This section discusses impacts on migratory shorebirds and migratory seabirds that are known to occur, or have a moderate likelihood of occurrence within the Project impact areas.

The likelihood of occurrence assessments undertaken for the Project confirmed the presence of 18 migratory bird species within the Project impacts areas, including species, which are listed as species of conservation significance. A range of migratory bird species were considered to have a moderate likelihood of occurrence (refer Appendix I1 (Section 12)), however, these are not addressed specifically in this impact assessment as potential impacts are not expected to occur as a result of the Project activities. Section 9.7 (intertidal and terrestrial fauna) addresses the potential Project impacts on terrestrial and aerial migratory species, and resident shorebirds, and these species groupings are therefore not included within this section.

The definition of 'important habitat' for migratory shorebird species used throughout this section is defined in accordance with the EPBC Act Policy Statement 3.21 (DoEE 2017a). This definition applies to all migratory shorebird species, with the exception of Latham's snipe (*Gallinago hardwickii*), which has its own definition. Table 9.59 includes definitions for important migratory shorebird habitat.

Table 9.59 Important migratory shorebird habitat as defined in the EPBC Act Policy Statement 3.21

Important habitat type	Definition
Internationally important habitat	The habitat regularly supports: ▪ 1% of the individuals in a population of one species or a subspecies of waterbird **OR** ▪ A total abundance of at least 20,000 waterbirds.
Nationally important habitat	The habitat regularly supports: ▪ 0.1% of the flyway population of a single species of migratory shorebird **OR** ▪ 2,000 migratory shorebirds **OR** ▪ 15 migratory shorebird species.
Latham's snipe (*Gallinago hardwickii*)	Important habitat for Latham's snipe is described as areas that have previously been identified as internationally important for the species, or areas that support at least 18 individuals of the species

Source: DoEE (2017a)

This section provides a discussion of the potential impacts on migratory shorebirds, migratory seabirds, and their habitat, associated with the following Project activities. Table 9.60 summarises the Project activities and the relevant section containing the impact assessment discussion.

Table 9.60 Summary of Project activities and section addressed (migratory birds)

Project activity	Section
Establishment of the WBE reclamation area and BUF, including: ▪ Site preparation ▪ Establishment of the site compound, offices and temporary areas ▪ Source and transport of reclamation bund wall material ▪ Placement of core and armour material, and geotextile fabric ▪ Sheet piling (or similar earth retaining structure) and fill placement for the BUF	Section 9.17.2
Dredging activities, including: ▪ Initial dredging works for the barge access channel ▪ Dredging to duplicate the Gatcombe and Golding Cutting shipping channels ▪ Dredging vessel movements ▪ Unloading and placement of dredged material in the WB and WBE reclamation areas	Section 9.17.3
Removal and installation of navigational aids	Section 9.17.4
Stabilisation and maintenance activities on the WBE reclamation area	Section 9.17.5

Operation of the duplicated shipping channels and maintenance dredging activities are discussed in Sections 9.23 and 9.24, respectively.

Appendix I2, Table 18.2 provides an overview of these Project activities and the key potential impacts on ecological values/receptors, including migratory shorebirds, migratory seabirds and their habitat.

Migratory shorebirds have been grouped for the purposes of this impact assessment as they are generally considered to occupy similar habitats within the Project direct impact and potential indirect impact areas. This approach has also been adopted for migratory seabirds. Where relevant, species-specific habitat requirements are considered, particularly for species for which the site is considered important habitat.

9.17.1.2 Sensitivity ratings

Based on the sensitivity descriptions in Appendix I2 (Section 3.1 (refer Table 3.1 for the criteria used to define sensitivity ratings)), the sensitivity ratings for migratory shorebirds and migratory seabirds, and their habitat, are as follows:

- Important habitat, and migratory shorebirds and migratory seabirds birds listed as Critically endangered or Endangered, have a sensitivity rating of very high
- All other migratory shorebirds and migratory seabirds, and habitat which is not considered important habitat, have a sensitivity rating of high.

9.17.2 Establishment of the dredged material placement area and barge unloading facility

9.17.2.1 Permanent loss and alteration of habitat

Context of impact

The establishment of the WBE reclamation area will result in the direct and permanent loss of migratory shorebird habitat which is considered to have a sensitivity rating of high to very high.

It is unlikely that the establishment of the WBE reclamation area will result in the loss of any migratory seabird habitat as the WBE reclamation area is situated in intertidal environments (refer Figure 9.62). There is no known breeding habitat within the Project's direct and potential indirect impact areas.

The location of the BUF has not been identified as being potential habitat for migratory birds and therefore the establishment of the BUF is not expected to result in any significant loss of migratory shorebird habitat or migratory seabird habitat.

The establishment of the WBE reclamation area will result in the direct and permanent loss of 275.37ha of potential migratory shorebird habitat, with the majority of this loss from within the WBE reclamation area bund walls (refer Table 9.61 and Figure 9.62). Overall, the direct and permanent loss of this potential habitat due to establishment of the WBE reclamation area, equates to approximately 1.18% of the total area of the potential habitat in the Port Curtis region.

Table 9.61 Western Basin Expansion reclamation area direct disturbance areas and the area of shorebird habitat within the reclamation area and associated direct impact areas

Direct disturbance area (total area in ha)	Area situated within shorebird habitat[1] (proportion of the total Project direct impact area as a percentage)
WBE reclamation area (southern area) (111.12ha)	110.39ha (99.34%)
WBE reclamation area (northern area) (164.98ha)	164.98ha (100%)
WBE reclamation area construction compound (1.98ha)	0ha[3] (0%)
BUF	0ha (0%)
Total direct disturbance area of 278.08ha	**275.37ha (99.03%)**
Total proportion of the migratory shorebird habitat within the Port Curtis region (23,392.05ha)[2]	**1.18%**

Table notes:

1 Refer Figure 9.62
2 Area shown in Figure 9.62
3 This mapped area is situated on reclaimed land associated with the existing WB reclamation area.

The WBE reclamation area is situated in close proximity to a number of sites that have been identified through shorebird surveys as important roosting sites, including sites associated with Friend Point on Kangaroo Island (refer Figure 9.62). Previous surveys show that roosts surrounding the WBE reclamation area have been identified as important roost sites over multiple survey periods (refer Figure 9.62), and continue to be reported as important habitat (IMEMS 2013; Wildlife Unlimited 2013; 2015; 2016).

Although the establishment of the WBE reclamation area will not result in the direct and permanent loss of important roost sites, most shorebird species prefer roosts close to foraging habitat (Zharikov and Milton 2009), and it is likely that the foraging habitat within the WBE reclamation area is important foraging habitat for shorebirds that utilise the important roost sites at Friend Point.

Many migratory shorebirds show fidelity to sites in their non-breeding grounds (Coleman and Milton 2012). This fidelity to roosting and foraging habitat in their non-breeding grounds can adversely impact on their survival rates where important habitats have been developed or otherwise lost (Coleman and Milton 2012). Coleman and Milton (2012) conclude that fidelity and access to safe roost sites and productive foraging sites is critical for enabling shorebirds to prepare for and recover from long migrations. Coleman and Milton (2012) report that changes to non-breeding habitat can have consequences for long-distance migratory shorebirds at the population scale, and that it is important to consider the protection of foraging and roosting sites together as a single system.

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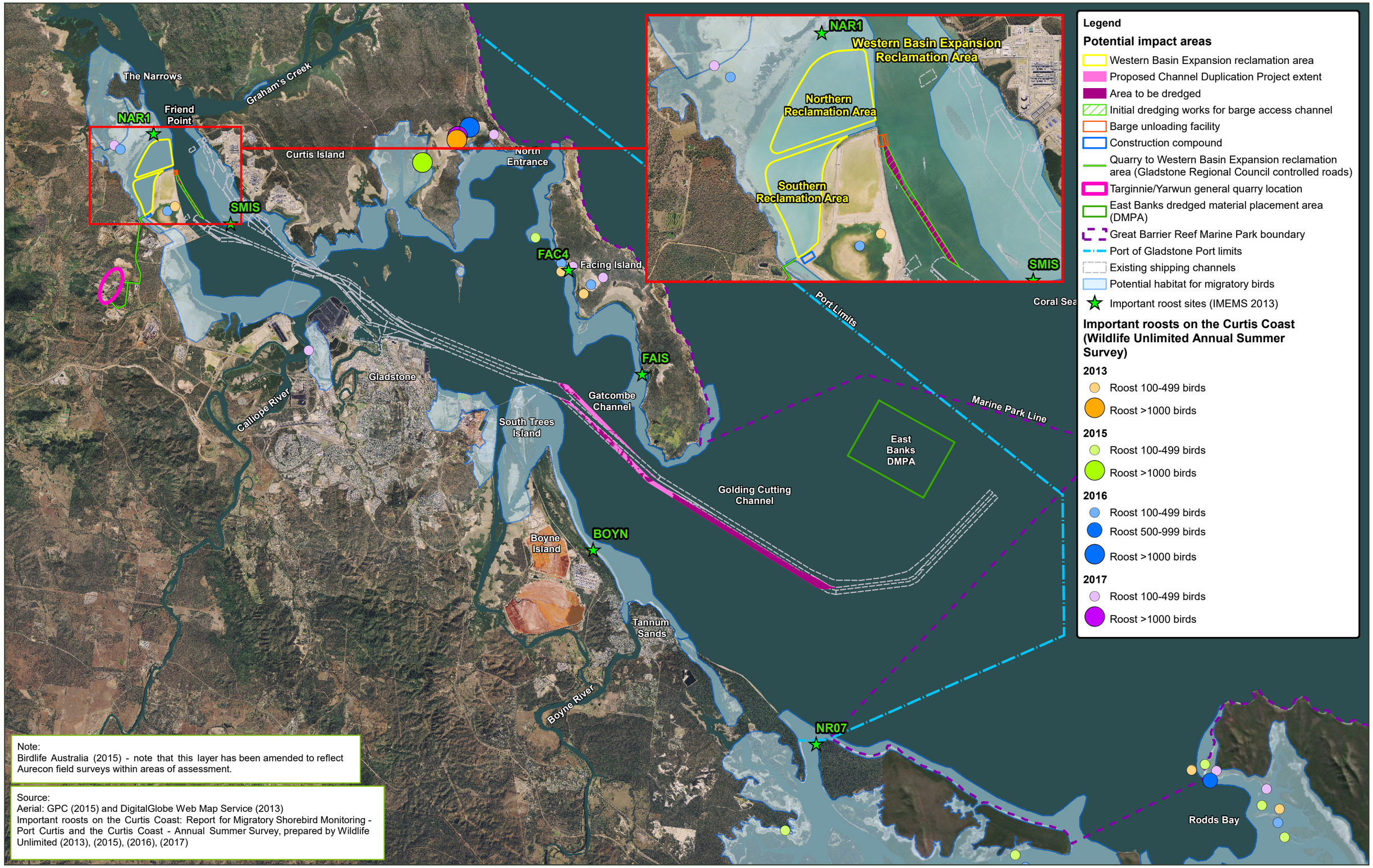

Note:
Birdlife Australia (2015) - note that this layer has been amended to reflect Aurecon field surveys within areas of assessment.

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Important roosts on the Curtis Coast: Report for Migratory Shorebird Monitoring - Port Curtis and the Curtis Coast - Annual Summer Survey, prepared by Wildlife Unlimited (2013), (2015), (2016), (2017)

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_275.mxd 07/02/2019 16:35

0 1,900 3,800 Metres

Date: 07/02/2019 Version: 3 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.62: Potential habitat for migratory birds and important roost sites

Wildlife Unlimited (2015) reports that the existing WB reclamation area appears to continue to experience a localised reduction in migratory shorebird numbers, and that it remains unclear if the development associated with the WBDDP has resulted in significant habitat change or a permanent decline in migratory shorebird numbers returning to the Port. In 2016, Wildlife Unlimited identified that one potential cause of the decline in the upper harbour of Port Curtis is potentially due to the loss of foraging habitat; however stated that the shorebird population dynamics on the Curtis Coast are not well enough understood to accurately identify population trajectories with certainty (Wildlife Unlimited 2016).

The loss of the foraging habitat as a result of the establishment of the WBE reclamation area has the potential to result in the movement of shorebirds to roost and foraging sites in other areas of the Port. This has the potential to result in adverse impacts on the survival of migratory shorebirds and their breeding success where shorebirds are unable to find suitable alternative foraging sites within close proximity to suitable roosting sites.

The potential impacts on migratory birds as a result of the loss of suitable habitat within the WBE reclamation area will be permanent and within a contained area, and is therefore moderate is magnitude. The magnitude of the direct and permanent loss of migratory shorebird habitat associated with the establishment of the reclamation area will be reduced through the implementation of adaptive design measures during detailed design (refer Section 9.27). Project mitigation measures are provided in Section 9.27 and the Project EMP (refer Appendix Q2).

During the establishment of the WBE reclamation area, the post mitigation risk ratings associated with the direct and permanent loss and fragmentation of migratory shorebird habitat are very high. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.17.2.2 Direct mortality and injury

Site preparation activities and onsite truck and vehicle movements have the potential to result in the direct mortality or injury of migratory shorebirds during the establishment of the WBE reclamation area and BUF. The transport of bund wall material for the WBE reclamation area and BUF from the Yarwun/Targinnie quarry area also has the potential to result in mortality or injury of migratory shorebirds as a result of vehicle strike. As the potential migratory shorebird habitat located along the quarry access road is predominantly situated immediately adjacent to the WB and WBE reclamation areas, and the likelihood and consequences are not expected to be significantly different, these risk sources have been considered together in the assessment of this potential impact.

Physical trauma as a result of vehicle strike and/or site preparation activities is a direct impact which has the potential to reduce population numbers of migratory shorebirds, or individual migratory shorebird species populations (Coffin 2007; Rowden et al. 2008). The magnitude of impact associated with potential fauna mortality or injury would be proportionate to the extent of potential species habitat that is impacted, and whether the habitat is considered to be important habitat for migratory shorebirds (as defined in Table 9.59).

The effect of construction on migratory species has appeared to vary from place to place within Port Curtis. Previous studies have documented the apparent displacement and change in migratory shorebird populations at two roosts (WICT and Clinton Ash Ponds) (Wildlife Unlimited 2016; 2017). It was further documented that migratory birds were flying further west down the gas pipeline at Friend Point and settling near the shoreline noting another option for migratory shorebirds to use. The area near Western Basin found a decline in migratory shorebirds which could be associated with the reduction in foraging habitat (Wildlife Unlimited 2017).

Due to the susceptibility of migratory shorebirds to disturbance (e.g. noise, movements) and their highly mobile nature, it is considered likely that these species would move away from areas of disturbance (i.e. site preparation, vehicle movements) and may therefore be less likely to be impacted in comparison to less mobile fauna species (i.e. small reptile or arboreal mammals). The potential impacts associated with the disturbance and subsequent movement of migratory shorebirds are further discussed in Section 9.17.3.4.

The risk of physical trauma to migratory shorebirds as a result of the establishment of the WBE reclamation area and BUF is considered to be medium term in duration and within a contained extent, and therefore moderate in magnitude. The risk of potential impacts will be minimised through the implementation of mitigation measures included in Section 9.27 the Project EMP (refer Appendix Q2). Appropriate signage will be installed and reduced speed zones established within the direct impact areas in sensitive or high risk areas, to promote driver awareness and to reduce the risk of direct mortality or injury of fauna as a result of vehicle collision.

It is unlikely that the establishment of the WBE reclamation area and BUF will result in direct injury or mortality to the extent that numbers of migratory shorebirds or species populations of migratory shorebirds are likely to decline or be significantly impacted as a result.

During the establishment of the WBE reclamation area and BUF, the post mitigation risk ratings associated with the direct mortality and injury of migratory shorebirds are medium (vulnerable and/or migratory species) to high (critically endangered or endangered species). Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.17.2.3 Potential noise, vibration and dust impacts

Establishment of the WBE reclamation area and BUF is anticipated to increase the level of noise, vibration and dust in adjacent migratory shorebird habitat.

Noise, vibration and dust will be generated as a result of the increased truck movements associated with the transport of reclamation bund wall material. The placement of core and armour material and geotextile fabric for the reclamation bund wall is also expected to generate noise, vibration and dust which have the potential to impact on the behaviour of migratory shorebirds (e.g. disruption of roosting or foraging behaviour) in adjacent migratory shorebird habitat.

In addition to bund wall works, the placement of dredged material within the northern section of the WBE reclamation area has the potential to impact on the behaviour of migratory shorebirds.

Modelling based on the L_{Aeq} noise levels predicts <55 dBA to 70 dBA at roost site NAR1 and <50 dBA at roost site SMIS with respect to bund wall construction activities. These noise levels suggest the potential for alert reaction impacts with associated minor impact for habitat use at NAR1, but no impacts are anticipated at SMIS. For material placement activities within the northern section of the WBE reclamation area, noise level modelling predicts <50 dBA to 60 dBA at roost site NAR1 and <50 dBA at roost site SMIS with the potential for alert reaction impacts with associated minor impact for habitat use at NAR1.

For construction equipment which will most likely be used at the WBE reclamation area, it is noted that LA_{max} noise levels are typically 8 dBA greater than the LA_{eq} noise level. Applying a +8 dBA adjustment to the predicted LA_{eq} noise levels results in a LA_{max} 78 dBA at the nearest shoreline to the WBE northern reclamation area from the Project activities, and this has the potential for single event or suddenly short term noise events to cause alert responses and sometimes an alarm or flight reaction.

Additional information on the Project noise and vibration impact assessment is provided in Section 13.6.1.2 and Appendix K1.

Roosting and foraging migratory shorebirds are most susceptible to disturbances that are discrete and unpredictable, such as sudden loud noises (e.g. boat motors, demolition noise). Response to disturbance will vary depending on the species of migratory shorebird, with disturbance-sensitive species such as the Eastern curlew likely to be the first shorebird species to fly off when a flock is disturbed (Geering et al. 2008). Disturbance of migratory shorebirds can result in reduced food intake and increased energy expenditure, and has the potential to result in reduced use or abandonment of preferred feeding and roosting areas (Geering et al. 2008). Disturbances resulting in increased time spent in alarm flight, can adversely impact shorebird energy reserves required for migration, can alter the selection of roosting and foraging sites, and has the potential to ultimately affect the survival of migratory shorebirds (Collop et al. 2016; Lilleyman et al. 2016).

The air quality and greenhouse gas impact assessment (refer Chapter 12) assessed the potential impact of the Project on ground level concentrations of dust (TSP, PM_{10} and $PM_{2.5}$) as well as dust deposition rates.

Due to the proximity of the potential migratory bird habitat to the WBE reclamation area, ground-level concentrations of TSP, PM_{10}, $PM_{2.5}$ and dust deposition rates are predicted to exceed ambient air quality objectives within the habitat area as a result of bund wall construction and dredged material placement activities. The extent of exceedances is greater during dredged material placement activities. The extent of these exceedances is summarised in Table 9.62. Ground-level concentrations of PM_{10} and $PM_{2.5}$ at the NAR1 roosting site are predicted to exceed the relevant objectives during the construction of the bund walls and during dredging predominantly due to the transport of dredged material from the BUF to the reclamation areas.

Figure 12.11 to Figure 12.15 present the predicted ground-level concentrations of TSP, PM_{10}, $PM_{2.5}$ and dust deposition rates due to the dust generated from transport of dredged material from the BUF to the reclamation areas. The results for PM_{10} and $PM_{2.5}$ include emissions from the TSHD, pushbusters and tugboat.

Table 9.62 Area of potential migratory bird habitat where concentrations of particulate matter and dust deposition exceed objectives during dredging

Pollutant	Averaging period	Air quality objective (µg/m³)	Potential migratory bird habitat		Ground-level concentration at roosting sites (µg/m³)	
			Area of habitat affected (ha)	Proportion of habitat affected*	NAR1	SMIS
TSP	1-year	90	523	2.7%	120.6	31.2
PM_{10}	24-hour	50	2,102	20.1%	291.7	74.5
$PM_{2.5}$	24-hour	25	608	3.5%	42.2	14.0
	1-year	8	54	0.3%	9.1	5.4
Dust deposition rate for total insoluble solids	1 month	120 mg/m²/day	84	0.6%	365.2	33.6

Table note:

* Excluding the WBE reclamation areas, extent of habitat considered indicated in Figure 12.11 to Figure 12.15

The EPBC Act Policy Statement 3.21 identifies actions involving disturbance at important habitat areas during vital stages of migratory shorebird life cycles as 'highly likely' to be significant to migratory shorebirds (DoEE 2017a).

The IMEMS report (2013) identified an important roost site in proximity to the WBE reclamation area at Friend Point (refer Figure 9.62). There is potential for noise, dust, and vibration impacts to result in disturbance to migratory shorebirds utilising important habitat at Friend Point during the establishment of the WBE reclamation area. The Friend Point roost site has been identified as containing more than 0.1% of the East-Asian Australasian Flyway (EAAF) population of Eastern curlews on at least one occasion during shorebird monitoring (IMEMS 2013; Wildlife Unlimited 2017). Roosting and foraging habitat for migratory shorebirds within and adjacent to the Friend Point roost site is therefore considered to be 'Nationally important habitat' in accordance with the EPBC Act Policy Statement 3.21 (DoEE 2017a), as it has been identified as regularly containing 0.1% of the EAAF flyway population of Eastern curlews (IMEMS 2013; Wildlife Unlimited 2017). This includes both contiguous and non-contiguous habitat where there is evidence of regular movement between foraging and roosting habitats within the same general area (DoEE 2017a).

Furthermore, the total number of Eastern curlews recorded within the Curtis Coast region (i.e. Port Curtis, Fitzroy Estuary/North Curtis Island, Mundoolin Rocks/Colosseum Inlet/Rodds Bay) during the 2013, 2015, 2016 and 2017 Ecosystem Research and Monitoring Program (ERMP) annual summer shorebird surveys have exceeded 1% of the EAAF population (Wildlife Unlimited 2013; 2015; 2016; 2017). This indicates that the Curtis Coast is, as a whole, 'Internationally important habitat' in accordance with the EPBC Act Policy Statement 3.21 (DoEE 2017a).

Migratory shorebird activity within the existing WB reclamation area was recorded in 2013, 2016 and 2017 (Wildlife Unlimited 2013; 2016; 2017). During the 2017 surveys, four migratory shorebirds were recorded within the existing WB reclamation area, however the 2016 recorded higher numbers of migratory shorebirds utilising the reclamation area (Wildlife Unlimited 2017). A total of 327 migratory shorebirds were recorded within the existing WB reclamation area ponds in the 2016 summer shorebird survey at high tide, including small numbers of roosting Eastern curlew and Whimbrel, and Red-necked stints in a range of flock sizes that were recorded foraging (Wildlife Unlimited 2016). Red-necked stints are known to be flexible and opportunistic foragers in comparison to other migratory shorebirds (Minton et al. 2012), and it is likely that they were feeding on prey items from the dredged material within the existing reclamation area (Wildlife Unlimited 2016). It is not expected that the Red-necked stint will be able to use this habitat once stabilisation has commenced (i.e. as there is unlikely to be suitable foraging habitat available following dewatering and stabilisation of the landform); however, this does show that this species has been recorded in areas that have been subject to disturbance as a result of dredging activities.

The 2016 annual summer shorebird survey report (Wildlife Unlimited 2016) identifies that many of the migratory shorebird species on the Curtis Coast have exhibited considerable variation in their temporal and spatial distribution. The report concluded that the population dynamics of the constituent migratory shorebird species were not understood well enough to establish accurate conclusions on the trajectories of individual species populations (Wildlife Unlimited 2016). Though migratory shorebird abundance at sites subject to construction disturbance were generally lower than recorded at the beginning of the ERMP in 2011, this was not the case for all individual migratory shorebird species (Wildlife Unlimited 2016).

In the 2017 annual summer shorebird monitoring report (Wildlife Unlimited 2017), the total abundance of migratory shorebirds for the Curtis Coast had increased by 21% in comparison to the 2016 survey. This increase was reportedly due to a 229% increase in the number of Terek sandpipers recorded, though other species also showed increases (e.g. Red-necked stint and Whimbrel) (Wildlife Unlimited 2017).

The annual summer migratory shorebird survey reports conclude that it is unclear as to whether the existing WB reclamation area activities have resulted in a significant change to important habitat or the long term decline of migratory shorebirds in the Port Curtis region (Wildlife Unlimited 2013; 2016; 2017). Furthermore, changes due to disturbance are not directly detectable or attributable using the Shorebird 2020 survey methodology (Wildlife Unlimited 2013; 2016).

Potential noise and dust impacts associated with the establishment of the WBE reclamation area and BUF have the potential to result in the disturbance of migratory shorebirds and changes behaviour. Impacts will be managed and mitigated through the implementation of mitigation measures in Section 9.27 and the Project EMP (refer Appendix Q2). Migratory shorebird behaviour will be monitored during establishment of the WBE reclamation area and BUF with adaptive management strategies implemented where activities are likely to result in a significant impact on migratory shorebird species in important habitats adjacent to the WBE reclamation area (refer Section 9.27).

The potential impacts associated with potential noise and dust impacts on shorebirds during the establishment of the WBE reclamation area and BUF may occur over the medium term and will be contained in extent, and therefore moderate in magnitude.

During the establishment of the WBE reclamation area and BUF, the post mitigation risk ratings associated with potential impacts on shorebirds as a result of increased noise and dust are high. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.17.2.4 Indirect impacts associated with the establishment of the reclamation area and barge unloading facility

Potential increase in waste material and marine debris

Construction activities associated with the establishment of the WBE reclamation area and BUF has the potential to generate some waste material (e.g. plastic debris). Commonwealth of Australia (2016) identifies the direct impacts to migratory shorebirds and migratory seabirds from ingestion and entablement of marine debris. This Project activity and potential exposure of migratory birds to these impacts will be within the short term and restricted to a contained area, and therefore low in magnitude.

The post mitigation risk ratings associated with impacts on migratory shorebirds from a potential increase in waste material and marine debris during establishment of the WBE reclamation area and BUF are low (vulnerable and/or migratory species) to medium (critically endangered or endangered species). Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to minimise and avoid waste materials entering the marine environment during the WBE reclamation area and BUF establishment will be included in Section 9.27 and the Project EMP (refer Appendix Q2).

Hydrodynamic and water quality impacts resulting in habitat alteration

Hydrodynamic changes to the areas within the channel between the northern and southern reclamation areas, and between the reclamation area and coastline, have the potential to impact on seagrass meadows directly adjacent to the WBE reclamation area.

The hydrodynamic modelling of erosion and siltation impacts indicate that there will be an increase in the velocity in the channel and between the reclamation area and the coastline area and therefore increasing the potential for erosion and siltation as shown in Figure 9.26 (refer Section 9.9.2.4).

Benthic taxa assemblages in intertidal areas have been shown to be directly associated with duration of submergence, sediment composition and the nearest distance to channels. Therefore, changes in marine water velocities, erosion and siltation have the potential to result in the decrease in abundance or altered distribution of prey resources.

This has the potential to indirectly impact on migratory shorebirds by altering the suitability of foraging habitat resulting in changes in foraging and roosting behaviour (e.g. reduced intake of prey items or movement to alternative foraging locations if available). Alterations to non-breeding foraging and roosting habitat have a strong influence on the timing of migration and subsequent nesting success (Coleman and Milton 2012; Gunnarsson et al. 2006).

Adaptive design measures will be implemented during the Project detailed design phase to reduce the magnitude of potential hydrodynamic changes on the suitability of intertidal foraging habitat for migratory shorebirds (refer Section 9.27).

The potential impacts to potential foraging habitat as a result of the hydrodynamic changes after the establishment of the WBE reclamation area will be generally restricted to a contained area and permanent. Therefore, the potential impacts are moderate in magnitude.

During the establishment of the WBE reclamation area and BUF, the post mitigation risk ratings associated with the direct mortality and injury of migratory shorebirds are medium (vulnerable and/or migratory species) to high (critically endangered or endangered species). Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to minimise the potential hydrodynamic changes and impacts on shorebird habitat as a result of the establishment of the WBE reclamation and BUF are included in Section 9.27 and the Project EMP (refer Appendix Q2).

Contaminant and sediment releases resulting in impacts on habitat

Migratory shorebirds and suitable habitat adjacent to the WBE reclamation area and BUF have the potential to be adversely impacted by contaminant and sediment releases during the establishment of the WBE reclamation area and BUF.

Activities that have the potential to result in the release of contaminants and sediment during establishment of the WBE reclamation area and BUF include:

- Site preparation activities
- Establishment of the site compound and other temporary construction areas
- Placement of core and armour material and geotextile fabric
- Sheet piling (or similar earth retaining works) associated with the establishment of the BUF
- Movement of trucks onsite associated with the transport of reclamation bund wall material
- Use of machinery onsite during the establishment of the WBE reclamation area and BUF.

Sediment entering into water has the potential to temporarily increase turbidity levels in the vicinity of the Project activities and with Port Curtis as the plume disperses. Following significant rain events, runoff from disturbed areas has the potential to result in the release of sediments from the WBE reclamation area and BUF into adjacent intertidal and marine areas. This sediment has the potential to impact on marine flora and fauna, and has the potential to affect the distribution and abundance of migratory shorebird prey.

Contamination of soils and shallow groundwater has the potential to occur as a result of accidental spillage of hydrocarbons (e.g. fuels, hydraulic oils and lubricants) from construction machinery, particularly during refuelling or from fuel or chemical storage tanks. These contaminants have the potential to be released into adjacent habitat areas, resulting in the degradation of the migratory shorebird habitat adjacent to the WBE reclamation area. Injury and mortality of migratory shorebirds has the potential to occur where there is either direct contact with the contaminant, or indirectly through adverse impacts on prey items (e.g. altered prey abundance or composition as a result of the effects of smothering or toxicity) (Zengel et al. 2016).

Waste materials such as plastic debris released during Project activities are a potential source of toxic chemicals such as PCBs, endocrine-active substances and chemicals similar to DDT. These chemicals are known to compromise immunity and cause infertility in animals, even at very low levels (Diamanti-Kandarakis et al. 2009).

This represents a potential source of contaminants during establishment of the WBE reclamation area and BUF for migratory shorebirds and their prey.

The magnitude of potential impacts to migratory shorebirds and habitat due to the potential release of contaminants and sediments during the establishment of the WBE reclamation area and BUF will be managed and mitigated through the implementation of mitigation measures in Section 9.27 and the Project EMP (refer Appendix Q2). These potential impacts may occur over the medium term and are expected to be contained in extent, and are therefore moderate in magnitude.

During the establishment of the WBE reclamation area and BUF, the post mitigation risk ratings associated with contaminant and sediment releases and impacts on migratory shorebirds and their habitat are medium (vulnerable and/or migratory species) to high (critically endangered or endangered species). Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Reduced suitability of migratory shorebird habitat due to the introduction and/or spread of pests and/or weeds

The movement of equipment, material and vehicles during the establishment of the WBE reclamation area and BUF have the potential to result in the introduction and/or spread of weed and pest species. The site preparation activities associated with establishment of the WBE reclamation area and BUF have the potential to result in the introduction of new pest and weeds, or the spread of existing pest and weed species within the local area.

Three invasive flora species listed under the provisions of the Biosecurity Act have been recorded within the Project impact areas during Project EIS field investigations (refer Appendix I1 (Section 3)). The movement of equipment, material and vehicles has the potential to inadvertently introduce and spread pest and weed species occurring within the Project impact areas across the region if unmitigated.

The establishment of the WBE reclamation area and BUF is unlikely to result in the introduction or spread of weed species into adjacent areas of habitat associated with Friend Point, however, there is potential for an increase in the pressures associated with predation by invasive animal species (e.g. feral cats, foxes and feral dogs) as the reclamation bund wall provides a potential movement pathway for feral animals to move into adjacent areas of migratory shorebird habitat.

The magnitude and likelihood of adverse impacts on migratory shorebirds and adjacent habitat as a result of the introduction or spread of pest and weed species will be managed and mitigated through the implementation of mitigation measures in Section 9.27 and the Project EMP (refer Appendix Q2).

These potential impacts may occur over the medium term and are expected to be contained in extent, and are therefore moderate in magnitude.

During the establishment of the WBE reclamation area and BUF, the post mitigation risk ratings associated with indirect impacts on migratory shorebird habitat as a result of the introduction and spread of weed or pest species are medium (vulnerable and/or migratory species) to high (critically endangered or endangered species). Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.17.3 Dredging activities

9.17.3.1 Potential noise, vibration and dust impacts

Dredging activities have the potential to result in increased noise, dust and vibration impacts on migratory shorebirds and migratory seabirds. The key dredging activities with potential to adversely impact migratory shorebirds and migratory seabirds include:

- Dredging within the areas to be dredged (i.e. for the barge access channel and the duplication of the channels)
- Increased dredging vessel movements throughout the Port associated with Project activities
- Dredged material unloading and placement within the WB and WBE reclamation areas.

Noise, vibration, and dust impacts have the potential to impact on the behaviour of migratory shorebirds (e.g. disruption of roosting or foraging behaviour) and the foraging behaviour of migratory seabirds. The potential impacts on migratory shorebirds as a result of noise, vibration and dust impacts are included in Section 9.17.2.3 in relation to establishment of the WBE reclamation area and BUF and these impact pathways remain relevant for the impact sources listed in this section.

Noise, vibration and dust impacts have the potential to impact on the foraging behaviour of migratory seabirds during dredging activities. Migratory seabird foraging behaviour has the potential to be impacted by the movements of marine vessels throughout the Port, associated with dredging activities and the operations of existing Port, industrial and recreational uses. This has the potential to result in the movement of migratory seabirds to alternative foraging areas within or outside of the Port Curtis region.

These Project impact areas are situated in an environment currently subject to noise, vibration and dust impacts associated with existing infrastructure, industry and recreational activities (e.g. noise from recreational boating). These existing disturbances have also been considered in the Project risk assessment and the potential for significant impacts on migratory shorebirds (in accordance with the EPBC Act Policy Statement 3.21 (DoEE 2017a)).

Dredging works area have the potential to impact on the behaviour of migratory shorebirds. Modelling based on the L_{Aeq} noise levels predicts <50 dBA to 60 dBA at roost site NAR1 and <50 dBA at roost site SMIS with the potential for alert reaction impacts with associated minor impact for habitat use at NAR1 but no impacts are anticipated at SMIS.

Impacts will be managed and mitigated through the implementation of mitigation measures in Section 9.27 and the Dredging EMP (refer Appendix Q1). Migratory shorebird and migratory seabird behaviour will be monitored during the Project activities adaptive management strategies implemented where activities are likely to result in a significant impact on species or important habitats adjacent to the WBE reclamation area (refer Section 9.27).

The potential impacts associated with potential noise impacts on migratory birds during dredging activities may occur over the short term and will be contained in extent, and are therefore low in magnitude.

During the dredging activities, the post mitigation risk ratings associated with the potential noise, dust and vibration on migratory shorebirds and migratory seabirds are medium (vulnerable and/or migratory species) to high (critically endangered or endangered species). Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.17.3.2 Direct mortality and injury due to vessel movements

Vessel movements associated with dredging activities pose a potential risk to migratory shorebirds and migratory seabirds in Port Curtis. It is expected that direct injury or mortality of migratory birds as a result of vessel movements will be limited, as these species have been reported to respond to disturbance by marine vessels by taking flight (when foraging or roosting) (Milton et al. 2011) or by avoiding areas of disturbance.

A vulnerability assessment of offshore and migratory seabirds undertaken by GBRMPA in 2012 indicated that these species are not thought to be widely impacted by the port and shipping activities in the Great Barrier Reef (GBRMPA 2012e). This assessment concluded that given the large extent and broad distribution of foraging grounds for offshore and migratory seabirds, the degree of exposure to impacts associated with ports and shipping, their sensitivity to these impacts and the residual vulnerability of these species to these impacts are considered to be low (i.e. in consideration of their natural adaptive capacity and the implementation of adaptive environmental management strategies) (GBRMPA 2012e).

The Port of Gladstone currently experiences a high volume of commercial and recreational vessel traffic. The nature, scale and volume of Project vessel movements are considered minor compared to the existing Port vessel movements. It should be noted that vessel numbers required to complete the Project will be considerably lower than those required during the Western Basin capital dredging and LNG development on Curtis Island between 2011 and 2015.

Dredging activities will be short term and the potential for direct injury or mortality as a result of a vessel strike would be contained to the direct area of the dredging activity or vessel movement. These potential impacts are therefore expected to be moderate in magnitude.

The potential impacts on migratory shorebirds and migratory seabirds will be managed and mitigated during dredging activities to reduce the risk of direct injury and/or mortality through implementation of mitigation measures in Section 9.27, the Dredging EMP and the Project EMP (refer Appendices Q1 and Q2, respectively).

During the dredging activities, the post mitigation risk ratings associated with the potential for direct injury and mortality of migratory shorebirds and migratory seabirds as a result of marine vessel movements are medium (vulnerable and/or migratory species) to high (critically endangered or endangered species). Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.17.3.3 Short term decline in water quality

During dredging activities there is potential for adverse impacts on migratory shorebirds and migratory seabirds as a result of adverse impacts on water quality within and surrounding the Project impact areas. The potential sources of water quality impacts are discussed in Section 9.17.2.4 for establishment of the WBE reclamation area and BUF.

Contaminated marine waters, soils and shallow groundwater have the potential to occur as a result of accidental spillage of hydrocarbons (e.g. fuels, hydraulic oils and lubricants) from dredging vessels and construction machinery associated with dredging activities (including activities within the WB and WBE reclamation areas). These contaminants have the potential to result in the injury and/or mortality of migratory shorebirds and migratory seabirds in the event of a significant spill. Migratory shorebird habitat also has the potential to be adversely impacted as a result of hydrocarbon spills, and prey composition or abundance may be reduced or altered due to the effects of smothering or toxicity (Zengel et al. 2016).

Dredging activities that have the potential to affect water quality will likely be contained to certain areas at any given time (i.e. only one dredger will be working at particular points within the areas to be dredged at any given time). The zone of impact models for dredging activities indicate the expected spatial and temporal patterns of the dredging sediment plume associated with the Project. Within the zones of high and moderate impacts, there is potential for temporary changes in the distribution and abundance of food sources for migratory shorebirds (e.g. worms, bivalves and crustaceans), however due to the limited extent of impacts within the zone of high impact, it is not expected that dredging activities will have a significant impact on water quality to therefore impact the food sources of migratory shorebirds or migratory seabirds. Desktop and field geochemical investigations undertaken for the Project concluded that the marine sediments to be removed from the areas to be dredged are considered ‘clean’ as per NAGD (2009) and the potential for contaminants to be mobilised into the water column during dredging activities is considered to be low (refer Section 6.5 and Appendices E4 and E6).

Based on these results the potential for direct impacts on migratory shorebirds and migratory seabirds as a result of increased levels of contaminants in the water column or their food chain is considered unlikely to occur.

The Dredging EMP (refer Appendix Q1) will be implemented during dredging activities which will minimise and mitigate potential impacts to water quality from dredging activities. These plans include adaptive and reactive mitigation measures to be adopted during dredging activities. Mitigation measures to minimise water quality impacts are provided in Section 9.27.

These potential impacts may occur over the short term and are expected to be contained in extent, and are therefore low in magnitude.

During the dredging activities, the post mitigation risk ratings associated with the release of contaminants or sediments and potential impact on migratory shorebirds and migratory seabirds are low (vulnerable and/or migratory species) to medium (critically endangered or endangered species). Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.17.3.4 Indirect impacts

Loss of food sources and impacts on migratory shorebird and migratory seabird prey

Dredging activities will result in the direct loss of benthic habitats which provide habitat for a range of migratory shorebird and migratory seabird prey within Port Curtis. The benthic communities within the areas to be dredged support the production of macroinvertebrates, fish and marine reptiles (excluding marine turtles), which provide a food source for migratory shorebirds, migratory seabirds and a range of other marine and intertidal fauna species.

Approximately 247.77ha of benthic habitat will be directly lost from the area to be dredged for the channel duplication, and a further 94.06ha of benthic habitat is situated within the zone of moderate impact and could potentially be adversely impacted as a result of the dredging activities.

Dredging activities that have the potential to result in the loss of food sources for migratory shorebirds and migratory seabirds are expected to occur within and directly adjacent to the areas to be dredged. This has the potential to result in adverse impacts on the survival of migratory shorebirds and migratory seabirds, as the potential adverse impacts on food sources may limit their ability to accumulate/store adequate energy reserves for a successful migration to breeding habitat.

The distribution of benthic taxa have been shown to be influenced by the duration of submergence and sediment composition, therefore it is expected that within the zones of high and moderate impacts, there is potential for temporary changes in the distribution and abundance of food sources for migratory shorebirds (e.g. worms, bivalves and crustaceans). Due to the limited extent of impacts within the zone of high impact, it is not expected that dredging activities will have a significant impact on food sources of migratory shorebirds or migratory seabirds.

The Project will result in the permanent loss of benthic habitat in this area as annual maintenance dredging will occur within this area. The loss of these benthic communities is not expected to significantly impact on the foraging behaviour of migratory shorebirds or migratory seabirds.

Adaptive design measures will be implemented during the Project detailed design phase, including dredging methodology to reduce the impact of benthic habitat loss within the areas to be dredged (refer Section 9.27). Mitigation measures to minimise water quality impacts are provided in Section 9.27.

These potential impacts may occur over the short term and within the local area, and are therefore moderate in magnitude.

The post mitigation risk ratings associated with dredging activities and the potential for indirect adverse impacts on migratory shorebirds and migratory seabirds as a result of the loss of food sources for the species are medium (vulnerable and/or migratory species) to high (critically endangered or endangered species). Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.17.4 Removal and installation of navigational aids

The removal (via air blasting), installation and repositioning of navigational aids will result in a small increase in vessel movements in close proximity to the proposed duplicated channel extent.

During the removal and installation of the navigational aids there is potential for the accidental release of contaminants from vessels (e.g. spills), which has the potential to adversely impact on migratory shorebirds, migratory seabirds and their habitat. The impacts associated with spills are included in Section 9.17.3.3 in relation to the dredging activities, and also apply to this Project activity.

These potential impacts will be temporary in duration and are expected to be contained in extent, and are therefore low in magnitude.

Impacts on migratory shorebirds and migratory seabirds as a result of the navigational aid activities will be minimised and mitigated through the implementation of mitigation measures in Section 9.27 and the Project EMP (refer Appendix Q2).

The post mitigation risk ratings associated with the removal and installation of navigational aids and the potential for impacts on migratory shorebirds and migratory seabirds are low (vulnerable and/or migratory species) to medium (critically endangered or endangered species). Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.17.5 Stabilisation and maintenance activities

Stabilisation and establishment of the final Project landform in the WB and WBE reclamation areas has the potential to result in impacts on adjacent migratory shorebird habitat.

These potential impacts are provided in detail in Section 9.17.2.4 with respect to the establishment of the WBE reclamation area and BUF. The potential impact pathways and receptors are similar for stabilisation and maintenance activities on the final Project landform areas. These impacts are expected to be short to medium term and contained, and will be mitigated through the Project EMP (refer Appendix Q2).

Other minor impacts associated with the operation of vehicles onsite, including potential accidental releases of hydrocarbons and other contaminants, noise impacts and potential for interaction between fauna and vehicles onsite resulting in injury or mortality of fauna species. These impacts are expected to be minimal as the post-dredging workforce will require a minimal onsite workforce, with a maximum workforce of 8 people during stabilisation activities (i.e. 2 to 3 month period).

These potential impacts may occur over the short term and are expected to be contained in extent, and are therefore low in magnitude.

The post mitigation risk ratings associated with stabilisation and establishment of the final Project landform and the potential impacts on migratory shorebirds and migratory seabirds are low (vulnerable and/or migratory species) to medium (critically endangered or endangered species). Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.17.6 Threatening processes for migratory shorebirds and migratory seabird species

Threatening processes which may lead to the progressive loss of migratory species and species of conservation significance, including ecologically significant habitat, have been assessed with regards to the potential Project impacts. Threatening processes for listed migratory shorebird species which have been confirmed to occur, or are considered to have a high or moderate likelihood of occurrence within the Project impact areas (refer Appendix I1 (Appendix B)), have been identified from the relevant species recovery plan, conservation listing advice and/or threat abatement plan.

The potential Project impacts which have been provided in Sections 9.17.2 to 9.17.5 have been assessed with regard to their potential contribution to the species threatening processes (refer Appendix I3).

Residual impacts on a threatening process have the potential to result where an impact has a high or very high risk rating. Migratory shorebird and/or migratory seabird species or habitat for which potential Project impacts are considered to have a residual impact on a threatening process which may lead to the progressive loss of the species or ecologically significant habitat (refer Appendix I3), will be subject a significant residual adverse impact assessment. The significant residual adverse impact assessment is provided in Section 9.17.7.

9.17.7 Significant residual adverse impact assessment

9.17.7.1 Summary of species requiring assessment

A significant residual adverse impact assessment has been conducted to identify if the Project will, or is considered likely to have, a significant residual adverse impact on a species of conservation significance and/or migratory shorebird or migratory seabird value which is defined as a MNES or a MSES. The impact assessment included in this section has been conducted in accordance with the *Matters of National Environmental Significance Significant Impact Guidelines, Version 1.1* (DoE 2013) and the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (EHP 2014a).

This assessment of significant residual adverse impacts considers the significance of potential Project impacts after the implementation of the Project mitigation measures included in Section 9.27.

Table 9.63 includes the shorebirds of conservation significance and/or migratory shorebird and migratory seabird species which are subject to this significant residual adverse impact assessment, due to Project activities having the potential to result in the following impacts on the species, including ecologically significant habitat:

- Very high or high risk (post mitigation measures) on a species, and/or
- A residual impact to a key threatening process (refer Appendix I3, Item 4.0).

Table 9.63 Shorebirds of conservation significance and/or migratory shorebird and migratory seabird MNES and MSES subject to significant residual adverse impact assessment

Value	MNES	MSES	Significance assessment
Migratory shorebirds of conservation significance, including: - Curlew sandpiper (*Calidris ferruginea*); Conservation status: Critically endangered, Migratory (EPBC Act); Endangered, Special least concern (NC Act) - Great knot (*Calidris tenuirostris*); Conservation status: Critically endangered, Migratory (EPBC Act); Endangered, Special least concern (NC Act) - Greater sand plover (*Charadrius leschenaultii*); Conservation status: Vulnerable, Migratory (EPBC Act); Vulnerable, Special least concern (NC Act) - Eastern curlew (*Numenius madagascariensis*); Conservation status: Critically endangered, Migratory (EPBC Act); Endangered, Special least concern (NC Act) - Lesser sand plover (*Charadrius mongolus*): Endangered, Migratory (EPBC Act); Endangered, Special least concern (NC Act) - Northern Siberian bar-tailed godwit (*Limosa lapponica menzbieri*); Conservation status: Critically endangered, Migratory/Marine (EPBC Act); Endangered (NC Act) - Red knot (*Calidris canutus*); Conservation status: Endangered, Migratory (EPBC Act); Endangered, Special least concern (NC Act) - Western Alaskan bar-tailed godwit (*Limosa lapponica baueri*); Conservation status: Vulnerable, Migratory/Marine (EPBC Act); Vulnerable (NC Act)	Listed species, Migratory species	Protected Wildlife Habitat	Table 9.64

Value	MNES	MSES	Significance assessment
Migratory shorebirds (all listed as Migratory (EPBC Act) and Special least concern (NC Act). Species include: ▪ Black-tailed godwit (*Limosa limosa*) ▪ Broad-billed sandpiper (*Limicola falcinellus*) ▪ Common greenshank (*Tringa nebularia*) ▪ Common sandpiper (*Actitis hypoleucos*) ▪ Double-banded plover (*Charadrius bicinctus*) ▪ Glossy ibis (*Plegadis falcinellus*) ▪ Grey plover (*Pluvialis squatarola*) ▪ Grey-tailed tattler (*Tringa brevipes*) ▪ Latham's snipe (*Gallinago hardwickii*) ▪ Little curlew (*Numenius minutus*) ▪ Marsh sandpiper (*Tringa stagnatilis*) ▪ Pacific golden plover (*Pluvialis fulva*) ▪ Pectoral sandpiper (*Calidris melanotos*) ▪ Pin-tailed snipe (*Gallinago stenura*) ▪ Red-necked stint (*Calidris ruficollis*) ▪ Ruddy turnstone (*Arenaria interpres*) ▪ Sharp-tailed sandpiper (*Calidris acuminata*) ▪ Swinhoe's snipe (*Gallinago megala*) ▪ Terek sandpiper (*Xenus cinereus*) ▪ Wandering tattler (*Tringa incana*) ▪ Whimbrel (*Numenius phaeopus*)	Migratory species	Protected Wildlife Habitat	Table 9.64
Migratory pelagic birds (i.e. migratory seabirds), including: ▪ Black-browed albatross (*Thalassarche melanophris*); Conservation status: Vulnerable, Migratory (EPBC Act); Special least concern (NC Act) ▪ Black-naped tern (*Sterna sumatrana*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act) ▪ Bridled tern (*Onychoprion anaethetus*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act) ▪ Brown booby (*Sula leucogaster*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act) ▪ Campbell albatross (*Thalassarche impavida*); Conservation status: Vulnerable, Migratory (EPBC Act); Special least concern (NC Act) ▪ Caspian tern (*Hydroprogne caspia*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act) ▪ Chatham albatross (*Thalassarche eremita*); Conservation status: Endangered, Migratory (EPBC Act); Special least concern (NC Act) ▪ Common noddy (*Anous stolidus*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act) ▪ Common tern (*Sterna hirundo*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act) ▪ Crested tern (*Thalasseus bergii*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act)	Listed species, Migratory species	Protected Wildlife Habitat	Table 9.65

Value	MNES	MSES	Significance assessment
▪ Fairy prion (southern) (*Pachyptila turtur subantarctica*); Conservation status: Vulnerable (EPBC Act); Special least concern (NC Act) ▪ Flesh-footed shearwater (*Ardenna carneipes*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act) ▪ Giant frigatebird (*Fregata minor*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act) ▪ Gull-billed tern (*Gelochelidon nilotica*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act) ▪ Kermadec petrel (western) (*Pterodroma neglecta neglecta*); Conservation status: Vulnerable (EPBC Act); Special least concern (NC Act) ▪ Lesser frigatebird (*Fregata ariel*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act) ▪ Light-mantled sooty albatross (*Phoebetria palpebrata*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act) ▪ Little tern (*Sterna albifrons*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act) ▪ Osprey (*Pandion cristatus*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act) ▪ Roseate tern (*Sterna dougallii*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act) ▪ Salvin's albatross (*Thalassarche salvini*); Conservation status: Vulnerable, Migratory (EPBC Act); Special least concern (NC Act) ▪ Short-tailed shearwater (*Ardenna tenuirostris*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act) ▪ Shy albatross (*Thalassarche cauta cauta*); Conservation status: Vulnerable, Migratory (EPBC Act), Vulnerable, Special least concern (NC Act) ▪ Sooty albatross (*Phoebetria fusca*); Conservation status: Vulnerable, Migratory (EPBC Act); Vulnerable, Special least concern (NC Act) ▪ South polar skua (*Stercorarius maccormicki*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act) ▪ Southern giant-petrel (*Macronectes giganteus*); Conservation status: Endangered, Migratory (EPBC Act), Endangered, Special least concern (NC Act) ▪ Wedge-tailed shearwater (*Ardenna pacifica*); Conservation status: Migratory (EPBC Act); Vulnerable, Special least concern (NC Act) ▪ White bellied storm petrel (*Fregetta grallaria grallaria*); Conservation status: Vulnerable (EPBC Act); Special least concern (NC Act) ▪ White-capped albatross (*Thalassarche cauta steadi*); Conservation status: Vulnerable, Migratory (EPBC Act), Vulnerable, Special least concern (NC Act) ▪ White-winged black tern (*Chlidonias leucopterus*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act) ▪ Wilson's storm-petrel (*Oceanites oceanicus*); Conservation status: Migratory (EPBC Act); Special least concern (NC Act)			

9.17.7.2 Migratory shorebirds

The migratory shorebirds species subject to this significant residual adverse impact assessment (refer Table 9.63), include species listed as migratory under the EPBC Act, and migratory shorebird species which are listed as having conservation significance under the EPBC Act and/or the NC Act.

Migratory shorebirds have been grouped for the purposes of this significant residual adverse impact assessment as they are generally considered to occupy similar habitats within the Project impact areas. Where relevant, species-specific habitat requirements are considered and referenced in the impact assessment.

The MNES significant impact assessment criteria for listed and migratory species (DoE 2013) and the significant impact assessment criteria for protected wildlife habitat (EHP 2014a) have been used for the migratory shorebird significant residual adverse impact assessment (refer Table 9.64).

The significant residual adverse impact assessment concluded that the proposed Project activities will have a significant residual adverse impact on migratory shorebirds.

Table 9.64 Significant residual adverse impact assessment – Migratory shorebirds

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
MNES – Endangered, vulnerable, migratory species ▪ Lead to a long term decrease in the size of a population of a species# ▪ Reduce the area of occupancy of the species# ▪ Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline# ▪ Adversely affect habitat critical to the survival of a species# ▪ Substantially modify (including by fragmentation, altering fire regimes, alerting nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species
MSES – Protected wildlife habitat# ▪ Lead to a long term decrease in the size of a local population ▪ Reduce the extent of occurrence of the species ▪ Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species
Potentially significant impact Project activities have the potential to reduce the area of occupancy for migratory shorebirds and have the potential to impact on important foraging and roosting habitat near the WBE reclamation area. The establishment of the WBE reclamation area will result in the direct and permanent loss of 275.37ha of shorebird habitat, representing approximately 1.18% of the mapped potential shorebird habitat in the Port Curtis region. Though this is a small percentage of the potential shorebird habitat available within Port Curtis, it is foraging habitat located adjacent to an important roost site at Friend Point on Kangaroo Island. The location of the proposed BUF has not been identified as being potential habitat for migratory birds and therefore the establishment of the BUF is not expected to result in any significant loss of migratory shorebird habitat or migratory seabird habitat. Although the establishment of the WBE reclamation area will not result in the direct loss of important roost sites, most shorebird species prefer roosts close to foraging areas (Zharikov and Milton 2009), and it is likely that the foraging habitat within the WBE reclamation area is important foraging habitat for shorebirds that utilise the important roost sites at Friend Point. The EPBC Act Policy Statement 3.21 identifies actions involving disturbance at important habitat areas during vital stages of migratory shorebird life cycles as 'highly likely' to be significant to migratory shorebirds (DEWHA 2009).

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
The loss of the foraging habitat as a result of the establishment of the WBE reclamation area has the potential to result in the movement of shorebirds to roost and foraging sites in other areas of the Port. This has the potential to result in adverse impacts on the survival of migratory shorebirds (and their breeding success following migration to breeding habitat) where shorebirds are unable to find suitable alternative foraging sites within close proximity to suitable roosting sites. The magnitude of the direct and permanent loss of migratory shorebird habitat associated with the establishment of the reclamation area will be minimised through the implementation of adaptive design measures (refer Section 9.27) during the Project detailed design phase. Project mitigation measures are provided in Section 9.27 and the Project EMP (refer Appendix Q2). However, the WBE reclamation area will result in the permanent loss of foraging habitat adjacent to an important roost site. Consequently, the Project is considered to have a potential significant impact on migratory shorebird populations.
MNES – Endangered, vulnerable, migratory species Fragment an existing population into two or more populations[#] **MSES – Protected wildlife habitat[#]** ▪ Fragment an existing population ▪ Result in genetically distinct populations forming as a result of habitat isolation
Unlikely to have a significant impact The Project activities are not considered to impede the movement of migratory shorebird species. The establishment of the WBE reclamation area and BUF is not considered to create a barrier to migratory shorebird movement between habitat areas. Furthermore, the dredging activities are associated with the existing shipping channel, and as such, will not create disturbance or barriers to movement in new areas. The nature of the Project activities is not considered to fragment species populations or result in genetically distinct species populations forming due to the isolation of habitat.
MNES – Endangered, vulnerable, migratory species ▪ Disrupt the breeding cycle of a population[#] ▪ Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species
Potentially significant impact The EPBC Act Policy Statement 3.21 identifies actions involving disturbance at important habitat areas during vital stages of migratory shorebird life cycles as 'highly likely' to be significant to migratory shorebirds (DEWHA 2009). Project activities will involve the direct disturbance of migratory shorebird foraging habitat, including disturbance within and adjacent to areas of important migratory shorebird habitat (i.e. important roost sites). The disturbance of migratory shorebird habitat has the potential to displace individuals to other areas of Port Curtis. Subsequently, this may significantly disrupt the lifecycle of migratory shorebird species if individuals are unable to find suitable alternative foraging sites within close proximity to suitable roosting sites. Project activities are anticipated to increase the level of noise and dust in areas of adjacent shorebird habitat. These Project activities have the potential to disturb roosting and foraging behaviours of migratory shorebirds. Disturbance of migratory shorebirds can result in reduced food intake and increased energy expenditure, and has the potential to result in reduced use or abandonment of preferred feeding and roosting areas (Geering et al. 2008). Disturbances resulting in increased time spent in alarm flight, can adversely impact shorebird energy reserves required for migration, and can alter the selection of roosting and foraging sites, and has the potential to ultimately affect the survival of migratory shorebirds (Collop et al. 2016; Lilleyman et al. 2016). Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of migratory shorebird habitat loss at the WBE reclamation area. Shorebird behaviour will be monitored during establishment of the WBE reclamation area, with adaptive management strategies implemented where activities are likely to result in a significant impact on migratory shorebird species in important habitats (refer Section 9.27). The Dredging EMP and Project EMP (Appendices Q1 and Q2, respectively) include mitigation measures to minimise the potential to disturb migratory shorebirds as a result of noise and dust impacts associated with Project activities.

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
MNES – Endangered, vulnerable, migratory species ▪ Result in invasive species that are harmful to an endangered, vulnerable or migratory species becoming established in the species' habitat **MSES – Protected wildlife habitat#** ▪ Result in invasive species that are harmful to an endangered or vulnerable species becoming established in the endangered or vulnerable species' habitat
Unlikely to have a significant impact Invasive species are a threatening process to migratory shorebirds. Invasive flora species and invasive fauna species, such as the Feral pig (*Sus scrofa*) and the Cane toad (*Rhinella marina*), have the potential to adversely impact migratory shorebird habitat by degrading the ecological character and biodiversity of wetland and intertidal habitats. The introduction of exotic marine pests is a potentially significant threat to migratory shorebirds due to the potential of impact on the species benthic food sources at important intertidal habitat areas (DEWHA 2009). Invasive species also have the potential to have a significant impact on migratory shorebirds due to predation pressures from invasive fauna species such as Feral cats (*Felis catus*) and the European fox (*Vulpes vulpes*) (DEWHA 2009). Project activities, including the establishment of the WBE reclamation area and dredging activities, have the potential to introduce and/or spread invasive species into adjacent intertidal migratory shorebird habitat areas. However, the likelihood of these impacts occurring and resulting in adverse impacts on migratory shorebirds is low. Mitigation measures to reduce the likelihood of Project activities resulting in the introduction and spread of pest and weed species are included in the Dredging EMP and Project EMP (refer Appendices Q1 and Q2, respectively).
MNES – Endangered, vulnerable, migratory species ▪ Introduce disease that may cause the species to decline# **MSES – Protected wildlife habitat#** ▪ Introduce disease that may cause the population to decline
Unlikely to have a significant impact Disease transmission can be caused by the modification of migratory shorebird habitats. The modification of habitat areas has the potential to result in increased resource competition and overcrowding of suitable habitat areas by migratory shorebirds, increasing the potential for the introduction and spread of avian diseases (DEWHA 2009). Chronic and acute pollution has the potential to introduce and spread harmful pathogens and disease into the marine environment and have a detrimental impact on migratory shorebird species. Project activities (i.e. the establishment of the WBE reclamation area and BUF, dredging activities and the removal and installation of navigational aids) have the potential to release contaminants and sediments into the marine environment which may impact on foraging habitat and prey for migratory shorebirds. It is unlikely that this would result in chronic or acute impacts, and is therefore unlikely to increase the potential for the introduction or transmission of avian disease. Mitigation measures to reduce the likelihood of Project activities resulting in increased marine debris and contaminants (which has the potential to increase the risk of the introduction or transmission of avian disease) will be included in the Dredging EMP and Project EMP (refer Appendices Q1 and Q2, respectively). Further, the movement of materials and equipment, which have the potential to act as transport mediums for disease, will be managed in accordance with these EMPs, and will include measures to reduce the risk of introducing avian diseases into the Project impact areas.

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
MNES – Endangered, vulnerable, migratory species ▪ Interfere with the recovery of the species# **MSES – Protected wildlife habitat#** ▪ Interfere with the recovery of the species
Potentially significant impact The *Wildlife Conservation Plan for Migratory Shorebirds* (DoE 2015b) provides a framework to guide the conservation of migratory shorebirds and their habitat in Australia. The *Wildlife Conservation Plan for Migratory Shorebirds* will be implemented for a five year period and will be reviewed in 2020 (DoE 2015b). Migratory shorebird species subject to this impact assessment, which are not listed as species of conservation significance under the EPBC Act and/or NC Act (refer Table 9.63), are included in the *Wildlife Conservation Plan for Migratory Shorebirds* (DoE 2015b). Recovery actions for conservation listed migratory shorebird species are included in the species approved conservation advice. The *Wildlife Conservation Plan for Migratory Shorebirds* (DoE 2015b), and the approved conservation advices for migratory shorebird species of conservation significance are subject to this assessment, identify a number of recommended management actions to ensure the long term survival and recovery of migratory shorebird species. Management actions have been recommended to achieve key recovery objectives, including: ▪ Protection of important habitats for migratory shorebirds has occurred throughout the East Asian Australasian Flyway ▪ Wetland habitats in Australia, on which migratory shorebirds depend, are protected and conserved ▪ Anthropogenic threats to migratory shorebirds in Australia are minimised or, where practical, eliminated ▪ Threats to migratory shorebirds in Australia from invasive species are controlled and minimised ▪ Knowledge gaps in migratory shorebird ecology in Australia are identified and addressed to inform decision makers, land managers and the public ▪ Stable or increasing populations of migratory shorebirds are achieved ▪ Awareness of migratory shorebirds is raised within the local community.
The Project will result in the direct and permanent loss of migratory shorebird foraging habitat. The Friend Point roost (NAR1) located adjacent to the WBE reclamation area, and the Six Mile Island roost (SMIS) located approximately 2.75km southeast of the WBE reclamation area, have been identified as containing more than 0.1% of the EAAF population of Eastern curlews on at least one occasion during shorebird monitoring (IMEMS 2013). Furthermore, four roost sites (FAC4, FAIS, BOYN and NR07) located within approximately 20km of the areas to be dredged have been identified as containing more than 0.1% of the EAAF population of Eastern curlews, Grey-tailed tattlers, Lesser sand plovers, Terek sandpipers and Ruddy turnstones on at least one occasion during shorebird monitoring (IMEMS 2013). Roosting and foraging habitat for migratory shorebirds within and adjacent to the aforementioned roost sites is therefore considered to be 'Nationally important habitat' in accordance with the EPBC Act Policy Statement 3.21 (DEWHA 2009), as the roost sites have been identified as containing 0.1% of the EAAF flyway population of migratory shorebird species (IMEMS 2013). This includes both contiguous and non-contiguous habitat where there is evidence of regular movement between foraging and roosting habitats within the same general area (DEWHA 2009). The loss of nationally important habitat for migratory shorebird species, especially for the Eastern curlew and the Lesser sand plover which are of conservation significance, has the potential to interfere with the species recovery.

Table notes

Criteria is not relevant for migratory species which are not listed as species of conservation significance under the EPBC Act and/or NC Act (refer Table 9.63)

9.17.7.3 Migratory seabirds

The migratory seabirds subject to this significant residual adverse impact assessment (refer Table 9.63), include species which are listed as migratory under the EPBC Act and/or listed as species of conservation significance under the EPBC Act and/or the NC Act.

Migratory seabirds have been grouped for the purposes of this significant residual adverse impact assessment as they are generally considered to occupy similar habitats within the Project impact areas. Where relevant, species-specific habitat requirements are considered and referenced in the impact assessment.

The Osprey (*Pandion cristatus*) has been included in the significant residual adverse impact assessment for migratory seabirds. As a coastal species, the Osprey shares similar habitat requirements to migratory seabirds and as such, has been grouped with migratory seabirds for the purposes of this assessment.

The MNES significant impact assessment criteria for listed and migratory species (DoE 2013) and the significant impact assessment criteria for protected wildlife habitat (EHP 2014a) have been used for the migratory seabird significant residual adverse impact assessment (refer Table 9.65).

The significant residual adverse impact assessment concluded that the proposed Project activities will not have a significant residual adverse impact on migratory seabirds.

Table 9.65 Significant residual adverse impact assessment – Migratory seabirds

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
MNES – Endangered, vulnerable, migratory species ▪ Lead to a long term decrease in the size of a population of a species ▪ Reduce the area of occupancy of the species ▪ Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline ▪ Adversely affect habitat critical to the survival of a species ▪ Substantially modify (including by fragmentation, altering fire regimes, alerting nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species **MSES – Protected wildlife habitat** ▪ Lead to a long term decrease in the size of a local population ▪ Reduce the extent of occurrence of the species ▪ Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species
Unlikely to have a significant impact The Project is not considered likely to destroy an area of important habitat or cause significant disruption to an ecologically significant area of habitat for migratory seabird species. There are no known areas of breeding habitat for migratory seabird species situated within the direct or potential indirect Project impact areas. Migratory seabird species exhibit a broad range of diets and foraging behaviours (DSEWPaC 2011), and thus are not reliant on specific habitat requirements to facilitate foraging activities. The migratory seabird species subject to this assessment feed predominantly on fish, however they also eat crustaceans, insects, annelids and molluscs (Garnett and Crowley 2000). Migratory seabird species are not considered to be reliant on specific microhabitats or prey resources to facilitate foraging activity. With consideration to the species capacity for long range movements, all waters within Australian jurisdiction can be considered to constitute foraging habitat for albatross and giant petrel species. Critical foraging habitat for albatross and giant petrel species is considered to occur in waters south of 25 degrees latitude, due to the closer proximity of these waters to nesting locations (DSEWPaC 2011). The Project impact areas are situated north of 25 degrees latitude and thus are not considered to represent critical foraging habitat for albatross and giant petrel species. The 'Referral guideline for 14 birds listed as migratory species under the EPBC Act' (DoE 2015c) provides significant impact assessment criteria for the Osprey. The Project impact areas are located within the core range for the Osprey, as illustrated in the referral guidelines (DoE 2015c). The Project impact areas provide potentially important habitat for the Osprey. Important habitat for the Osprey includes bays, estuaries, tidal stretches of large coastal rivers, mangrove swamps, coral and rock reefs, terrestrial wetlands, coastal lands and offshore islands of tropical and temperate Australia (DoE 2015c).

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
The establishment of the WBE reclamation area has the potential to have an impact on approximately 5km of coastline (indirect impact area). However, this does not meet the 1% area threshold (840km of coastline) or the 0.1% area threshold (84km coastline) for the species (DoE 2015b). Consequently, the Project activities are not considered likely to substantially modify, destroy or isolate an area of important habitat for the Osprey. Direct mortality and injury of migratory seabirds via interactions with human fishing operations is a key threat to the species. Although the Project will not have an impact on fishing operations, there is the potential for increased vessel movements throughout the Port, particularly during dredging activities. This has the potential to increase the risk of mortality and injury to seabird species due to vessel strike. Dredging activities will be temporary and the potential for direct injury or mortality as a result of a vessel strike would be contained to the direct area of the dredging activity or vessel movement. The nature, scale and volume of Project vessel movements are considered minor compared to the existing Port vessel movements. Mitigation measures to reduce the risk of vessel strike on migratory seabirds will be included in the Dredging EMP and Project EMP (refer Appendices Q1 and Q2, respectively). Project dredging activities have the potential to result in increased levels of noise and dust in the local landscape. These impacts have the potential to impact on the foraging behaviour of migratory seabirds. Potential adverse impacts on environmental values, including migratory seabirds, as a result of noise and dust will be reduced via the implementation of appropriate mitigation measures contained Dredging EMP and Project EMP (refer Appendices Q1 and Q2, respectively). The Project has a potential to result in decreased water quality associated with the establishment of the WBE reclamation area and dredging activities. Contamination of marine waters has the potential to occur as a result of accidental spillage of hydrocarbons during Project activities. These contaminants have the potential to result in the injury and/or mortality of migratory seabirds, via direct contact or ingestion of affected prey items, in the event of a significant spill. Sediment to water has the potential to temporarily increase turbidity levels in the vicinity of the Project activities. This sediment has the potential to impact on marine flora and fauna, and has the potential to affect the distribution and abundance of migratory seabird prey. Through the implementation of mitigation measures contained in the Dredging EMP and Project EMP (refer Appendices Q1 and Q2, respectively), it is unlikely that the short term declines in water quality associated with the Project activities will result in a significant impact on migratory seabird species. In summary, it is unlikely that the Project activities will result in significant impacts on the potential migratory seabird foraging habitat located in the Project impact areas, and it is therefore unlikely that the Project would impact on migratory seabird populations.
MNES – Endangered, vulnerable, migratory species ▪ Fragment an existing population into two or more populations **MSES – Protected wildlife habitat** ▪ Fragment an existing population ▪ Result in genetically distinct populations forming as a result of habitat isolation
Unlikely to have a significant impact The Project activities are not considered to impede the movement of migratory seabird species. The establishment of the WBE reclamation area and BUF is not considered to create a barrier to migratory seabird movement between habitat areas. Furthermore, the dredging activities are associated with the existing shipping channel, and as such, will not create disturbance or barriers to movement in new areas. With respect to the capacity for migratory seabirds to exhibit long range movements over vast oceanic distances (DSEWPC 2011) and that the Project impact areas are not considered to have a direct or indirect impact on species breeding habitat or critical foraging habitat, the Project activities are not anticipated to result in genetically distinct populations forming as a result of habitat isolation. The Project is not considered likely to create a significant barrier to species movement through the marine environment or fragment migratory seabird populations.

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
MNES – Endangered, vulnerable, migratory species ▪ Disrupt the breeding cycle of a population ▪ Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species
Unlikely to have a significant impact The Project activities are not considered likely to disrupt the breeding cycle of migratory seabird populations. Albatross and giant petrel species breed at six localities under Australian jurisdiction; Macquarie Island, Albatross Island, Pedra Branca, the Mewstone, Heard and McDonalad Islands and the Australian Antarctic Territory. As the aforementioned breeding localities represent the only suitable Australian breeding habitat for albatross and giant petrel species, these remote island locations are considered to constitute critical habitat to the species survival (DSEWPC 2011). The six Australian localities at which albatross and giant petrel species breed are situated on offshore remote islands south of Tasmania and thus are not within proximity to the Project impact areas. The Project will not have an impact on breeding habitat, or habitat critical to the survival of albatross or giant petrel species. The Little tern nests between the high tide mark and shore vegetation on undisturbed, unvegetated sites near estuaries, adjacent to freshwater lakes, on estuarine and continental islands, on coral cays and on islands within commercial saltfields (Garnett and Crowley 2000). In a summary of the status of Queensland migratory seabirds, listed breeding of Little terns was recorded on one of the major migratory seabird breeding islands in Queensland. The species was also recorded to breed occasionally on islands of the inner Great Barrier Reef and on isolated mainland beaches. The species is also known to breed in the Wellesley Islands in the Gulf of Carpentaria (DoEE 2019b). Breeding locations for the Little tern are not known to occur within the Project impact areas.
Breeding habitat for the Osprey includes areas in close proximity to water bodies, where the species constructs large nests in the canopy of tall trees or artificial structures such as communication towers (DoE 2015b). An action is considered likely to have a significant impact on the Osprey if there is a real chance or possibility that it will seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population (DoE 2015c). An action is considered a significant impact on an ecologically significant portion of a species population if the action exceeds the lower threshold (0.1%) for important habitat for the species (DoE 2015c). Therefore, the Project activities will not exceed the lower thresholds (0.1%) for impacts on important habitat for the Osprey. As such, the Project activities are not considered likely to seriously disrupt the lifecycle of an ecologically significant proportion of the Osprey population. The remainder of migratory seabird species subject to this assessment (refer Table 9.63, i.e. terns, shearwaters, frigatebirds, the Brown booby, Common noddy and Fairy prion), which breed within Australian territories do so on offshore islands, vegetated coral cays and rock stacks. The Project will not have a direct impact on breeding habitat for migratory seabird species. Project activities are unlikely to have an impact on the lifecycle of an ecologically significant proportion of the population, or on the breeding cycles of migratory seabird species.
MNES – Endangered, vulnerable, migratory species ▪ Result in invasive species that are harmful to an endangered, vulnerable or migratory species becoming established in the species' habitat **MSES – Protected wildlife habitat** ▪ Result in invasive species that are harmful to an endangered or vulnerable species becoming established in the endangered or vulnerable species' habitat
Unlikely to have a significant impact Predation and competition pressures from invasive species (i.e. feral cats and foxes) has been identified as a threatening process to migratory seabirds (DSEWPC 2011; Garnett and Crowley 2000). Invasive species have the potential to be harmful to migratory seabirds at breeding sites through predation of eggs and chicks by introduced mammals. Invasive species may also threaten migratory seabird breeding habitat via the erosion of colony sites through grazing by European rabbits (*Oryctolagus cuniculus*) (Garnett and Crowley 2000; DSEWPC 2011). However, as outlined above, there is no migratory seabird breeding habitat located within the Project impact areas and therefore no adverse impacts are expected to occur as a result of Project activities.

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
Furthermore, the potential introduction of pest and weed species during Project activities will be minimised through the implementation of the Dredging EMP and Project EMP (refer Appendices Q1 and Q2, respectively). Vegetation clearing activities have the potential to facilitate the spread of pest species across the landscape. The likelihood of the Project introducing or spreading pest species across the local landscape is considered to be reduced and effectively managed via the implementation of mitigation measures included in the Project EMP and Dredging EMP.
MNES – Endangered, vulnerable, migratory species ▪ Introduce disease that may cause the species to decline **MSES – Protected wildlife habitat** ▪ Introduce disease that may cause the population to decline
Unlikely to have a significant impact Direct mortality of albatross and giant petrel species has been attributed to the Avian pox virus, which is transmitted by parasitic fleas and ticks (DSEWPC 2011). The introduction and spread of avian parasites and disease on breeding islands has been identified as a threatening process for migratory seabird species (DSEWPC 2011). However, as outlined above, there is no migratory seabird breeding habitat located within the Project impact areas and therefore no adverse impacts are expected to occur as a result of Project activities. Furthermore, the potential introduction of pest and weed species during Project activities will be minimised through the implementation of the Dredging EMP and Project EMP (refer Appendices Q1 and Q2, respectively). Pollution and the release of contaminants has the potential to introduce/spread harmful pathogens and disease into the marine environment and have a detrimental impact on migratory seabird species via direct contact or ingestion of affected prey species. Harmful contaminants such as pesticides, heavy metals, organochlorides and sewage from the land or from boats can pollute the marine environment and increase incidence of disease. Project activities (i.e. the establishment of the WBE reclamation area and BUF, dredging activities and the removal and installation of navigational aids) have the potential to release contaminants (e.g. hydrocarbons and fuels) and sediments into the marine environment which have the potential to have an adverse impact on marine water quality, and subsequently, foraging habitat for migratory seabird species. These potential impacts will be managed through the implementation of the Project EMP and Dredging EMP (refer Appendix Q2 and Q1, respectively). As such, the potential release of contaminants and/or sediments into the marine environment is likely to be contained in extent. It is therefore considered unlikely that this would result in adverse impacts on migratory seabird species likely to result in the introduction of an avian disease.
MNES – Endangered, vulnerable, migratory species ▪ Interfere with the recovery of the species **MSES – Protected wildlife habitat** ▪ Interfere with the recovery of the species
Unlikely to have a significant impact *The Action Plan for Australian Birds 2000* (Garnett and Crowley 2000) and the *National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016* (DSEWPC 2011) identify recommended actions to ensure the long term survival and recovery of threatened and migratory seabird species. The recovery actions identify measures to be implemented to reduce or eliminate human-related threats to the species at sea and on land. Key recovery actions which have been identified, include: ▪ Research and monitor the biology, ecology and population dynamics of species breeding within Australian jurisdiction to understand conservation status and to implement effective and efficient conservation measures ▪ Continued management of nest sites in areas with high rates of disturbance ▪ Quantify and reduce land based threats to the survival and breeding parameters of species breeding and foraging within areas under Australian jurisdiction ▪ Educate fishers and promote public awareness of species threats ▪ Achieve substantial progress towards global species conservation.

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
With respect to the nature of the Project activities, the Project is not considered likely to result in impacts that will interfere or impede with the aforementioned recovery actions for migratory seabirds. The Project activities will not impact on nest sites for migratory seabird species or significantly contribute to land based threats to migratory seabird species in nesting locations. Potential Project impacts to foraging habitat and prey resources (i.e. potential release of contaminants and sediments to the marine environment and increased noise, vibration and dust levels), will be effectively managed via the Project management plan framework (i.e. the implementation of mitigation measures contained in the Project EMP and Dredging EMP).

9.17.8 Assessment summary

The WBE reclamation area will result in permanent loss of approximately 275.37ha of migratory potential shorebird foraging habitat (99.74% of the direct disturbance area). The habitat within the WBE reclamation area is foraging habitat in close proximity to a number of important roosting habitats for migratory shorebird species (refer Figure 9.62), and is likely important foraging habitat for birds utilising these roosts. The establishment of the BUF is not expected to result in any significant loss of migratory shorebird habitat or migratory seabird habitat.

Loss of foraging habitat due to establishment of the WBE reclamation area has the potential to impact on migratory shorebirds via the potential to cause disruption to roosting and foraging behaviour. As a result, adverse impacts on the survival of migratory shorebirds and their breeding success is potentially likely if shorebirds are unable to find suitable alternative foraging sites within close proximity to current suitable roosting sites.

During dredging activities, there are several potential impacts to migratory bird species and their habitats in the area. A short term decline in water quality is expected to occur in the form of increased turbidity caused by sediment resuspension, predominately concentrated in and around the areas to be dredged (referred to as the zone of high impact and zone of moderate impact).

Increased levels of contaminants in the water column and/or food chain associated with the dredging plume, accidental release of chemicals or spills as well as fine sediments entering marine area from the WBE reclamation area and BUF has the potential to result in injury and/or mortality of migratory bird species, prey composition and alter habitats. However, due to the management measures proposed and the limited extent of the dredging plume zone of high impact, it is not expected that dredging activities will have a significant impact on food sources of migratory shorebirds or migratory seabirds. Hydrodynamic modelling suggests dredging activities associated with the licenced dewatering discharge from the WB and WBE reclamation areas will not result in licenced discharge zones of high and moderate impact.

An increase in noise, vibration and dust through increased truck movements associated with the transport of reclamation bund wall material for the placement of core and armour material for the reclamation bund wall is expected. An increase in noise, from construction plant and equipment undertaking dredged material placement within the northern section of the WBE reclamation area is also expected. The activity will generate noise, vibration and dust which have the potential to impact on the behaviour of migratory shorebirds (e.g. disruption of roosting or foraging behaviour) in adjacent migratory shorebird habitats. Noise, vibration and dust impacts generated during the establishment of the WBE reclamation area has the potential to disturb sensitive species causing reduced food intake, increased energy expenditure, and has the potential to result in reduced use or abandonment of preferred feeding and roosting areas (Geering et al. 2008).

Due to the susceptibility of migratory shorebirds to disturbance (e.g. noise, movements) and their highly mobile nature, it is considered likely that these species would move away from areas of disturbance (i.e. site preparation, vehicle movements) and may therefore be less likely to be impacted.

Other Project impacts (e.g. removal and installation of navigational aids, stabilisation and final Project landform) are not expected to have significant impacts on migratory shorebirds, migratory seabirds or their habitat. Project operational potential impacts are minimal and are not expected to have a significant impact on the migratory shorebird or migratory seabird populations, or their habitat. The potential impacts are expected to have medium term impact and expected to be contained to relatively small areas within the marine environment.

The Project will implement mitigation measures provided in the Dredging EMP and Project EMP (refer Appendices Q1 and Q2, respectively), and associated management plans to reduce the likelihood and magnitude of potential Project impacts on migratory shorebirds and migratory seabirds. Shorebird behaviour will be monitored during establishment of the WBE reclamation area and BUF, with adaptive management strategies implemented if activities are likely to result in a significant impact on migratory shorebird species in important habitats (refer Section 9.27). The Project EMP and Dredging EMP include mitigation measures to minimise the potential to disturb migratory shorebirds as a result of noise and dust impacts associated with Project activities.

The potential for a Project impact to have a residual impact and contribution to a migratory shorebird and migratory seabird species threatening process has been assessed for species of conservation significance, which have been confirmed to occur, or are considered to have a high or moderate likelihood of occurrence within the Project impact areas. A significant residual adverse impact assessment was conducted for the species if the Project was identified as potentially having a residual impact on a species of conservation significance, which has the potential to lead to the progressive loss of the species or areas of ecologically significant habitat.

The significant residual adverse impact assessment was conducted for migratory shorebirds and migratory seabirds, concluding that while the Project activities are not likely to have a significant impact on migratory seabirds, however, there is potential for significant impacts to occur for migratory shorebird species.

9.18 Marine turtles – existing environment

9.18.1 Background

There are seven extant species of marine turtle worldwide and Australia has resident or migratory populations of six of these species, all of which occur within the GBRWHA (GBRMPA 2018). These species include the Green turtle (*Chelonia mydas*), Loggerhead turtle (*Caretta caretta*), Hawksbill turtle (*Eretmochelys imbricata*), Flatback turtle (*Natator depressus*), Leatherback turtle (*Dermochelys coriacea*), and Olive ridley turtle (*Lepidochelys olivacea*) (GBRMPA 2018).

It is commonly known that the Port Curtis region supports populations of Green, Loggerhead, and Flatback turtles, while other species such as the Hawksbill, Olive ridley, Leatherback turtles are known to occur in the GBRWHA but are recorded within Port Curtis either occasionally or rarely (as is the case for Leatherback turtles) (GBRMPA 2018; Limpus et al. 2013).

Marine turtles undertake extensive migrations of up to 3,000km between nesting beaches and feeding areas, but repeatedly return to the same nesting and feeding areas throughout their lives. In Queensland, marine turtles breed at a limited number of nesting sites with varying density. Individual females return at intervals to nest at beaches in the same area in which they were born (Limpus and Chatto 2004).

The methodology implemented to describe the marine turtles values is provided in Appendix I1 (Section 14.2).

9.18.2 Marine turtle values

9.18.2.1 Species of conservation significance

The results of the desktop assessment were used to determine the likelihood of occurrence of marine turtle species within the Port Curtis region. Appendix I1 (Appendix B), provides the likelihood of occurrence assessments for all migratory species identified in the database searches.

Table 9.66 identifies the likelihood of occurrence for the six marine turtles known from the GBRWHA, and their likelihood of occurring in Port Curtis. This assessment identified that the Flatback and Green turtles are known to occur in the region on a regular basis (e.g. nesting and/or foraging), with the Loggerhead turtle occasionally nesting in Port Curtis. The Hawksbill turtle is identified as having a moderate likelihood of occurrence as they are known to occasionally migrate through Port Curtis. The Leatherback and the Olive ridley turtles are considered to have a low likelihood of occurrence within Port Curtis, as they are rarely encountered in waters in or surrounding Port Curtis (Limpus et al. 2013).

Table 9.66 Conservation status of marine turtles found in Australia and likelihood of occurring in Port Curtis

Common name	Scientific name	Conservation status		Preferred habitat	Likelihood of occurring in Port Curtis
		NC Act	EPBC Act		
Flatback turtle	*Natator depressus*	Vulnerable	Vulnerable Migratory Marine	Nests on open sandy beaches without reef front, shallow inshore waters	Confirmed (breed in the region)
Green turtle	*Chelonia mydas*	Vulnerable	Vulnerable Migratory Marine	Open, sandy beaches, rocky reef, inshore seagrass beds or algae mats	Confirmed (feed in the region and occasionally breed in the region)
Loggerhead turtle	*Caretta caretta*	Endangered	Endangered Migratory Marine	Open, sandy beaches, tidal and sub-tidal habitat	Moderate (occasionally breed in the region)
Hawksbill turtle	*Eretmochelys imbricata*	Endangered	Vulnerable Migratory Marine	Open sandy beaches, coral and rocky reefs, and seagrass	Moderate (may occasionally migrate through the region)
Olive ridley turtle	*Lepidochelys olivacea*	Endangered	Endangered Migratory Marine	Open, sandy beaches, open marine waters	Low (rarely sighted, may migrate through the region)
Leatherback turtle	*Dermochelys coriacea*	Endangered	Endangered Migratory Marine	Open, sandy beaches, open marine waters	Low (oceanic species, may occasionally migrate through the region)

Source: DoEE (2019c); DES (2019a); SKM (2014); BMT WBM (2014a)

9.18.2.2 Important habitat

This section provides an overview of important habitat for the four species of marine turtles that are most commonly recorded in the Port Curtis region (i.e. Green, Flatback, Hawksbill and Loggerhead turtles).

The Port Curtis region provides a range of niche habitats for these four species of turtles, including nesting and foraging areas (refer Figure 9.63), making it an important location for the conservation of marine turtles in Australia. Flatback turtles are known to nest on several beaches in the region, including Curtis Island (South End Beach), Facing Island, Hummock Hill Island, and Tannum Sands (Limpus et al. 2002; 2013), with peak nesting activity occurring in mid-November to mid-December, and peak hatching period during February. The Port of Gladstone is known internesting habitat for Flatback turtles (Hamman et al. 2015c; 2017).

While Green turtles have been recorded nesting within the Port Curtis region on the beaches of Curtis Island and Facing Island, they prefer the offshore islands of the Great Barrier Reef (Limpus et al. 2000; Limpus et al. 2006; Limpus 2008a). However, the region provides foraging internesting habitat for southern Great Barrier Reef populations of nesting females (Limpus et al. 2013; Hamman et al. 2015c; 2016).

While habitat for the Olive ridley turtle occurs within Port Curtis, the species has been rarely recorded throughout the Port or broader area and there has been no recorded breeding by Olive ridley turtles in eastern Australia or in fact around the rim of the Coral Sea (Limpus et al. 2013). For Leatherback turtles, no large rookeries have been recorded in Australia however scattered nesting is known to occur from Bundaberg to Round Hill Head, approximately 75km southeast of Gladstone. During the two-week census in the 2017-2018 breeding period, a total of 28 nesting individuals were recorded at Curtis Island, and Peak and Avoid Island experienced nesting populations of 158 and 69, respectively during the same period (Limpus et al.2018).

Long term baseline data has been collected for a number of important nesting beaches in the Port Curtis region over the years by former EHP (now DES) and JCU TropWATER. Long term monitoring of nesting sites at Curtis Island by EHP has occurred since 1969 (and annually since 1994). More recently, monitoring of turtle nesting behaviour has been undertaken by Clifton and Bell (2003); Limpus et al. (2012a); Hamann et al. (2015a; 2015b); Limpus et al. (2015); Fitzsimmons and Limpus (2016); Limpus et al. (2016a; 2016b); Pople et al. (2016), Hamann et al. (2017), Limpus et al. (2017a; 2017b) and Limpus et al. (2018).

In Queensland, marine turtles breed at a limited number of nesting sites with varying density. In a breeding year, individual females migrate over long distances between feeding and nesting grounds, and return to nest at beaches in the same area in which they were born (Limpus and Chotto 2004). The nesting females of most species will nest multiple times during a nesting season, at intervals of two to four years over the course of their lifetime.

The incubation period of the eggs varies from six weeks to two months, during which time the eggs in each nest hatch synchronously. Emergence from the nesting chamber occurs synchronously during the night and hatchlings instinctively head towards the light horizon (i.e. moonlight on the sea) which indicates the location of the sea. In general, mature marine turtles have extremely small home ranges and single turtles will generally forage over little more than a few kilometres (Mustoe 2011; Hamann et al. 2015b).

Flatback turtles have been known to enter Port Curtis during part of their internesting period (Limpus et al. 2013; Hamman et al. 2015c; Hamann et al. 2017). Satellite tracking studies have shown internesting Flatback turtles utilising habitat in the Mid Harbour (around the existing Gatcombe and Auckland Shipping Channels) and in the Outer Harbour zone and in waters off the coasts of Facing and Curtis Islands (Hamann et al. 2015c; Hamann et al. 2017).

Satellite tagging studies undertaken as part of the ERMP by Hamann et al. (2015a; 2016) have indicated Green turtles have very distinct home ranges and strong fidelity to Port Curtis. Large numbers of Green turtles have been observed converging at Pelican Banks seagrass meadows, and Wiggins Island (Hamann et al. 2015a; Limpus 2016b; Limpus et al. 2017).

Further species-specific information is provided for the four marine turtle species most commonly recorded within Port Curtis, and additional information is also provided in Appendix I1 (Section 14).

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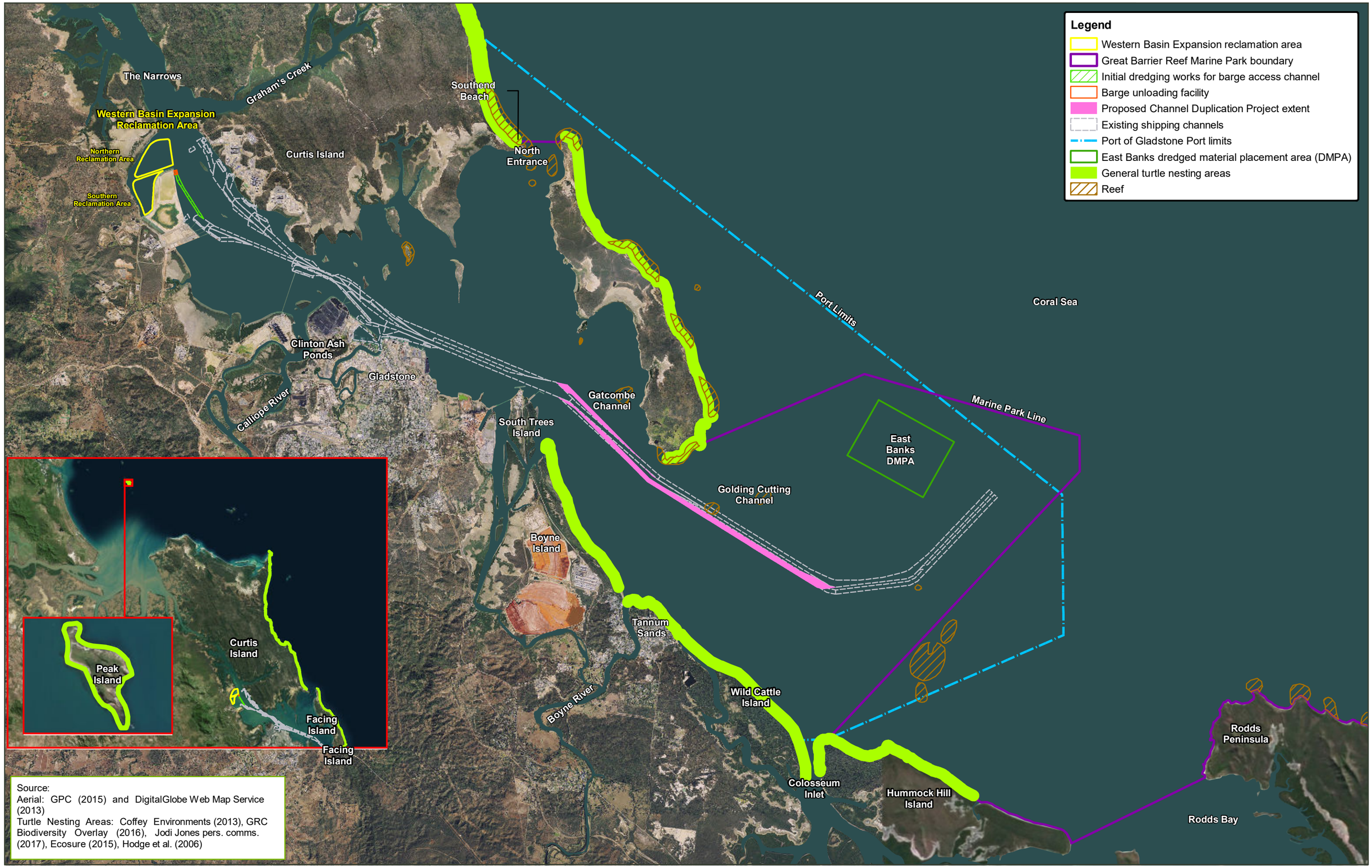

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Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.63: General location of marine turtle nesting areas in Port Curtis and Peak Island

9.18.2.3 Green turtle

Green turtles are the most common species of turtle found in Port Curtis utilising the area for feeding on a diet of seagrass (including *Halophila, Halodule and Zostera* species), algae and mangrove fruits (Limpus 2008a; Limpus et al. 2013). Aerial and boat-based surveys for marine turtles undertaken in Port Curtis in 2008/2009 and 2011 to assess habitat utilisation, recorded a total of 522 turtles with the most commonly observed species being Green turtles (GHD 2009c). These surveys recorded a large number of juvenile and sub-adult Green turtles, although overall the densities of these local cohorts are not well documented. Immature turtles are regularly encountered in the shallow water habitats, while larger turtles are found in the deeper sub-tidal water (Limpus et al. 2013; Limpus et al. 2017).

With a rich diversity of seagrasses, reef algae and mangroves, Port Curtis provides an important resource to foraging Green turtles. Within Port Curtis during a 2016 study, Green turtles were recorded foraging on seagrass (*Zostera muelleri* and *Halophila ovalis*), mangrove (*Avicennia marina* propagules; *Rhizophora stylosa* propagules and apical shoots) and a range of algal species (Chlorophyte: *Ulva polyclada*, Rhodophyte: *Catenella nipae*, *Hynea* sp. and *Gracillaria* sp.) (Limpus et al. 2016b). This study observed Green turtles foraging within Port Curtis displaying very diverse vegetarian diets across a range of sampling sites throughout the Port, with diet also varying seasonally between sampling locations within the Port (Limpus et al. 2016b).

While Green turtles have been recorded nesting within the Port Curtis region on the beaches of Curtis Island and Facing Island, they prefer the offshore islands of the Great Barrier Reef (Limpus et al. 2000; Limpus et. al. 2006; Limpus 2008a). Green turtle nesting for the southern Great Barrier Reef management unit (population) commences in mid to late October, peaking in late December to early January, and ends in late March to early April (Limpus et al. 2013). The region provides internesting habitat for southern Great Barrier Reef populations of nesting females (Limpus et al. 2013).

Limpus et al. (2016b; 2017) collected data on Green turtles within Port Curtis to determine if the area is an important aggregation area for the species. Observations were made of their behaviour (i.e. courtship behaviour) and the breeding condition of captured individuals during their 2016 and 2017 breeding seasons (Limpus et al. 2016b; 2017). The data collected by Limpus et al. (2016b; 2017), indicate that Port Curtis is not a significant area for aggregation of breeding Green turtles for courtship and mating.

Satellite tagging studies undertaken as part of the ERMP by Hamann et al. (2015a; 2016) indicate that Green turtles have very distinct home ranges and strong site fidelity within Port Curtis. The 2014 study recorded small home ranges for the tracked turtles (ranging from 4km^2 to 62km^2 (mean of 24km^2)) and that the tracked turtles predominantly used intertidal and shallow water habitats, including areas of Port Curtis that coincide with high levels of human use (e.g. vessel activity, fishing) (refer Figure 9.64 and Figure 9.65). Not unexpectedly, a large number of turtles were observed to have converged at Pelican Banks seagrass meadows. Diving data revealed that the turtles spent most of their time at water depths less than 4m and had regular dive patterns (Hamann et al. 2015a).

The final report, examining tracking data from the 2014 to 2017 period (34 turtles) similarly found a high degree of site fidelity to foraging habitat (Hamann et al. 2017a). Diving data from the final report also demonstrated that Green turtles in the Port of Gladstone region spend most of their time at water depths of less than 10m.

The satellite tagging study results from the 2015 also recorded small home ranges for the 11 tracked Green turtles, ranging from 4 to 81km^2, with a median of 7km^2 (refer Figure 9.66) (Hamman et al. 2016). The tracked turtles predominantly utilised intertidal and shallow water habitats, including areas that coincide with vessel movements and fishing activities, as was also recorded during the 2014 study (Hamman et al. 2015a; 2016).

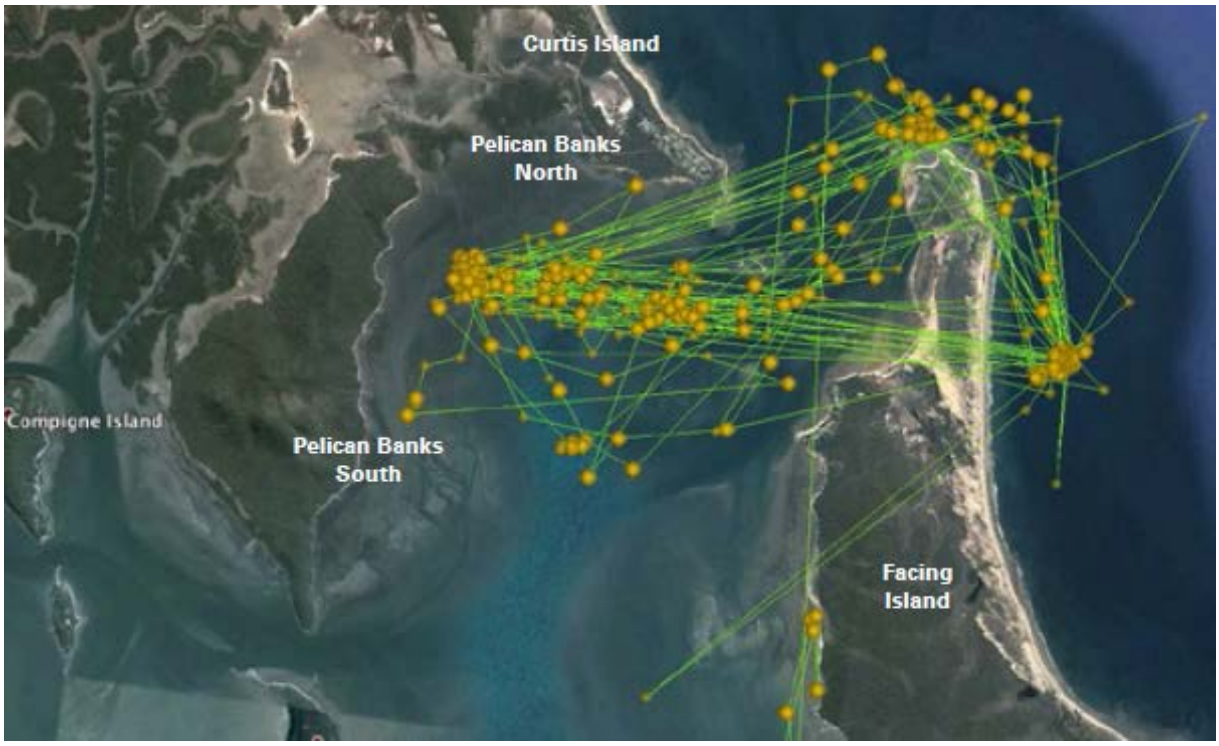

Figure 9.64 Tracking data of a Green turtle tagged in Port Curtis

Source: GPC (2015) via JCU TropWATER

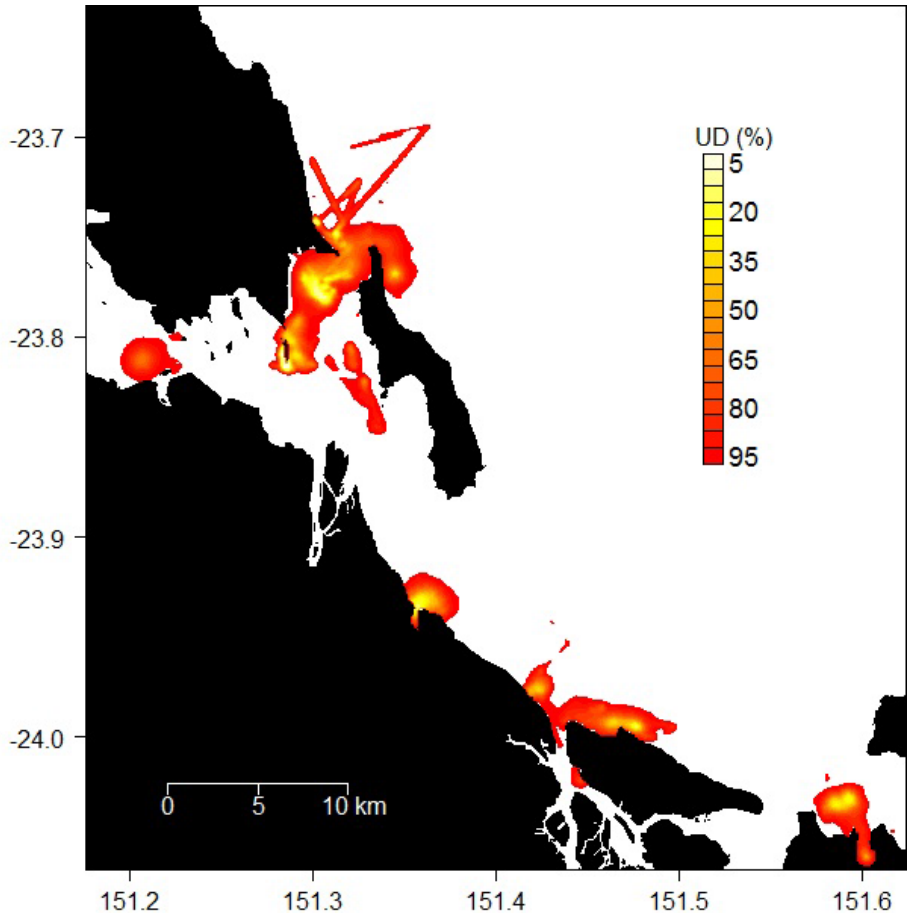

Figure 9.65 Home ranges of Green turtles tracked via satellite within Port Curtis (2014)

Figure note:

UD (%) = refers to the percentage of time each 100m grid is used by the turtle during foraging

Source: Hamann et al. (2015a)

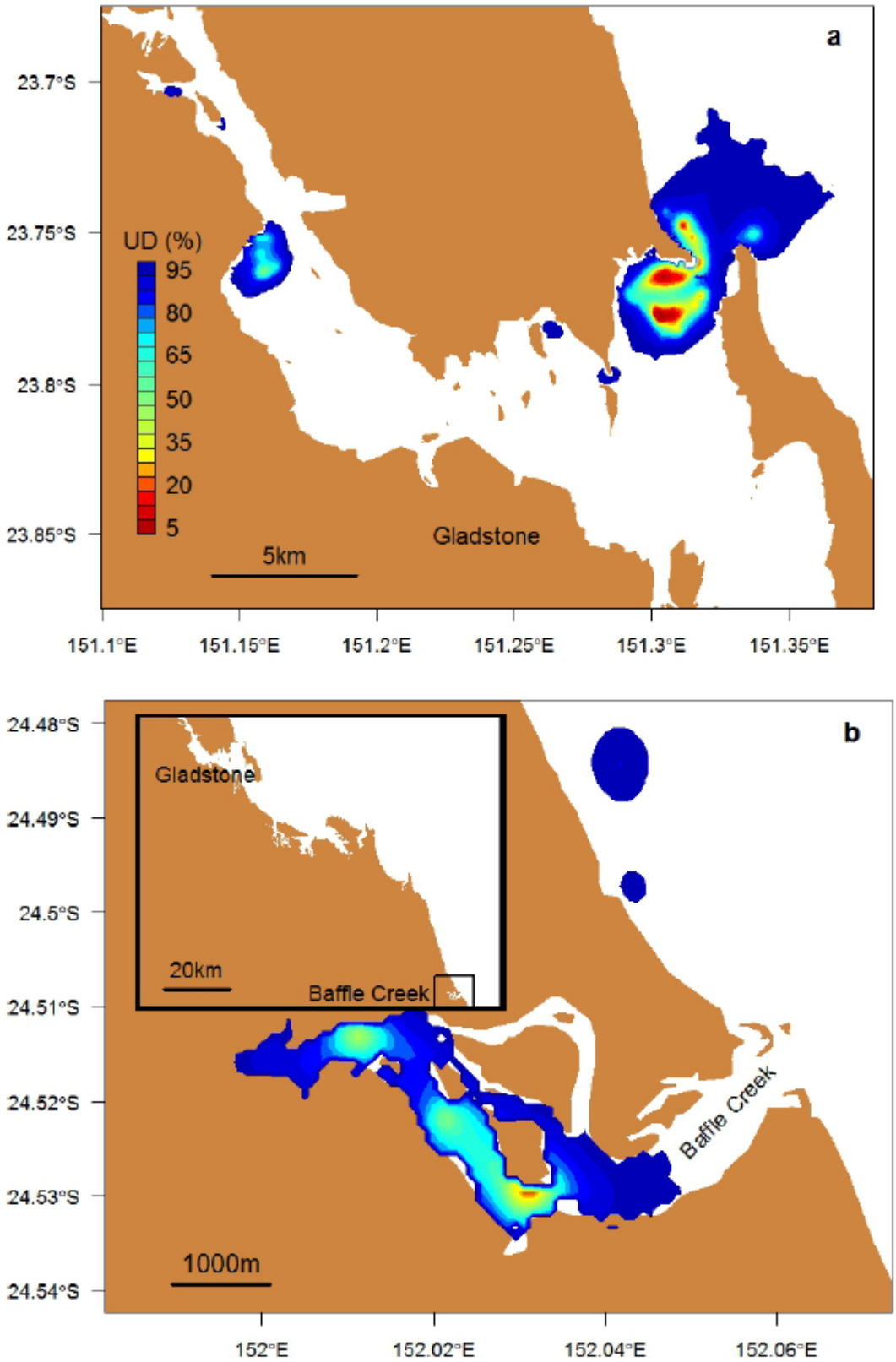

Figure 9.66 Home ranges of Green turtles tracked via satellite within Port Curtis (2015-2016)

Figure note:

UD (%) = refers to the percentage of time each 100m grid is used by the turtle during foraging
This is based on the 11 Green turtles captured and release in Port Curtis between July 2015 and February 2016. Ten of the turtles resettled in the vicinity of the original capture points, and one turtle moved south and settled in Baffle Creek.

Source: Hamann et al. (2016).

Limpus et al. (2016b) assessed foraging behaviour of Green turtles within Port Curtis. Turtles were either captured or observed during the study, with approximately half of the Green turtles captured from Pelican Banks (refer Figure 9.67 and Figure 9.68) (n=162, 49.4% of all captures) (Limpus et al. 2016b). Green turtles that were observed but not captured were also observed predominantly located at Pelican Banks (refer Figure 9.69). Similar results were also found by Limpus et al. (2017). The data collected indicated that adult Green turtles were most abundant at Pelican Banks and Wiggins Island, with small, juvenile turtles dominating the captures in proximity to mangrove habitats (Limpus et al. 2016b; 2017).

Figure 9.67 Locations where Green turtles were captured in Port Curtis 2016

Source: Limpus (2016b)

Figure 9.68 Locations where Green turtles were captured in Port Curtis 2017

Source: Limpus et al. (2017)

Figure 9.69 Locations where Green turtles were observed but not captured in Port Curtis 2016

Source: Limpus (2016b)

Figure 9.70 Locations where Green turtles were observed but not captured in Port Curtis 2017

Source: Limpus et al. (2017)

In response to the increasing incidence of strandings of sick, injured and dead Green turtles by mid-2011, especially small immature turtles, studies were undertaken by the former DERM to assess the health of resident Green turtle populations in Queensland. A more in depth veterinary assessment associated with this study was also conducted in July 2011 by Eden et al. (2011).

A range of health assessments of Green turtles have been undertaken in the Port of Gladstone since 2011 (Eden et al. 2011; Gaus et al. 2012; Limpus et al. 2012b; Flint 2015) (refer Appendix I1 (Section 14.5.2)). These health assessments included the general external health assessments as well as clinical assessments (e.g. sampling and analysis of blood and tissue samples to determine levels of contaminant groups present in samples) of the Green turtle population within the Port. High levels of heavy metals, and underlying disease processes consistent with potential toxin exposure and chronic environmental stressors, were found in Green turtles sampled in 2012 (Limpus et al. 2012b; Gaus et al. 2012).

Poor health assessments and clinical results indicating high levels of contaminants were present in a large proportion of the Green turtles within the Port of Gladstone, indicating regional level factors (of natural or anthropogenic origin) affecting all age classes of the population (Flint 2015). It has been reported that this is likely as a result of the ingestion of toxins present in either water or seagrass, though based on the current data, it is not able to be determined if this is an acute or chronic impact (Flint 2015). The most recent health assessments of Green turtles indicate that the population has recovered significantly from the 2011 and 2013 population health assessments in Port Curtis (Flint 2015).

9.18.2.4 Flatback turtle

A carnivorous species with a diet that includes soft corals, jellyfish, cuttlefish, sea-pens and sea-cucumbers, Flatback turtles utilise the abundant invertebrate resources of the Great Barrier Reef and its coastal areas, including Port Curtis (Chatto 1998; Limpus 2007). Flatback turtles are the dominant nesting marine turtle species in the Port Curtis region and around 20% of Queensland's Flatback turtle population nests on inshore islands of the region (EPA 2003).

The species is known to nest at beaches in the region, including Facing Island, Hummock Hill Island and Tannum Sands (refer Figure 9.63) (though these are not known as primary rookeries) (Limpus et al. 2002). South End Beach on the southern tip of Curtis Island is approximately 5km in length and is one of 30 rookeries reporting 10 to 100 females present at the nesting beach annually, and there are at least 50 additional, smaller rookeries reporting between 1 and 10 females present at the nesting habitat in each reproductive season (Limpus et al. 2013). In some years, there is occasional nesting by Green turtles and/or Loggerhead turtles. While the rookery has been monitored intermittently since 1969 (Limpus et al. 2014; 2016a), it has been monitored annually since 1994 (Limpus et al. 2014; 2016a).

The peak period of nesting activity is mid-November to mid-December, with the peak period of hatching during February. Nesting numbers vary between seasons (Limpus et al. 2014). During the 2014-2015 breeding season a moderately sized population with 40 nesting females was recorded on Curtis Island during peak nesting in late November to early December 2014 (Limpus et al. 2015). The 2015-2016 breeding season again recorded a moderately sized population of nesting Flatback turtles, with 44 nesting females recorded at South End Beach on Curtis Island (Limpus et al. 2016b). Again, recent studies have found that the Curtis Island Flatback turtle population is of moderate size however it was also mentioned that the nesting population has approximately halved during the past decade during the two-week mid-season census period (Limpus et al. 2017a; 2017b; 2018).

Flatback turtles have been known to enter Port Curtis during part of their internesting period (Hamman et al. 2015c; Limpus et al. 2013). The behaviour between nesting events within the same season and physiology of the Flatback turtle has been reported in Sperling et al. (2010) and more recently by Hamann et al. (2015c).

Recent studies by Hamann et al. (2015b; 2015c) undertaken as part of the ERMP, used GPS satellite tags to examine the movement patterns of female Flatback turtles nesting at Curtis Island to understand whether the turtles used the Port Curtis region during their internesting period. Data was collected from November 2013 to March 2014, and then again in November 2014 to July 2015. A recent report was compiled using data from November 2013 to January 2016. To examine habitat use, the distribution and density of GPS locations was examined for each tagged turtle to determine key use areas (refer Figure 9.71 and Figure 9.72) (Hamann et al. 2015b; Hamman et al. 2015c; Hamann et al. 2017).

During the 2013-2014 study, seven of the eight turtles that were tracked spent time within the waters of the Port. Three had 50% core use areas in the Mid Harbour zone of the Port, around the existing Gatcombe and Auckland Channels, and another four turtles used habitat within the limits of the Port, but outside of the Mid Harbour zone. Overall, approximately 20% of all habitat used by the seven turtles was located within the Port limits (Hamann et al. 2015b). A final report, summarising data from 2013 to 2015 found similar results (Hamann et al. 2017b). The results of the 2014-2015 study show that seven of the 11 tracked turtles spent at least 50% of their time (during the internesting period) within the Mid Harbour zone of the Port (Hamman et al. 2015c). The 2013 to 2016 report concluded that the waters around Curtis and Facing Islands and the waters between Facing Island and the mainland were significant habitats for the Flatback turtle (Hamann et al. 2017).

It is noted that management actions for the Flatback turtle in the Port Curtis region should be focussed on the preservation of deep water foraging grounds and maintenance of the index beach on Curtis Island. Given the individuals are not believed to leave the continental shelf, Australia has a distinct east coast genetic stock of Flatback turtles and preservation of all breeding sites within the Great Barrier Reef is important for conservation of the species (Limpus et al. 2013).

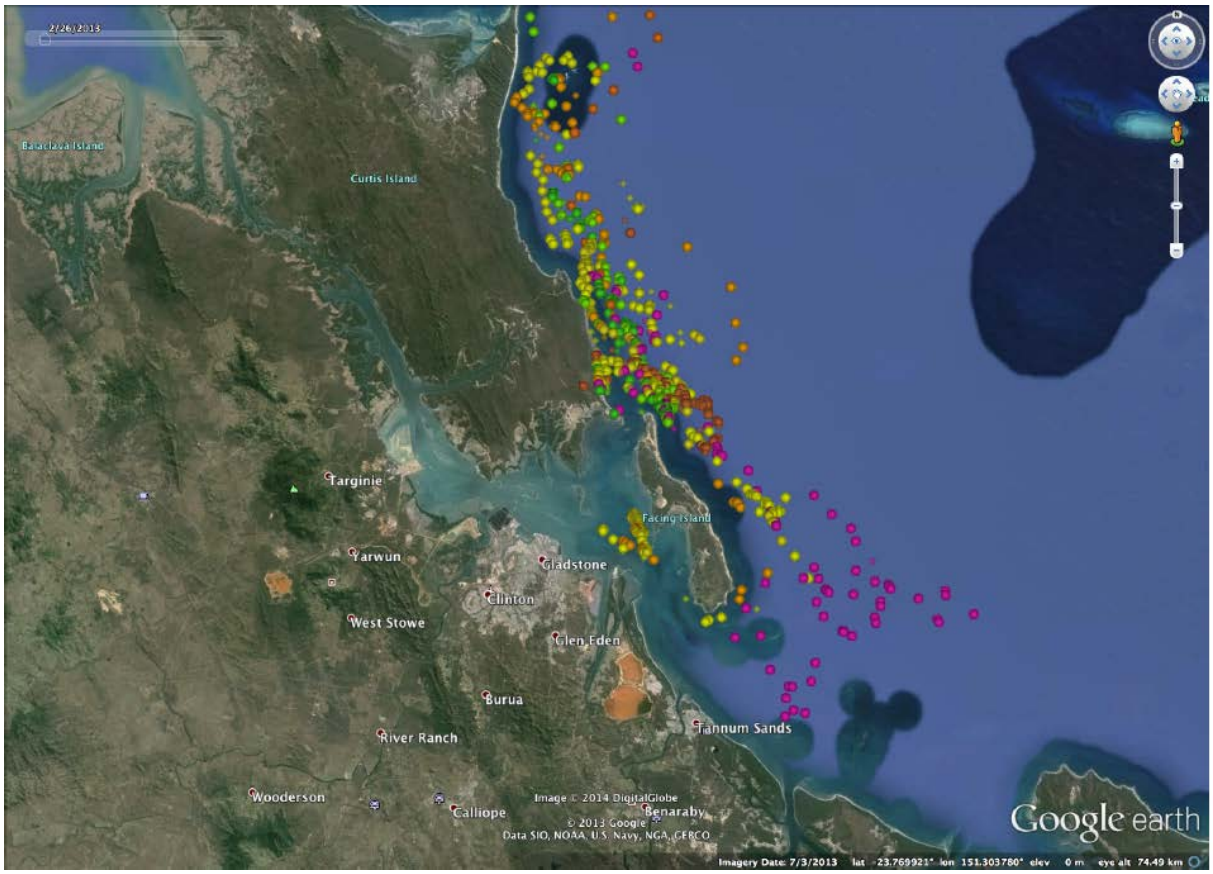

Figure 9.71 GPS points for eight Flatback turtles tracked during their internesting period (November to December 2013)

Figure note:

Different coloured points represent individually tagged turtles

Source: Hamann et al. (2015b)

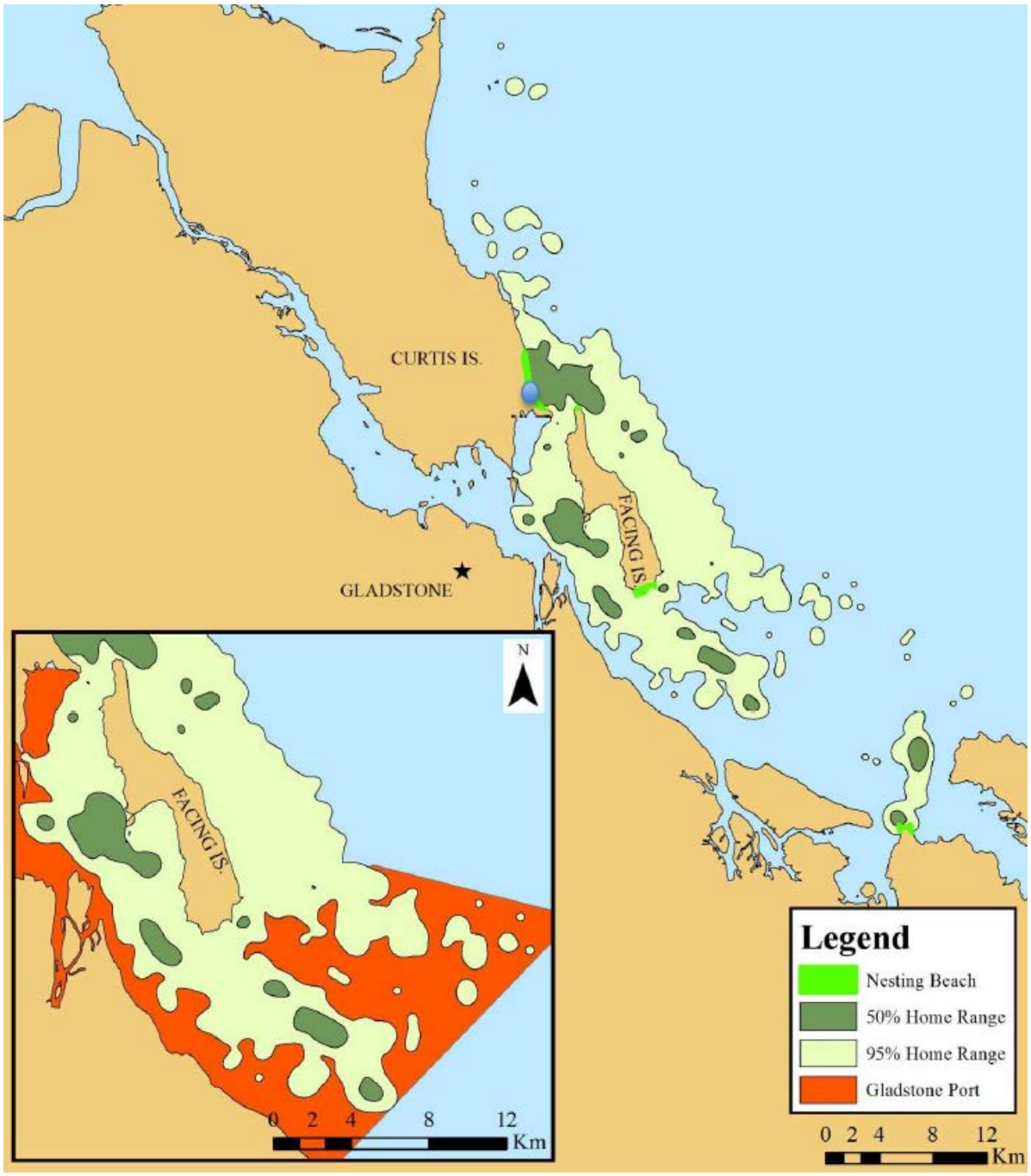

Figure 9.72 Core habitat use areas for 11 Flatback turtles tracked during their internesting period(s) during November and December 2015

Figure note:

Each turtle was tagged after nesting on South End beach on Curtis Island (blue dot). This figure does not show all nesting beaches for marine turtles, only those beaches where the 11 satellite tagged Flatback turtles were recorded using beaches for additional nesting attempts.

Source: Hamann et al. (2015c)

9.18.2.5 Loggerhead turtle

The Port Curtis region and southern Great Barrier Reef provide a potential foraging resource for breeding Loggerhead turtles, with turtles known to nest occasionally on the beaches of Curtis and Facing Islands, but not on an annual basis (Limpus et al. 2013). Loggerhead turtles have been recorded within the Port limits, although to date no known studies of the Loggerhead turtle within Port Curtis have been conducted (Limpus et al. 2013).

The peak period of nesting is during December, with hatching occurring in the following months up until the end of April (DoEE 2017b). In addition to the Woongarra coast (including Mon Repos beach), other nesting rookeries for Loggerhead turtles include Wreck Rock beaches (to the south of Port Curtis), Wreck Island, Heron Island, and North West Island (to the northwest of Port Curtis) (Limpus et al. 2013). These nesting habitats collectively form the major rookery of the Capricornia Cays National Park (Limpus 2008b) with breeding Loggerhead turtles supported by the foraging resources of the Port Curtis region.

The Port Curtis region offers a diverse perennial resource for feeding grounds of internesting females and resident Loggerhead turtles. The invertebrate biomass is supported by the rich diversity of seagrasses, algal turfs, and sand and mud flats, the latter of which are utilised by Loggerhead turtles during high tides (SKM 2014).

9.18.2.6 Hawksbill turtle

There are no known Hawksbill turtle nesting beaches in Queensland outside of the northern Great Barrier Reef and Torres Strait. However, small populations of predominantly sub-adult and juvenile turtles are found in resident populations in the southern parts of Queensland. This is in contrast with the northern parts of Queensland, where the largest remaining populations in the world are found (Limpus et al. 2013).

Although there is a significant Hawksbill turtle population in the coral reefs offshore from Port Curtis, and Hawksbill turtles may forage in Port Curtis, it has not been demonstrated that there is a significant feeding population within Port Curtis. However, the broader Port Curtis region (including areas of the Great Barrier Reef east of Port Curtis) includes areas of soft coral, algae and seagrass, which form part of their dietary requirements (Limpus 2009), making the Port Curtis region a potential resident feeding ground and resource for the species. In this context, it is important for the conservation of the species that resident foraging grounds and surrounding reefs for juvenile and sub-adult age classes are preserved (SKM 2014).

Migration data has indicated that Hawksbill turtles foraging within a 500km radius of Port Alma and Port Curtis are most likely to originate from the nesting populations in eastern Papua New Guinea, Solomon Islands or Vanuatu (Limpus et al. 2013).

Similar to the Green turtle, disease is a significant cause of mortality in Hawksbill turtles and may be utilised as an indicator of environmental health. According to the Marine wildlife stranding and mortality database annual report 2011, 19 out of the 107 deceased Hawksbill turtles examined in Queensland in 2011 were determined to have died from disease/ill health; with 61 out of 107 examinations resulting in undetermined causes of mortality (Meager and Limpus 2012). Fishing activities and other anthropogenic activities are also known threats to this species (Limpus 2009).

9.19 Marine turtles – potential impacts and risk assessment

9.19.1 Background

9.19.1.1 Section content

This section provides a discussion of the potential impacts and risk assessment for marine turtles and their habitats associated with the following Project activities. Table 9.67 summarises the Project activities and the relevant section containing the impact assessment discussion.

Table 9.67 Summary of Project activities and section addressed (marine turtles)

Project activity	Section
Establishment of the WBE reclamation area and BUF, including: ▪ Site preparation ▪ Establishment of the site compound, offices and temporary areas ▪ Source and transport of reclamation bund wall material ▪ Placement of core and armour material, and geotextile fabric ▪ Sheet piling (or similar earth retaining structure) and fill placement for the BUF	Section 9.19.2
Dredging activities, including: ▪ Initial dredging works for the barge access channel ▪ Dredging to duplicate the Gatcombe and Golding Cutting shipping channels ▪ Dredging vessel movements ▪ Unloading and placement of dredged material in the WB and WBE reclamation areas	Section 9.19.3
Removal and installation of navigational aids	Section 9.19.4
Stabilisation and maintenance activities on the WBE reclamation area	Section 9.19.5

Operation of the duplicated shipping channels and maintenance dredging activities are discussed in Sections 9.23 and 9.24, respectively.

It is important to note that this section focuses on marine turtle species which are commonly associated with intertidal and subtidal habitats. The Project potential impact and risk assessment for other marine fauna values are provided in Section 9.9 (seagrass meadows), Section 9.13 (fish and marine reptiles (excluding marine turtles)) and Section 9.20 (marine mammals), which is an important habitat and food resource for Green turtles.

A potential impact and risk assessment has been conducted based on the marine turtle values described in Appendix I1 (Section 14). Specific marine turtle species references have been made for those species which have been confirmed to occur or are considered to have a high or moderate likelihood of occurrence within the Project impact areas, therefore Leatherback and Olive ridley turtles (i.e. low likelihood of occurrence) are not assessed in the potential impact and risk assessment sections.

9.19.1.2 Sensitivity ratings

The sensitivity criteria and ratings which are used to assess the consequence of potential impacts ecological receptors are provided in Appendix I2. Based on the sensitivity descriptions in Appendix I2 (Section 3.1 (refer Table 3.1 for the criteria used to define sensitivity ratings)), the sensitivity ratings for marine turtles are as defined in Table 9.68.

Table 9.68 Sensitivity ratings for marine turtles

Marine turtle species	Conservation status under the EPBC Act and/or NC Act	Sensitivity rating	Likelihood of occurrence within Project impact areas
Green turtle (*Chelonia mydas*)	EPBC Act – Vulnerable, Migratory, Marine NC Act – Vulnerable	High	Confirmed
Flatback turtle (*Natator depressus*)	EPBC Act - Vulnerable, Migratory, Marine NC Act – Vulnerable	High	Confirmed
Hawksbill turtle (*Eretmochelys imbricata*)	EPBC Act – Vulnerable, Migratory, Marine NC Act – Endangered	Very high	Moderate

Marine turtle species	Conservation status under the EPBC Act and/or NC Act	Sensitivity rating	Likelihood of occurrence within Project impact areas
Loggerhead turtle (*Caretta caretta*)	EPBC Act – Endangered, Migratory, Marine NC Act – Endangered	Very high	Moderate
Olive ridley turtle (*Lepidochelys olivacea*)	EPBC Act – Endangered, Migratory, Marine NC Act – Endangered	Very high	Low
Leatherback turtle (*Dermochelys coriacea*)	EPBC Act – Endangered, Migratory, Marine NC Act – Endangered	Very high	Low

Table note:

There are no marine turtle species that are not listed as species of conservation significance

9.19.2 Establishment of the dredged material placement area and barge unloading facility

9.19.2.1 Permanent loss and alteration of habitat

According to the *Vulnerability Assessment for the Great Barrier Reef: Marine Turtles* (GBRMPA 2014b) a significant pressure on marine turtles in the Great Barrier Reef region is the loss and degradation of habitat through coastal development. The inshore region of Port Curtis, including the WBE reclamation area, provides valuable habitat for juvenile and adult Green turtles in the form of foraging at seagrass meadows (including species *Z. muelleri*, *Halodule and Halophila*) and other food sources such as mangroves and macroalgae, as well as internesting grounds for adult female Green turtles (Limpus 2008a).

The Loggerhead turtle feeds in a wide range of tidal and subtidal habitats, including reefs, seagrass meadows and/or soft-bottomed sand or mud areas (Limpus 2008b). However, the Flatback turtle is rarely encountered in inter-tidal seagrass meadows or reef habitats, preferring to feed at sub-tidal soft bottomed habitats (Limpus 2007). The Hawksbill turtle is often found foraging on living, hard structured habitats such as coral reefs, however are also known to occur in low densities in open seagrass meadows, in both clear water conditions and inshore turbid waters near the mainland (Limpus 2009a).

The areas of intertidal and subtidal habitat loss associated with the establishment of the WBE reclamation area and BUF are provided in Table 9.69. The potential seagrass habitat disturbance areas included in Table 9.69 have been calculated based on 2017 annual long term monitoring surveys by TropWATER (refer Appendix I1 (Section 7)).

Table 9.69 Estimated permanent loss of intertidal and subtidal areas associated with the establishment of the Western Basin Expansion reclamation area and barge unloading facility

Reclamation area	Total reclamation area (ha)	Potential seagrass habitat in reclamation area direct disturbance area (ha)	Area of seagrass meadow recorded in reclamation area direct disturbance area in 2017 (ha)	Percentage of total coastal seagrass habitat within the Port Curtis region (2017)
WBE reclamation area (southern area)	111.12	110.48	7.67	0.21% to 0.27%
WBE reclamation area (northern area)	164.98	164.75	114.66	3.17% to 4.05%
Areas adjoining WBE reclamation area (indirect impacts)	n/a	99.33	34.08	0.94% to 1.21%
BUF	1.89	0.50	0.00	0% to 0%

Several tagging studies using satellite and acoustic tracking have found that Pelican Banks and Wiggins Island seagrass meadows are critical habitat for the Green turtle population of Port Curtis (Babcock et al. 2015; Limpus et al. 2016b). Recent studies have shown many Green turtles in Port Curtis have small home ranges and were resident for all or most of the study period, although an unusually high proportion left the Port, for unknown reasons (Babcock et al. 2015).

The WBE reclamation area (northern and southern areas) contains a seagrass meadow (GPC Monitoring Meadow 8) made up of aggregated patches of light *H. ovalis* with mixed species, including *H. ovalis, Z. muelleri*, and *H. decipiens* based on the latest annual long term monitoring survey (Chartrand et al. 2018). The total area of seagrass meadows mapped within the WBE reclamation area in 2017 was 7.67ha at the southern area and 114.66ha at the northern area which represents 0.23% (± 0.06%) and 3.56% (± 0.88%) respectively of coastal seagrasses mapped in Port Curtis in 2017 (Chartrand et al. 2018). A total of 34.08ha of seagrass was mapped in the areas adjoining the WBE reclamation area which represents 1.06% (± 0.26%) of coastal seagrasses mapped in Port Curtis in 2017. The BUF does not contain any mapped seagrass in 2017.

Green turtle tracking studies undertaken in July 2015 found that 1 Green turtle out of 11 captured at Pelican Banks shifted between Pelican Banks and the Western Basin area (within the area of the WBE reclamation area) (Hamann et al. 2016). Green turtles and Loggerhead turtles were located/sighted from boat and land based surveys in the area of the WBE reclamation area (FRC Environmental 2011).

Seagrass habitat and species types found in the coastal areas of Port Curtis are abundant in the wider Fitzroy NRM region at Shoalwater Bay, Keppel Islands, Rodds Bay and Hervey Bay (McKenzie et al. 2014) representing habitat for Green turtles in the wider region.

This Project activity and potential exposure of marine turtles to these impacts will be permanent and irreversible and restricted to a contained area, and is therefore considered moderate in magnitude.

The post mitigation risk ratings associated with an unavoidable direct and permanent loss of intertidal and subtidal marine turtle habitat during the establishment of the WBE reclamation area and BUF are very high for the Green turtle, and medium for other species. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of habitat loss at the WBE reclamation area and BUF (refer Section 9.27). Project design will minimise where practical the permanent loss of areas that are very high and high sensitivity within the WBE reclamation area and BUF direct disturbance area. Project mitigation measures are provided further in Section 9.27.

A post mitigation risk level of very high for Green turtles represents a residual impact on a listed species under the EPBC Act or a prescribed environmental matter under the NC Act. To identify which fauna species have the potential to be subject to a significant residual adverse impact, an assessment of potential Project impacts and corresponding potential to contribute to key threatening processes has been conducted. The assessment was conducted for marine fauna species of conservation significance which have been confirmed to occur, or are considered to have a high or moderate likelihood of occurrence within the WBE reclamation area and BUF (refer Appendix I1 (Appendix B)).

The loss of these intertidal or subtidal areas as a result of the establishment of the WBE reclamation and BUF area is expected to have a lower level of risk to species of marine turtles with a lower likelihood of occurrence within the Port Curtis region (i.e. ‘moderate’ for Loggerhead and Hawksbill turtles). These species are unlikely to depend on the intertidal and subtidal areas at the WBE reclamation area and BUF enough for populations to be adversely impacted by the WBE reclamation area and BUF establishment.

9.19.2.2 Potential noise impacts

Increased underwater noise has the potential to be generated during the construction of the bund walls at the WBE reclamation area and piling works (or similar earth retaining structural works) at the BUF. Excessive levels of underwater noise have the potential to impact a variety of marine animals, including marine turtles through:

- Trauma to hearing (temporary or permanent)
- Trauma to non-hearing tissue (barotraumas)
- Alteration of behaviour (e.g. avoidance of predators, interfering with the acquisition of prey or mates, displacement from essential habitat areas, selection of appropriate nesting sites)
- Masking of biologically significant sounds (BOEM 2014; McCarthy 2004; Slade and Dunlop 2014).

Marine animals vary in their sensitivities to underwater noise with ear anatomy, frequency range and amplitude sensitivity each playing a role (Ketten 1998). A limited number of studies have been conducted on the acoustic sensitivity of marine turtles and little is known about the extent to which marine turtles use their auditory environment (BOEM 2014).

The auditory range of marine turtles is believed to be of low frequency and significantly less than other marine animals such as dolphins and dugongs, in the range of 50Hz to 1,000Hz depending on species and age (Ketten and Bartol 2005). Marine turtles appear most sensitive to noise at frequencies of between 100Hz to 400Hz (Ketten and Bartol 2005; Popper et al. 2014). Green turtles are thought to detect a limited frequency range (200Hz to 700Hz) (BOEM 2014). In the absence of recommended damage criteria for marine turtles, it was recommended that the same criteria used for fish is considered applicable as a conservative measure (Popper et al. 2014). Impacts to marine turtles from shipping noise of other continuous noise are considered low and no relevant assessment criteria are suggested (refer Chapter 13).

An assessment of the underwater noise to be generated as a result of Project activities was undertaken (refer Chapter 13 and Appendix K2). The primary sources of noise from the establishment of the WBE reclamation area and BUF are predicted to occur during the placement of armour and core material into marine waters, primarily the dumping of rocks from trucks during bund wall construction. Sheet piling will also be a source of noise from the BUF.

When modelled for a variety of hertz values across the one-third octave bank central frequency, underwater noise generated during rock dumping events was calculated not to exceed a SEL of approximately 182dB re 1μPa^{2}S at 1m from the rock dumping area.

An assessment of the potential underwater noise impacts during rock dumping indicated that it is unlikely that marine turtles would be at risk of peak acoustic pressure damage from underwater rock dumping until they are within the range of direct physical impact from the dumping rock material. For marine turtles, the SEL threshold level for mortality and potential mortal injury is 210dB re 1μPa^{2}S. The underwater noise predicted to be generated from rock dumping is significantly below this threshold (i.e. 182dB re 1μPa^{2}S at 1m from the rock dumping area). Given the relatively low noise emissions and non-impulsive characteristics of dumping rock material at WBE reclamation area (as well as the relatively higher baseline underwater noise environment within the Inner Harbour) it is likely that marine turtles will avoid the rock dumping locations. As such, it is unlikely that they would remain stationary near rock dumping locations and be affected by this activity.

Non-pulse development activities such as vibratory sheet piling (for BUF construction) are not expected to result in significant adverse noise impacts to marine turtles due to the relatively low noise emissions from these activities.

Further information of the zones of impact are provided in Section 13.6.2 and Appendix K2.

Analysis of potential noise masking indicates marine turtles will not respond with a behavioural displacement response during foraging and communication during rock dumping activity.

This Project activity and potential exposure of marine turtles to these impacts will be temporary and restricted to a contained area and therefore low in magnitude.

The post mitigation risk ratings associated with potential impacts of increased noise on marine turtle species during the establishment of the WBE reclamation area and BUF are medium. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating. The impact and risk assessment for this activity is informed by the results of the Project noise impact assessment (refer Chapter 13 and Appendix K2).

Mitigation measures to reduce the impacts of underwater noise on marine turtles during the WBE reclamation area and BUF establishment are included in the Project EMP (refer Appendix Q2).

9.19.2.3 Short term decline in water quality in the marine environment

Establishment of the WBE reclamation area (northern and southern areas) bund walls and BUF will be undertaken over a three year period and will involve the placement of core material directly over existing sediments, followed by armour material being placed along the seaward exposed face. Fine material of less than 12mm in diameter will be removed from the bund wall construction material prior to use, to reduce the potential turbidity and sedimentation impacts when it is placed into the marine environment. The construction activities associated with the establishment of the WBE reclamation area and BUF have the potential to impact the water quality of the receiving environment (i.e. enclosed coastal waters of Port Curtis) and impact marine turtles either directly through exposure to contaminants and increased turbidity, or indirectly through a decline of important habitat. A detailed assessment of the potential impacts to water quality as a result of Project activities is provided in Section 8.6.

The presence of PASS was evident in the samples collected at the WBE reclamation area (refer Chapter 5). If PASS is encountered during establishment of the WBE reclamation area mitigation measures will be implemented (refer Chapter 5).

Suspended sediments in the water column can increase light attenuation and reduce the amount of benthic light reaching seagrass meadows, which are potential foraging habitat for Green turtles (Erftemeijer and Lewis 2006; Sofonia and Unsworth 2010). Sediment deposition can also smother sessile benthic organisms and promote epiphytic growth, placing further pressure on seagrass meadows (Erftemeijer and Lewis 2006).

Water quality, in particular the presence of contaminants in water, has been identified as a significant source of marine turtle illness, injury and death (Brodie et al. 2014), and declining water quality due to catchment runoff has been outlined as a major pressure on marine turtles in the GBRMP (GBRMPA 2014b). Declines in water quality can lead to harmful and potentially fatal outcomes in marine turtle populations such as:

- Potentially toxic levels of contaminants building up in tissues and eggs as a result of contaminants from agricultural, urban and industrial sources
- Immunosuppression as a result of exposure to heavy metals, organic contaminants and algal toxins
- Adverse health effects through harmful algal and cyanobacterial blooms as a result of eutrophication in waters through increased nutrient supply (Brodie et al. 2014; Arthur et al. 2008).

The waters of Port Curtis are naturally turbid with higher turbidity levels experienced during the wet season flood events and during the spring and neap tide periods of the tidal cycle (Commonwealth of Australia 2013). However, despite the naturally high levels of turbidity experienced within Port Curtis, the area is known to support Green turtles (Limpus 2008a). During 2011, a significant increase in turtle strandings was recorded along with an increased prevalence of ill health and disease (EHP 2012). This was attributed to poor health as a result of malnutrition (Eden et al. 2011), which was partly attributed to the decline of seagrass abundance across all Port Curtis seagrass meadows particularly following major flood events (McCormack et al. 2013).

A study was undertaken in May 2014 by the University of Queensland and the former EHP to assess the health status of Green turtles within Port Curtis. The findings from the study suggested that the Green turtle population of Port Curtis has made a significant, but not a complete recovery since the increase in strandings and elevated disease prevalence recorded in 2011 (Flint 2015).

Previous studies on marine turtles suggest they have good eyesight and that their ability to distinguish colours are an important factor in their foraging ecology (Swimmer et al. 2005; Fehring 1972). This suggests that turtle species that feed in seagrass meadows and reef environments (i.e. Green turtles and Hawksbill turtles) that have the potential to be impacted by turbid waters are expected to actively avoid turbid waters generated by Project activities.

Flatback turtles forage in the sub-tidal deeper soft bottom habitats between the coral reefs of the Great Barrier Reef and the mainland, and have been most frequently trawled at depths from 6m to 35m (Robins and Mayer 1998). Capture data from trawlers reported in Robins (1995) indicated that Flatback turtles feed in turbid, shallow inshore waters, which suggests their foraging is not expected to be disrupted by turbid waters that will be generated by Project activities.

Contaminants (e.g. hydrocarbons) and sediment-laden runoff have the potential to be released during the Project placement of core and armour material at the WBE reclamation area and BUF or via spills from vehicles and/or onsite storage facilities. The risks of contaminants in water and their impact on marine turtles have been highlighted in recent years through studies in Port Curtis which found a range of heavy metals (e.g. arsenic, cadmium, cobalt, mercury, nickel, selenium, and vanadium) present in Green turtles at concentrations above those reported for Green turtles and marine mammal species from other locations (Gaus et al. 2012; Flint et al. 2015).

This Project activity and potential exposure of marine turtles to these impacts will be within the medium term and restricted to a contained area and therefore moderate in magnitude.

The post mitigation risk ratings associated with potential impacts of a release of sediment laden runoff and/or contaminants to marine waters impacting marine turtles during the establishment of the WBE reclamation area and BUF are medium. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to minimise marine water quality being impacted during the WBE reclamation area and BUF establishment and adversely impacting marine turtles are included in the Project EMP (refer Appendix Q2).

9.19.2.4 Entrapment and direct contact with construction plant

Construction equipment required for the establishment of the reclamation bund walls includes trucks and a small number of excavators and/or dozers required to assist in the placement of material. Core material will be placed directly over the existing sediments and bund material will then be shaped by bulldozer, grader or long arm excavator depending on location and required bund profile. Armour material will then be placed along the outer exposed face of the bund wall.

The *Marine wildlife stranding and mortality database annual report* (Meager and Limpus 2012) reported six Green turtles were trapped inside bund walls during land reclamation works in Port Curtis in 2011, although all turtles were rescued and released back into their natural habitat. Therefore the closure of the WBE reclamation area and BUF has the potential to entrap turtle species.

The risk of construction plant directly impacting marine turtles is considered low given the land-based construction methods to be employed. However, there is potential for marine turtles to be impacted by the placement of rock into marine areas during construction of the bund wall. In the unlikely instance that work boats are required as part of these construction works, to avoid striking marine turtles the work boats would be slow moving with movements localised between the WBE reclamation area, the BUF and the existing Port facilities (e.g. Gladstone Marina).

This Project activity and potential exposure of marine turtles to these impacts will be within the temporary and within a local area and therefore low in magnitude.

The post mitigation risk ratings associated with adverse impacts on marine turtles associated with the direct contact or entrapment within the reclamation areas are during establishment of the WBE reclamation area and BUF are low for Green and Flatback turtles, and medium for Hawksbill and Loggerhead turtles. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to avoid injury or death to marine turtles occurring as a result of direct contact with construction plant, rock placement, or entrapment within a reclamation area are included in Section 9.27 and the Project EMP (refer Appendix Q2).

9.19.2.5 Potential artificial lighting impacts

No night time works are proposed as part of the establishment of the WBE reclamation area and BUF. However, artificial lighting will be required for safety during night time hours which will generate minor light spillage into the marine environment.

Artificial light is not known to have a major effect on the foraging behaviour in turtles (Mustoe 2008). However, hatchlings which use natural lighting to guide them to the ocean (a pivotal moment in their lifecycle) may become disorientated from altered light horizons from coastal development or brightly illuminated facilities on islands or at sea (e.g. oil and gas facilities) (Witherington 1992; Limpus 2007). Artificial lighting also has the potential to impact on the number of female adult turtles attempting to nest (Witherington 1992).

As no night works are proposed to be undertaken during the establishment of the WBE reclamation area and BUF and is not located in the vicinity of any known turtle nesting beaches, this Project activity will not adversely impact on marine turtles within Port Curtis. Furthermore, the inner harbour of the Port currently receives elevated artificial light levels from existing Port, industrial and residential development on the mainland or Curtis Island.

This Project activity and potential exposure of marine turtles to these impacts will be within the short term and restricted to a contained area and therefore low in magnitude.

The post mitigation risk ratings associated with adverse impacts on marine turtles from a potential increase in artificial lighting during establishment of the WBE reclamation area and BUF are low for Green and Flatback turtles, and medium for Hawksbill and Loggerhead turtles. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to avoid potential lighting impacts on marine turtles during the WBE reclamation area and BUF establishment are included in Section 9.27 and Project EMP (refer Appendix Q2).

9.19.2.6 Potential increase in waste material and marine debris

Construction activities associated with the establishment of the WBE reclamation area and BUF will involve the generation of some waste material which has the potential to enter the marine environment (i.e. potential marine debris). Direct impacts to marine turtles from ingestion and entanglement with marine debris is a well-documented source of turtle injury and death (EHP 2012).

Harmful marine debris is commonly associated with discarded fishing equipment, but it may also include solid non-biodegradable floating materials and plastic waste washed or blown from the land or vessels into the sea. This can include (but not limited to) plastics bags, bottles, food packaging, strapping bands, sheeting and synthetic ropes.

This Project activity, and potential exposure of marine turtles to these impacts will be within the short term and restricted to a contained area, therefore low in magnitude.

The post mitigation risk ratings associated with impacts on marine turtles from a potential increase in waste material and marine debris during establishment of the WBE reclamation area and BUF are low for Green and Flatback turtles, and medium for Hawksbill and Loggerhead turtles. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to minimise and avoid waste materials entering the marine environment during the WBE reclamation area and BUF establishment are included in Section 9.27 and the Project EMP (refer Appendix Q2).

9.19.2.7 Increase in hard substrate

The establishment of the WBE reclamation area will involve the construction of outer (i.e. seaward) reclamation area bund walls, and internal bund walls for the management of dredging decant water. Part of the BUF outer wall will also be constructed of the same rock material. The construction of rock walls within the marine environment provides three dimensional artificial habitats in intertidal and subtidal areas which have the potential to promote species settlement such as algae, fish and sessile fauna. While it is expected to take several years for the rock wall to establish diverse fauna and flora assemblages, there is the potential for the bund walls to provide reef-like habitat and food resources for some marine turtles.

The creation of new rock wall habitat has the potential to lead to a localised increase in food resource availability for some marine turtle species, although it is not well understood to what extent marine turtles feed on the existing rock wall habitats in Port Curtis.

9.19.3 Dredging activities

9.19.3.1 Context of impact

Approximately 12.6Mm^3 of seabed material will be removed from the channel duplication area to be dredged during dredging activities for the Project and approximately 0.25Mm^3 of material to be dredged for the barge access channel (refer Section 2.4).

9.19.3.2 Permanent loss and alteration of habitat

For the assessment of the loss and alteration of habitat for marine turtles associated with this Project activity, foraging habitat and internesting habitat are considered in this section. Dredging activities will not result in impacts on known nesting beaches. It is acknowledged that turtles will move throughout Port Curtis and may come in contact with vessels as a result of dredging activities, this potential impact is discussed in Section 9.19.3.5.

Potential foraging habitat (i.e. deep water seagrass meadows) is mapped within the area to be dredged for the duplication of the shipping channels. Baseline deep water seagrass surveys within Port Curtis and Rodds Bay undertaken in years 2002, 2009, 2013 and 2014 only recorded sparse seagrass meadows in the area to be dredged for the channel duplication in 2002. Based on the results of the 2014 survey and the Project hydrodynamic modelling, it is unlikely that deep water seagrass meadows will be significantly impacted by dredging activities as the zone of high impact predicts that small areas of deep sea seagrass meadows previously surveyed within and adjacent to the Golding Cutting Channel have the potential to be impacted (refer Section 9.9.3).

Given that there are limited areas of seagrass meadows within the high or moderate zones of impact, the temporary nature of dredge plume and the ability to modify the dredger to reduce the impacts and the limited extent of seagrass meadows within the zones of high and moderate impact, it is expected that the water quality impacts from Project activities are unlikely to impact the seagrass meadows in the area for a long term duration. Ensuring that the seagrasses near the channel receive adequate light during the growing season for seed regeneration and recruitment will assist in ensuring long term impacts are reduced. Even so, regionally the Project is unlikely to cause recruitment failure due to the large extent of seagrass and therefore seed recruitment within the area is unlikely to be impacted by dredging in the long term. Seagrass monitoring will occur, however, prior, during and after dredging to ensure that no significant impacts do occur to seagrass meadows and that reactive mitigation can occur.

The zone of medium impact extends to the seagrass meadows surveyed east of South Trees Island and Boyne Island. Although the short term turbidity plumes are not expected to impact these meadows in the long term, regular water quality and BPAR monitoring will occur to ensure that adaptive management is adopted to reduce the potential impacts to these meadows. Other seagrass meadows within the Port are within the zone of low impact or zone of influence, however the monitoring proposed in the Environmental Monitoring Procedure (refer Appendix Q3) will confirm their presence prior to dredging.

It is unknown how marine turtles utilise shipping channels, however it is possible that they may use the Gatcombe and Golding Cutting shipping channels. Female Flatback turtles have been tracked during the internesting period in the Mid and Outer Harbour zones of Port Curtis around the deeper channels (Hamann et al. 2015b) (refer Figure 9.18a for zone locations). Green turtle tracking studies undertaken to date have focused on capturing turtles from foraging areas (e.g. seagrass meadows), rather than from the shipping channels within Port Curtis.

Long term changes in benthic habitat conditions (e.g. sediment types, water depths) as a result of dredging activities are not expected to have a significant adverse impact on marine turtles in Port Curtis.

This Project activity and the potential for impacts on marine turtle foraging habitat areas may be long term and within a contained area, and therefore moderate in magnitude.

The post mitigation risk ratings associated with impacts on marine turtles from an unavoidable permanent loss of foraging habitat in areas to be dredged are medium. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Adaptive design measures will be implemented during the Project detailed design phase, including dredging methodology to reduce the impact of habitat loss at the areas to be dredged (refer Section 9.27). Project design will minimise where practical the permanent loss of areas of important habitat within the areas to be dredged.

9.19.3.3 Potential underwater noise impacts

Dredging activities will generate underwater noise at the areas to be dredged. This will form a persistent source of underwater noise, and will continue intermittently during dredging activities. Dredging activities will generate underwater noise primarily through the operation of underwater pumps/piping and draghead dragging of seabed material. Excessive levels of underwater noise have the potential to impact a variety of marine animals, including turtles (refer examples in Section 9.19.2.2). The primary sources of noise from dredging activities are predicted to occur during dredging using a TSHD and CSD.

A detailed review of underwater sound propagation, natural and anthropogenic sources of marine noise, and the potential vulnerabilities of receptors (i.e. marine fauna) of interest is provided in Appendix I1 (Section 13). Noise modelling was undertaken at the following locations as part of this impact assessment (refer Chapter 13 and Appendix K2):

- TSHD and CSD dredging of the barge access channel
- WBE reclamation area (northern area)
- WBE reclamation area (southern area)
- TSHD dredging operation at Gatcombe Channel (northern end) adjacent to South Trees Island seagrass meadows
- TSHD dredging of Golding Cutting Channel (middle area)
- TSHD dredging of Golding Cutting Channel (southern end).

Impacts to marine turtles from shipping noise or other continuous noise are considered low and no relevant assessment criteria are suggested (refer Appendix K2).

The risk of underwater noise generated through dredging activities resulting in acute hearing damage to marine turtles is considered low. Intermittent cumulative increases to ambient underwater noise is also considered to be low. Data on marine turtle underwater hearing is limited to a few relevant studies however these studies indicate low frequencies between 50Hz and 1,200Hz with most sensitivity at a range of about 100Hz to 400Hz (refer Appendix K2).

This Project activity and potential exposure of marine turtles to these impacts will be short term and within a contained area, therefore low in magnitude. This is due to the relatively low noise emissions from these activities.

The post mitigation risk ratings associated with increased noise and vibration impacting on marine turtles during dredging activities are medium for Loggerhead turtles and low for Green, Flatback and Hawksbill turtles. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to reduce the impacts of underwater noise on marine turtles during dredging activities are included in the Dredging EMP (refer Appendix Q1).

9.19.3.4 Potential vessel strike impacts

Vessel movements associated with dredging activities pose a potential risk to marine turtles in Port Curtis. Marine turtles are particularly prone to vessel collision while surfacing to breathe and rest after dives, or whilst feeding or mating in shallow seagrass meadows or coral reef areas (DoE 2007; Brodie et al. 2014). The risk of vessel strike for marine turtles is highly influenced by vessel speed and water depth (Hazel et al. 2007).

While specific vessel types and sizes have not been confirmed for the Project, based on the nature and volume of the material to be dredged, the preferred dredging equipment includes TSHD and CSD dredgers and other vessels (including barges, pushbusters, tugs and other support vessels).

Studies suggest that the risk of boat strike is considerably reduced when vessel speeds are below 10 knots, allowing sufficient time for both turtles and vessel operators to avoid collision (SKM 2014; Hazel et al. 2007). Larger vessels such as dredgers and work boats are slow-moving and are not likely to present a significant threat to marine turtles in terms of vessel strike due, while smaller work boats capable of travelling at faster speeds may present a higher risk (refer Section 9.19.3.5 for impact assessment associated with direct contact with dredging equipment).

The *Vulnerability Assessment for the Great Barrier Reef* (GBRMPA 2014b) describes the direct impact of boat strike and port dredging on marine turtles as a ‘moderate concern’ for Green turtles and Loggerhead turtles in the southern Great Barrier Reef region behind other ‘high concern’ impacts such as cumulative impacts from human-related activities (i.e. coastal development, declining water quality, climate change, ingestion and entanglement of marine debris, fishing by-catch, and Indigenous fishing).

The distance between the vessel hull or propeller and the seabed can also play a role in the risk of boat strike particularly for Green turtles in shallower areas where they may be foraging or resting at the seabed (Hazel 2009). Deeper waters present less of a risk. Dredging activities at the area to be dredged associated with the channel duplication will be undertaken in deeper waters (approximately -7m and -16m LAT) presenting less of a risk of vessel strike to marine turtles during these works.

The Port of Gladstone currently experiences a high volume of commercial and recreational vessel traffic. The nature, scale and volume of Project vessel movements are considered minor compared to the existing Port vessel movements. It should be noted that vessel numbers required to complete the Project will be considerably lower than those required during the Western Basin capital dredging and LNG development on Curtis Island between 2011 and 2015.

This Project activity and potential for impacts on marine turtles will be within the short term and within a contained extent, therefore low in magnitude.

The post mitigation risk ratings associated with vessel strike on marine turtles during dredging activities are low for Green and Flatback turtles, and medium for Hawksbill and Loggerhead turtles. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to reduce the risk of vessel strike on marine turtles during dredging activities are included in the Dredging EMP (refer Appendix Q1).

9.19.3.5 Direct contact with dredging equipment

Dredging activities have the potential to impact on marine turtles through direct contact with dredging equipment. However, the annual reported mortality of Green turtles in Queensland during port dredging operations from 1999 to 2011 is relatively low with 0.5 per year recorded for Green turtles, and 0.6 per year for Loggerhead turtles (Limpus et al. 2013). Two turtle deaths (one juvenile Green turtle and one juvenile Olive Ridley turtle) recorded in the Gladstone region during 2011 were attributed to dredging operations (Meager and Limpus 2012).

This risk of dredgers directly impacting on marine turtles will depend on the type of dredging plant being used. A TSHD poses a greater risk of interaction with a turtle, often resulting in injury or death, as TSHD are slow-moving, quiet and have strong suction power at the draghead (Goldberg et al. 2015). Some turtles are known to inhabit deep water channels, including navigation channels particularly during the cooler months which may increase this risk (Dobbs 2001). In Gladstone, Green turtle tracking and habitat studies by Hamann et al. (2015) recorded Green turtles regularly using the North Entrance between Curtis Island and Facing Island (i.e. access point in and out of the Port for small vessels), while female Flatback turtles have been tracked in the Mid and Outer Harbour zones around the deeper channels (i.e. shipping channels) during internesting periods (Hamann et al. 2015b; Hamann et al. 2015) (refer Figure 9.18a for the zone locations).

The CSD, clamshell, pipeline, and other types of dredgers generally pose a lower risk of impacts to marine turtles due to design and operational differences (Dickerson et al. 2004).

This Project activity and potential exposure of marine turtles to these impacts will be short term and within a contained extent and therefore low in magnitude. While the likelihood of the impact occurring post mitigation is possible it is unlikely that these potential impacts will result in an adverse impact on marine turtle populations, or their habitat.

The post mitigation risk ratings associated with potential impacts on marine turtles through direct contact with dredging equipment are low for Green and Flatback turtles, and medium for Hawksbill and Loggerhead turtles. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to reduce the risk of injury or death to marine turtles occurring as a result of direct contact with dredging equipment during dredging activities are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

9.19.3.6 Short term decline in water quality in the marine environment

The potential impacts to water quality as a result of dredging projects have been widely studied and water quality, in particular the presence of contaminants in water has been identified as a major source of marine turtle illness, injury and death (Brodie et al. 2014).

A detailed assessment of the potential impacts to water quality as a result of Project dredging activities is provided in Section 8.6. This includes an assessment of the risk of dredging activities resulting in a decline in water quality, predominantly through increased turbidity, including:

- Dredging (i.e. turbidity generated at the dredger head, overflow and propwash)
- Dredging vessel movements
- Dredged material unloading and placement (e.g. potential bund wall seepage)

- Licenced discharge of dredging decant water from the WB and WBE reclamation areas.

Section 9.19.2.3 discusses the sources of potential impacts on marine turtles associated with short term declines in water quality. Therefore, these sources are not further discussed in this section.

During dredging activities, there is potential for impacts on marine turtle foraging habitat (e.g. seagrass meadows) and the release of contaminants into marine environments (and potential indirect impacts on turtle health) (refer Section 9.19.2.3). It is important to note that limited areas of deep water seagrass meadows have been recorded within and around the channel duplication area to be dredged since baseline monitoring began in 2002. While some deep water seagrass meadows were recorded in the channel duplication area to be dredged in 2002, subsequent baseline seagrass surveys (i.e. 2009, 2013 and 2014) have not recorded seagrass in this area.

Section 9.19.3.2 discusses the outcome of the hydrodynamic modelling and the predicted impacts to water quality and potential impact that this might have on seagrass meadows and suitable habitat for marine turtles. It is important to note that there are large areas of comparable habitat within the Port Curtis region that are not expected to experience a decline in water quality from Project dredging activities.

Implementation of the Environmental Monitoring Procedure as part of the Dredging EMP (refer Appendix Q1) will ensure seagrass meadows in the zones of low to medium impact and the zone of influence will remain available for marine turtles subject to natural variations throughout the year.

Dredging activities that effect water quality will likely be contained to certain areas at any given time (i.e. only one dredger will be working at particular points within the areas to be dredged at any given time). The Dredging EMP will be implemented during dredging activities which will minimise and mitigate potential impacts to water quality from dredging activities. A detailed monitoring procedure has also been designed to survey coastal and deep water seagrass meadows and monitoring water quality, throughout the Port and offshore areas prior to, during and after Project activities to ensure that any changes to water quality is identified and management measures can be implemented. These plans include adaptive and reactive management measures to be adopted during dredging activities which will focus on minimising impacts at key sensitive receptors such as seagrass meadows. Mitigation measures to minimise water quality impacts are provided in Section 9.27.

Desktop and field geochemical investigations undertaken for the Project concluded that the marine sediments to be removed from the areas to be dredged are considered ‘clean’ as per NAGD (2009) and the potential for contaminants to be mobilised into the water column during dredging activities is considered to be low (refer Section 6.5 and Appendices E4 and E6). Based on these results the potential for marine turtles to be impacted by contaminants from sediment to be dredged during the Project is therefore also considered low.

Adaptive design measures will be implemented during the Project detailed design phase to minimise the potential impacts to water quality (refer Section 9.27). Project design of the WBE reclamation area and BUF will incorporate geotextile material to be placed within the inner face of the bund wall reclamation area in order to minimise the migration of dredged material fines through the bund wall to the marine waters of Port Curtis. Furthermore, the location of the reclamation area licenced dewatering discharge point will be placed at a location where seagrass is not present (or have the potential to grow), to avoid potential impacts to marine turtle habitat through scouring of the seabed. The release of dredging decant waters will be controlled by a licenced discharge point and weir box with conditions which will dictate the water quality criteria to be met prior to discharge.

This Project activity and potential exposure of marine turtles to these impacts will be within the short term and within a local area, and therefore moderate in magnitude.

The post mitigation risk ratings associated with a short term decline in water quality impacting marine turtles during dredging activities are medium. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to minimise the impact of short term declines in water quality during dredging activities on marine turtles are included in Section 9.27 and the Dredging EMP (Appendix Q1).

9.19.3.7 Potential artificial lighting impacts

Artificial lighting will be required for safety and navigation during night time hours on dredgers and work boats for dredging activities. Artificial lighting will also be used at the BUF and on the WB and WBE reclamation areas during night time unloading and placement activities. This will generate minor light spillage into the marine environment. Artificial light is not known to have a major effect on the foraging behaviour in turtles (Mustoe 2008) but it has the potential to impact nesting females and hatchings, as detailed in Section 9.19.2.5.

The closest nesting areas for Flatback turtles in relation to the area to be dredged for the channel duplication are located 2km north at Gatcombe Head on Facing Island. Other nesting areas located approximately 4.5km to 5.5km south of the channel duplication area to be dredged at Lilley's Beach (Boyne Island), Tannum Sands and along the coast to Colosseum Inlet (refer Figure 9.15). Additional nesting areas further from the channel duplication area to be dredged include the eastern coast of Facing Island, Curtis Island and Peak Island. The seaward position of dredgers and vessels during dredging activities at all times poses a low risk to disturbing hatching and nesting behaviour. Furthermore, the increase of artificial lighting from dredgers and work boats to the overall background light levels from industrial facilities and commercial vessels in Port Curtis areas is considered low.

This Project activity and potential exposure of marine turtles to these impacts will be within the short term and restricted to a contained area and therefore low in magnitude.

The post mitigation risk ratings associated with an increase in artificial lighting during dredging activities impacting marine turtles are low for Green and Flatback turtles, and medium for Hawksbill and Loggerhead turtles. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to minimise impacts from artificial lighting on marine turtles are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

9.19.3.8 Increase in waste material and marine debris

Project dredging activities have the potential for some waste material (e.g. marine debris) to enter the marine environment. Direct impacts to marine turtles from ingestion and entanglement of marine debris are a major source of turtle injury and death (EHP 2012). Section 9.19.2.6 contains further information on the potential sources of waste material and marine debris associated with Project activities.

This Project activity and potential exposure of marine turtles to these impacts will be within the short term and restricted to a contained area, therefore low in magnitude. It is unlikely that these potential impacts will result in adverse impacts on marine turtle populations, or their habitat.

The post mitigation risk ratings associated with impacts on marine turtles from a potential increase in waste material and marine debris during dredging activities are low for Green and Flatback turtles, and medium for Hawksbill and Loggerhead turtles. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to minimise and avoid waste materials entering the marine environment dredging activities are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

9.19.4 Removal and installation of navigational aids

9.19.4.1 Noise and vibration impacts

The installation of navigational aids will involve use of a hydraulic piling hammer that is anticipated to generate the highest levels of underwater noise, approximately 204dB for the impact piling and 168dB for the piling barge, during the Project (refer Chapter 13 and Appendix K2). As stated in Section 9.19.2.2, excessive levels of underwater noise have the potential to impact a variety of marine animals, including turtles. The specific size of the Junttan hydraulic hammer is yet to be determined but is expected to be in the range of 124dB. Two existing navigational aids will be removed and five existing navigational aids will be removed and reinstalled using a barge pile extractor.

The installation of new navigational aids (i.e. pilling) is estimated to take two to three days per pile. Installation is anticipated to be undertaken during daylight hours over a period of two to three months, with hammering undertaken intermittently. An assessment of underwater noise and vibration baseline levels along with predicted noise and vibration impacts from installation of the navigational aids were modelled by SLR (refer Appendix K2). The following criteria were modelled as part of this assessment:

- Range of SEL levels for impact piling and operation of the piling barge
- Noise sources, including Junttan hydraulic impact hammer use and piling barge operation supporting navigational aid installation
- Noise generating mechanisms of impact piling and propeller/thruster use
- Modelled point source depth ‘mid water column’ for the impact piling and ‘near surface’ for the supporting barge
- Multiple pulses noise type for the impact piling and non-pulses, continuous noise type for the supporting barge.

Estimates of the underwater noise generated from the installation of navigational aids range from 15dB (RMS SPL parameter) and 28dB (Peak SPL parameter) for distances closer than 2km to the source, whilst for distances further than 10km away, an estimation of 10dB is derived.

Mortal injuries can be inflicted on marine turtles through a single piling strike within a distance of 35m during piling activity associated with the removal and installation of navigational aids (SLR 2019b). Noise emitted by a single strike is also predicted to cause avoidance at a distance of up to 600m whilst changes in behaviour can be expected up to a distance of 2km from piling location (SLR 2019b).

Piling noise exposure for an extended duration also has potential to cause mortal injury to marine turtles at further distances (SLR 2019b). The maximum zone of impact that will cause mortal injury to marine turtles for a one hour exposure duration (i.e. 6,000 strikes) was predicted as up to 160m from the piling location (SLR 2019b).

It is important to note that there has been minimal research undertaken on the impacts of noise and vibration impact assessment on marine turtles.

This Project activity and potential exposure of marine turtles to these impacts will be temporary and within the local area, and therefore low in magnitude. It is considered that the regular pulses from piling activities may result in avoidance behaviour, therefore the likelihood of the impact occurring post mitigation is possible.

The post mitigation risk ratings associated with an increase in noise and vibration during the removal and installation of navigational aids impacting marine turtles are medium. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating. This impact and risk assessment for this activity is informed by the results of the Project noise and vibration impact assessment (refer Chapter 13 and Appendix K2).

Mitigation measures to avoid or minimise potential noise impacts to marine turtles generated through piling activities are included in Section 9.27 and the Project EMP (refer Appendix Q2). A range of noise mitigation techniques can be utilised for marine piling activities that can reliably reduce the sound energy at the source across the range of frequencies that overlap the functional auditory range of marine megafauna species, including marine turtles.

9.19.4.2 Direct contact with construction plant

Vessel activity associated with the removal and installation of navigational aids has the potential to pose a risk to marine turtles in Port Curtis. The risk of vessel strike for marine turtles is highly influenced by vessel speed and water depth (Hazel et al. 2007). While specific vessel types and sizes have not been confirmed for the removal and installation of navigational aids, based on the proposed activities a barge, tug boat and work boats will be required to complete the works. Installation and removal of navigational aids will be undertaken in a variety of depths which can influence the risks associated with vessel strike.

Port Curtis currently experiences a high volume of commercial and recreational vessel traffic and the addition of the Project vessels will not significantly increase the risk of vessel strike to marine turtles above the overall existing risk that exists in Port Curtis.

The post mitigation risk ratings associated with potential impacts on marine turtles through direct contact with construction plant during removal and installation of navigational aids is negligible.

9.19.4.3 Potential artificial lighting impacts

Artificial lighting on the Project navigational aid vessels will be required for safety and navigation. The removal and installation of navigational aids is not proposed to occur outside of daylight hours. The artificial lighting risk to marine turtles during this Project activity is therefore negligible.

9.19.5 Stabilisation and maintenance activities

9.19.5.1 Short term decline in water quality

Release of contaminants

The use of vehicles during surface stabilisation and maintenance works at the WB and WBE reclamation areas has the potential to result in the release of contaminants (e.g. hydrocarbons). The release of contaminants may lead to the degradation of intertidal or subtidal habitats located downstream of, or adjacent to, the final Project landform. This may impact marine life, including turtles via direct contact with contaminants or the ingestion of contaminated food source.

This Project activity and potential exposure of marine turtles to these impacts will be within the short term and within a contained extent and therefore low in magnitude.

The post mitigation risk ratings associated with potential impacts of a release of contaminants to marine waters impacting marine turtles during stabilisation and establishment of the final Project landform are low for Green and Flatback turtles, and medium for Hawksbill and Loggerhead turtles. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to avoid contaminant releases impacting marine turtles and marine turtle habitat during surface stabilisation and maintenance works at the WBE reclamation area and BUF are included in Section 9.27 and the Project EMP (refer Appendix Q2).

Soil erosion and sedimentation

Soil erosion of the final Project landforms and downstream sedimentation have the potential to have an impact on the quality of adjacent intertidal and subtidal habitats. Erosion and runoff can result in decreased water quality which has the potential to impact on the condition of marine turtle habitat such as seagrass meadows. This Project activity and potential exposure of marine turtles to these impacts will be within the short term and within a contained extent and therefore low in magnitude.

The post mitigation risk ratings associated with potential impacts of a release of sediment laden runoff to marine waters impacting marine turtles during stabilisation and establishment of the final Project landforms are low for Green and Flatback turtles, and medium for Hawksbill and Loggerhead turtles. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to avoid soil erosion and runoff impacting marine turtles or marine turtle habitat during surface stabilisation and maintenance works at the WBE reclamation area and BUF are included in Section 9.27 and the Project EMP (refer Appendix Q2).

9.19.5.2 Potential artificial lighting impacts

Artificial lighting on the stabilisation and maintenance activities will be required for safety. The stabilisation and maintenance activities works is not proposed to occur outside of daylight hours. The artificial lighting risk to marine turtles during this Project activity is therefore negligible.

9.19.6 Threatening processes for species of conservation significance and migratory species

Threatening processes which may lead to the progressive loss of species of conservation significance or migratory species, including ecologically significant habitat, have been assessed with regards to the potential Project impacts. Threatening processes for species of conservation significance and migratory marine turtle species which have been confirmed to occur, or are considered to have a high or moderate likelihood of occurrence within the Project impact areas (refer Appendix I1 (Appendix B)), have been identified from the relevant species recovery plan, conservation listing advice and/or threat abatement plan.

The potential Project impacts which have been provided in Sections 9.19.2 to 9.19.5 have been assessed with regard to their potential contribution to the species threatening processes (refer Appendix I3).

Residual impacts on threatening process have the potential to result where an impact has a high or very high risk rating. Marine turtle species for which potential Project impacts are considered to have a residual impact on a threatening process which may lead to the progressive loss of the species or ecologically significant habitat (refer Appendix I (Appendix I3), Item Q3.1) will be subject a significant residual adverse impact assessment. The significant residual adverse impact assessment is provided in Section 9.19.7.

9.19.7 Significant residual adverse impact assessment

A significant residual adverse impact assessment has been conducted to identify if the Project will, or is considered likely to have a significant residual adverse impact on a marine turtle species which are defined as a MNES or a MSES. The impact assessment included in this section has been conducted in accordance with the *Matters of National Environmental Significance Significant Impact Guidelines, Version 1.1* (DoE 2013) and the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (EHP 2014a).

The significant residual adverse impact assessment provided in Table 9.84 has been prepared for marine turtle species which are considered to have a moderate or high likelihood of occurrence within the Project impact areas (refer Appendix I (Appendix B)).

This assessment of significant residual adverse impacts considers the significance of potential Project impacts after the implementation of the Project mitigation measures included in Section 9.27.

Table 9.63 includes the marine turtle species which are subject to this significant residual adverse impact assessment, due to Project impacts having:

- Very high or high consequence (post mitigation measures) on a species (refer Sections 26.2 to 26.7), and/or
- A residual impact to a key threatening process (refer Appendix I (Appendix I3), Item Q3.1).

Table 9.70 Marine turtle Matters of National Environmental Significance and Matters of State Environmental Significance subject to significant residual adverse impact assessment

Fauna value	MNES	MSES	Significance assessment
Flatback turtle (*Natator depressus*) *Conservation status:* EPBC Act: Vulnerable and Migratory NC Act: Vulnerable	Vulnerable listed species Migratory species	Protected wildlife habitat	Table 9.71
Green turtle (*Chelonia mydas*) *Conservation status:* EPBC Act: Vulnerable and Migratory NC Act: Vulnerable	Vulnerable listed species Migratory species	Protected wildlife habitat	Table 9.71
Hawksbill turtle (*Eretmochelys imbricata*) *Conservation status:* EPBC Act: Vulnerable and Migratory NC Act: Endangered	Vulnerable listed species Migratory species	Protected wildlife habitat	Table 9.71
Loggerhead turtle (*Caretta caretta*) *Conservation status:* EPBC Act: Endangered and Migratory NC Act: Endangered	Endangered listed species Migratory species	Protected wildlife habitat	Table 9.71

The MNES significant impact assessment criteria for listed and migratory species (DoE 2013) and the significant impact assessment criteria for protected wildlife habitat (EHP 2014a) have been used for the marine turtle significant residual adverse impact assessment (refer Table 9.84). The significant residual adverse impact assessment concluded that the proposed Project activities will not have a significant residual adverse impact on marine turtle species.

Table 9.71 Significant residual adverse impact assessment – Marine turtles

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: - Lead to a long term decrease in the size of a population of a species - Reduce the area of occupancy of the species - Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline - Adversely affect habitat critical to the survival of a species - Substantially modify (including by fragmentation, altering fire regimes, alerting nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
MSES significant impact assessment criteria – Protected wildlife habitat: ▪ Lead to a long term decrease in the size of a local population ▪ Reduce the extent of occurrence of the species ▪ Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species.
Unlikely to have a significant impact The establishment of the WBE reclamation area, BUF and dredging activities will result in the direct removal and permanent loss of seagrass, algae and benthic habitats which provide potential foraging resources for marine turtle species. The inshore region of Port Curtis provides habitat for juvenile and sub-adult Green turtles in the form of foraging grounds and food sources such as seagrass meadows (including species *Z. muelleri*, *Halodule* and *Halophila*) along with mangroves and macroalgae (Limpus 2008a). The total area of seagrass meadows mapped at the WBE reclamation area footprint and areas adjoining the WBE reclamation area was 156.41ha in 2017, which represents approximately 4.33% to 5.53% of coastal seagrass mapped in Port Curtis in 2017 (Chartrand et al. 2018). There were no seagrass meadows mapped within the BUF in 2017. There were no seagrass meadows mapped within the Project dredging footprint in 2017. The loss of seagrass meadows within the Project impact areas is not anticipated to affect the overall abundance of Green turtles in Port Curtis, given that *H. ovalis* and *Z. muelleri* are the dominant seagrass species in coastal meadows in Port Curtis (Carter et al. 2015). Any impacts to seagrass meadows as a result of increased turbidity through dredging activities is expected to be temporary and effectively mitigated through an adaptive Project EMP (refer Appendix Q2) and the Dredging EMP (refer Appendix Q1). The seagrass habitat and species types found in the coastal areas of Port Curtis are abundant in the wider Fitzory NRM region at Shoalwater Bay, Keppel Islands, Rodds Bay and Hervey Bay (McKenzie et al. 2014) which suggests there remains appropriate habitat for Green turtles in the wider region. The Flatback turtle and the Loggerhead turtle are carnivorous species with a diet that includes soft corals, jellyfish, cuttlefish, sea-pens, sea-cucumbers and invertebrates such as gastropods and bivalve molluscs (Chatto 1998; Limpus 2007). The Hawksbill turtle is not considered to have a significant population within Port Curtis. Areas of soft coral, algae and seagrass within Port Curtis provide potential foraging habitat for the species (Limpus 2009). The Flatback turtle, Loggerhead turtle and Hawksbill turtle are considered unlikely to heavily depend on the intertidal and subtidal areas around the WBE reclamation area and BUF footprint to the extent that the direct loss of seagrass and benthic habitat would result in a negative impact on species populations. Impacts to coastal processes and hydrodynamics through establishment of the duplicated shipping channel are expected to be minor. It is important to note that no part of Port Cutis is listed as an area of 'Critical Habitat' for marine turtles, as defined under Section 207A of the EPBC Act (DoEE 2017b).
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ▪ Fragment an existing population into two or more populations. **MSES significant impact assessment criteria – Protected wildlife habitat:** ▪ Fragment an existing population ▪ Result in genetically distinct populations forming as a result of habitat isolation.
Unlikely to have a significant impact As marine turtles move through different stages of their life history they require different habitats. Different habitat requirements include natal beaches, mating habitats, internesting habitats, foraging habitats and pelagic habitats (DoEE 2017b). The establishment of the WBE reclamation area and BUF are not considered to create a barrier to species movement between habitats. Furthermore, the dredging activities are associated with the existing shipping channel, as such, not creating disturbance or barriers to movement in new areas. The Project activities are not anticipated to result in genetically distinct populations forming as a result of habitat isolation. The Project is not considered likely to create a significant barrier to species movement through the marine environment or fragment marine turtle populations.

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact

MNES significant impact assessment criteria – Endangered, vulnerable, migratory species:

- Disrupt the breeding cycle of a population
- Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

Unlikely to have a significant impact

Nesting marine turtles will often move from their feeding grounds to areas near nesting beaches for mating. Marine turtle nesting beaches are present within Port Curtis.

Flatback turtles are the dominant nesting marine turtle species in the Port Curtis region, with approximately 20% of Queensland's Flatback turtle population recorded to nest on inshore islands of the region (EPA 2003). The 2015-2016 breeding season recorded a moderately sized population of nesting Flatback turtles, with 44 nesting females recorded at South End Beach on Curtis Island (Limpus et al. 2016b). The stability of the previous two years of census data indicates that the eastern Australian Flatback turtle stock breeding at Curtis Island has had a stable breeding population over recent decades (or a single generation for this species) (Limpus et al. 2015; 2016b). The nature of the Project works is considered to be consistent with existing disturbances within the area and as such the Project is not anticipated to adversely impact the current stability of Flatback turtle nesting within the Port Curtis region.

The Green turtle has been recorded nesting within the Port Curtis region on the beaches of Curtis Island and Facing Island (Limpus et al. 2000; Limpus et al. 2006; Limpus 2008a). Limpus et al. (2016b) collected data on Green turtles within Port Curtis to determine if the area is an important aggregation area for the species. The results from the first year (of the four year study) identified that none of the 264 observations of Green turtles in Port Curtis were of turtles engaged in courtship or mating behaviour. Furthermore, none of the Green turtles that were captured were in breeding condition for the 2016-2017 breeding season (Limpus et al. 2016b). The data collected by Limpus et al. (2016b) indicate that Port Curtis is not a significant area for aggregation of breeding Green turtles for courtship and mating.

Loggerhead turtles are known to nest occasionally on the beaches of Curtis and Facing Islands, but not on an annual basis (Limpus et al. 2013).

There are no known Hawksbill turtle nesting beaches in Queensland outside of the northern Great Barrier Reef and Torres Strait.

Project activities will not involve direct disturbance in areas within or adjacent to marine turtle nesting beaches. The Project will not have a direct impact on marine turtle nesting areas in Port Curtis. The Project is not considered to have a direct, adverse impact on the marine turtle breeding.

The establishment of the WBE reclamation area, BUF and dredging activities have the potential to result in acoustic impacts and light spill from machinery and dredgers.

Noise may alter the behaviour patterns of marine turtles (e.g. avoidance of predators, interfering with the acquisition of prey or mates, selection of appropriate nesting sites). It is unlikely that temporary or permanent hearing trauma will result from the establishment of the WBE reclamation area, BUF or the dredging activities. Underwater noise impacts from navigational aid activity is expected to have the largest impact on marine turtles with a single strike having potential to cause mortal injury within 35m from piling location, avoidance of source at up to 600m and behavioural changes exhibited within 2km from piling location.

Marine turtle hatchlings use natural lighting to guide them to the ocean and may become disorientated from altered light horizons from artificial light sources. Artificial lighting may also affect the number of female adult turtles attempting to nest (Witherington 1992; Limpus 2007).

Marine turtle nesting beaches in relation to the areas to be dredged, the WBE reclamation area and BUF are located at Southend Beach on Curtis Island, along the east coast of Facing Island from Gatcombe Head and on beaches from Tannum Sands to Wild Cattle Island/Colosseum Inlet. The seaward position of dredge plant and vessels during dredging activities poses a low risk to disturbing hatching and nesting behaviour. Furthermore, the increase of artificial lighting from dredging vessels with comparison to the overall background light levels from industrial facilities and commercial ships in Port Curtis is considered low.

Potential adverse impacts on environmental values, including marine turtles, as a result of noise and artificial light sources will be reduced via the implementation of appropriate mitigation measures contained in the Project EMP (Appendix Q2) and Dredging EMP (Appendix Q1).

Potential indirect Project impacts are not considered to have a significant impact on the marine turtle lifecycle, including nesting activities.

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ▪ Result in invasive species that are harmful to an endangered, vulnerable or migratory species becoming established in the species' habitat. **MSES significant impact assessment criteria – Protected wildlife habitat:** ▪ Result in invasive species that are harmful to an endangered or vulnerable species becoming established in the endangered or vulnerable species' habitat.
Unlikely to have a significant impact The predation of marine turtle eggs by native and introduced fauna is a threatening process to marine turtle species (DoEE 2017b). The establishment of the WBE reclamation area and BUF may facilitate the spread of pest species across the landscape. There are no marine turtle nesting beaches within the direct or indirect Project impact areas where vegetation clearing works will occur (i.e. WBE reclamation area and BUF). Project activities will not involve direct disturbance in areas within or adjacent to marine turtle nesting beaches. Any potential Project impact in regards to species predation vulnerability is considered negligible The likelihood of the Project introducing or spreading pest species across the local landscape is considered to be reduced and managed via the implementation of mitigation measures included in the Project EMP and Dredging EMP.
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ▪ Introduce disease that may cause the species to decline. **MSES significant impact assessment criteria – Protected wildlife habitat:** ▪ Introduce disease that may cause the species to decline.
Unlikely to have a significant impact Disease is a contributing process to mortality in marine turtles. Harmful contaminants such as pesticides, heavy metals, organochlorides and sewage from the land or from boats can pollute marine turtle feeding grounds and increase incidence of disease. High levels of heavy metals, and underlying disease processes consistent with potential toxin exposure and chronic environmental stressors have been recorded in Green turtles sampled in the Boyne River estuary (Limpus et al. 2012b; Gaus et al. 2012; Flint 2015). The marine wildlife stranding and mortality database annual report 2011 found that one out of the 39 deceased Loggerhead turtles examined in Queensland in 2011 was determined to have died from disease/ill health. The annual report also found that 19 out of the 107 deceased Hawksbill turtles examined in Queensland in 2011 were determined to have died from disease/ill health (Meager and Limpus 2012). The study in May 2014 re-assessed the health of Green turtles to utilise turtle health as an indicator of environmental recovery and/or stressor persistence (Flint 2015). The study determined that the population has recovered significantly from the 2011 and 2013 population health assessments in Port Curtis (Flint 2015). The nature of Project activities is considered unlikely to introduce disease that may cause species decline. The movement of materials, equipment and sediment, which may act as transport mediums for disease, will be subject to the Project EMP and Dredging EMP. Any potential Project impacts in regards to the introduction or spread of harmful diseases to marine turtles is considered to be negligible.

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ■ Interfere with the recovery of the species. **MSES significant impact assessment criteria – Protected wildlife habitat:** ■ Interfere with the recovery of the species.
Unlikely to have a significant impact The objective of the Recovery plan for Marine Turtles in Australia (DoEE 2017b) is to 'minimise anthropogenic threats to allow for the conservation status of marine turtles to improve so that they can be removed from the EPBC Act threatened species list'. Key actions identified in the species recovery plan include: ■ Assessing and addressing threats – Maintain and improve efficacy of legal and management protection – Adaptively manage turtle stocks to reduce risk and build resilience to climate change and variability – Reduce the impacts from marine debris – Minimise chemical and terrestrial discharge – Address international take within and outside Australia's jurisdiction – Reduce impacts from terrestrial predation – Reduce international and domestic fisheries bycatch – Minimise light pollution – Address the impacts of coastal development/infrastructure and dredging and trawling – Maintain and improve sustainable Indigenous management of marine turtles ■ Enabling and measuring recovery – Determine trends at index beaches – Understand population demographics at key foraging grounds – Address information gaps to better facilitate the recovery of marine turtle stocks (DoEE 2017b) The species recovery plan will address impacts from dredging and enable the recovery of turtle species. However, the Project is not likely to result in un-mitigated impacts that will interfere with the recovery of the species. The nature of the Project activities will not interfere or impede the aforementioned recovery actions for marine turtles.

9.19.8 Assessment summary

To describe the marine fauna assemblages and key habitat values within the Project impact areas, a review of government databases, scientific literature and recent ecological surveys was conducted. The Project impact areas include intertidal and subtidal environments which provide habitat value for marine turtle species most notably Green turtles and Flatback turtles. Other marine turtle species are occasionally recorded in the Port Curtis region such as Loggerhead turtles (which occasionally nest in the region) and Hawksbill turtles, while Olive ridley turtles and Leatherback turtles are rarely encountered (Limpus et al. 2013).

The inshore region of Port Curtis provides valuable habitat for Green turtles (listed as Vulnerable under the EBPC Act and NC Act) in the form of foraging and internesting grounds at seagrass meadows (including species *Z. muelleri*, *Halodule* spp. *and Halophila* spp.) and other food sources such as mangroves and macroalgae (Limpus 2008a). They also occasionally nest in the region (Limpus et al. 2014).

Seaward facing beaches in the Port Curtis region provide nesting areas for Flatback turtles (listed as Vulnerable under the EBPC Act and NC Act) with one intermediate sized nesting population located at South End on Curtis Island (i.e. a known index nesting beach). Other low density turtle nesting sites can be found at beaches along Facing Island and from Boyne Island to Colosseum Inlet. Female Flatback turtles have also been recorded entering Port Curtis during internesting periods (Sperling et al. 2010).

The most notable potential impact to marine turtles from the Project is the direct and permanent loss of coastal seagrass habitat as a result of the WBE reclamation area as well as indirect impacts from areas adjoining the WBE reclamation area (156.41ha of coastal seagrass habitat).

During dredging activities, a short term decline in water quality is expected to occur in the form of increased turbidity caused by sediment resuspension predominantly concentrated in and around the areas to be dredged and within the immediate vicinity of the WBE reclamation area and BUF. Increased turbidity has the potential to impact important Green turtle habitat at seagrass meadows through temporarily decreasing benthic light conditions and smothering through sediment deposition. The hydrodynamic model indicates that the zone of high impact is within the immediate vicinity of the dredged channels and extends approximately 1km in a northwest direction of the Gatcombe Channel and approximately 2km southeast from the Golding Cutting Channel. The zone of high impact also extends 6-7km in both east and west directions from the Golding Cutting Channel. These potential impacts to water quality are short term and will not significantly impact the availability of seagrass habitat for marine turtles.

Vessel movements associated with dredging activities pose a potential risk to marine turtles in Port Curtis. The Port of Gladstone currently experiences a high volume of commercial and recreational vessel traffic. The nature, scale and volume of Project vessel movements are considered minor compared to the existing Port vessel movements. It should be noted that vessel numbers required to complete the Project will be considerably lower than those required during the Western Basin capital dredging and LNG development on Curtis Island between 2011 and 2015. These impacts are expected to occur in the short term (i.e. up to 12 months) and within a contained extent.

The implementation of the Project Environmental Monitoring Procedure, which forms part of the Dredging EMP (refer Appendix Q1) will decrease impacts to seagrass due to the implementation of light thresholds and adaptive management (refer Section 9.27).

Other water quality impacts also have the potential to occur as a result of WBE reclamation area and BUF establishment through sediment-laden runoff and spills of hazardous substances and through dredging activities through the mobilisation of contaminated sediments, although these represent lower likelihood and lower risk impacts after implementation of mitigation measures.

An increase to underwater noise above background levels has the potential to occur through Project activities, including construction of the WBE reclamation area (i.e. rock dumping), BUF wall construction, dredging activities, and piling of new piles for navigational aids. It is unlikely that temporary or permanent hearing trauma will result from the establishment of the WBE reclamation area, BUF or the dredging activities. Underwater noise impacts from navigational aid activity is expected to have the largest impact on marine turtles with a single strike having potential to cause mortal injury within 35m from piling location, avoidance of source at up to 600m and behavioural changes exhibited within 2km from piling location.

Other unmitigated Project activities have the potential to result in the injury or death to individual marine turtles through an increase of waste materials entering the marine environment (i.e. ingestion or entanglement marine debris), vessel strike or direct contact with construction plant or entrapment in reclamation areas.

The disruption of nesting and hatchling activity through increases in artificial lighting are unlikely given the location of Project activities and the low levels of light to be produced, particularly when compared to the artificial light generated by the surrounding industries of Port Curtis.

The Project will implement mitigation measures provided in Section 9.27, the Project EMP (refer Appendix Q2), Dredging EMP (refer Appendix Q1), and associated management plans to reduce the likelihood and magnitude of potential Project impacts on marine turtles. The implementation of mitigation measures contained in the aforementioned management plans will reduce residual Project impacts on marine turtles.

The potential for a Project impact to have a residual impact and contribution to a fauna species threatening process has been assessed for marine fauna species of conservation significance which have been confirmed to occur, or are considered to have a high or moderate likelihood of occurrence within the Project impact areas. If the Project was found to have the potential to have a residual impact on a species of conservation significance which has the potential to lead to the progressive loss of the species or areas of ecologically significant habitat, a significant residual adverse impact assessment was conducted for the species.

The significant residual adverse impact assessment concluded that the proposed Project activities are unlikely to result in a significant residual adverse impact on marine turtles.

It is important to note that there is difficultly in predicting the impacts and consequences of isolated Project activities on marine turtles without acknowledging the cumulative effect of multiple pressures that marine turtles may experience outside of the Project. The cumulative impact assessment is provided in Chapter 21 and Appendix P.

9.20 Marine mammals – existing environment

9.20.1 Background

Port Curtis and adjoining waterways support a range of marine mammal species, including whales, dolphins and dugongs. Marine mammal species form an important component of the marine biodiversity values of the GBRMPA due to their ability to regulate and maintain balance in the food chain. They do this by managing the abundance of prey species that have the ability to reduce the populations of species at the bottom of the food chain to unsustainable levels. In addition, whales, dolphins and dugongs are iconic species that hold special significance for many users of the Great Barrier Reef.

The 10 marine mammal species of conservation significance (listed under the provisions of the EPBC Act or the NC Act) that are known to occur within Australian waters are listed in Table 9.72.

Table 9.72 Marine mammal species of conservation significance known from Australian waters

Common name	Scientific name	EPBC Act status	NC Act status
Australian humpback dolphin	*Sousa sahulensis*	Migratory	Vulnerable
Australian snubfin dolphin	*Orcaella heinsohni*	Migratory	Vulnerable
Blue whale	*Balaenoptera musculus*	Endangered	Least concern
Bryde's whale	Balaenoptera edenig	Migratory	Least concern
Dugong	*Dugong dugon*	Migratory	Vulnerable
Humpback whale	*Megaptera novaeangliae*	Vulnerable	Vulnerable
Killer whale	*Orcinus orca*	Migratory	Not listed
Sei whale	*Balaenoptera borealis*	Vulnerable	Least concern
Southern right whale	*Eubalaena australis*	Endangered	Least concern
Sperm whale	*Physeter microcephalus*	Migratory (Bonn)	Least concern

The methodology implemented to describe the marine mammal values is provided in Appendix I1 (Section 15.2).

9.20.2 Marine mammal values

9.20.2.1 Whales

Overview

The desktop assessment identified eight whale species with potential to occur within the regional search area (refer Table 9.73).

Table 9.73 Whale species known or predicted to occur within the Project EIS search area and regional search area

Scientific name	Common name	EPBC Act status	NC Act status	Likelihood of occurrence
Balaenoptera acutorostrata	Minke whale	Not listed	Least concern	Low
Balaenoptera acutorostrata unknown *subsp.*	Dwarf minke whale	Not listed	Not listed	Low
Balaenoptera borealis	Sei whale	Vulnerable Migratory	Least concern	Low
Balaenoptera edeni	Bryde's whale	Migratory	Least concern	Low
Balaenoptera musculus	Blue whale	Endangered Migratory	Least concern	Low
Eubalaena australis	Southern right whale	Endangered Migratory	Least concern	Low
Megaptera novaeangliae	Humpback whale	Vulnerable Migratory	Vulnerable	Confirmed
Physeter macrocephalus	Sperm whale	Migratory	Least concern	Low

Table note:

Excludes data recorded prior to 1980

Source: DoEE (2019c); DES (2019) and ALA (2019)

Important habitat

The Humpback whale is considered to be seasonally present within offshore waters in the vicinity of Port Curtis (GHD 2011a; GHD 2011b). Five sightings of Humpback whales have been recorded within the Project EIS search area (refer Figure 9.1), between 1985 and 2012, all within the months of June and September (ALA 2019; DES 2019a). The Humpback whale's distribution within Australian waters is shown in Appendix I1 (Figure 15.3).

Waters off Port Curtis are known to support calving activities for the Humpback whale, which correspond with migration routes for the species (refer Figure 9.73). Other important areas, for aggregation, foraging, breeding and resting are not in proximity to the Port of Gladstone, and are not expected to be impacted by the Project.

Figure 9.74 shows the location of confirmed whale recordings within the regional search area (ALA 2019). Data has been sourced from the Atlas of Living Australia (ALA) which compiles species records collected from academic, scientific and environmental organisations. The most recent whale recordings within the regional search area identified in the ALA (2019). All of these records are outside the Port limits, with the nearest records more than 5km off the coast of the northern end of Facing Island. The majority of records are associated with the waters surrounding the offshore coral reefs of the Capricorn Bunker Group.

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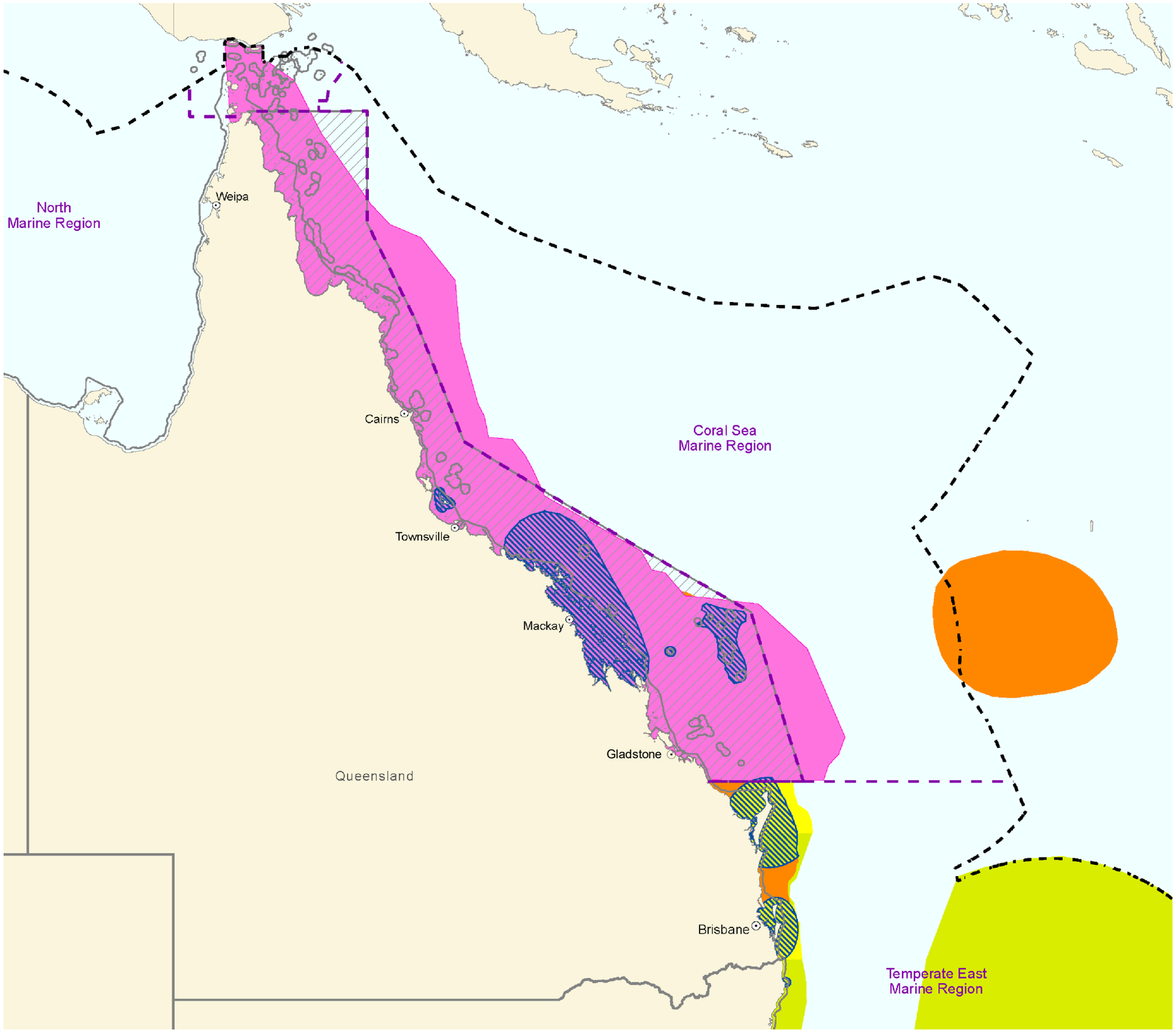

Legend

Behaviour
- Calving known to occur
- Breeding known to occur
- Foraging known to occur
- Resting known to occur
- Migration known to occur
- Species known core range
- Other known aggregation area

Maritime boundaries
- Limit of coastal waters
- Marine region boundaries
- Limit of Australian exclusive economic zone
- Great Barrier Reef Marine Park

Source:
Department of the Environment (2015b)

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Figure 9.73: Important areas for the Humpback whale

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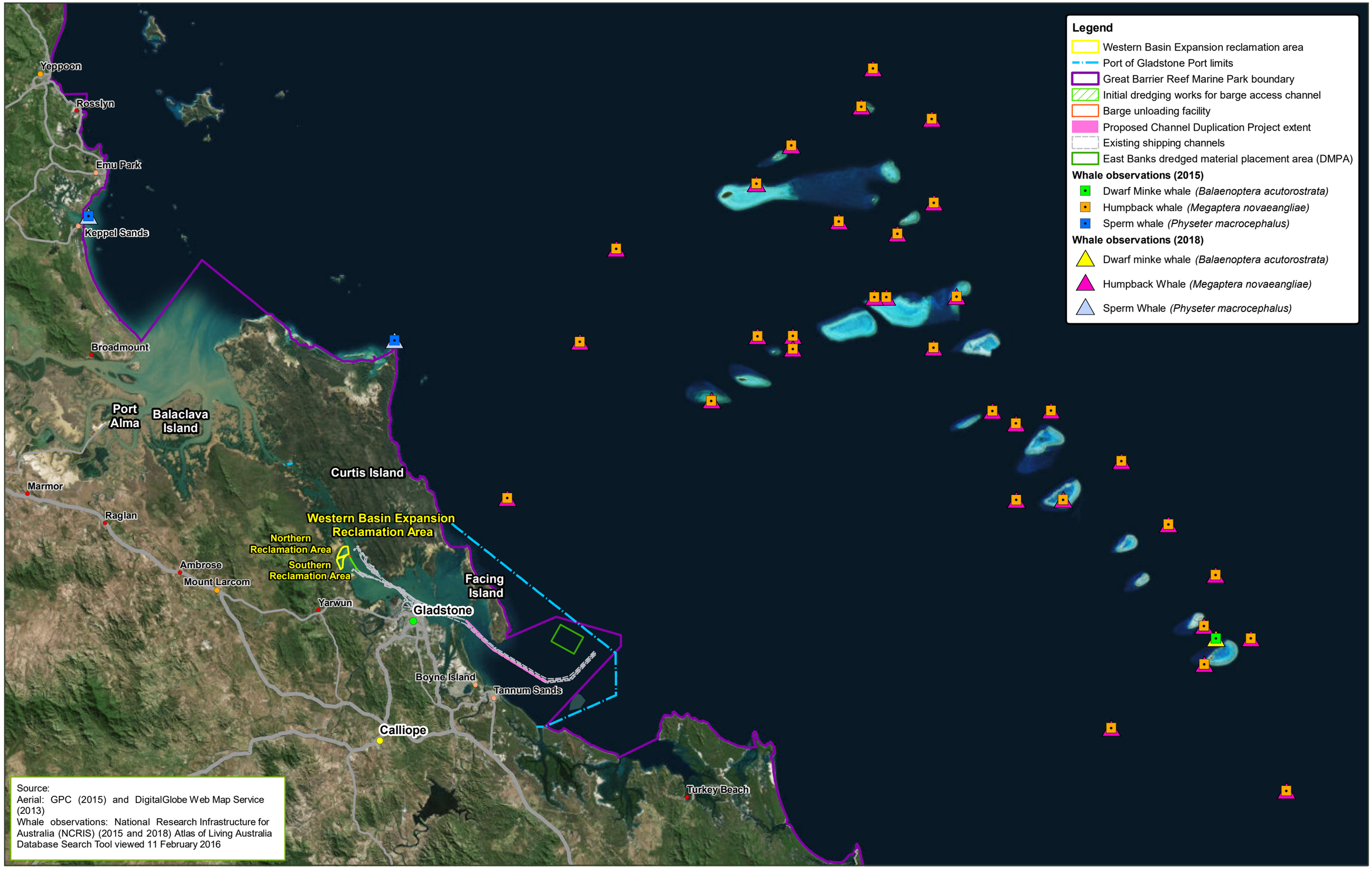

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Figure 9.74: Whale observations within the regional search area

9.20.2.2 Dolphins

Overview

The desktop assessment identified the potential for occurrence of 10 dolphin species within the Project search area (refer Table 9.74).

Though ten species of dolphin are predicted to potentially occur within the Project EIS search area (i.e. those species listed in Table 9.74), only three species of coastal dolphin (i.e. Australian humpback dolphin, Coastal bottlenose dolphin and the Indian Ocean bottlenose dolphin) are frequently encountered within the vicinity of Port Curtis and adjacent areas such as Port Alma (GPC 2012a; GHD 2009d; GHD 2011a; GHD 2011b; GHD 2012; Blue Planet Marine 2013; Cagnazzi 2013; 2015a; 2015b; 2016; 2017). Therefore, the information provided in this section is related to these key species. Additional information on these species is also provided in Appendix I1 (Section 15.6).

Table 9.74 Dolphin species known or predicted to occur within the Project EIS search area

Scientific name	Common name	EPBC Act	NC Act	Likelihood of occurrence within Port Curtis
Delphinus delphis	Common dolphin	Not listed	Least concern	Moderate (typically recorded off the coast of Curtis Island and Facing Island)
Grampus griseus	Risso's dolphin	Not listed	Least concern	Low (prefers deep water habitats)
Orcaella heinsohni+	Australian snubfin dolphin	Migratory	Vulnerable	Low (typically encountered in the Port Alma region, to the north of Curtis Island)
Orcinus orca	Killer whale	Migratory	Least concern	Low (preferred habitat not present within Port Curtis)
Pseudorca crassidens	False killer whale	Not listed	Least concern	Low (preferred habitat not present within Port Curtis)
*Sousa sahulensis**	Australian humpback dolphin	Migratory	Vulnerable	Confirmed (frequently recorded within Port Curtis, including The Narrows)
Stenella attenuata	Pantropical spotted dolphin	Not listed	Least concern	Low (this species has not been detected during recent targeted dolphin surveys within Port Curtis (Cagnazzi 2014, 2015a, 2015b, 2016, 2017))
Stenella longirostris	Spinner dolphin	Not listed	Least concern	Moderate (typically recorded off the coast of Curtis Island and Facing Island)
Tursiops aduncus	Indian Ocean bottlenose dolphin	Not listed	Least concern	Moderate (this species has been identified in open waters, off the coast of Curtis Island)
Tursiops truncatus s. str.	Coastal bottlenose dolphin	Not listed	Least concern	Moderate (typically recorded off the coast of Curtis Island and Facing Island)

Table notes:

+ Formerly known as Irrawaddy dolphin (*Orcaella brevirostris*)
* Formerly known as Indo-Pacific humpback dolphin (*Sousa chinensis*)

Source: DoEE (2019c); DES (2019); ALA (2019); Cagnazzi (2015a; 2015b, 2016)

Australian humpback dolphin

Dolphin surveys conducted within the Port Curtis and Port Alma regions recorded the Australian humpback dolphin as the most frequently encountered dolphin species throughout the survey area (refer Appendix I1 (Section 15.2.3)) (Cagnazzi 2017). During these surveys, a large number of sightings of Australian humpback dolphins were observed throughout The Narrows, however, it was noted that the extent to which this species uses The Narrows is not yet fully understood (Cagnazzi 2017).

Australian humpback dolphins are thought to be opportunist-generalist feeders, eating a wide variety of coastal and estuarine-associated fishes, although reef, littoral and demersal fish species are also taken. Bony fish, some cephalopods and crustaceans have also been recorded as prey. Australian humpback dolphins are recorded feeding in association with prawn trawlers in Moreton Bay and presumably elsewhere throughout the species' range in Australia (Bannister et al. 1996; Ross et al. 1994). Feeding may occur in a variety of habitats, from mangroves to sandy bottom estuaries and embankments to rock and/or coral reefs. Feeding primarily occurs in shallow waters (< 20m depth) and may incorporate beaching behaviour on sandbanks.

Australian snubfin dolphin

Within Australia, Australian snubfin dolphins have been recorded almost exclusively in coastal and estuarine waters. It is doubtful that they venture very far upstream in river systems, although occasional vagrants may venture upstream (Parra et al. 2002).

Australian snubfin dolphins share similar habitat preferences with Australian humpback dolphins, with these two species potentially sympatric (occurring in the same areas) throughout most of their Australian range (Parra 2006).

Dolphin surveys conducted within the Port Curtis and Port Alma regions recorded the Australian snubfin dolphin as occurring only within the northern area of The Narrows (Cagnazzi 2017). It has been noted that the extent to which this species uses The Narrows is not yet fully understood (Cagnazzi 2017).

Australian snubfin dolphin prey includes fish of the families Engraulidae, Clupeidae, Chirocentridae, Anguillidae, Hemirhampidae, Leiognathidae, Apogonidae, Pomadasydae, Terapontidae and Sillaginidae (Heinsohn 1979; Marsh et al. 1989). These fishes are typically associated with shallow coastal waters and estuaries in tropical regions (Parra et al. 2002).

Coastal bottlenose dolphin

Coastal bottlenose dolphins inhabit inshore areas such as bays, lagoons, fjords and estuaries, and nearshore (open coast) and offshore environments, including the coast of oceanic islands (Reynolds et al. 2000). They are associated with many types of substrate and habitats, including mud, sand, seagrasses, mangroves and reefs (Barros and Wells 1998).

Coastal bottlenose dolphins feed mainly on a variety of fish and invertebrates from both the littoral and sub-littoral zones, while offshore animals feed primarily on mesopelagic fish and oceanic squids (Reyes 1991). They usually feed individually, but cooperative feeding is also observed.

Indian Ocean bottlenose dolphin

In Australia, the Indian Ocean bottlenose dolphin is restricted to inshore areas such as bays and estuaries, nearshore waters, open coast environments, and shallow offshore waters, including coastal areas around oceanic islands (Hale et al. 2000).

Results of monitoring surveys in Port Curtis

Within the Gladstone region, aerial and boat-based surveys conducted by GHD (2011a; 2011b) resulted in the recording of 81 dolphins (including the Australian humpback, Australian snubfin and inshore Bottlenose dolphins). The survey area covered by GHD (2011a; 2011b) extended from the Fitzroy River entrance (Port Alma) to the southern region of Rodds Bay, encompassing eastern Curtis Island and Facing Island.

GHD reported that dolphins were observed to occur in association with recreational vessel traffic, which was widespread throughout much of the survey area, particularly in The Narrows and Port Curtis. Dolphins were observed to be present in association with anthropogenic activities such as commercial fishing, slow shipping movements, ferries used for transporting construction crews and adjacent (west) to the Curtis Island LNG development site.

During these surveys, dolphins were not recorded in the presence of pile driving or rock dumping activity. The average group size of Australian humpback dolphins observed on boat-based surveys was 3.5 individuals, with the majority of groups sighted in Port Curtis. During the WBDDP, Australian humpback dolphins were sighted throughout the survey area. Australian humpback dolphins were the most frequently observed species on boat-based surveys (25 groups, comprising 85 sightings). A total of 34 Australia snubfin dolphins were observed during the boat-based surveys with all Australian snubfin dolphin groups (n=8) being sighted in Port Alma and to the north of Curtis Island (adjacent to Port Alma). Two inshore Coastal bottlenose dolphins were observed north of Curtis Island (GHD 2011b).

Dolphin mark-recapture (photo-identification) surveys were conducted over the period of 2014 to 2016, extending on previous baseline programs (Cagnazzi 2015b). In total, five species of dolphin (i.e. Australian humpback dolphin, Australian snubfin dolphin, Coastal bottlenose dolphin, Common dolphin (*Delphinus delphis*) and Spinner dolphin (*Stenella longirostris*)) were identified during surveys conducted between 2014 and 2016 (Cagnazzi 2016).

Dolphin surveys conducted within the Port Curtis and Port Alma regions recorded the Australian humpback dolphin as the most frequently encountered dolphin species throughout the survey area (Cagnazzi 2017). During these surveys, a large number of sightings of Australian humpback dolphins were observed throughout The Narrows (refer Figure 9.75). Australian snubfin dolphins were recorded only in the northern section of The Narrows (Cagnazzi 2017) (refer Figure 9.76). It was noted that the extent to which both of these species use The Narrows is not yet fully understood (Cagnazzi 2017).

Relatively few Coastal bottlenose dolphins, Spinner dolphins and Common dolphins were observed within the survey area, hence the 2014 to 2016 mark-recapture surveys focussed on Australian snubfin and Australian humpback dolphins (Cagnazzi 2015a; 2015b; 2016).

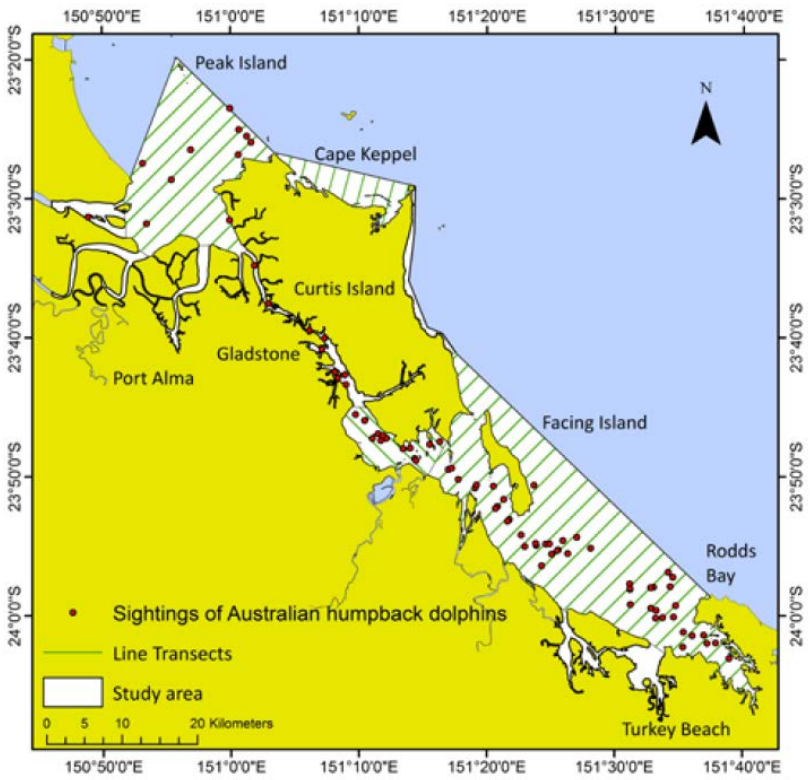

Figure 9.75 **Distribution of groups of Australian humpback dolphins sighted in the Ecosystem Research Monitoring Program survey area during boat-based surveys using line transects in 2016**

Source: Cagnazzi (2016)

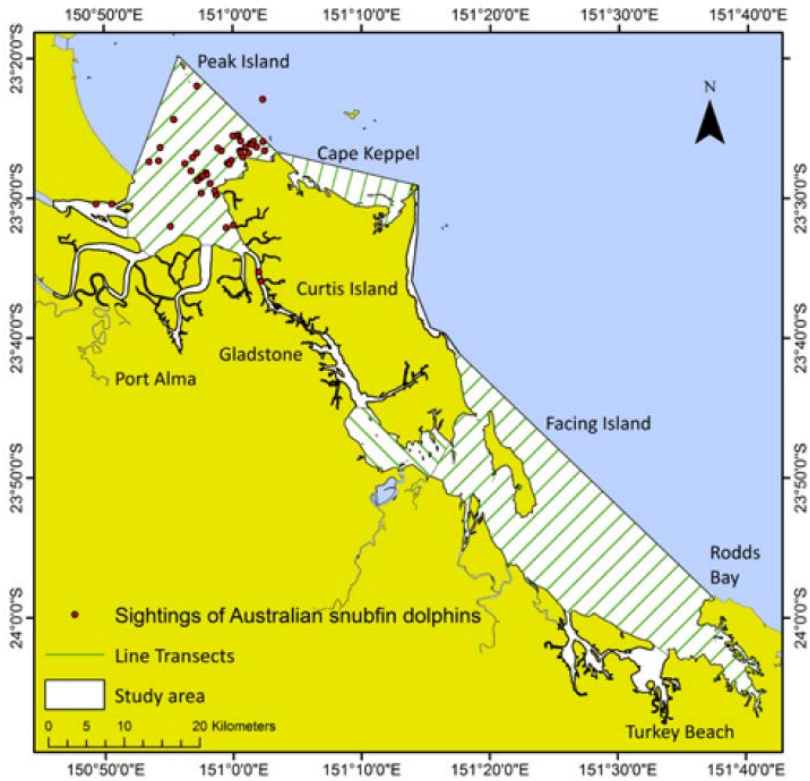

Figure 9.76 **Distribution of groups of Australian snubfin dolphins sighted in the Ecosystem Research and Monitoring Program survey area during boat-based surveys using line transects in 2016**

Source: Cagnazzi (2016)

9.20.2.3 Dugong

Overview

In Australia, Dugongs (*Dugong dugon*) are protected as a migratory species under the EPBC Act and are considered a MNES. The dugong is also listed as a vulnerable species under the NC Act.

The information in this section has been largely sourced from the key review report of the status of dugongs within the Gladstone area undertaken by Sobtzick et al. (2013), as well as more recent studies on dugong habitat and usage conducted by Rasheed et al. 2017a.

Dugongs are long-lived animals with late maturity, low fecundity, and a low potential rate of population increase even under ideal conditions. Adult survivorship needs to be very high (> 95% per annum) for dugong numbers to be maintained (Marsh et al. 2011).

Seagrasses are undoubtedly the most important component of dugongs' diet, however, this can be supplemented with algae and invertebrate animals such as shellfish, sea squirts, and polychaete worms. Most, if not all, seagrass species that occur in their range are consumed by dugongs, including species from the following genera *Halodule, Halophila, Zostera, Thalassia, Thalassodendron* and *Enhalus*.

Further information on dugong biology and the results of monitoring programs is provided in Appendix I1 (Section 15.7).

Important habitat

In August 1997, the Great Barrier Reef Ministerial Council recognised the importance of several areas along the Queensland coast to support significant dugong populations by announcing a chain of DPAs in the southern Great Barrier Reef. Seven DPAs A and eight DPAs B (which differ in restrictions referring to fishing practices) cover a total of 4,650km^2 along the southern Great Barrier Reef coastline. One of them, Rodds Bay, is a DPA B located within Port Curtis, from The Narrows to Rodds Bay (refer Figure 9.77).

The seagrass communities of Port Curtis and Rodds Bay are of regional significance, functioning as important habitat for the dugong (Lanyon 1991; Preen 1995). The Gladstone region supports extensive areas of seagrass (refer Section 9.6). As these meadows are the only known major areas of seagrass between Hervey Bay and Shoalwater Bay, the meadows are likely to provide important connecting habitat for dugong populations in southern Queensland (Blair 2012; Sheppard et al. 2006; Sobtzick et al. 2013).

Rasheed et al. (2017a) conducted a series of ERMP Seagrass Surveys which identified key seagrass areas within Port Curtis and Rodds Bay. The ERMP surveys involved quarterly assessments within established dugong feeding trail monitoring areas, to assess temporal and spatial feeding activity by dugongs between May 2015 to November 2016 (Rasheed et al. 2017a). Three dugong feeding trail monitoring areas occur within the Project impact area (i.e. Pelican Banks, South Trees Island, and Wiggins Island), as depicted in Figure 9.78.

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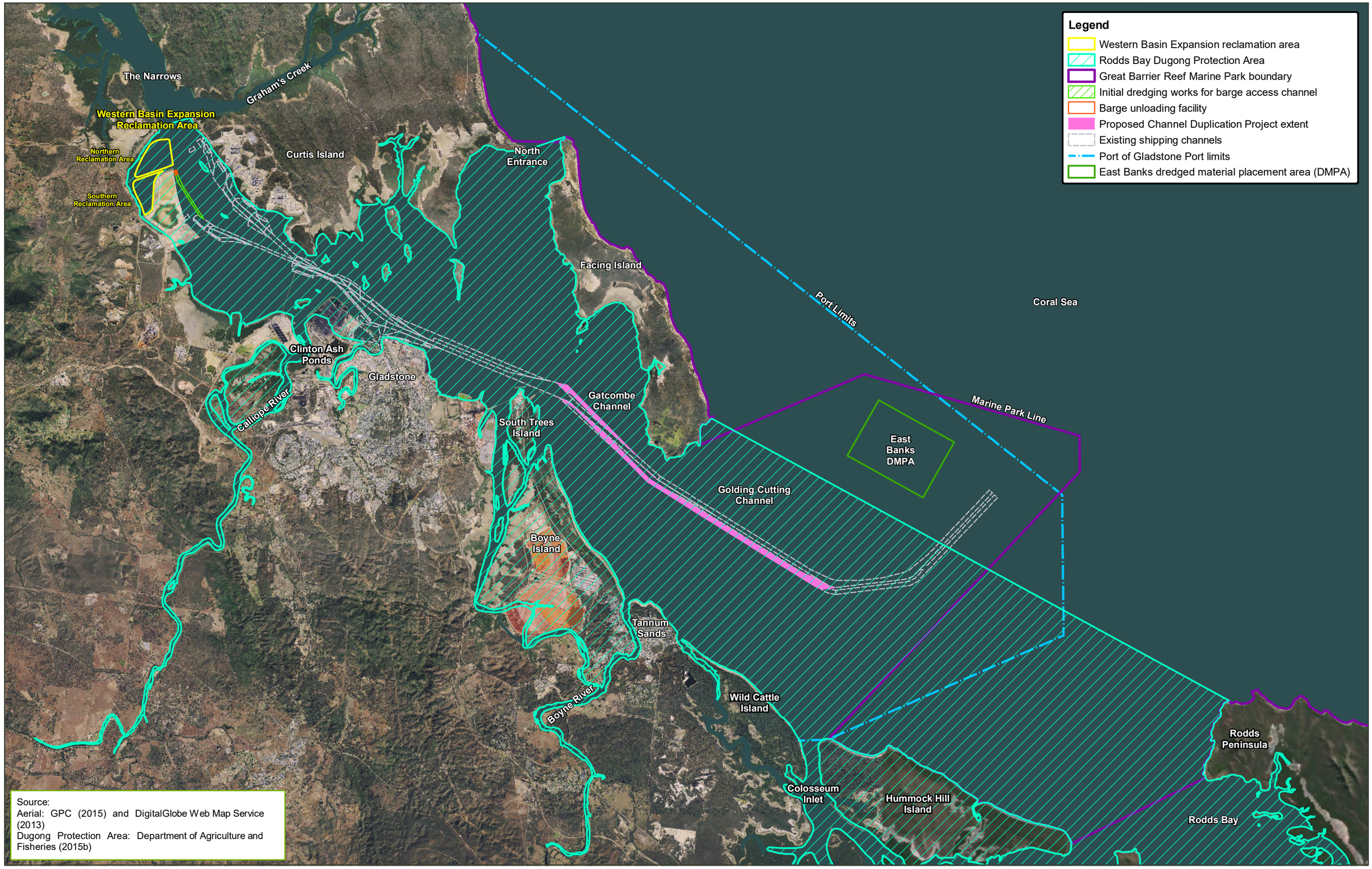

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Figure 9.77: Rodds Bay Dugong Protection Area

Figure 9.78 Dugong feeding trail monitoring areas (2013)

Source: Rasheed et al. (2017a)

The results of this monitoring highlight the importance of intertidal seagrass meadows as foraging habitat for the dugong population of Port Curtis and Rodds Bay throughout the region (Rasheed et al 2017a). The report also indicates that dugong feeding activity occurred within the sampling meadows throughout the year, with no consistent temporal patterns among sites (Rasheed et al. 2017a). It was noted that sites closest to the Port (i.e. Wiggins Island, South Trees and Pelican Banks) exhibited higher levels of feeding than the Rodds Bay meadows (Rasheed et al. 2017a).

Rasheed et al. (2017a) concluded that, in general, dugong feeding trails were positively correlated with increased seagrass presence and aboveground biomass. It was noted that seagrass abundance was typically linked to the amount of rainfall (and linked river flow), received in the previous months.

Results of monitoring surveys in Port Curtis

There have been numerous dedicated dugong aerial surveys conducted within the Port Curtis region since 1986. Six of these surveys have been conducted by JCU TropWATER within the Port Curtis region, including surveys conducted in 1986, 1992, 1994, 1999, 2005 and 2011. Aerial surveys in the Port Curtis region were also undertaken as part of the WBDDP EIS and consisted of a series of three surveys completed by GHD over a period of nine months from 2008 to 2009 (GHD 2009d) (refer Appendix I1 (Section 15.7)).

These aerial surveys were designed to investigate the spatial patterns of abundance and temporal trends in dugong populations (Sobtzick et al. 2013). Due to the large-scale movements of dugong and their response to changes in habitat availability and quality, aerial surveys are not designed to investigate relative abundance at local spatial scales (e.g. Port Curtis and Rodds Bay) and tend towards underestimating actual population size, providing standardised minimum estimates only (Marsh and Sinclair 1989a; 1989b; Marsh et al. 2002; 2011; Sobtzick et al. 2013).

The sighting distribution of dugong varied between surveys, with the highest number of dugong in Port Curtis and Rodds Bay recorded by GHD in 2009 with 19 sightings, and abnormally low numbers of dugong sighted in the same area during 2011 (JCU TropWATER), likely as a result of extreme weather events restricting visibility (Sobtzick et al. 2013). The results of the JCU TropWATER and GHD surveys are shown in Figure 9.79 and Figure 9.80, respectively.

Population estimates

The JCU TropWATER dugong survey data (1986 to 2011) was utilised to estimate population size for the urban coastal waters of Queensland.

Dugong population size estimates from aerial surveys showed large standard errors and variations between surveys. At local spatial scales (e.g. individual bays or ports), dugong population sizes fluctuate due to animal movements (Marsh and Lawler 2007). Variations in relative distribution between dedicated aerial surveys may at least be partially attributed to such movements either within a survey region or between regions, driven either by changes in sea surface temperature (seasonal differences) or changes in seagrass distribution (inter-annual differences) (Sobtzick et al. 2013).

On the basis that aerial surveys generally underestimate dugong population size, Sobtzick et al. (2013) suggest that the Port Curtis and Rodds Bay supports a dugong population in the low hundreds of individuals at the most.

Dugong population estimates prior to aerial survey data were largely based on anecdotal evidence and inferenced data (Sobtzick et al. 2013). Though there are no historical records on the population size of dugong population along the Queensland coast, anecdotal evidence suggest that historical population sizes exceeded estimations from recent years. From 1847 to 1969 dugong populations were of a sufficient size to support European commercial fisheries in the Moreton Bay area, and for shorter periods in other locations along the Queensland coast (Daley et al. 2008).

Other historical data shows large variations in population size estimates, some of which are partially attributable to spatial and temporal changes in habitat availability and large-scale movements of individuals (Sobtzick et al. 2013). Overall, however, the available information suggests a long term decline in the abundance of dugong at a regional scale along the Queensland coast.

9.21 Marine mammals – potential impacts and risk assessment

9.21.1 Background

9.21.1.1 Section content

This section provides a discussion of the potential impacts on marine mammals associated with Project activities. Table 9.75 summarises the Project activities and section containing the impact assessment discussion.

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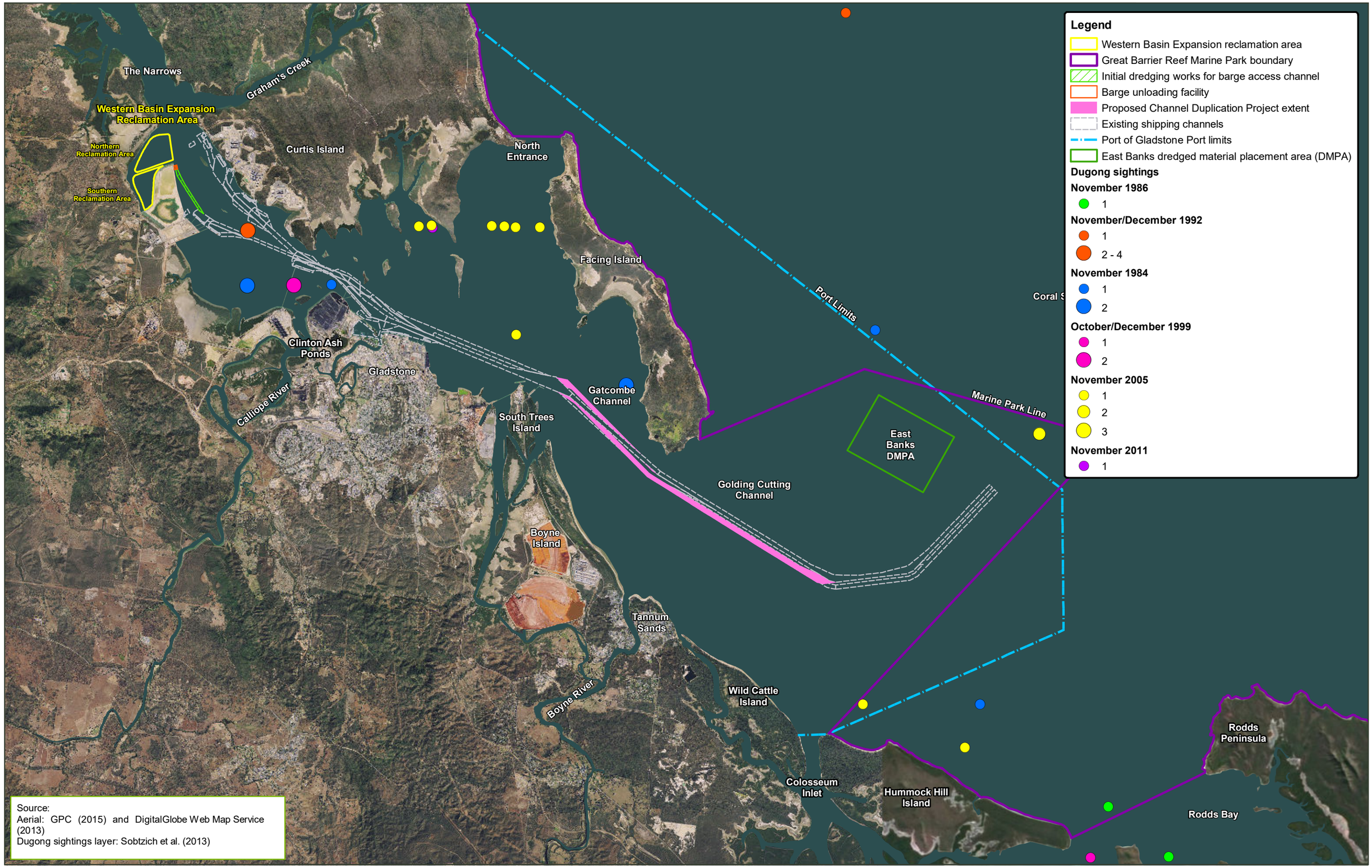

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Figure 9.79: Dugong sightings and group sizes during JCU TropWATER aerial Dugong and megafauna surveys (1986 to 2011)

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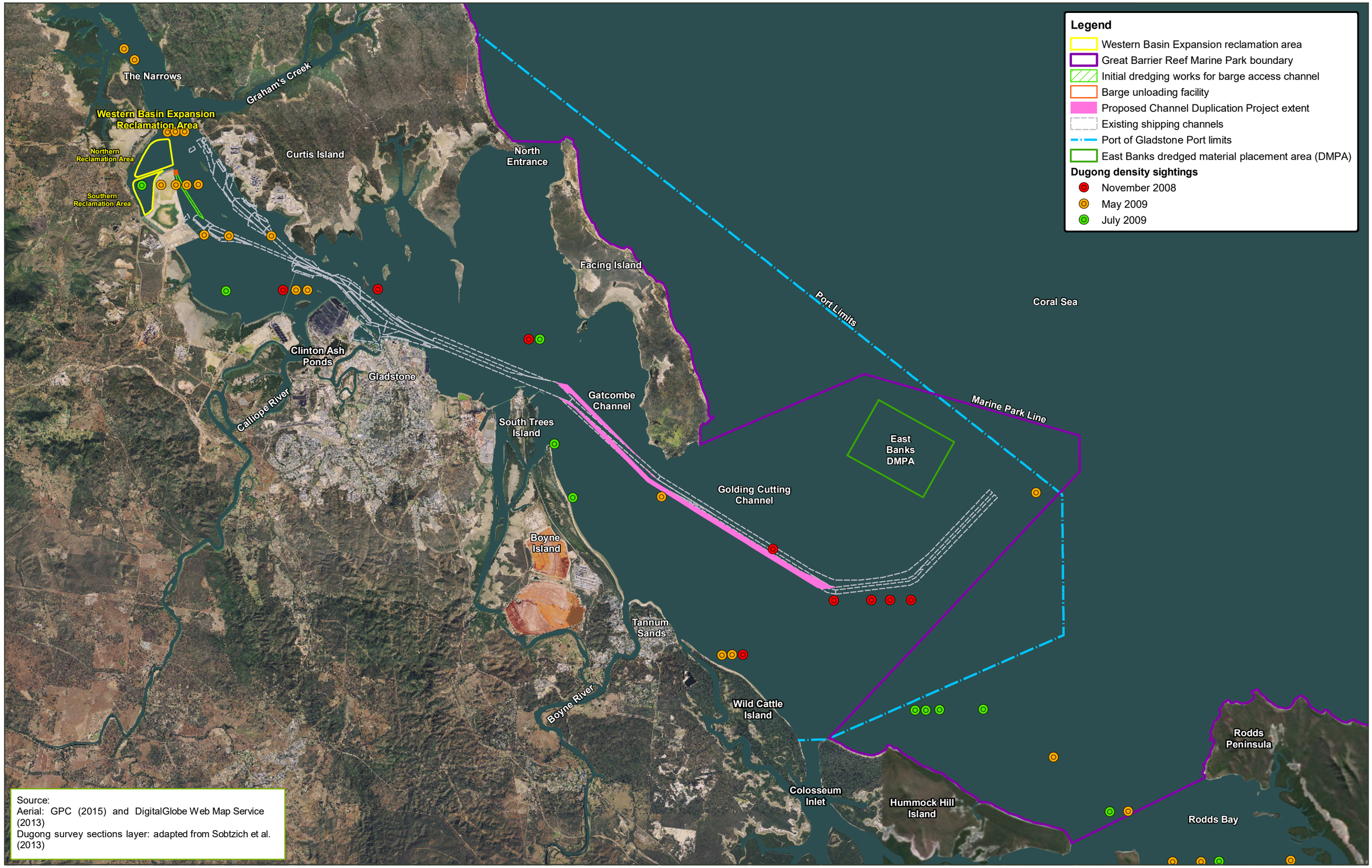

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Figure 9.80: Dugong density sightings during aerial surveys conducted by GHD (2009d)

Table 9.75 Summary of Project activities and section addressed (marine mammals)

Project activity	Section
Establishment of the WBE reclamation area and BUF, including: ▪ Site preparation ▪ Establishment of the site compound, offices and temporary areas ▪ Source and transport of reclamation bund wall material ▪ Placement of core and armour material, and geotextile fabric ▪ Sheet piling (or similar earth retaining structure) and fill placement for the BUF	Section 9.21.2
Dredging activities, including: ▪ Initial dredging works for the barge access channel ▪ Dredging to duplicate the Gatcombe and Golding Cutting shipping channels ▪ Dredging vessel movements ▪ Unloading and placement of dredged material in the WB and WBE reclamation areas	Section 9.21.3
Removal and installation of navigational aids	Section 9.21.4
Stabilisation and maintenance activities on the WBE reclamation area	Section 9.21.5

Operation of the duplicated shipping channels and maintenance dredging activities are discussed in Sections 9.23 and 9.24, respectively.

This section includes the potential impact and risk assessment, including the magnitude and consequence of the potential impacts on the marine mammal values, and their habitats as described in Appendix I1 (Section 15). Marine mammal species confirmed to occur, or with a moderate or high likelihood of occurrence, within the Project impact areas are addressed in this section.

It is important to note that this section focuses on marine mammals commonly associated with estuarine, intertidal and subtidal marine habitats. Potential impacts and risk assessments for the Project for other marine fauna, such as marine turtles, is provided in Section 9.19, and fish and fisheries values is provided in Section 9.13. The potential impact and risk assessment for seagrass meadows, an important habitat for several marine mammal species, is provided in Section 9.9.

9.21.1.2 Sensitivity rating

The sensitivity criteria and ratings which are used to assess the consequence of potential impacts on ecological receptors are provided in Appendix I2. The sensitivity ratings for marine mammals are provided in Table 9.76, which are based on the sensitivity descriptions in Appendix I2 (Section 3.1 (refer Table 9.76 for the criteria used to define sensitivity ratings). Section 9.21.7 provides an assessment of significant residual adverse impacts.

Table 9.76 Sensitivity ratings for marine mammals

Marine mammal species	Conservation status under the EPBC Act or NC Act	Sensitivity rating	Likelihood of occurrence within Project impact areas
Dugong (*Dugong dugon*)	EPBC Act – Migratory, Marine NC Act – Vulnerable	High	Confirmed
Australian humpback dolphin (*Sousa sahulensis*)	EPBC Act – Migratory NC Act – Vulnerable	High	Confirmed
Australian snubfin dolphin *(Orcaella heinsohni)*	EPBC Act – Migratory NC Act – Vulnerable	High	Low

Marine mammal species	Conservation status under the EPBC Act or NC Act	Sensitivity rating	Likelihood of occurrence within Project impact areas
Coastal bottlenose dolphin (*Tursiops truncatus s. str.*)	Not listed	Low	Confirmed
Indian Ocean bottlenose dolphin (*Tursiops aduncus*)	Not listed	Low	Confirmed
Humpback whale (*Megaptera novae-angliae*)	EPBC Act – Vulnerable, Migratory NC Act – Vulnerable	High	Confirmed

9.21.2 Establishment of the dredged material placement area and barge unloading facility

9.21.2.1 Permanent loss and alteration of habitat

Context of impact

The Project impact areas encompass intertidal and subtidal areas at the WBE reclamation area and BUF which provide habitat value for a variety of marine mammal populations, including for species of conservation significance. The intertidal and subtidal seagrass values of the Project impact areas, which are subject to this impact and risk assessment, are provided in Sections 9.6 and 9.9.

The direct disturbance from the WBE reclamation area and BUF is a total of 278ha (southern area – 111.1ha; northern area – 164.9ha; BUF – 1.89ha). For discussion of the potential loss of seagrass habitat refer Section 9.9.

Dugongs

The Port Curtis and Rodds Bay regions provide suitable habitat for dugongs in the form of extensive seagrass meadows. Impacts of greatest significance to dugongs in the Great Barrier Reef region include the loss and degradation of habitat through coastal development and reclamation (GBRMPA 2014c).

The Port Curtis region supports a relatively small dugong population although the area is considered regionally significant to the south Queensland dugong population, and potentially provides connecting habitat between other major dugong habitats at Shoalwater Bay and Hervey Bay (Sobtzick et al. 2013; Cleguer et al. 2015a; Cleguer et al. 2015b).

The diet of dugongs consists primarily of seagrass (along with macroinvertebrates and algae) (Marsh et al. 2011). Five seagrass species known to be consumed by dugongs were identified during 2016 baseline seagrass survey, including *H. decipiens, H. ovalis, H. spinulosa, H. uninervis*, and *Z. capricorni* (Rasheed et al. 2016). Dugongs have the potential to be displaced by a lack of suitable habitat, or a loss of food resources, and can travel long distances in search of seagrass (Marsh et al. 2002; Sheppard et al. 2006). They have also been known to substitute seagrass with algae if seagrass is scarce, although it is thought that they are not well adapted to using algae as a food source (Marsh et al. 1982). The area of Port Curtis from Rodds Bay to The Narrows was declared a DPA Zone B (restricted use) in 1997 to recognise the importance of local seagrass habitat to dugong populations (Sobtzick et al. 2013; Cleguer et al. 2015a).

Dugongs are also thought to use specialised habitats for various activities, such as the use of tidal sandbanks and estuaries for calving (Hughes and Oxley-Oxland 1971; Marsh et al. 1984; Marsh et al. 2003).

Dugong tracking studies in Port Curtis, undertaken in 2014, found dugongs utilised several areas of the Mid and Inner Harbour, including Parsons Point and other areas within proximity to the proposed areas to be dredged (Cleguer et al. 2015a). Aerial surveys conducted by GHD for the WBDDP EIS baseline surveys in 2009 confirmed several dugong sightings within, and immediately adjacent to, the WBE reclamation area during May and November (GHD 2009d).

Rasheed et al. (2017a) identified three seagrass meadows within the Project area that are actively grazed by dugongs (i.e. Pelican Banks, South Trees Island, and Wiggins Island).

The WBE reclamation area (northern and southern areas) contains a seagrass meadow (GPC Monitoring Meadow 8), which consists of isolated patches of moderate *H. ovalis and Z. muelleri*, based on the latest annual survey (Rasheed et al. 2016). The total area of seagrass meadows mapped within the WBE reclamation area in 2017 was 7.67ha within the southern area, 114.66ha within the northern area and 34.08ha within the areas adjoining the WBE reclamation area, which represents 0.23%, 3.56% and 1.05% (respectively) of the total area of coastal seagrass mapped in Port Curtis in 2017 (Chartrand et al. 2018).

This Project activity, and potential exposure of dugongs to impacts, will be permanent and irreversible, however restricted to a contained area, therefore moderate in magnitude.

The post mitigation risk rating associated with a permanent and irreversible loss of intertidal and subtidal habitat for dugong during the establishment of the WBE reclamation area and BUF is very high. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of habitat loss at the WBE reclamation area and BUF (refer Section 9.27). Other Project mitigation measures will be implemented during establishment of the reclamation area to reduce potential impacts to other nearby potential dugong habitats (refer Section 9.27).

Dolphins

Port Curtis and surrounding regions provide suitable habitat and food resources for inshore and coastal dolphin species. Australian humpback dolphin and Australian snubfin dolphins are commonly found in protective, shallow waters (< 20m), at the mouths of creeks and estuaries, and tidal channels, feeding primarily on coastal and estuarine fish species, along with crustaceans, bivalves, and cephalopods (Australian snubfin dolphin only) (Parra and Jedensjö 2009). Australian humpback dolphins and Australian snubfin dolphins are considered strictly inshore coastal and estuarine dolphin species (Cagnazzi 2013). Australian humpback dolphins have been found to have two geographically distinct sub-populations within the Port Curtis region, referred to as the Port Curtis and the Fitzroy River humpback dolphin sub-populations (Cagnazzi 2013).

Coastal dolphin species such as the Indian Ocean bottlenose dolphin and the Coastal bottlenose dolphin have a broad distribution and are much less common within the waters of Port Curtis. These species are not listed under the provisions of the EPBC Act or NC Act.

Vulnerability assessments for the Great Barrier Reef for Australian humpback dolphins, Australian snubfin dolphins and Indian Ocean bottlenose dolphins describe habitat loss and degradation as major threats for these species (GBRMPA 2012f). Isolated populations of Australian snubfin dolphins and Australian humpback dolphins, such as those found in the Fitzroy River and Port Curtis, are likely to be particularly vulnerable to disturbance from coastal development and rapid population decline due to their small populations, discrete home ranges and life history traits (GBRMPA 2012f).

Surveys of nearshore dolphins in Port Curtis reported in Cagnazzi (2013), found that small to medium groups of Australian humpback dolphins used the area of the WBE reclamation area as an area for foraging and feeding/travelling. The Australian snubfin dolphin has been recorded in the northern areas of The Narrows and in the coastal waters of Port Alma, though have not been recorded in the Port of Gladstone during the ERMP surveys (Cagnazzi 2017).

The loss of inshore habitat associated with this Project activity, will be permanent and irreversible and restricted to a contained area, therefore moderate in magnitude. The establishment of the WBE reclamation area and BUF has the potential to have residual adverse impacts on the Australian humpback dolphin population in Port Curtis.

The post mitigation risk ratings associated with a permanent and irreversible loss of intertidal and subtidal habitat for inshore dolphins during the establishment of the WBE reclamation area and BUF are low for the two bottlenose dolphin species, medium for the Australian snubfin dolphin, and very high for the Australian humpback dolphin. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating. Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of habitat loss at the WBE reclamation area and BUF (refer Section 9.27).

Whales

The intertidal and subtidal habitat at the WBE reclamation area and BUF does not represent key habitat for whale species associated with Port Curtis (i.e. Humpback whale). Therefore the risk of potential impacts on the Humpback whale occurring as a result of the permanent and irreversible loss of intertidal and subtidal habitat during the establishment of the WBE reclamation area and BUF is considered negligible.

9.21.2.2 Potential noise impacts

Context of impact

Increased underwater noise has the potential to be generated during the construction of the bund walls at the WBE reclamation area and BUF and sheet piling associated with construction of the BUF earth retaining wall. The impacts of anthropogenic noise on marine mammals have been widely studied, and excessive levels of underwater noise have been shown to impact a variety of marine mammals in ways such as:

- Trauma to hearing (temporary or permanent)
- Trauma to non-hearing tissue (barotraumas)
- Alteration of behaviour (e.g. avoidance of predators, interfering with the acquisition of prey or mates, displacement from essential habitat areas)
- Masking of biologically significant sounds (BOEM 2014; McCarthy 2004; Slade and Dunlop 2014).

Different marine mammal species vary in their sensitivities to underwater noise with ear anatomy, frequency range and amplitude sensitivity all playing a role (Ketten 1998). Based on information from Southall et al. (2007) and Slade and Dunlop (2014), the marine mammals of Port Curtis and surrounds can be categorised into the functional hearing groups outlined in Table 9.77.

Table 9.77 Port Curtis marine mammal auditory frequency groupings

Grouping	Species	Estimated auditory frequency usage range	Estimated auditory frequency production range
Dugongs	Dugongs	24/34Hz to 24/27kHz	Chirp-squeak: 3kHz to 19kHz Bark: 500 Hz and 2.2kHz
Mid-frequency hearing cetaceans	Most odontocetes (i.e. toothed cetaceans such as dolphins)	150Hz to 160kHz	1kHz to > 100kHz
Low-frequency hearing cetaceans	Most mysticetes (i.e. baleen whales such as humpback whales)	7Hz to > 22kHz	7Hz to > 22kHz

Source: Southall et al. (2007); Slade and Dunlop (2014)

The potential impacts on marine mammals as a result of underwater noise are influenced by the nature of the underwater noise source, such as the amplitude, duration, frequency content, temporal pattern, and energy distribution of noise exposure (Southall et al. 2007).

An assessment of the underwater noise and vibration predicted to be generated as a result of Project activities was undertaken by SLR (refer Appendix K2). Impacts to marine mammals are expressed as:

- Temporary Threshold Shift (TTS), describing the potential for temporary hearing loss
- Permanent Threshold Shift (PTS), describing the effect of more severe sudden or cumulative noise exposure, causing permanent loss of hearing sensitivity due to tissue damage in the auditory system
- Behavioural changes
- Avoidance
- Species mortality or potential mortal injury
- Recoverable injury

The primary sources of noise and vibration from the establishment of the WBE reclamation area and BUF are predicted to occur during the placement of armour and core material into marine waters, primarily the dumping of rocks from trucks during bund wall construction.

When modelled for a variety of hertz values across the one-third octave band central frequency, underwater noise generated during rock dumping events was calculated not to exceed a SEL of approximately 182dB re 1μPa^{2}S at 1m from the rock dumping area.

Modelling of underwater noise impacts during rock dumping indicates that it is unlikely that marine mammals in Port Curtis (i.e. Dugongs, dolphins and whales) would be at risk of peak acoustic pressure damage from underwater rock dumping until they are within the range of direct physical impact from the dumping rock material. Given the mobile nature of marine mammals, relatively low noise emissions, non-impulsive characteristics and relatively high baseline underwater noise environment within the Inner Harbour, it is unlikely that they would remain stationary near rock dumping locations long enough to be affected by this activity.

Analysis of potential noise masking indicates the possibility of a behavioural displacement response during foraging and communication for the period of rock dumping works at distances less than 4.5km from the activity. Due to the relatively low noise emissions, non-impulsive characteristics, and relatively high baseline underwater noise environment within the Inner Harbour, it is unlikely that this activity will result in significant adverse underwater noise impacts for dugong, dolphins, or whales likely to occur in Port Curtis (SLR 2019b).

Non-pulse development activities such as support vessels and vibratory sheet piling (for BUF construction) are not expected to result in significant adverse noise impacts to marine turtles and dugongs. This is due to the relatively low noise emissions from these activities.

For marine mammal species, behavioural changes might occur. The assessed impact zones, therefore, extend from 3.5km to 4.5km from the source locations for rock dumping, medium sized CSD and small sized TSHD initial dredging activities, 5.5km for vibratory sheet piling at the BUF and up to 12km for large sized TSHD channel duplication dredging activities.

Dugongs

Activities associated with the establishment of the WBE reclamation area and BUF are not expected to result in any significant adverse noise impacts on dugongs due to the low levels of noise emissions being emitted (refer Appendix K2). For dugongs, the SEL threshold level for mortality and potential mortal injury is 210dB re 1μPa^{2}S. The underwater noise predicted to be generated from rock dumping is significantly below this threshold (i.e. 182dB re 1μPa^{2}S at 1m from the rock dumping area).

Non-pulse development activities such as support vessels and vibratory sheet piling (for BUF construction) are not expected to result in significant adverse noise impacts to dugongs due to the relatively low noise emissions from these activities.

The potential noise impacts associated with this Project activity, and the potential for impacts on dugong, will be short term in duration and within a contained extent and are therefore low in magnitude.

The post mitigation risk rating associated with potential impacts of increased noise on dugongs during the establishment of the WBE reclamation and BUF is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating. Project mitigation measures will be implemented during establishment of the reclamation area to reduce potential impacts on dugongs as outlined in Section 9.27 and the Project EMP (refer Appendix Q2).

Dolphins

Activities associated with the establishment of the WBE reclamation area and BUF have the potential to cause behavioural changes in dolphins within a 4.5km radius of the WBE reclamation area and BUF, however these impacts are not considered likely to result in any significant adverse noise impacts on dolphins due to the low levels of noise emissions being emitted (refer Chapter 13). For dolphins, the PTS and TTS for non-pulse, continuous noise is 215dB re 1μPa^{2}S and 195dB re 1μPa^{2}S respectively. The underwater noise predicted to be generated from rock dumping is below this threshold (i.e. 182dB re 1μPa^{2}S at 1m from the rock dumping area).

The potential noise impacts associated with this Project activity, and the potential for impacts on dolphins, will be short term in duration and within a contained extent and are therefore low in magnitude.

The post mitigation risk ratings associated with potential impacts of increased noise on dolphins during the establishment of the WBE reclamation area and BUF are low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating. Mitigation measures to reduce the impacts of underwater noise on dolphins during establishment of the WBE reclamation area and BUF are included in the Project EMP (refer Appendix Q2).

Whales

Some whale species associated with Port Curtis and surrounding waters are vulnerable to potential impacts such as mortality, physical and hearing damage, masking of communication and other biologically important sounds as well as altering behaviour from increased underwater noise (e.g. Humpback whales) (GBRMPA 2014d; DoE 2015).

The location of the WBE reclamation area and BUF does not represent essential habitat for whale species. The post mitigation risk rating associated with potential impacts of increased noise on whales during the establishment of the WBE reclamation area and BUF is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

The potential noise impacts associated with this Project activity, and the potential for impacts on whales, will be short term in duration and within a contained extent and therefore low in magnitude.

The impact and risk assessment for this activity is informed by the results of the Project noise and vibration impact assessment (refer Appendix K2). Mitigation measures to reduce the impacts of underwater noise on whales during establishment of the WBE reclamation area and BUF are included in the Project EMP (refer Appendix Q2).

9.21.2.3 Short term decline in water quality in the marine environment

Context of impact

Establishment of the WBE reclamation area (northern and southern areas) and BUF will be undertaken over a three year period and will involve the placement of core material (or earth material) directly over existing sediments, followed by armour material being placed along the seaward exposed face. The construction activities associated with the establishment of the WBE reclamation area and BUF have the potential to impact the water quality of the receiving environment (i.e. enclosed coastal waters of Port Curtis) and impact marine mammals directly though exposure to contaminants and increased turbidity, or indirectly through a decline of important habitat. A detailed assessment of the potential impacts to water quality as a result of Project activities is provided in Section 8.6.

Contaminants (e.g. hydrocarbons) and sediment-laden runoff have the potential to be released during the Project placement of core, armour and earth material at the WBE reclamation area and BUF, or via spills from vehicles and/or onsite storage facilities.

Suspended sediments in the water column can increase light attenuation and reduce the amount of benthic light reaching key dugong and dolphin habitat, like seagrass meadows (Erftemeijer and Lewis 2006; Sofonia and Unsworth 2010). Sediment deposition can also impact sessile benthic organisms (through smothering), and promote epiphytic growth, further impacting the health of seagrass meadows (Erftemeijer and Lewis 2006).

Any changes to water quality are expected to be short term. Longer term impacts to water quality would only occur if maintenance dredging was expected to be significant and had the potential to cause environmental harm. The increase in maintenance dredging as a result of the channel duplication is deemed insignificant to the total volumes currently dredged during maintenance activities and therefore would pose no risk to long term water quality within the Port. Other risks to consider long term are the potential increase in shipping numbers to the Port and therefore potential risk of oil spills however this risk is considered low and would be managed according to existing Port procedures.

Dugongs

The waters of the Port Curtis estuary are naturally and generally turbid with higher turbidity levels experienced during the wet season (Commonwealth of Australia 2013; Herzfeld et al. 2004). Despite this, the area supports a small resident population of dugongs (Cleguer et al. 2015). Dugongs have poorly developed eyesight and rely on the sensitive bristles on their upper lip to detect seagrass, as opposed to visual cues (CRC Reef Research Centre 2002). As a result, any short term elevated turbidity concentrations and increased sedimentation generated from dredged material placement, are not expected to affect foraging success for the local dugong population.

Little is known about the impacts of specific contaminants to dugongs, although exposure to contaminants is described as a potential threat to dugongs (Woinarski et al. 2014; GBRMPA 2014c). Some studies have recorded heavy metals and other contaminants in samples from dugongs (e.g. Marsh et al. 2011) and contaminants in water such as organochlorine compounds (predominantly associated with agricultural sources), increased sedimentation and excess nutrients are known to indirectly impact dugongs through contributing to declines in seagrass meadows (Schaffelke et al. 2013). It should be noted that limited volumes of contaminants will be present onsite during establishment of the WBE reclamation area and BUF.

Potential short term declines in water quality during the establishment of the WBE reclamation area and BUF may occur in the medium term and will be within a contained extent, and are therefore moderate in magnitude.

The post mitigation risk rating associated with potential impacts of short term declines in water quality on dugongs during the establishment of the WBE reclamation area and BUF is medium. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating. Mitigation measures to reduce these impacts during the establishment of the WBE reclamation area and BUF are included in Section 9.27 and the Project EMP (refer Appendix Q2).

Dolphins

There is limited available information on the impacts of increased turbidity to marine mammals (Todd et al. 2015). The waters of the Port Curtis estuary are generally and naturally turbid with higher turbidity levels experienced during the wet season (Commonwealth of Australia 2013; Herzfeld et al. 2004). Despite this, the area supports a resident sub-population of Australian humpback dolphins. This is likely due to the fact that marine mammals utilise other senses such as sonar and do not solely rely on visual cues (Todd et al. 2015).

Higher rates of fatalities and strandings recorded within the southern Great Barrier Reef region in 2011, which included elevated rates for Australian humpback dolphins, Indian ocean bottlenose dolphins and Australian snubfin dolphins, have been linked to extreme weather events and large-scale declines in Port Curtis water quality during the 2010/2011 wet season (Meager et al. 2012). Since then, the total number of stranded or dead cetaceans has declined, although dolphin stranding assemblages continues to be dominated by Coastal bottlenose dolphin species and Australian Humpback dolphins (Meager 2016). In the latest marine wildlife stranding and mortality database annual report (for 2013-2015), no apparent associations were made between the dolphin strandings and water quality (Meager 2016).

Inshore dolphin species are susceptible to impacts of declining water quality through contaminants and increased nutrient loads associated with anthropogenic sources such as urban stormwater, agricultural runoff, and industrial and river discharges (Cagnazzi 2017). Declines in water quality have been linked to impacts on inshore dolphin health and the productivity of the ecosystems on which they depend (GBRMPA 2012f).

Inshore dolphins living in coastal waters close to agricultural and industrial activity are known to accumulate high concentrations of anthropogenic contaminants such as pesticides, aromatic hydrocarbons and heavy metals, and this exposure may increase their risk of disease (Cagnazzi 2017).

Marine mammals may absorb heavy metals from the atmosphere through the lungs, through contact with the skin, across the placenta during gestation, via milk during lactation, sea water ingestion, and ingestion of food (Cagnazzi 2017). Bioaccumulation through the food chain is considered a major route for heavy metal contamination for cetaceans (Cagnazzi 2017).

Potentially dangerous anthropogenic contaminants in Australian humpback dolphins living in Port Curtis, and Australian snubfin dolphins in Port Alma, were confirmed from the analysis of 24 biopsy samples collected in 2010 to 2011 (Cagnazzi et al. 2013). The investigation by Cagnazzi et al. (2013) reported on results of biopsy samples and found that:

- Levels of Polycyclic aromatic hydrocarbons (PAHs) were comparable to those reported from highly industrialised countries
- Levels of PCBs in some individuals were above thresholds over which immunosuppression and reproductive anomalies occur
- Organochlorine compounds DDT and Hexachlorobenzene (HCB) were at low levels.

More recently, potentially dangerous anthropogenic contaminants in Australian humpback dolphins living in Port Curtis, and Australian snubfin dolphins in Port Alma, were re-confirmed from the analysis of a further 35 biopsy samples collected in 2014 to 2016 (Cagnazzi 2017). This study found that:

- The concentrations of PCBs were found to be at levels near, or above, the toxicological thresholds associated with immune and reproductive toxicity or population declines in other marine mammals

- DDT levels were very high
- Levels of HCB were generally low.

Cagnazzi (2017) compared the levels of DDTs, HCB and PCBs detected in Australian humpback dolphin samples collected in 2014 to 2016 (in Port Curtis) to the 2010 to 2011 survey results. It was found that DDTs and HCB levels were recorded at significantly higher values in this species in the 2014 to 2016 survey, whist PCB levels were similar between sampling seasons (Cagnazzi 2017). The levels of DDTs, HCB and PCBs recorded in this study for Australian snubfin dolphins in Port Alma were significantly higher than those recorded in 2010 to 2011 (Cagnazzi 2017).

It is unlikely that short term decline in water quality will occur as a result of WBE reclamation area and BUF due to the limited volumes of contaminants that will be present onsite (refer Section 8.6). Potential short term declines in water quality during the establishment of the WBE reclamation area and BUF may occur in the medium term and will be within a contained extent, and are therefore moderate in magnitude.

The post mitigation risk ratings associated with potential impacts of water quality on dolphins during the establishment of the WBE reclamation area and BUF are low for the two bottlenose dolphin species, and medium for the Australian snubfin and Australian humpback dolphins. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating. Mitigation measures to reduce the impacts of short term declines in water quality on inshore dolphins during the establishment of the WBE reclamation area and BUF are included in Section 9.27 and the Project EMP (refer Appendix Q2).

Whales

The water quality impacts associated with the WBE reclamation area and BUF are expected to be contained in extent. The WBE reclamation area and BUF, and immediately adjacent marine areas do not represent key habitat for whale species associated with Port Curtis (i.e. Humpback whale). The potential risks of impacts on the Humpback whale due to short term water quality impacts associated with the establishment of the WBE reclamation area and BUF is considered negligible.

9.21.2.4 Entrapment and direct contact with construction plant

Context of impact

Construction equipment required for the establishment of the reclamation bund walls includes trucks and a small number of excavators and/or dozers required to assist in the placement of material. Core material will be placed directly over the existing sediments and bund material will then be shaped by bulldozer, grader or long arm excavator depending on location and required bund profile. Armour material will then be placed along the seaward exposed face.

The risk of construction plant directly impacting marine mammals is considered low, given the land-based construction methods to be employed. In the unlikely instance that work boats are required as part of these construction works, the work boat movements will be localised between the WBE reclamation area, BUF and existing Port facilities (e.g. Gladstone Marina).

Dugongs

Previous bund wall construction activities during the WBDDP suggest that the risk of dugong entrapment within the bund walls is low, with no dugongs trapped or sighted by marine fauna spotter during construction and closure of the existing WB reclamation area (frc environmental 2011). Given the intertidal nature of the WBE reclamation area, and the small area of the BUF, the likelihood of dugongs being trapped within the outer bund and sheet pile (or similar earth retaining structure) walls is unlikely.

The potential impacts associated with entrapment during the establishment of the WBE reclamation area and BUF may occur over the medium term and will be contained in extent, and therefore moderate in magnitude.

The post mitigation risk rating for dugongs for impacts associated with direct contact or entrapment during establishment of the WBE reclamation area and BUF is medium. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to reduce the impacts of entrapment of dugong, or direct contact with construction plant, during the WBE reclamation area and BUF establishment are included in Section 9.27 and the Project EMP (refer Appendix Q2).

Dolphins

During construction of the existing WB reclamation area, dolphins, including a mother and calf, were observed close to the entrance of the bund wall enclosure and required passive herding away from the area (frc environmental 2011). No dolphins were trapped after the closure of the bund, and mitigation measures were shown to successfully manage potential impacts to dolphins during construction.

The potential impacts associated with entrapment during the establishment of the WBE reclamation area and BUF may occur over the medium term and will be contained in extent, and therefore moderate in magnitude.

The post mitigation risk ratings associated with adverse impacts on dolphins due to direct contact or entrapment within the reclamation area during establishment of the WBE reclamation area and BUF are low for the two bottlenose dolphin species, and medium for the Australian snubfin and Australian humpback dolphins. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to reduce the impacts of entrapment of dolphin, or direct contact with construction plant, during the WBE reclamation area and BUF establishment are included in Section 9.27 and the Project EMP (refer Appendix Q2).

Whales

The WBE reclamation area does not represent essential habitat for whale species. Therefore the likelihood of whales being trapped in the WBE reclamation area or BUF is negligible.

The intertidal and subtidal habitat at the WBE reclamation area and BUF does not represent key habitat for whale species associated with Port Curtis (i.e. Humpback whale). Therefore the likelihood of potential impacts on whales associated with this activity is negligible.

9.21.2.5 Potential increase in waste material and marine debris

Context of impact

Construction activities associated with the establishment of the WBE reclamation area and BUF will involve the generation of some waste material which has the potential to enter the marine environment (i.e. potential marine debris). Injury and fatality to vertebrate marine life as a result of ingestion, or entanglement in, harmful marine debris is listed as a key threatening process under the EPBC Act (DoEE 2016).

Harmful marine debris is commonly associated with discarded fishing equipment, but it may also include solid non-biodegradable floating materials and plastic waste washed or blown from the land or dredging vessels into the sea. This can include (but not limited to) plastic bags, bottles, food packaging, strapping bands, sheeting and synthetic ropes.

Entanglement in marine debris can affect several species of marine mammals and can cause restricted mobility, starvation, infection, amputation, drowning and smothering. If ingested, marine debris can cause internal injuries as a result of a physical blockage in the digestive system (DoEE 2016).

Dugongs

Incidental entanglement or ingestion of marine debris is a well documented threat to dugongs in Queensland waters (GBRMPA 2014c; Marsh et al. 2005). The likelihood of waste materials entering into the marine areas and resulting in injury or death of the transient dugong population is unlikely.

The potential impacts associated with the increase in marine debris during the establishment of the WBE reclamation area and BUF may occur over the medium term and will be contained in extent, and therefore moderate in magnitude.

The post mitigation risk rating associated with impacts on dugongs from a potential increase in waste material and marine debris during establishment of the WBE reclamation area and BUF is medium. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to reduce the impacts of marine debris on marine fauna during establishment of the WBE reclamation area are included in Section 9.27 and the Project EMP (refer Appendix Q2).

Dolphins

Incidental entanglement or ingestion of marine debris is a well documented threat to dolphins in Queensland waters (GBRMPA 2012f). The likelihood of waste materials entering into the marine environment during construction and resulting in the injury or death of dolphins is unlikely.

The potential impacts associated with the increase in marine debris during the establishment of the WBE reclamation area and BUF may occur over the medium term and will be contained in extent, and therefore moderate in magnitude.

The post mitigation risk ratings associated with impacts on dolphins from a potential increase in waste material and marine debris during establishment of the WBE reclamation area and BUF are low for the two bottlenose dolphin species, and medium for the Australian snubfin and Australian humpback dolphins. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to reduce the impacts of marine debris on marine fauna during establishment of the WBE reclamation area and BUF are included in Section 9.27 and the Project EMP (refer Appendix Q2).

Whales

Humpback whales can be found seasonally in coastal waters around the Port Curtis region and are also very occasionally observed within Port of Gladstone (Barnham 2016a; 2016b). Humpback whales are adversely affected by the threatening process of marine debris (DoEE 2016). Blue whales are predicted to occur within oceanic waters offshore from Port Curtis and are also vulnerable to the threat of marine debris (DoEE 2016). The waters adjacent to the WBE reclamation area and BUF do not represent essential habitat or critical for the whale species associated with the Port Curtis and surrounding regions.

The potential impacts associated with the increase in marine debris during the establishment of the WBE reclamation area and BUF may occur over the medium term and will be contained in extent, and therefore moderate in magnitude.

The post mitigation risk rating associated with adverse impacts on whales from a potential increase in waste material and marine debris during establishment of the WBE reclamation area and BUF is medium. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to reduce the impacts of marine debris on marine fauna during establishment of the WBE reclamation area and BUF are included in Section 9.27 and the Project EMP (refer Appendix Q2).

9.21.3 Dredging activities

9.21.3.1 Permanent loss and alteration of habitat

Context of impact

Approximately 12.6Mm^3 of seabed material will be removed from the channel duplication area to be dredged during dredging activities for the Project and approximately 0.25Mm^3 of material to be dredged for the barge access channel (refer Section 2.4).

Dugongs

While dugong habitats generally correspond with intertidal and shallow subtidal seagrass meadows in wide, shallow, protected bays and mangrove channels such as those present in Port Curtis, dugongs may also be found foraging in deep water areas more than 20m deep (Lee Long et al. 1989; 1996a; 1996b; Schaffelke et al. 2001). Here they feed on deep water seagrass meadows (e.g. *Halophila* spp.) such as those present in the open coastal waters of Port Curtis when present (i.e. high levels of natural variability in the density of seagrass biomass in deep water meadows). Dugong feeding trails have been found as deep as 33m in waters of northeastern Queensland (Lee Long et al. 1996a; 1996b).

Dugongs have also been known to utilise deep water areas at times of changing or declining shallow water seagrass meadows (e.g. following extreme events such as cyclones and floods) (GBRMPA 2014c; Marsh and Kwan 2008). Rasheed et al. (2017a) suggests that preferences for feeding in deeper seagrass areas when available may be linked to reduced risk of predation and may provide better escape routes from sharks. Section 9.21.2.1 includes further discussion of the potential sources of impact associated with the permanent loss of habitat for dugong within the WBE reclamation area and BUF.

Ephemeral deep-water seagrass meadows have not been recorded in the channel duplication area to be dredged since the baseline survey undertaken in 2002 (from baseline survey years in 2002, 2009, 2013 and 2014). Based on the latest results of the 2014 deep water survey, no seagrass meadows will be impacted by the zone of high impact at the channel duplication area to be dredged (refer Section 9.9).

Historical seagrass mapping shows that there were deep water seagrass meadows located within and adjacent to the Golding Cutting Channel that may be impacted by the increase in turbidity within the zone of high impact. There has not been any new deep water seagrass survey undertaken since 2014 therefore an updated survey will be conducted prior to dredging to determine the current location of seagrass meadows in the immediate vicinity of the channel. The areas to be dredged for the remainder of the barge access channel do not support seagrass meadows.

Dredging the barge access channel, and the channel duplication area will not result in the permanent loss of dugong habitat. Any impacts to seagrasses in these areas will be temporary, however due to the WBE reclamation area and BUF habitat loss, dredging activities are considered high in magnitude. The post mitigation risk rating associated with impacts from this activity is medium.

The potential impacts associated with the permanent loss of habitat associated with dredging activities will be long term and will be contained in extent, and therefore moderate in magnitude.

The post mitigation risk rating for dugongs from a long term loss of potential foraging habitat at the areas to be dredged is medium. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of habitat loss associated with dredging activities (refer Section 9.27).

Dolphins

Surveys of inshore dolphins in Port Curtis reported in Cagnazzi (2013 and 2016) found that large groups (11 to 21) of Australian humpback dolphins used the waters around the channel duplication area to be dredged, predominantly for foraging, but also for travelling, milling, feeding and socialising. However, the Australian snubfin dolphin has not been recorded further south than The Narrows during these surveys (Cagnazzi 2017).

Although the proportion of subtidal soft sediment habitat lost as a result of the Project dredging is relatively small in relation to comparable areas of habitat within Port Curtis, it is evident that this area is an important area for the Port Curtis Australian humpback dolphin sub-population. Dredging activities have the potential to result in a direct loss and/or alteration of dolphin habitat in Port Curtis, although it is unclear as to what extent this will affect the local sub-population.

It is important to note that dredging the barge access channel, and the channel duplication area to be dredged will result in the alteration of habitat within a contained extent over the short term, therefore this activity is low in magnitude. The post mitigation risk rating associated with impacts on Australian humpback dolphins from this activity is high, whereas it is low risk for the Australian snubfin dolphin as they have not been recorded during the ERMP surveys as utilising coastal areas in proximity to the areas to be dredged (Cagnazzi 2017). The post mitigation risk rating associated with impacts on Coastal bottlenose dolphin and Indian Ocean bottlenose dolphin from this activity is medium.

The post mitigation risk ratings associated with impacts on dolphins from an unavoidable loss of benthic substrate at the area to be dredged are low for the Australian snubfin dolphin, medium for the two bottlenose dolphin species, and high for the Australian humpback dolphin. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of habitat loss associated with dredging activities (refer Section 9.27).

Whales

While Humpback whales can be found seasonally in coastal waters around the Port Curtis region during migrations and on rare occasions within the Port of Gladstone, the areas to be dredged does not represent essential habitat for the whale species associated with the Port Curtis and surrounding regions.

The loss of benthic substrate over the short term will be for a contained extent, therefore a low magnitude. The likelihood of impacts on whale species is rare.

The post mitigation risk rating associated with impacts on whales from a permanent and irreversible loss of benthic substrate at the areas to be dredged is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of habitat loss associated with dredging activities (refer Section 9.27).

9.21.3.2 Potential noise and vibration impacts

Context of impact

Dredging activities will generate underwater noise and vibration at the areas to be dredged. This will form a persistent source of underwater noise and vibration, and will continue intermittently during dredging activities. Dredging activities will generate underwater noise primarily through the operation of underwater pumps/piping and draghead dragging of seabed material. The vibration impacts are not considered to be substantial, and are not further assessed. Excessive levels of underwater noise have the potential to impact a variety of marine mammals (refer examples in Section 9.19.2.2).

A detailed review of underwater sound propagation, natural and anthropogenic sources of marine noise, and the potential vulnerabilities of receptors (i.e. marine fauna) of interest is provided in Appendix K2. The primary sources of noise from dredging activities are predicted to occur during dredging using a TSHD and CSD.

When modelled for a variety of hertz values across the one-third octave band central frequency, underwater noise generated during dredging activities was calculated not to exceed a SEL of:

- Approximately 191dB re 1μPa^{2}S at 1m from the dredging activities using a large sized TSHD
- Approximately 175dB re 1μPa^{2}S at 1m from the dredging activities using a small sized TSHD.

Dugongs

Dredging activities associated with the Project are not expected to result in any significant adverse noise impacts on dugongs due to the low levels of noise emissions. Behavioural changes in dugongs due to underwater noise generated during dredging activities have the potential to occur within a 3.5km to 4.5km radius of medium sized CSD and small sized TSHD dredging activities, and within approximately 12km radius of large sized TSHD dredging activities (refer Section 13.6).

The SEL threshold level for mortality and potential mortal injury in dugongs is 210dB re 1μPa^{2}S. The underwater noise predicted to be generated from dredging is below this threshold (i.e. up to 191dB re 1μPa^{2}S at 1m from the dredging activities).

These potential impacts may occur over the short term and are expected to be contained in extent, and are therefore low in magnitude.

The post mitigation risk rating associated with increased noise impacts on dugongs during dredging activities is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating. Mitigation measures to reduce the impacts of underwater noise on marine fauna during dredging activities are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

Dolphins

Dredging activities associated with the Project are not expected to result in any significant adverse noise impacts on dolphins due to the low levels of noise emissions. Behavioural changes in dolphins due to underwater noise generated during dredging activities have the potential to occur within a 3.5km to 4.5km radius of medium sized CSD and small sized TSHD dredging activities, and within approximately 12km radius of large sized TSHD dredging activities (refer Chapter 13).

The PTS and TTS for non-pulse, continuous noise for dolphins is 215dB re 1μPa^{2}S and 195dB re 1μPa^{2}S respectively. The underwater noise predicted to be generated from dredging activities is below this threshold (i.e. up to 191dB re 1μPa^{2}S at 1m from the dredging activities).

These potential impacts may occur over the short term and are expected to be contained in extent, and are therefore low in magnitude.

The post mitigation risk ratings associated with increased noise impacting on dolphins during dredging activities are low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating. Mitigation measures to reduce the impacts of underwater noise on marine fauna during dredging activities are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

Whales

Dredging activities associated with the Project are not expected to result in any significant adverse noise impacts on whales due to the low levels of noise emissions being emitted. Behavioural changes in whale species due to underwater noise generated during dredging activities have the potential to occur within a 3.5km to 4.5km radius of medium sized CSD and small sized TSHD dredging activities, and within approximately 12km radius of large sized TSHD dredging activities (refer Chapter 13).

The PTS and TTS for non-pulse, continuous noise for whales is 215dB re 1μPa^{2}S and 195dB re 1μPa^{2}S respectively. The underwater noise predicted to be generated from dredging activities is below this threshold (i.e. up to 191dB re 1μPa^{2}S at 1m from the dredging activities).

These potential impacts may occur over the short term and are expected to be contained in extent, and are therefore low in magnitude.

The post mitigation risk rating associated with increased noise impacting on whales during dredging activities is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating. Mitigation measures to reduce the impacts of underwater noise on marine fauna during dredging activities are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

9.21.3.3 Short term decline in water quality in the marine environment

Context of impact

Turbidity and impacts on marine mammal habitat

A detailed assessment of the potential impacts to water quality as a result of Project activities is provided in Section 8.6. This includes an assessment of the risk of dredging activities resulting in a decline in water quality, predominantly through increased turbidity, including:

- Dredging (i.e. turbidity generated at the dredger head)
- Dredging vessel movements
- Dredged material unloading and placement (e.g. potential bund wall seepage)
- Discharge of dredging decant water and potential impacts associated with ASS.

A short term decline in water quality and the effect on marine mammal habitat (e.g. seagrass meadows) has the potential to be the predominant indirect impact on marine mammals from Project dredging activities.

Hydrodynamic modelling results for the Project provide an understanding of the spatial and temporal patterns of the dredging sediment plume and represent modelled turbidity, sedimentation and impacts to benthic light at sensitive receptors.

The impact zone mapping describes each zone as follows:

- Zone of influence – full extent of detectable plume, but no ecological impacts
- Zone of low impact – water quality may be pushed beyond natural variation potentially resulting in sub-lethal impacts to ecological receptors
- Zone of moderate impact – water quality is likely be pushed beyond natural variation potentially resulting in some mortality with recovery < 12-24 months

- Zone of high impact – water quality is very likely to be pushed beyond natural variation potentially resulting in mortality of ecological receptors with recovery >24 months.

Nearly all the seagrass meadows and potential marine mammal habitat are located within the zone of low impact or within the zone influence except for a few meadows detailed below:

- Seagrass meadows off the coast of Boyne Island (zone of medium impact)
- Deep water meadows within and adjacent to the Golding Cutting Channel area to be dredged (zone of high impact)
- Southern portion of the seagrass meadows off Quoin Island (zone of moderate impact).

It is important to note that there are large areas of comparable marine mammal habitat within the Port Curtis region that are not expected to experience a temporary decline in water quality from dredging activities. Dredging activities that affect water quality will likely be contained to certain areas at any given time (i.e. only one dredger will be working at particular points within the areas to be dredged at any given time).

This Project activity and the potential exposure of marine mammals to these impacts will be within the short term and within a local area and therefore moderate in magnitude.

Adaptive design measures will be implemented during the Project detailed design phase to minimise the potential impacts to water quality (refer Section 9.27). Project design of the WBE reclamation area and BUF will incorporate the placement of geotextile material within the inner face of the bund wall reclamation area to minimise the migration of dredged material fines through the bund wall and into the waters of Port Curtis. Furthermore, the location of the reclamation area licenced dewatering discharge point will be placed at a location where seagrass is not present (or has the potential to grow), to avoid potential impacts to marine mammals habitat or scouring of the seabed. The release of dredging decant waters will be controlled by a licenced discharge point and weir box with water quality criteria to be met prior to discharge.

The Dredging EMP will be implemented during dredging activities which will minimise potential impacts to water quality from dredging activities (refer Appendix Q1). These plans include adaptive and proactive management measures to be adopted during dredging activities which will focus on minimising impacts at key sensitive receptors such as seagrass meadows (e.g. by focussing on benthic light thresholds). Mitigation measures to minimise water quality impacts are provided in Section 9.27 and the Dredging EMP (refer Appendix Q1).

Mobilisation of contaminants

Contaminants that enter coastal waters can accumulate to potentially toxic levels in the tissues of marine mammals (e.g. dolphins), as outlined in Section 9.21.2.3. Desktop and field geochemical investigations undertaken for the Project concluded that the marine sediments to be removed from the areas to be dredged are considered ‘clean’ as per NAGD (2009) and the potential for contaminants to be mobilised into the water column during dredging activities is considered to be low (refer Section 6.5 and Appendices E4 and E6).

The Environmental Monitoring Procedure will be implemented during dredging activities which include measures to monitor contaminant levels in the water column during dredging activities (refer Appendix Q3).

Dugongs

The waters of Port Curtis support a resident population of dugongs despite the generally and naturally turbid conditions. As discussed, dugongs have poorly developed eyesight and rely on the sensitive bristles on their upper lip to detect seagrass, therefore, any short term high suspended solid concentrations generated from dredging activities are not expected to affect foraging success for the local dugong population.

The potential impacts associated with declines in water quality during dredging activities may occur over the medium term and will be within the local area, and therefore moderate in magnitude.

The post mitigation risk rating associated with a short term decline in water quality impacting dugongs during dredging activities is medium. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to minimise the impact of short term declines in water quality during dredging activities on marine mammals are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

Dolphins

The waters of Port Curtis support a resident sub-population of Australian humpback dolphins while experiencing generally turbid background conditions.

Dolphins exhibit well developed vision, which is considered important in the role of predator avoidance and social interaction (Mustoe 2008). However, the benefit of well developed vision for prey detection is considered limited, as pursuit of prey is achieved using echolocation adaptors (Mustoe 2008). Dolphins are commonly observed in turbid water, where vision would not be of any significant benefit and they are known to agitate bed sediments when foraging for benthic prey, which results in limited to no visibility for prey detection (Mustoe 2008). As a species capable of successfully foraging in turbid waters, it is considered unlikely that dolphin species that are known or expected to occur within Port Curtis would be substantially affected by increased turbidity associated with Project dredging activities.

The potential impacts associated with declines in water quality during dredging activities may occur over the medium term and will be within the local area, and therefore moderate in magnitude.

The post mitigation risk ratings associated with a short term decline in water quality impacting dolphins during dredging activities are low for the two bottlenose dolphin species, and medium for the Australian snubfin and Australian humpback dolphins. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to minimise the impact of short term declines in water quality during dredging activities on marine mammals are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

Whales

The areas to be dredged do not represent Essential Habitat for the whale species associated with Port Curtis. Therefore the likelihood of whales being impacted by a short term decline in water quality from the Project is rare.

The potential impacts associated with declines in water quality during dredging activities may occur over the medium term and will be within the local area, and therefore moderate in magnitude.

The post mitigation risk rating associated with a short term decline in water quality impacting whales during dredging activities is medium. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to minimise the impact of short term declines in water quality during dredging activities on marine mammals are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

9.21.3.4 Potential vessel strike impacts

Context of impact

Vessel movements in general pose a potential risk to marine mammals in Port Curtis. Marine mammals are particularly prone to vessel collision while surfacing to breathe and rest after dives. The Port of Gladstone currently experiences a high volume of commercial and recreational vessel traffic. The nature, scale and volume of Project vessel movements are considered minor compared to the existing Port vessel movements. It should be noted that vessel numbers required to complete the Project will be considerably lower than those required during the WBDDP and LNG development on Curtis Island between 2011 and 2014.

While specific vessel types and sizes have not been confirmed for the Project, based on the nature and volume of the material to be dredged, the preferred dredging equipment options include TSHD and CSD dredgers and other vessels (including barges, pushbusters, tugs and other support vessels).

Dugongs

Vessel strike is considered to be a major anthropogenic threat to dugongs in urbanised and near-urban sections of the Queensland coast (Grech and Marsh 2008). Dugongs are at higher risk of boat strike especially from vessels travelling at high speeds. Some studies suggest dugongs do not appear to swim away from passing vessels, or have delayed responses to boats passing (Hodgson and Marsh 2007). Dredging vessels would have localised movements between the channel duplication areas to be dredged, WBE reclamation area, BUF, and the existing Port facilities (e.g. Gladstone Marina).

The distance between the vessel hull or propeller and the seabed can also play a role in the risk of boat strike for dugongs as there is limited opportunity in shallow water for dugongs to avoid boats by diving (Hodgson and Marsh 2007). This risk is reduced in deeper waters. Dredging activities at the channel duplication area to be dredged will be undertaken in deeper waters (approximately -7m and -16m LAT) presenting less of a risk of vessel strike to dugongs during these works.

The potential impacts associated with vessel strike during dredging activities will be short term in duration and may occur in the local area, and therefore moderate in magnitude.

The post mitigation risk rating associated with vessel strike on dugongs during dredging activities is medium. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk. Mitigation measures to reduce the impacts of vessel strike on marine fauna during dredging activities are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

Dolphins

The Queensland marine wildlife strandings and mortality database ‘StrandNet’ has reported few records of boat strike to Australian humpback and Australian snubfin dolphins within Queensland (GBRMPA 2012f). The risk of vessel strike to inshore dolphin species appears less of a threat in the Port Curtis region in relation to other marine mammals, as well as in relation to other regions in Australia (e.g. Roebuck Bay, Western Australia (Thiele 2010)).

The potential impacts associated with vessel strike during dredging activities will be short term in duration and may occur in the local area, and therefore moderate in magnitude.

The post mitigation risk ratings associated with vessel strike on dolphins during dredging activities are low for the two bottlenose dolphin species, and medium for the Australian snubfin and Australian humpback dolphins. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating. Mitigation measures to reduce the impacts of vessel strike on marine fauna during dredging activities are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

Whales

The waters of the areas to be dredged do not represent Essential Habitat for Humpback whales and other whale species associated with the Port Curtis region. Therefore, the likelihood of whales being impacted by vessel strike during dredging activities is rare.

The potential impacts associated with vessel strike during dredging activities will be short term in duration and may occur in the local area, and therefore moderate in magnitude.

The post mitigation risk rating associated with vessel strike on whales during dredging activities is medium. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating. Mitigation measures to reduce the impacts of vessel strike on marine fauna during dredging activities are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

9.21.3.5 Direct contact with dredging equipment

Context of impact

Direct contact and entrainment in dredging equipment during Project dredging activities is not considered to be a significant potential impact to marine mammals. As the dredger heads will be fitted with fauna exclusion devices, and a fauna spotter will be on the vessels to manage interactions with marine mammals, the likelihood of marine fauna coming in direct contact with the dredging equipment is unlikely.

This risk of dredgers directly impacting on marine mammals will depend on the type of dredging plant being used. A TSHD poses a greater risk to marine mammals in terms of direct contact, often resulting in injury or death, as they are slow-moving, quiet and have strong suction power at the draghead (Goldberg et al. 2015).

Dugongs

This Project activity and potential exposure of marine mammals to these impacts will be in the short term and within a contained extent, and therefore low in magnitude.

Mitigation measures to reduce the risk of injury or death to marine mammals occurring as a result of direct contact with dredging equipment during dredging activities are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

The post mitigation risk rating associated with potential impacts on dugongs through direct contact with dredging equipment is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Dolphins

This Project activity and potential exposure of marine mammals to these impacts will be in the short term and within a contained extent, and therefore low in magnitude.

Mitigation measures to reduce the risk of injury or death to marine mammals occurring as a result of direct contact with dredging equipment during dredging activities are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

The post mitigation risk ratings associated with potential impacts on dolphins through direct contact with dredging equipment are low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Whales

The waters of the areas to be dredged do not represent key habitat for Humpback whales and other whale species associated with the Port Curtis region. Therefore the likelihood of whales coming in direct contact with dredging equipment is rare.

This Project activity and potential exposure of marine mammals to these impacts will be in the short term and within a contained extent, therefore low in magnitude.

Mitigation measures to reduce the risk of injury or death to marine mammals occurring as a result of direct contact with dredging equipment during dredging activities are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

The post mitigation risk rating associated with potential impacts on whales through direct contact with dredging equipment is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.21.3.6 Increase in waste material and marine debris

Context of impact

Project dredging activities have the potential for some waste material (i.e. marine debris) to enter the marine environment (refer Section 9.21.2.5). Incidental entanglement or ingestion of marine debris is a well-documented threat to dolphin and dugongs in Queensland waters (GBRMPA 2014c; Marsh et al. 2005).

Dugongs

The likelihood of waste materials entering into the marine areas in and resulting in injury or death of the dugongs is unlikely.

This Project activity and the potential exposure of dugong to these impacts will be in the short term and within a contained extent, therefore low in magnitude.

Mitigation measures to minimise and avoid waste materials entering the marine environment during dredging activities and impacting on marine mammals are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

The post mitigation risk rating associated with impacts to dugongs from a potential increase in waste material and marine debris during dredging activities is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Dolphins

The likelihood of waste materials entering into the marine areas and resulting in injury or death of the dolphins is unlikely.

This Project activity and the potential exposure of dolphin to these impacts will be in the short term and within a contained extent, therefore low in magnitude.

Mitigation measures to minimise and avoid waste materials entering the marine environment during dredging activities and impacting on marine mammals are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

The post mitigation risk ratings associated with impacts to dolphins from a potential increase in waste material and marine debris during dredging activities are low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Whales

As discussed in Section 9.21.2.5 some whale species associated with Port Curtis and the surrounding region are adversely affected by the threatening process of marine debris (DoEE 2016). The waters of the areas to be dredged do not represent Essential Habitat for the whale species associated with Port Curtis and surrounding regions. Therefore, the likelihood of marine debris impacting on whales is rare.

This Project activity and the potential exposure of whales to these impacts will be in the short term and within a contained extent, and therefore low in magnitude.

Mitigation measures to minimise and avoid waste materials entering the marine environment during dredging activities and impacting on marine mammals are included in Section 9.27 and the Dredging EMP (refer Appendix Q1).

The post mitigation risk rating associated with impacts to whales from a potential increase in waste material and marine debris during dredging activities is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

9.21.4 Removal and installation of navigational aids

9.21.4.1 Noise and vibration

Context of impact

The installation of navigational aids will involve use of a hydraulic piling hammer that is anticipated to generate the highest levels of underwater noise, approximately 204dB for the impact piling and 168dB for the piling barge, during removal and installation of navigational aids. As stated in Section 9.19.2.2, excessive levels of underwater noise have the potential to impact a variety of marine mammals. The specific size of the Junttan hydraulic hammer is yet to be determined but is expected to be in the range of 124dBA. Two existing navigational aids will be removed and five existing navigational aids will be removed and reinstalled using a barge and pile extractor.

The installation of new navigational aids (i.e. piling) is estimated to take two to three days per pile. Installation is anticipated to be undertaken during daylight hours, over a period of two to three months, with hammering undertaken intermittently. An assessment of underwater noise and vibration baseline levels along with predicted noise and vibration impacts from installation of the navigational aids were modelled (refer Chapter 13 and Appendix K2).

Estimates of the underwater noise generated from the installation of navigational aids range from 15dB (RMS SPL parameter) and 28dB (Peak SPL parameter) for distances closer than 2km to the source, whilst for distances further than 10km away an estimation of 10dB is derived.

While a single piling strike would not cause injury to marine mammals, exposure for a 1 minute duration (i.e. 100 strikes) was predicted to cause PTS onset within 50m of piling while exposure for an hour direction (i.e. 6,000 strikes) was predicted to cause PTS onset within 1.4km of piling (SLR 2019b).

Marine mammals would experience TTS onset from a single piling strike within 18m from the source, while multiple piling strikes for a duration of 1 minute (i.e. 100 strikes) and an hour (i.e. 6,000 strikes) was predicted to cause TTS onset within 700m and 6.0km respectively (SLR 2019b). It is considered that the regular pulses from piling activities may result in avoidance behaviour. It is considered that the regular pulses from piling activities may result in avoidance behaviour.

It should be noted that the above distances are based on a worst case scenario and assume marine mammals remain within a certain distance from the source location for the duration of the piling. However, high level impulsive noise from the piling activities would likely cause marine mammals to move away from the noise source.

Dugongs

Removal and installation of navigational aids during the Project has the potential to cause significant impacts to dugongs, including mortal injuries, as a result of entering the zones of impact for piling locations. Mortal injury to dugongs could potentially occur due to a single impact strike within a radius of 35m of the activity (SLR 2019b). Mortal injury has the potential to occur within a 160m radius of the piling locations if the species is exposed to the activity for a period up to 1 hour (i.e. 6,000 strikes) (SLR 2019b). Noise emitted by a single strike is also predicted to cause avoidance at a distance of up to 600m whilst changes in behaviour can be expected up to a distance of 2km from piling location (SLR 2019b)

This Project activity and potential exposure of dugongs to these impacts will be temporary and within the local area, therefore low in magnitude

The post mitigation risk rating associated with an increase in noise during the removal and installation of navigational aids impacting dugongs is medium. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating. Mitigation measures to avoid or minimise potential noise and vibration impacts to marine mammals generated through piling activities are included in Section 9.27 and the Project EMP (refer Appendix Q2).

Dolphins

Noise emitted from the removal and installation of navigational aids from a single piling strike was found to not cause PTS onset injury for dolphins however, zones of impact for PTS onset extend from 50m for 1 minute duration (i.e. 100 strikes), 310m for a 10 minute duration (i.e. 1,000 strikes) and 1.4km for a 1 hour duration (i.e. 6,000 strikes).

Noise from a single piling strike associated with navigational aid activity is predicted to cause TTS onset in dolphins within 18m of the source location, while multiple piling strikes would cause TTS onset within 700m for 100 strikes (i.e. 1 minute duration) and 6km for 6,000 strikes (i.e. 1 hour duration).

The zone of impact for potential behavioural changes in dolphins are predicted to be up to 3.4km from the piling location (SLR 2019b). This Project activity and potential exposure of dolphins to these impacts will be temporary and within the local area, therefore low in magnitude.

The post mitigation risk ratings associated with an increase in noise during the removal and installation of navigational aids impacting dolphins are low for the two bottlenose dolphins and the Australian snubfin dolphin, and medium for the Australian humpback dolphin. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating. Mitigation measures to avoid or minimise potential noise and vibration impacts to marine mammals generated through piling activities are included in Section 9.27 and the Project EMP (refer Appendix Q2).

Whales

Noise emitted from the removal and installation of navigational aids from a single piling strike was found to unlikely cause PTS onset injury for whale species however, zones of impact for PTS onset extend from 50m for 1 minute duration (i.e. 100 strikes), 310m for a 10 minute duration (i.e. 1,000 strikes) and 1.4km for a 1 hour duration (i.e. 6,000 strikes).

Noise from a single piling strike associated with navigational aid activity is predicted to cause TTS onset in whale species within 18m of the source location, while multiple piling strikes would cause TTS onset within 700m for 100 strikes (i.e. 1 minute duration) and 6km for 6,000 strikes (i.e. 1 hour duration). Zone of impact for potential behavioural changes in whales are predicted to be up to 3.4km from piling location (SLR 2019b).

This Project activity and potential exposure of dolphins to these impacts will be temporary and within the local area, therefore low in magnitude.

The post mitigation risk rating associated with an increase in noise during the removal and installation of navigational aids impacting whales is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating. Mitigation measures to avoid or minimise potential noise and vibration impacts to marine mammals generated through piling activities are included in Section 9.27 and the Project EMP (refer Appendix Q2).

9.21.4.2 Direct contact with construction plant

Context of impact

Vessel activity associated with the removal and installation of navigational aids has the potential to pose a risk to marine mammals in Port Curtis. While specific vessel types and sizes have not been confirmed for the removal and installation of navigational aids, based on the proposed activities a barge, tug boat and work boats will be required to complete the works. Installation and removal of navigational aids will be undertaken in a variety of depths which can influence the risks associated with vessel strike.

Port Curtis currently experiences a high volume of commercial and recreational vessel traffic and the addition of these Project vessels over the short term will not significantly increase the risk of vessel strike to marine mammals above the overall risk that currently exists in Port Curtis.

The post mitigation risk ratings associated with potential impacts on marine mammals through direct contact with construction plant during removal and installation of navigational aids is considered to be negligible.

9.21.5 Stabilisation and final Project landform

9.21.5.1 Short term decline in water quality in the marine environment

Context of impact

The use of vehicles during surface stabilisation and maintenance works at the WB and WBE reclamation areas has the potential to result in the release of contaminants (e.g. hydrocarbons). The release of contaminants may lead to the degradation of intertidal or subtidal habitats located in the receiving marine environment adjoining the final Project landforms. This may impact marine mammals via direct contact with contaminants or the ingestion of a contaminated food source.

Soil erosion and runoff from the final Project landform areas has the potential to have an impact on the quality of the adjacent intertidal and subtidal habitats. Suspended sediments in the water column can increase light attenuation and reduce the amount of benthic light reaching key dugong and dolphin habitat such as seagrass meadows (Erftemeijer and Lewis 2006; Sofonia and Unsworth 2010).

As outlined in Section 9.21.2.3, a potential short term decline in water quality through elevated turbidity and increased sedimentation is not expected to adversely impact marine mammal populations given the naturally elevated turbidity background conditions in Port Curtis. It should also be noted that limited volumes of contaminants will be present onsite during surface stabilisation and maintenance works.

Dugongs

The potential impacts to dugong as a result of water quality through a release of sediment laden runoff and/or contaminants during surface stabilisation and maintenance works at the WB and WBE reclamation areas will be generally restricted to a contained area and within the short term, therefore low in magnitude.

Mitigation measures to avoid a decline in water quality through contaminant releases or sediment laden runoff impacting marine mammal habitat during surface stabilisation and maintenance works within the WB and WBE reclamation areas, are included in Section 9.27 and the Project EMP (refer Appendix Q2). Mitigation measures to manage the risk of PASS disturbance during surface stabilisation and maintenance works within the WB and WBE reclamation areas are included in Section 6.7.

The post mitigation risk rating associated with potential impacts of water quality on dugongs during surface stabilisation and maintenance works is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Dolphins

The potential impacts to dolphins as a result of water quality through a release of sediment laden runoff and/or contaminants during surface stabilisation and maintenance works at the WB and WBE reclamation areas will be generally restricted to a contained area and within the short term, therefore low in magnitude.

Mitigation measures to avoid a decline in water quality through contaminant releases or sediment laden runoff impacting marine mammal habitat during surface stabilisation and maintenance works within the WB and WBE reclamation areas, are included in Section 9.27 and the Project EMP (refer Appendix Q2). Mitigation measures to manage the risk of PASS disturbance during surface stabilisation and maintenance works within the WB and WBE reclamation areas are outlined in Section 6.7.

The post mitigation risk ratings associated with potential impacts of water quality on dolphins during surface stabilisation and maintenance works are low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Whales

The potential impacts to whales as a result of water quality through a release of sediment laden runoff and/or contaminants during surface stabilisation and maintenance works at the WB and WBE reclamation areas will be generally restricted to a contained area and within the short term, therefore low in magnitude.

The post mitigation risk rating associated with potential impacts of water quality on whales during surface stabilisation and maintenance works is low. Appendix I4 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to avoid a decline in water quality through contaminant releases or sediment laden runoff impacting marine mammal habitat during surface stabilisation and maintenance works within the WBE reclamation area, are included in Section 9.27 and the Project EMP (refer Appendix Q2).

9.21.6 Threatening processes for species of conservation significance and migratory species

Threatening processes which may lead to the progressive loss of species of conservation significance and migratory species, including ecologically significant habitat, have been assessed with regards to the potential Project impacts. Threatening processes for species of conservation significance and migratory marine mammal species which have been confirmed to occur, or are considered to have a high or moderate likelihood of occurrence within the Project impact areas (refer Appendix B), have been identified from the relevant species recovery plan, conservation listing advice and/or threat abatement plan.

The potential Project impacts which have been provided in Sections 9.21.2 to 9.21.5 have been assessed with regard to their potential contribution to the species threatening processes (refer Appendix I3).

Residual impacts on a threatening process have the potential to result where an impact has a high or very high risk rating. Marine mammal species for which potential Project impacts are considered to have a residual impact on a threatening process which may lead to the progressive loss of the species or ecologically significant habitat (refer Appendix I3), will be subject a significant residual adverse impact assessment. The significant residual adverse impact assessment is provided in Section 9.21.7.

9.21.7 Significant residual adverse impact assessment

A significant residual adverse impact assessment has been conducted to identify if the Project will, or is considered likely to have, a significant residual adverse impact on any marine mammal value which is defined as a MNES or MSES. The impact assessment included in this section has been conducted in accordance with the *Matters of National Environmental Significance Significant Impact Guidelines, Version 1.1* (DoE 2013) and the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (EHP 2014a).

Significant residual adverse impact assessments have been conducted for marine mammal species which are considered to have a moderate or high likelihood of occurrence within the Project impact areas (refer Appendix B).

This assessment of significant residual adverse impacts considers the significance of potential Project impacts after the implementation of the Project mitigation measures included in Section 9.21.6, the Dredging EMP and Project EMP.

Table 9.63 includes the marine mammal species which are subject to this significant residual adverse impact assessment, due to Project impacts having the potential to result in:

- Very high or high risk (post mitigation measures) on a species (refer Sections 9.21.2 to 9.21.5), and/or
- A residual impact to a key threatening process (refer Appendix I3, Item 4.0)

Table 9.78 Marine mammal MNES and MSES subject to significant residual adverse impact assessment

Fauna value	MNES	MSES	Significance assessment
Dugong (*Dugong dugon*)	Migratory species	Protected wildlife habitat	Table 9.79
Australian snubfin dolphin (*Orcaella heinsohni*)	Migratory species	Protected wildlife habitat	Table 9.80
Australian humpback dolphin *(Sousa sahulensis)*	Migratory species	Protected wildlife habitat	Table 9.80

9.21.7.1 Dugong

The dugong is a migratory species under the EPBC Act and a vulnerable listed species under the NC Act. Consequently, the MNES significant impact assessment criteria for migratory species (DoE 2013) and the significant impact assessment criteria for protected wildlife habitat (EHP 2014a) have been used for the dugong significant residual adverse impact assessment (refer Table 9.84).

The significant residual adverse impact assessment concluded that the proposed Project activities have the potential to have a significant residual adverse impact on the dugong.

Table 9.79 Significant residual adverse impact assessment – dugong

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
MNES significant impact assessment criteria – Migratory species ▪ Substantially modify (including by fragmentation, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species **MSES significant impact assessment criteria – Protected wildlife habitat** ▪ Lead to a long term decrease in the size of a local population ▪ Reduce the extent of occurrence of the species ▪ Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species
Potentially significant (MSES criteria) **Unlikely (MNES criteria as the Project impact areas are not considered to be important habitat)** The Port Curtis region supports a relatively small population of dugongs, although the area is considered to be regionally significant to the south Queensland population. The area of Port Curtis from Rodds Bay to The Narrows was declared a DPA Zone B (restricted use) in 1997 to recognise the importance of Port Curtis seagrass habitat to populations (Sobtzick et al. 2013; Cleguer et al. 2015a). To identify important areas of habitat and to quantify habitat utilisation in the urban coastal waters of Queensland, Grech et al. (2011) incorporated the JCU TropWATER aerial survey data (1986 to 2011) to develop a spatial model of relative dugong density. Within Port Curtis and Rodds Bay, the relative density shown in the model outputs ranged between low and medium density (i.e. 0 to 0.25 dugongs per square kilometre). Aerial surveys conducted by GHD for the WBDDP EIS baseline surveys (2009) confirmed several dugong sightings within and immediately adjacent to the WBE reclamation area during May and November (GHD 2009d). The WBE reclamation area (northern and southern areas) and adjoining areas contain seagrass meadows (GPC Monitoring Meadow 8), which consists of isolated patches of moderate *H. ovalis* and *Z. muelleri*, based on the latest annual survey (Chartrand et al. 2018). The total area of seagrass meadows mapped within the WBE reclamation area and areas adjoining the WBE reclamation area was 156.41ha in 2017 which represents approximately 4.33% to 5.53% of coastal seagrass mapped in Port Curtis in 2017. Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of habitat loss at the WBE reclamation area (refer Section 9.27). Despite these mitigation measures, the establishment of the WBE reclamation area will result in an unavoidable permanent loss of dugong habitat. Project activities also have the potential to result in increased underwater noise and vibration. Excessive levels of underwater noise may disrupt the behaviour of dugongs at ecologically significant locations (e.g. alter foraging behaviour in seagrass meadows). Potential Project impacts to dugongs associated with the generation of underwater noise and vibration would be managed in accordance with the Project EMP and Dredging EMP. The Port Curtis region is situated within the Queensland Urban Coast. Port Curtis has not been identified as one of the important dugong habitat areas within the Queensland Urban Coast, with the most important habitat areas situated within the Moreton Bay and Hervey Bay regions. As such, potential Project impacts on dugong populations and habitat are not anticipated to impact on an area of important habitat for the migratory species. The Project is not anticipated to have a significant impact on the dugong in accordance with the MNES significant impact guidelines for migratory species (DoE 2013). The establishment of the WBE reclamation area will result in the direct loss of seagrass communities which have the potential to reduce the extent of occurrence of local dugong populations. Furthermore, noise generated during Project activities is considered likely to cause disruption to the species (i.e. foraging behaviour). The Project is considered to have a potential significant impact on local dugong populations in accordance with the MSES significant impact guidelines for protected wildlife habitat (EHP 2014a).

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
MSES significant impact assessment criteria – Protected wildlife habitat ▪ Fragment an existing population ▪ Result in genetically distinct populations forming as a result of habitat isolation
Unlikely to have a significant impact The scale of movement in dugongs is individualistic and heterogenous. Movement studies using tracking devices have recorded dugong movements on a micro-scale (< 15km), mesoscale (between 15-100km) and a macroscale (between 100-560km) (Sheppard et al. 2006). Movement studies have found that the home ranges of dugongs can overlap between individuals and that most individuals maintain a close association with inshore seagrass beds (DoEE 2018f). The seagrass meadows within the Port Curtis region potentially provide connectivity habitat between larger dugong habitat areas at Shoalwater Bay to the north and Hervey Bay to the south (Sobtzick et al. 2013; Cleguer et al. 2015a). The establishment of the WBE reclamation area will have a direct impact on seagrass meadows. The total area of seagrass meadows mapped within and adjoining the WBE reclamation area was 156.41ha in 2017 which represents approximately 4.33% to 5.53% of coastal seagrass mapped in Port Curtis. Any impacts to seagrass meadows as a result of increased turbidity through dredging activities is expected to be temporary and effectively mitigated through an adaptive Dredging EMP. The Project activities will not impede dugong movement. The establishment of the WBE reclamation area and BUF are not considered to create a barrier to dugong movement between habitats. Furthermore, the dredging activities are associated with the existing shipping channel, as such, will not create disturbance or barriers to species movement in new areas. The Project activities are not anticipated to result in genetically distinct dugong populations forming as a result of habitat isolation. The Project is not considered likely to create a significant barrier to species movement through the marine environment or fragment dugong populations. Additionally, with respect to the proportion of Port Curtis seagrass meadows being directly impacted by the Project and the capacity of dugongs for long range movements, the direct loss of seagrass meadows within the Project impact areas is not considered to have a significant impact on connectivity values for the dugong which would result in the fragmentation of populations or result in genetically distinct populations forming.
MNES significant impact assessment criteria – Migratory species ▪ Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species
Unlikely to have a significant impact The Project activities are not considered likely to seriously disrupt the lifecycle of an ecologically significant proportion of the dugong population. The dugong diet consists primarily of seagrass (along with macroinvertebrates and algae) (Marsh et al. 2011). Dugongs have the potential to be displaced by a lack of suitable habitat or a loss of food sources and can travel long distances in search for seagrass (Marsh et al. 2002; Sheppard et al. 2006). The Project will involve the direct removal of seagrass meadows and may disrupt the foraging activities of local dugong populations. Dugongs are thought to use specialised habitats for various activities, such as the use of tidal sandbanks and estuaries for calving (Hughes and Oxley-Oxland 1971; Marsh et al. 1984; Marsh et al. 2003). Mating herds of dugong have been observed in Moreton Bay, Shark Bay and the northern Great Barrier Reef region (DoEE 2018f). The Project will not have a direct impact on tidal sandbank or estuary areas which are known to support dugong calving. As the dugong is a long-lived and slow breeding species, direct mortality of dugongs through vessel strike may disrupt the species breeding cycle. Vessel movements during the Project activities have the potential to result in vessel strike with individuals. Mitigation measures to reduce the risk of vessel strike on dugongs will be included in the Dredging EMP. Dugongs delay breeding in adverse environmental conditions (DoEE 2018g). The Project has a potential to result in decreased water quality through works associated with the establishment of the WBE reclamation area and BUF and dredging activities. The resident population of dugongs within Port Curtis persist in an environment which experiences naturally turbid background conditions. Through the implementation of management measures contained in the Project management plan framework (i.e. Dredging EMP and Project EMP), the Project is not anticipated to result in significant impacts to the dugong behaviour due to decreased water quality.

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
Project activities have the potential to result in increased underwater noise and vibration. Excessive levels of underwater noise may impact on dugongs via trauma to hearing (temporary or permanent), trauma to non-hearing tissue (barotraumas), alteration of behaviour (e.g. avoidance of predators, interfering with the acquisition of prey or mates, displacement from essential habitat areas) and masking of biologically significant sounds. An assessment of the underwater noise and vibration predicted to be generated as a result of Project activities was undertaken by SLR (refer Chapter 13). The assessment concluded that it is unlikely that marine mammals in Port Curtis (i.e. dugongs, dolphins and whales) would be at risk of peak acoustic pressure damage from underwater noise and vibration levels generated by the establishment of the WBE reclamation area or dredging activities. Potential risk of dugong mortal injuries within a 160m radius of piling activities associated with the removal and installation of navigation aids was identified, and potential behavioural displacement responses by dugong was identified within a 2km radius of the activity (refer Chapter 13). Potential Project impacts to dugongs associated with the generation of underwater noise and vibration would be managed in accordance with the NVMP. The local dugong population present in Port Curtis is not considered to represent an ecologically significant proportion of the dugong population. The Queensland Urban Coast extends from Cooktown to the Queensland/New South Wales border and includes a number of specific areas along the urban coast, adjacent to the GBRWHA, which support dugong populations. Port Curtis is situated on the Queensland Urban Coast and supports dugong populations. Port Curtis has not been identified as one of the important dugong habitat areas within the Queensland Urban Coast, with the most important habitat areas situated within the Morton Bay and Hervey Bay regions (DoEE 2018g). The Project activities are not considered likely to have a significant impact on the lifecycle of an ecologically significant proportion of a dugong population.
MNES significant impact assessment criteria – Migratory species ▪ Result in invasive species that are harmful to an endangered, vulnerable or migratory species becoming established in the species' habitat **MSES significant impact assessment criteria – Protected wildlife habitat** ▪ Result in invasive species that are harmful to an endangered or vulnerable species becoming established in the endangered or vulnerable species' habitat
Unlikely to have a significant impact Invasive species have not been identified as a key threatening process to the dugong (DoEE 2018g; Woinarski et al. 2014). The operation and movement of marine plant during Project activities has the potential to result in the introduction and/or spread of invasive species in the marine environment. The likelihood of the Project introducing or spreading invasive species within the marine environment is considered to be reduced and effectively managed via the implementation of mitigation measures included in the Dredging EMP and Project EMP (refer to Appendix Q1 and Q2, respectively).
MSES significant impact assessment criteria – Protected wildlife habitat ▪ Introduce disease that may cause the population to decline
Unlikely to have a significant impact Disease has not been identified as a key threatening process to the dugong (DoEE 2018g; Woinarski et al. 2014). Marine pollution has been attributed to poor health status in dugong populations and has been identified as a threat factor to the species (DoEE 2018c; Woinarski et al. 2014). Harmful contaminants such as pesticides, heavy metals, organochlorides and sewage from the land or from boats can pollute marine waters and increase incidence of disease. The nature of Project activities is considered unlikely to introduce disease that may cause species decline. To minimise the potential of Project activities introducing disease to Port Curtis which may cause species decline, a Project EMP will be developed and implemented. The movement of materials and equipment, which may act as transport mediums for disease, will be subject to the Project EMP. Management plans within the Dredging EMP and Project EMP will contain measures to reduce the potential for Project activities to introduce harmful contaminants into the marine environment. Any potential Project impact in regards to the introduction or spread of harmful diseases to dugongs is considered to be negligible.

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
MSES significant impact assessment criteria – Protected wildlife habitat ▪ Interfere with the recovery of the species
Unlikely to have a significant impact There is no adopted or drafted recovery plan for the dugong (DoEE 2018g). The *Action Plan for Australian Mammals 2012* (Woinarski et al. 2014) identifies key management actions recommended to help conserve viable populations of the dugong. Specific management actions have been recommended across two themes, active mitigation of threats and community engagement. Specific actions include: ▪ Ensure high levels of protection in important habitats ▪ Reduce incidental catch in nets from shark exclusion devices and fisheries ▪ Manage Indigenous hunt to ensure it is sustainable ▪ Improve national coordinated planning and management of coastal development, port expansion, and vessel movements to reduce risks to dugong and their seagrass habitats ▪ Enhance education programs to inform fishers and other users of marine environments of best practice codes of conduct for avoiding dugong injury or death, minimising seagrass loss, and ensuring future hunting is sustainable With respect to the nature of the Project activities, the Project is not considered likely to result in impacts that will interfere or impede with the aforementioned specific actions for dugong recovery.

9.21.7.2 Dolphins

The Australian humpback dolphin and the Australian snubfin dolphin are listed as migratory species under the provisions of the EPBC Act and vulnerable under the provisions of the NC Act.

The significant residual adverse impact assessment presented in Table 9.80 has been conducted with respect to the MNES significant impact assessment criteria for migratory species (DoE 2013b) and the significant impact assessment criteria for protected wildlife habitat (EHP 2014a).

The significant residual adverse impact assessment concluded that the proposed Project activities are unlikely to have a significant residual adverse impact on the Australian humpback dolphin or the Australian snubfin dolphin.

Table 9.80 Significant residual adverse impact assessment – Australian humpback dolphin and the Australian snubfin dolphin

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
MNES significant impact assessment criteria – Migratory species ▪ Substantially modify (including by fragmentation, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species **MSES significant impact assessment criteria – Protected wildlife habitat** ▪ Lead to a long term decrease in the size of a local population ▪ Reduce the extent of occurrence of the species ▪ Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species
Unlikely to have a significant impact The Project is not considered likely to destroy an area of important habitat or cause significant disruption to an ecologically significant area of the Australian humpback dolphin or the Australian snubfin dolphin habitat. However, the Australian snubfin dolphin has not been recorded south of The Narrows during ERMP surveys (Cagnazzi 2017), though is still assessed as it is still potentially suitable habitat within proximity to a known population.

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
The Project will result in the direct removal of potential habitat for the Australian humpback dolphin and the Australian snubfin dolphin, however the Project activities are not anticipated to reduce the extent of species occurrence or lead to a long term decrease in the species populations. The establishment of the WBE reclamation area and BUF will have a direct impact on approximately 278ha of potential habitat for the Australian humpback dolphin and the Australian snubfin dolphin. The Australian humpback dolphin and the Australian snubfin dolphin are commonly found in protective shallow waters (< 20m), at the mouths of creeks and estuaries, and in tidal channels. The species feed primarily on coastal and estuarine fish species, along with crustaceans, bivalves, and cephalopods (Australian snubfin only) (Parra and Jedensjö 2009). The release of contaminants may lead to the degradation of intertidal or subtidal habitats located adjacent to the final Project land form and result in impacts to marine life, including inshore dolphin species, via direct contact with contaminants or the ingestion of contaminated food source. Mitigation measures to avoid contaminant releases impacting inshore dolphin species and their habitat during surface stabilisation and maintenance works at the WB and WBE reclamation areas will be included in the Project EMP and Dredging EMP (refer Appendix Q2 and Q1, respectively). Dredging activities may result in a short term decline in water quality and have a potential to adversely impact inshore dolphin habitat. Potential impacts to water quality as a result of dredging activities will be managed in accordance with the Dredging EMP. The Australian humpback dolphin does not display any apparent preference for clear or turbid waters, and have been reported in a variety of coastal habitats, from coastal lagoons and enclosed bays with mangrove forests and seagrass meadows through to open coastal waters with rock and/or coral reefs. The western section of Moreton Bay and the lower reaches of the Brisbane River have been identified as potential key habitats for the Australian humpback dolphin (Hale et al. 1998). With a continuous distribution along the east Australian coast (DoEE 2018e), the Australian humpback dolphin does not appear to have specialised habitat requirements. The Project works will occur outside of potential key habitat areas for the species and is not considered likely to remove ecologically significant locations for the species to the extent that the species populations would decline in extent and numbers. Surveys of inshore dolphins in Port Curtis reported in Cagnazzi (2013) found that small to medium groups of Australian humpback dolphins used the footprint of the WBE reclamation area as an area for foraging and feeding/travelling. Large groups (11 to 21) of Australian humpback dolphins were recorded to use the waters around the channel duplication areas to be dredged, predominantly for foraging, but also for travelling, milling, feeding and socialising (Cagnazzi 2013). Cagnazzi (2017) found that there was no clear evidence of genetic bottlenecks in the Port Curtis population of the Australian humpback dolphin, with low genetic diversity recorded in the species considered to be a natural characteristic of the species in Australian waters. The Australian humpback dolphin population in Port Curtis is considered to be resilient to a degree of disturbance. In 2011, following large flood events and the concurrent commencement of the WBDDP, the number of Australian humpback dolphins in Port Curtis declined by approximately 40%. Surveys conducted in 2014-2016 found that the population numbers of the species in Port Curtis returned to their pre-2011 population numbers (Cagnazzi 2017). With respect to the short timeframe of the population recovery, the observed decline in Australian humpback dolphins in Port Curtis could be partially explained by a temporary shift in the species distribution (i.e. it was considered that the core group of Australian humpback dolphins in Port Curtis moved to nearby regions and waited until more suitable conditions were re-established in Port Curtis before they returned) (Cagnazzi 2017). The Australian snubfin dolphin is known to occur within the Fitzroy River but there is little evidence in support of the species occupying Port Curtis. The closest species occurrence recorded in the ALA for the Australian snubfin dolphin to the Project impact areas was a single individual recorded in 1997, situated on the north coast of Camp Island, approximately 35km north of the WBE reclamation area. Isolated species occurrence recordings have been collected near Bundaberg (recorded in 1994) and Yeppoon (recorded in 1999) (ALA 2019). Recent studies suggest that the Australian snubfin dolphin is unlikely to occur in substantial numbers in waters south of The Narrows (Cagnazzi 2013; 2017). Dolphin mark-recapture (photo-identification) surveys conducted over the period of 2014-2016 within the Port Curtis and Port Alma regions recorded Australian snubfin dolphins only in the northern section of The Narrows (Cagnazzi 2017).

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
The Australian snubfin dolphin appears to occur in 'hotspots', with areas of higher population densities recorded along the east coast (DoEE 2018d). Australian snubfin dolphin occurrence recordings in the ALA database appear to be congregated around Townsville and Mackay (ALA 2019). With limited recordings of the Australian snubfin dolphin within Port Curtis, it is considered unlikely that potential species habitat within the Project impact areas supports significant populations of the Australian snubfin dolphin. Potential species habitat within the Project impact areas is considered unlikely to represent important habitat or ecologically significant locations for the species. The direct removal of potential habitat for the Australian snubfin dolphin is not considered likely to have a significant impact on the extent or size of any local species populations which may be present. Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of potential inshore dolphin habitat loss from the WBE reclamation area (refer Section 9.27).
MSES significant impact assessment criteria – Protected wildlife habitat ▪ Fragment an existing population ▪ Result in genetically distinct populations forming as a result of habitat isolation
Unlikely to have a significant impact Australian humpback dolphins and Australian snubfin dolphins are considered to be strictly inshore, coastal and estuarine dolphin species (Cagnazzi 2013). Australian humpback dolphins and Australian snubfin dolphins share similar habitat preferences. The species are considered to be potentially sympatric (occurring in the same areas) throughout most of their Australian range (Parra 2006; DoEE 2018d). The Australian humpback dolphin and Australian snubfin dolphin appear to occur in 'hotspots', with areas of higher population densities recorded along the east coast (DoEE 2018d; DoEE 2018e). Associated with coastal waters less than 10m deep and approximately 6km offshore, the Australian humpback dolphin is understood to have a continuous distribution along the east Australian coast (DoEE 2018e). The species is understood to have a large home range (DoEE 2018e). Recent studies suggest Australian snubfin dolphins are unlikely to inhabit Port Curtis and waters south of The Narrows (Cagnazzi 2013; 2017). Systematic boat-based surveys for the species conducted in Cleveland Bay, approximately 650km north of the Project impact areas, suggested that the Australian snubfin dolphin have large home ranges, with tracked individuals spending less than 30 days within the 310km^2 Cleveland Bay (Townsville) study area. The Project activities are not considered to impede the movement of inshore dolphin species, including the Australian humpback dolphin and the Australian snubfin dolphin. The establishment of the WBE reclamation area and BUF is not considered to create a barrier to dolphin movement between habitats. Furthermore, the dredging activities are associated with the existing shipping channel, and as such, will not create disturbance or barriers to movement in new areas. The Project activities are not anticipated to result in genetically distinct populations forming as a result of habitat isolation. Project impacts are not considered to fragment habitat or create barriers to movement which would result in the genetic isolation of a species. The Australian snubfin dolphin is considered unlikely to occur within Port Curtis and as such the Project is considered unlikely to impact on genetically distinct species populations or result in the genetic isolation of a species.
MNES significant impact assessment criteria – Migratory species ▪ Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species
Unlikely to have a significant impact The Project activities are not considered likely to seriously disrupt the lifecycle of an ecologically significant proportion of the Australian humpback dolphin or the Australian snubfin dolphin population. The Australian humpback dolphin is understood to have a large home range and a continuous distribution along the inshore environments of the eastern Australian coastline (DoEE 2018e). Studies have suggested that the Australian snubfin dolphin is unlikely to inhabit Port Curtis and waters south of The Narrows (Cagnazzi 2013), the Project impact areas are not considered likely to support an ecologically significant proportion of the Australian snubfin dolphin population.

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
The Australian humpback dolphin and the Australian snubfin dolphin are thought to be opportunist and generalist feeders, eating a wide variety of coastal and estuarine-associated fishes. Feeding may occur in a variety of habitats, from mangroves to sandy bottom estuaries and embankments to rock and/or coral reefs. Feeding primarily occurs in shallow waters (< 20m depth) and may incorporate beaching behaviour on sandbanks (DoEE 2018d; DoEE 2018e). The species are not considered to require specialised environments for to facilitate feeding activities. Limited life cycle data is available for the Australian humpback dolphin and the Australian snubfin dolphin. Australian humpback dolphin calves may be born throughout the year, with peaks in calves recorded in the spring and summer months (DoEE 2018e). Australian snubfin dolphins have been observed socialising year round in Cleveland Bay (Townsville, Queensland), suggesting that Australian snubfin dolphins may mate year round. Furthermore, Australian snubfin dolphin calves have been recorded year round in Cleveland Bay, indicating that this species may not have a particular calving period (DoEE 2018d). No calving areas for the Australian humpback dolphin or the Australian snubfin dolphin are known in Australian waters (DoEE 2018d; DoEE 2018e). Direct species mortality through vessel strike may disrupt the species breeding cycle. Vessel movements during the Project activities has the potential to result in vessel strike with individuals. Mitigation measures to reduce the risk of vessel strike on dolphins will be included in the Project EMP and Dredging EMP (refer Appendix Q2 and Q1, respectively). Elevated levels of some organochlorine compounds and PAH have been detected from dolphin biopsy samples in central and southern Great Barrier Reef. These elevated levels could impair the reproductive capabilities of the Australian humpback dolphin and the Australian snubfin dolphin (Woinarski et al. 2014). The movement of materials and equipment, which may act as transport mediums for toxic elements and disease, will be subject to the Project EMP. Management plans included in Project EMP and Dredging EMP will contain measures to reduce the potential for Project activities to introduce harmful contaminants into the marine environment. Australian humpback dolphins which occur within Port Curtis persist in an environment which experiences generally naturally turbid background conditions. The Project has a potential to result in decreased water quality through works associated with the establishment of the WBE reclamation area, BUF and dredging activities. Potential Project impacts associated with decreased water quality will be managed in accordance with the Dredging EMP (refer Appendix Q1). Project activities also have the potential to result in increased underwater noise and vibration. Excessive levels of underwater noise may impact on inshore dolphin species via trauma to hearing (temporary or permanent), trauma to non-hearing tissue (barotraumas), alteration of behaviour (e.g. avoidance of predators, interfering with the acquisition of prey or mates, displacement from essential habitat areas) and masking of biologically significant sounds. An assessment of the underwater noise and vibration predicted to be generated as a result of Project activities was undertaken (refer Chapter 13). The assessment concluded that it is unlikely that marine mammals in Port Curtis (i.e. dugongs, dolphins and whales) would be at risk of peak acoustic pressure damage from underwater noise and vibration levels generated by the establishment of the WBE reclamation area, BUF or dredging activities. Analysis of potential noise masking indicates the possibility of a behavioural displacement response during foraging and communication for the period of Project works at distances less than 3.4km from the activity. Noise emitted from the removal and installation of navigational aids from a single piling strike was found not to cause PTS-onset injury for dolphins however, zones of impact for PTS-onset extend from 50m for 1-minute duration, 310m for a 10-minute duration and 1.4km for a 1-hour duration. Noise from a single piling strike associated with navigational aid activity is predicted to cause TTS onset in dolphins within 18m of the source location, while multiple piling strikes would cause TTS onset within 700m for 100 strikes (i.e. 1 minute duration) and 6km for 6,000 strikes (i.e. 1 hour duration). Through the implementation of management measures contained in the Dredging EMP and Project EMP (refer Appendices Q1 and Q2, respectively), the Project is not anticipated to result in significant impacts to the behaviour or lifecycle of the Australian humpback dolphin or the Australian snubfin dolphin.

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
MNES significant impact assessment criteria – Migratory species ▪ Result in invasive species that are harmful to an endangered, vulnerable or migratory species becoming established in the species' habitat **MSES significant impact assessment criteria – Protected wildlife habitat** ▪ Result in invasive species that are harmful to an endangered or vulnerable species becoming established in the endangered or vulnerable species' habitat
Unlikely to have a significant impact Invasive species have not been identified as a key threatening process to the Australian humpback dolphin or the Australian snubfin dolphin (DoEE 2018d; DoEE 2018e; Woinarski et al. 2014). The operation and movement of marine plant during Project activities has the potential to result in the introduction and/or spread of invasive species in the marine environment. The likelihood of the Project introducing or spreading invasive species within the marine environment is considered to be reduced and effectively managed via the implementation of mitigation measures included in the Project EMP (refer Appendix Q2).
MSES significant impact assessment criteria – Protected wildlife habitat ▪ Introduce disease that may cause the population to decline
Unlikely to have a significant impact Pollution of habitat for the Australian humpback dolphin and the Australian snubfin dolphin has been identified as a threatening process to the species (DoEE 2018d; DoEE 2018e; Woinarski et al. 2014). Pollution can introduce and spread harmful pathogens and disease into the marine environment and have a detrimental impact on inshore dolphin species. Harmful contaminants such as pesticides, heavy metals, organochlorides and sewage from the land or from boats can pollute the marine environment and increase incidence of disease. Contaminants which have been recorded in marine mammals, including dolphins, and are suspected to have a negative impact on marine mammal health include organohalogen compounds, PCBs and polychlorinated dibenzo-p-dioxin and dibenzofuran compounds. Elevated levels of some organochlorine compounds and PAHs have been detected from dolphin biopsy samples collected from central and southern Great Barrier Reef. These elevated levels could impair the species immune, endocrine and nervous systems, health status or reproduction (Woinarski et al. 2014). Infections of the parasite *Toxoplasmosis gondii* have been recorded in Australian humpback dolphins in the Townsville region. *T.gondii* is a terrestrial parasite that can be fatal or have deleterious effects on the health of marine mammals (DoEE 2018d). Pathogens may enter the environment through pollution and present a risk to the inshore dolphin populations, including the Australian humpback dolphin and the Australian snubfin dolphin. The nature of Project activities is considered unlikely to introduce disease that may cause species decline. The Dredging EMP and Project EMP (refer Appendices Q1 and Q2, respectively) will include mitigation measures to minimise the potential of Project activities introducing disease to Port Curtis which may cause species decline. The movement of materials and equipment, which may act as transport mediums for disease, will be subject to the Project EMP. Management plans included in the Dredging EMP will contain measures to reduce the potential for Project activities to introduce harmful contaminants into the marine environment. Any potential Project impact associated with introduction or spread of harmful diseases to Australian humpback dolphin or the Australian snubfin dolphin is considered to be negligible.

Significant impact assessment criteria and likelihood of the action resulting in a significant residual adverse impact
MSES significant impact assessment criteria – Protected wildlife habitat ▪ Interfere with the recovery of the species
Unlikely to have a significant impact There are no adopted or made recovery plans for the Australian humpback dolphin or the Australian snubfin dolphin (DoEE 2018d; DoEE 2018e). The *Action Plan for Australian Mammals 2012* (Woinarski et al. 2014) identifies key management actions which are recommended to help conserve viable populations of the Australian humpback dolphin and the Australian snubfin dolphin. Specific management actions have been recommended across two themes, active mitigation of threats and community engagement. Specific actions include: ▪ Ensure high levels of protection in important habitats ▪ Reduce incidental catch in nets and other fisheries impacts ▪ Improve national coordinated planning and management of port and coastal development ▪ Enhance community education programs to increase awareness and reporting of sightings of the species. Inform stakeholders including Traditional Owners, fishers and other users of marine environments, of best practice codes of conduct for avoiding injury or death of Australian humpback dolphins and Australian snubfin dolphins. With respect to the nature of the Project activities, the Project is not considered likely to result in impacts that will interfere or impede with the aforementioned specific recovery actions for the Australian humpback dolphin or the Australian snubfin dolphin.

9.21.8 Assessment summary

To describe the marine mammal assemblages and key habitat values within the Project impact areas, a review of government databases, scientific literature and recent ecological surveys was conducted. The Project impact areas include intertidal and subtidal environments which provide habitat value for marine mammals of conservation significance, including dugongs, inshore dolphins and whales.

The Port Curtis and Rodds Bay regions provide suitable habitat for dugongs in the form of extensive coastal and deep-water seagrass meadows. The Port Curtis and surrounding regions also provide suitable habitat and food resources for inshore and coastal dolphin species. Several whale species can be can be found seasonally migrating in coastal waters around the Port Curtis region, and Humpback whales are very occasionally seen within Port of Gladstone.

The loss and degradation of habitat through coastal development and reclamation is a major impact to dugongs and inshore dolphin species in the Great Barrier Reef region (GBRMPA 2012f; 2014c). Therefore, the most notable potential impact to marine mammals from the Project is the direct and permanent loss of coastal seagrass habitat as a result of the establishment of the WBE reclamation area as well as indirect impacts from areas adjoining the WBE reclamation area (156.41ha of coastal seagrass habitat based on the 2017 seagrass surveys) (Chartrand et al. 2018).

During dredging activities, a short term decline in water quality is expected to occur in the form of increased turbidity caused by sediment resuspension, predominantly concentrated in and around the areas to be dredged (referred to as the ‘zone of high impact’). Increased turbidity has the potential to impact important dugong and dolphin habitat at seagrass meadows through temporarily decreasing benthic light conditions and smothering through sediment deposition. Hydrodynamic modelling suggests the licenced dewatering discharge from the WBE reclamation area will not result in a wide-reaching ‘zone of high impact’.

Other water quality impacts also have the potential to occur as a result of the establishment of the WBE reclamation area and BUF, via sediment-laden runoff, spills of hazardous substances and through dredging activities via the mobilisation of contaminated sediments. These potential water quality impacts represent lower likelihood and lower risk impacts after the implementation of mitigation measures.

An increase to underwater noise and vibration above background levels has the potential to occur through Project activities. The establishment of the WBE reclamation area and BUF, and dredging activities associated with the Project are not expected to result in any significant adverse noise impacts on marine mammal species due to the low levels of noise emissions being emitted. Behavioural changes may occur in marine mammal species in response to underwater noise generated during the aforementioned Project activities, however it is unlikely that temporary or permanent hearing trauma to marine mammals will result from these activities.

The removal and installation of navigational aids has the potential to result in mortal injuring to dugong within a 160m radius of piling activities and potential behavioural displacement responses by dugong have the potential to occur within a 2km radius of the activity. Noise emitted from the removal and installation of navigational aids from a single piling strike was found to not cause PTS-onset injury for dolphins however, zones of impact for PTS-onset extend from 50m for 1-minute duration, 310m for a 10-minute duration and 1.4km for a 1-hour duration. Noise from a single piling strike associated with navigational aid activity is predicted to cause TTS-onset in dolphins within 18m of the source location, 700m for 100 strikes and 6km for 6,000 strikes. Zones of impact for potential behavioural changes are predicted to be up to 3.4km from piling locations.

Other unmitigated Project activities have the potential to result in the injury or death to individual marine mammals, notably dugongs through an increase of waste materials entering the marine environment (i.e. ingestion or entanglement marine debris), vessel strike, direct contact with construction plant or entrapment in reclamation areas.

The Project will implement mitigation measures provided in the Project EMP and Dredging EMP, and associated management plans to reduce the likelihood and magnitude of potential Project impacts on marine mammals. The implementation of mitigation measures contained in the aforementioned EMPs will reduce residual Project impacts on marine mammals.

The potential for a Project impact to have a residual impact and contribution to a threatening process for a marine mammal species has been assessed for species of conservation significance which have been confirmed to occur, or are considered to have a high or moderate likelihood of occurrence within the Project impact areas. Where the Project was identified to have the potential to have a residual impact on a species of conservation significance. A significant residual adverse impact assessment was conducted for the species where Project activities have the potential to lead to the progressive loss of the species, or areas of ecologically significant habitat.

The significant residual adverse impact assessment concluded that the proposed Project activities at the WBE reclamation area have the potential to result in a significant residual adverse impact on dugongs in the area, while it is unlikely to have a significant residual adverse impact on inshore dolphin species. The Project is considered to have a potential significant impact on local dugong populations, in accordance with the MSES significant impact guidelines for protected wildlife habitat (EHP 2014a).

9.22 Marine pests

9.22.1 Background

A formal marine pest survey was undertaken in the Port of Gladstone in 2000 (Lewis et al. 2001), and though no introduced marine pest species were recorded at the time of the survey, eight of the species identified have since been included on the NIMPIS. The NIMPIS is an initiative of the Australian Government which aims to prevent the introduction of new marine pests, to guide the response to management of new pest species, and to minimise the spread and impact of pest species that are already established in Australia (Department of Agriculture 2013).

In the Port of Gladstone in 2006, investigation of a suspected marine pest incursion positively identified the presence of the pest bivalve species the Asian green mussel (*Perna viridis*) (Anderson et al. 2006; VE 2015d). Due to the potential for this species to cause extensive ecological, economic and human health impacts, measures were undertaken to eradicate the species and prevent the spread of the species (Anderson et al. 2006; VE 2015d).

An additional marine pest survey was undertaken in 2015, which included the survey of 18 locations within the Port of Gladstone, including wharves, anchorages, marina berths, slipways and other potential vector nodes for the introduction and/or spread of marine pest species (VE 2015d). This survey identified four introduced marine pest species within the Port, however the Asian green mussel was not recorded during the surveys (VE 2015d). The four introduced species identified in this survey are no new incursions to Australia, however two of the species had not been previously reported in the Port of Gladstone (VE 2015b).

The methodology implemented to describe the marine pests values is provided in Appendix I1 (Section 16.2).

9.22.2 Marine pest risks

In 2000, a survey of Port Curtis was undertaken to establish a baseline list of native and introduced species (Lewis et al. 2001). The survey was conducted by Central Queensland University, in collaboration with Commonwealth Scientific and Industrial Research Organisation's (CSIRO's) Centre for Research on Introduced Marine Pests. All specimens collected as part of the survey were formally taxonomically identified at museums. In total, 22 introduced species sites were surveyed and monitored within the greater Port Curtis area (refer Figure 9.81).

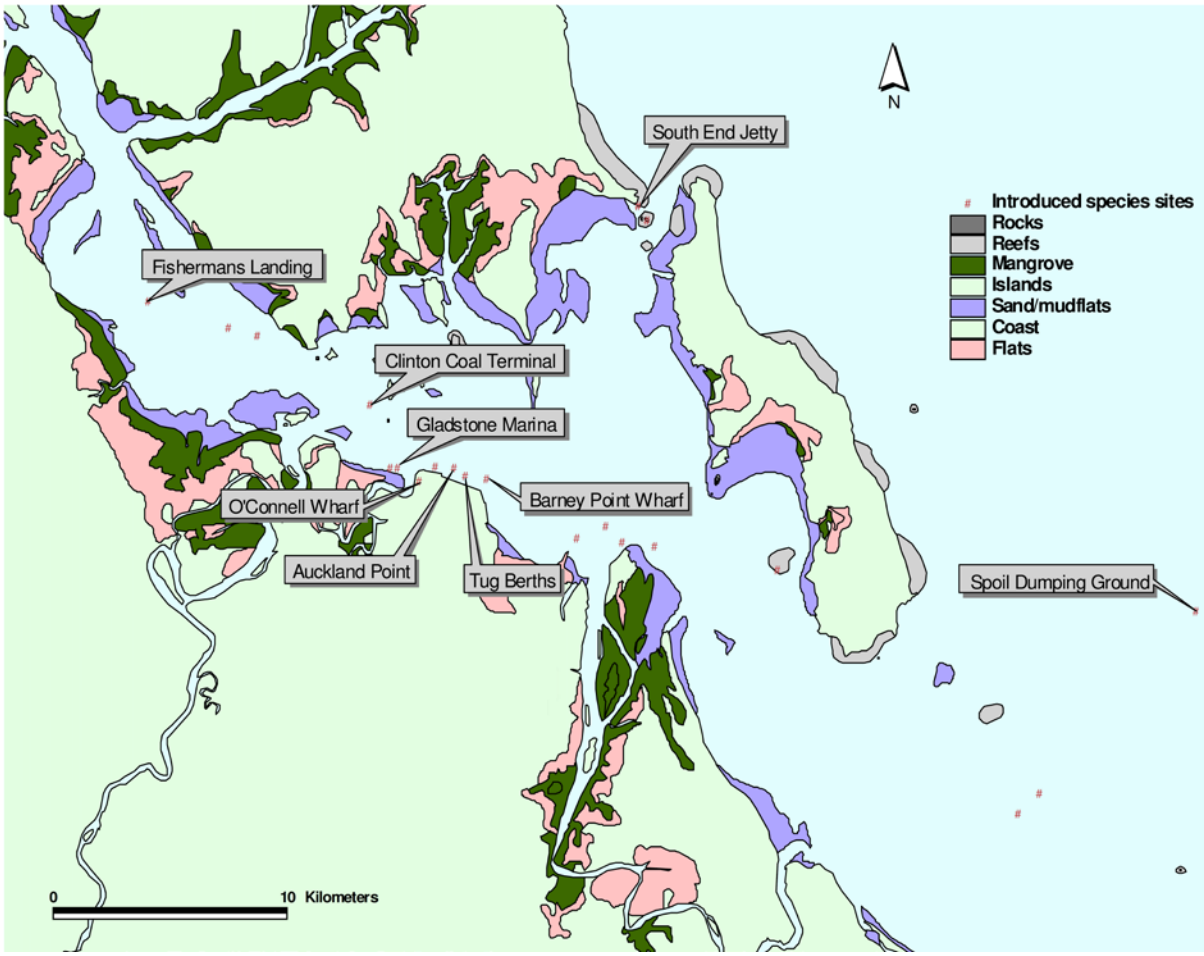

Figure 9.81 Marine pest survey locations undertaken in 2000

Source: Lewis et al. (2001)

Lewis et al. (2001) observed no marine pest species, during their investigations. However, 10 introduced species were identified. These species consisted of the following:

- Two ascidians:
  - *Styela plicata*
  - *Botrylloides leachi*
- Five bryozoans:
  - *Amathia distans*
  - *Bugula neritina*
  - *Cryptosula pallasiana*
  - *Watersipora subtorquata*
  - *Zoobotryon verticillatum*
- A hydrozoan: *Obelia dichotoma*
- An isopod: *Paracerceis sculpta*
- A dinoflagellate: *Alexandrium* sp.

The species identified by Lewis et al. (2001) were noted as being widespread in ports across Australia and across the world, and were not thought to represent a threat to native species in Port Curtis, other than through direct competition for habitat between some bryozoans (Lewis et al. 2001). Several of the species that were observed during the investigations have since been listed on the NIMPIS Queensland target pest species list (DAFF 2009).

In 2006, GPC and Queensland Parks and Wildlife Service investigated a suspected marine pest incursion in Port Curtis (Andersen et al. 2006; VE 2015d). A positive identification was made of a pest bivalve species (*P. viridis*), which is considered a marine pest emergency (DAFF 2005) due to its potential to cause extensive ecological, economic and human impacts. Measures were undertaken at the time to eradicate the species and to prevent spreading (Andersen et al. 2006).

In 2015, a survey of Port Curtis was undertaken to determine the presence/absence of introduced species and marine pest species within key areas frequented by vessels, and subject to shipping and dredging activities (VE 2015d). In total, 18 locations were surveyed to align with potential vector nodes, as identified by the Australian Marine Pest Monitoring Guidelines (DAFF 2010) (refer Figure 9.82).

Figure 9.82 Biosecurity survey locations undertaken in 2015

Source: VE (2015d)

Four introduced species from the NIMPIS Queensland target pest species list (DAFF 2009) were identified, including:

- *Hydroides sanctaecrucis* (Caribbean tubeworm)
- *Ulva fasciata* (Sea lettuce)
- *Paracerceis sculpta* (Sponge isopod)
- *Cryptosula pallasiana* (Encrusting bryozoan) (VE 2015d).

The above pest species have been previously recognised as having been translocated to Australia, potentially as biofouling on ships' hulls and through ballast water discharge (VE 2015d). Two of the species, the Caribbean tubeworm and Sponge isopod, were also previously recorded by Lewis et al. (2001) in Port Curtis.

None of the species recorded as part of the 2015 Biosecurity Survey are listed as high risk species in either the Introduced Marine Pest, or Declared Pest lists on NIMPIS (DAFF 2009), although *H. sanctaecrucis* is listed as a potential medium impact on the domestic list (VE 2015d). Similarly, these species do not appear on the Australian Emergency Marine Pest Plan (EMP Plan) Trigger List, nor do they satisfy the criteria to be included on this list (DAFF 2005), indicating that their identification does not warrant a marine pest emergency response. Actions to eradicate, or limit the distribution of these species were not recommended, as these species are ubiquitous nature in other Australian ports and that they are likely already well established in Port Curtis (VE 2015d).

The marine baseline assessment for the WBDDP EIS did not detect any introduced marine pest taxa within Port Curtis (GHD 2009c).

More recently, surveys conducted by Rasheed et al. (2003), McKenna et al. (2013), Davies et al. (2015c), VE (2015b), to assess microbenthic communities (i.e. macroinvertebrates and algae) did not identify the presence of any listed marine pest species within Port Curtis (refer Appendix I1 (Section 16.4)).

9.22.3 Potential impacts

The introduction of marine pest species to the GBRWHA is a threat to its OUV (DSEWPC 2013b). There is potential that the dredging equipment and other vessels could translocate introduced marine pests from the port of origin to the Port of Gladstone. Only a few marine pest outbreaks have occurred at the Port of Gladstone in recent years. While marine pests, if present, could be transported from the dredgers or barges to the local marine environment, the Project is not considered likely to have a notable risk in terms of the potential of introducing marine pests into the Port of Gladstone and surrounds if appropriate biosecurity inspections and management are employed.

9.22.4 Mitigation measures

In the event that marine pests are introduced into the local environment by the Project, the dredging contractors' Ballast Water Management Plan will be implemented in accordance with the Australian Ballast Water Management Requirements (Version 7) (Commonwealth Government 2017) and under the Project and Dredging EMPs. The management plans will include contingency measures that include, but are not limited to, the following:

- Immediate notification to DAF (Biosecurity Queensland), Department of Agriculture and Water Resources, DES and MSQ
- Follow any directions or notices given by a regulator in relation to marine pests
- Corrective actions (i.e. immediate investigation strategies, holding the balance of ballast on board, transferring the balance between tanks, examining ship to shore transfer options, etc.)
- Consequential reporting/liaison requirements.

Section 9.27.3 provides further details on the pest and weed management plan and Ballast Water Management Plan (BWMP) mitigation measures.

9.23 Operation of the duplicated shipping channels

Once the proposed changes to the navigational aids associated with the Project have been implemented, tested and commissioned, the duplicated shipping channels will be utilised by commercial vessels within the Port. The deepening of the channels will not change the existing Port maritime operations and the existing Port procedures will be implemented for vessel movements within the duplicated channels.

While the Project will facilitate an improvement in the existing and future vessel movement efficiency, and a reduction in the likelihood of vessel incident risk, the duplication of the shipping channels will not have any direct influence on increasing commercial vessel movement numbers within the Port.

Therefore, operation of the duplicated shipping channels, based on existing approved Port throughput, is not expected to result in a significant change to the current potential impacts on intertidal flora, terrestrial flora, wetland values, seagrass, macroalgae, fish species, fisheries values, other marine reptiles, migratory shorebirds, migratory seabirds, intertidal or terrestrial fauna assemblages or marine mammals in Port Curtis.

Operation of the established duplicated shipping channel has the potential to result in hydrodynamic changes, which have the potential to cause an increase in sedimentation and deposition on benthic macroinvertebrate assemblages and reef habitat.

Hydrodynamic changes associated with the established duplicated channel are not expected to be large in magnitude or extent. Numerical modelling results indicate that a slight increase in siltation will be a result of the duplicated Golding Cutting Channel due to a reduction in velocity caused by the increased water depth (refer Appendix G).

Potential hydrodynamic changes due to the operation of the duplicated shipping channel are not expected to result in major changes to soft sediment habitats or benthic macroinvertebrate communities in the affected areas and are unlikely to adversely affect reef habitat in Port Curtis.

9.24 Maintenance dredging

The existing Port of Gladstone shipping channels, swing basins and berthing pockets are subject to ongoing disturbance as a result of regular maintenance dredging. The small increase in maintenance dredging from the duplicated channels will result in no overall change to the potential impacts and risks associated with the GPC annual Port maintenance dredging campaign (refer Appendix G).

The potential impacts to ecological values from maintenance dredging include:

- Potential noise and vibration impacts
- Potential vessel strike impacts
- Direct contact or entrapment with dredgers
- Short term decline in water quality in the marine environment
- Contaminant releases
- Reduction of available light in the water column
- Loss and alteration of habitat and species through physical removal (i.e. benthic macroinvertebrates)
- Potential artificial lighting impacts
- Increase in waste material and marine debris
- Displacement and disorientation
- Increased competition, predation or disease due to pest and weed species which may be introduced or spread during works

The post mitigation risk ratings (refer Appendix I4) for each ecological value are shown in Table 9.81.

Table 9.81 Potential impacts to ecological values from maintenance dredging and post mitigation risk ratings

Ecological value	Post mitigation risk rating for values expected to be impacted
Terrestrial and intertidal flora and wetlands	▪ Medium for Port Curtis DIWA wetland ▪ Low for Queensland HES wetlands ▪ Negligible for other terrestrial and intertidal flora values
Seagrass meadows and epibenthic macroalgae	▪ Low for epibenthic macroalgae ▪ Medium for deep water seagrass meadows ▪ High for coastal seagrass meadows
Reef communities	▪ Low for rocky reef habitat (i.e. not coral reef habitat) ▪ Negligible for coral reef habitat
Fish and marine reptiles (excluding marine turtles)	▪ Low for estuarine and coastal fish communities ▪ Negligible for all other fish and fisheries values
Soft sediment habitats and benthic macroinvertebrates	▪ Low for soft sediment habitats and benthic macroinvertebrates
Migratory shorebirds and migratory seabirds	▪ Negligible for all migratory shorebirds and seabirds
Intertidal and terrestrial fauna	▪ Negligible for all intertidal and terrestrial fauna
Marine turtles	▪ Low for Green and Flatback turtles ▪ Medium for Hawksbill and Loggerhead turtles
Marine mammals	▪ Low for all species of marine mammals

Mitigation measures to reduce potential impacts to ecological values as a result of maintenance dredging are addressed in the following documents, prepared as part of the Commonwealth and State Government approval process for the Port-wide maintenance dredging campaign:

- Long Term Monitoring and Management Plan for Sea Disposal of Maintenance Dredge Material 2013-2018 (GPC 2015) (and subsequent versions)
- Port of Gladstone Maintenance Dredging Environmental Management Plan 2018 (GPC 2018c) (and subsequent versions)
- Gladstone Maintenance Dredging Environmental Monitoring Procedure (GPC 2018d).

9.25 World Heritage values of the Great Barrier Reef within Port Curtis

9.25.1 Summary of outstanding universal value

Table 9.82 summarises the attributes of the OUV of the GBRWHA that are present within the Port of Gladstone, and the relevant natural heritage criteria. These natural heritage criteria are defined and further discussed in Appendix I1 (Section 6).

The local expression of these OUV attributes has been undertaken for the Port of Gladstone, and a summary is provided in the following section.

Table 9.82 Outstanding universal value attributes of the Great Barrier Reef World Heritage Area present in the Port of Gladstone and surrounds

Overview of attributes	Criterion vii – aesthetic values and superlative natural phenomena	Criterion viii – ongoing geological processes	Criterion ix – ecological and biological processes	Criterion x – biodiversity conservation
Connectivity: cross-shelf, longshore and vertical		●	●	●
Continental island	●	●	●	●
Beaches	●			
Dune systems	●	●		
Fringing reefs	●	●	●	●
Inshore turbid reefs		●	●	●
River deltas	●	●	●	●
Marine faunal groups diversity	●		●	●
Coral species – diversity and extent	●	●	●	●
Total species diversity	●		●	●
Island plant species diversity	●		●	●
Seagrass	●	●	●	●
Mangroves	●	●	●	●
Marine turtles	●			●
Whales	●			●
Threatened and endangered species				●
Dolphins	●			●
Seabirds	●		●	●
Traditional Owner interaction with the natural environment[1]			●	

Table note:

1 While the Great Barrier Reef is not listed for cultural values, 'man's interaction with his natural environment' was part of the natural heritage criteria in use at the time of listing. While the criteria have changed and it is no longer explicit, the value is recognised in the property's Statement of OUV in relation to criterion ix – ongoing ecological processes

Source: Commonwealth of Australia (2013)

9.25.2 Local expression of the outstanding universal values

Under the Ports Act, the Port of Gladstone is defined as one of four priority ports in Queensland (along with Port of Abbot Point, Ports of Hay Point and Mackay, and Port of Townsville), requiring a port master plan to ensure sustainable development of the port into the future.

The key purpose and objectives of a master plan (for a priority port) is to:

- Define the master planned area and precincts
- To establish a long term vision for the priority port through development of a strategic vision
- To state the objectives, desired outcomes and relevant state interests for the priority port
- To include an environmental management framework (EMF) to manage the environmental values within the master planned area in accordance with the principles of ecologically sustainable development (ESD).

The Master Plan for the priority Port of Gladstone (PPG) was published in 2018 (TMR 2018b).

As part of the PPG master planning process, an assessment of the local expression of the OUV attributes within the PPG was undertaken, to determine the contribution of these locally expressed attributes to the overall OUV of the GBRWHA (refer Appendix I1 (Section 6.3)).

In summary, the key steps in identifying and describing the local expression attributes of the OUV of the GBRWHA in the PPG master planned area and surrounding areas included:

- Identify the presence of the attributes (as listed in the *Statement of Outstanding Universal Value for the Great Barrier Reef World Heritage Area* (DoE 2012)) within the PPG master planned area and surrounds
- Determine relative abundance, spatial distribution and condition of attributes present
- Evaluate the contribution of the attributes to the OUV (in accordance with the defined methodology)
- Compile and report on local expression of the attributes of the OUV of the GBRWHA.

The local expression of the attributes of the OUV of the GBRWHA in the PPG was then considered in the master planning process (including the risk assessment of different port development scenarios). It also assisted in developing the PPG precincts and the EMF objectives for the PPG Master Plan.

Table 9.83 summarises the locally expressed OUV attributes within the PPG master planned area and surrounding areas, and their contribution classifications relative to the overall OUV of the GBRWHA. Table 9.83 also includes a summary of the environmental values determined to be key contributors to the local expression of the attributes of the OUV of the GBRWHA (i.e. key environmental values). Other environmental values are recognised as locally contributing to the overall OUV of the GBRWHA and are identified in the addendum to the evidence base for the PPG (Aurecon 2017).

Table 9.83 Local attributes of the outstanding universal value of the Great Barrier Reef World Heritage Area within and surrounding the priority Port of Gladstone master planned area

Category	Local attribute	Relevant OUV criteria and contribution classifications[1]				Summary of the key environmental values
		vii[2]	viii[3]	ix[4]	x[5]	
Coral reefs	Fringing reefs	**Min**	**Min**	**Min**	**Min**	Fringing coral reefs
	Inshore turbid reefs	**-**	**Min**	**Min**	**Min**	Inshore turbid coral reefs
	Coral species diversity and extent	**Min**	**Min**	**Min**	**Min**	Various coral species
Marine water quality	Marine water quality	**-**	**-**	**Mod**	**Mod**	Marine water quality
Fish	Fish species and diversity	**Min**	**-**	**Min**	**Min**	Colosseum Inlet Fish Habitat Area Dē-răl-lĭ (Calliope River) Fish Habitat Area Other Fish Habitat Areas Coral reefs, seagrass meadows, mangrove communities, hard and soft benthic substrates, beach habitats, estuaries, creeks and rivers
Marine mammals	Dugong	**-**	**-**	**-**	**Mod**	Dugong species Seagrass meadows
	Species of whales	**-**	**-**	**-**	**Min**	Minke whales Sperm whales Humpback whales
	Migrating whales	**Min**	**-**	**-**	**-**	Humpback whales and calving habitat
	Species of dolphins	**Min**	**-**	**-**	**Sig**	Australian humpback dolphins

Category	Local attribute	Relevant OUV criteria and contribution classifications[1]				Summary of the key environmental values
		vii[2]	viii[3]	ix[4]	x[5]	
Marine turtles	Breeding colonies of marine turtles	**Mod**	-	-	**Mod**	Flatback turtle rookery on Curtis Island Nesting beaches on Facing, Curtis and Wild Cattle Islands, Boyne Island Beach and Tannum Sands
	Green turtle breeding	**Min**	-	-	**Min**	
	Marine turtle rookeries	**Mod**	-	-	**Mod**	
	Nesting turtles	**Min**	-	-	-	
Seagrass and macroalgae	Seagrass	**Min**	**Min**	**Mod**	**Mod**	Seagrass meadows
	Beds of *Halimeda* algae	-	-	**Min**	-	Beds of *Halimeda* algae
Shorebirds and migratory seabirds	Seabirds	**Min**	-	**Min**	**Min**	Potential foraging habitat
	Shorebirds and migratory birds	-	-	-	**Sig**	Threatened migratory shorebird species Shorebird habitat and important roost sites (note these vary from year to year)
Flora, fauna and ecological communities	Threatened and endangered flora and fauna species (including threatened ecological communities)	**Min**	-	-	**Mod**	Coastal Saltmarsh Threatened Ecological Community
	Vegetated mountains	**Min**	-	-	-	Mount Larcom landform
	Mangroves	**Min**	**Min**	**Min**	**Min**	Various mangrove species
	Mangrove species diversity	-	-	-	**Min**	Various mangrove species
	Vast mangrove forests	**Mod**	-	-	-	Mangrove sequences at The Narrows
Continental islands	Continental islands and green vegetated islands	**Mod**	**Mod**	-	-	Curtis Island
	Plant species diversity and endemism (species being unique to a defined geographic location)	-	-	-	**Sig**	Curtis Island
	Vegetation of the continental islands	-	-	**Sig**	**Sig**	Curtis Island
Geomorphology	Beaches	**Min**	-	-	-	Curtis Island beaches Facing Island beaches Boyne Island Beach
	Dune systems	**Min**	**Min**	-	-	Parabolic dunes Curtis Island
	River deltas	**Min**	**Min**	**Min**	**Min**	Marine tidal sand deltas (Curtis Island, Boyne River, Colosseum Inlet)

Category	Local attribute	Relevant OUV criteria and contribution classifications[1]				Summary of the key environmental values
		vii[2]	viii[3]	ix[4]	x[5]	
	Connectivity: cross-shelf, longshore and vertical	-	**Min**	**Min**	**Min**	The Narrows tidal passage
Cultural heritage values	Traditional Owner interaction with the natural environment	-	-	**Mod**	-	Indigenous cultural heritage sites and values
Marine fauna	Diversity supporting marine fauna species (global conservation significance)	**Min**	-	**Min**	**Mod**	A diverse range of marine fauna species
Total species diversity	Total species diversity	**Mod**	-	**Mod**	**Mod**	A diverse range of marine, intertidal and terrestrial flora and fauna species

Table notes:

1 Min Minor Mod Moderate Sig Significant
2 vii Aesthetic values and superlative natural phenomena
3 viii Ongoing geological processes
4 ix Ecological and biological processes
5 x Biodiversity conservation

9.25.3 Potential impacts and risk assessment

A significant residual adverse impact assessment has been conducted to identify if the Project will, or is considered likely to have, a significant residual adverse impact on values of the GBRWHA, which is defined as a MNES.

The GBRWHA values subject to this significant impact assessment form part of the:

- GBRWHA MNES
- Great Barrier Reef National Heritage Place MNES.

The impact assessment included in this section has been conducted in accordance with the *Matters of National Environmental Significance Significant Impact Guidelines, Version 1.1* (DoE 2013) and the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (EHP 2014a).

This assessment of significant residual adverse impacts considers the significance of potential Project impacts after the implementation of the Project mitigation measures included in Section 9.27, the Dredging EMP and Project EMP.

The significant residual adverse impact assessment provided in Table 9.84 provides the assessment against the World Heritage values and the National Heritage values for the Great Barrier Reef. The World Heritage values and the National Heritage values of the Great Barrier Reef which were considered for the purposes of the significant residual adverse impact assessment include the following:

- World Heritage values of the Great Barrier Reef
  - The 2012 *Statement of Outstanding Universal Value for the Great Barrier Reef World Heritage Area* establishes that the GBRWHA meets all four natural heritage criteria of the current Operational Guidelines, all of which are considered to be present within the Port of Gladstone. These are:
    - Criterion vii – Contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance

    - Criterion viii – Be outstanding examples representing major stages of earth's history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiographic features
    - Criterion ix – Be outstanding examples representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, freshwater, coastal and marine ecosystems and communities of plants and animals
    - Criterion x – Contain the most important and significant natural habitats for in situ conservation of biological diversity, including those containing threatened species of OUV from the point of view of science or conservation.
- National heritage values of the Great Barrier Reef
  - Criterion A, Events and processes
    - Value assessed as World Heritage criteria (vii), (viii), (ix) and (x)
    - This place is taken to meet this National Heritage criterion in accordance with subitem 1A(3) of Schedule 3 of the *Environment and Heritage Legislation Amendment Act (No.1) 2003*, as the World Heritage Committee has determined that this place meets World Heritage criteria (vii), (viii), (ix) and (x) (DoEE 2018b).
  - Criterion B, Rarity
    - Value assessed as World Heritage criteria (x)
    - This place is taken to meet this National Heritage criterion in accordance with subitem 1A(3) of Schedule 3 of the *Environment and Heritage Legislation Amendment Act (No.1) 2003*, as the World Heritage Committee has determined that this place meets World Heritage criterion (x) (DoEE 2018b).
  - Criterion C, Research
    - Value assessed as World Heritage criteria (viii), (ix) and (x)
    - This place is taken to meet this National Heritage criterion in accordance with subitem 1A(3) of Schedule 3 of the *Environment and Heritage Legislation Amendment Act (No.1) 2003*, as the World Heritage Committee has determined that this place meets World Heritage criteria (viii), (ix) and (x) (DoEE 2018b).
  - Criterion D, Principal characteristics of a class of places
    - Value assessed as World Heritage criteria (viii), (ix) and (x)
    - This place is taken to meet this National Heritage criterion in accordance with subitem 1A(3) of Schedule 3 of the *Environment and Heritage Legislation Amendment Act (No.1) 2003*, as the World Heritage Committee has determined that this place meets World Heritage criteria (viii), (ix) and (x) (DoEE 2018b).
  - Criterion E, Aesthetic characteristics
    - Value assessed as World Heritage criteria (vii)
    - This place is taken to meet this National Heritage criterion in accordance with subitem 1A(3) of Schedule 3 of the *Environment and Heritage Legislation Amendment Act (No.1) 2003*, as the World Heritage Committee has determined that this place meets World Heritage criterion (vii) (DoEE 2018b).

The significant residual adverse impact assessment (refer Table 9.84) concluded that the proposed Project activities have the potential to have a significant residual adverse impact on the GBRWHA and the Great Barrier Reef National Heritage Place.

Table 9.84 Significant residual adverse impact assessment for the GBRWHA and Great Barrier Reef National Heritage Place

Significant residual adverse impact assessment
MNES criteria (World Heritage properties): One or more of the World Heritage values to be lost **MNES criteria (National Heritage properties):** One or more of the National Heritage values to be lost
Unlikely to have a significant impact The Project activities are unlikely to result in the loss of World Heritage or National Heritage values. There is potential for impacts to occur on the local expression OUV attributes within the Port of Gladstone, however it is not likely that these impacts will result in the loss of the local expression of the value, or the value overall. OUV that may be impacted at the local level (i.e. local expression of OUV) include marine water quality, dugong, seagrass meadows, shorebirds and migratory birds. Of these locally expressed values, only the local expression of shorebirds and migratory birds contributes significantly to the overall OUV of the GBRWHA. It is not expected that the Project will result in the loss of the local expression of the OUV of the GBRWHA, or the values of the World Heritage properties. The Project will not have a direct or notable impact on the expression of these values to the extent that a value may be lost.
MNES criteria (World Heritage properties): One or more of the World Heritage values to be degraded or damaged; One or more of the World Heritage values to be notably altered, modified, obscured or diminished **MNES criteria (National Heritage properties):** One or more of the National Heritage values to be degraded or damaged; One or more of the National Heritage values to be notably altered, modified, obscured or diminished
Unlikely to have a significant impact The Project impact assessments conducted for seagrass (refer Section 9.9), migratory and resident shorebirds (refer Section 9.17 and Section 9.7) and the dugong (refer Section 9.21) concluded that the Project is likely to have a significant residual adverse impact on these values. However, these impacts are unlikely to result in the loss or notable impacts on the values of the GBRWHA. The Project is therefore likely to have an impact on the local expression of the values of the GBRWHA at the local-level (i.e. Port Curtis), however it is unlikely the Project will significantly diminish the local expression of these values in Port Curtis. The Project activities will result in permanent impacts to seagrass communities, including the direct removal of seagrass, the fragmentation of seagrass meadows and short term changes in water quality including the suspension and resuspension of fine sediments. This represented a notable diminishing in this World Heritage value within Port Curtis, however this is not expected to result in a change to the local expression of the OUV of the GBRWHA in the Port of Gladstone as the total area to be removed (156.41ha) equates to approximately 4.33% to 5.53% of the total area of seagrass recorded within Port Curtis during the most recent surveys (2017) (refer Section 9.9). The Port Curtis region supports a relatively small dugong population although the area is considered to be regionally significant to the south Queensland dugong population. The establishment of the WBE reclamation area will result in the direct loss of seagrass communities which is potentially suitable foraging habitat for local dugong populations. Underwater noise generated during Project activities may impact on the behavioural responses of dugong within proximity to activities (i.e. associated with dredging activities and installation of navigational aids). It is not likely that these potential impacts would result in a change to the local expression of the OUV of the GBRWHA within Port Curtis. Project activities will potentially reduce the area of suitable foraging habitat for migratory and resident shorebirds due to the establishment of the WBE reclamation area and BUF. There is also potential for impacts on shorebird habitat use in areas adjacent to the WBE reclamation area and BUF during construction (e.g. noise and dust impacts). The loss of the foraging habitat as a result of the establishment of the WBE reclamation area and BUF, has the potential to interfere with the recovery of migratory shorebird populations within Port Curtis due to the loss of wetland habitat and important habitat areas. Potential impacts associated with noise and dust from the WBE reclamation area and BUF are only expected to occur until the final Project landform is achieved. Due to the availability of other important foraging and roosting sites within Port Curtis, it is not expected that the Project will result in the alteration of the local expression of this OUV attribute. With the implementation of the Dredging EMP (refer Appendix Q1) and the Project EMP (refer Appendix Q2), it is unlikely that the Project will result in the loss of the local expression of these attributes. Subsequently, it is unlikely that the Project will result in the loss of a World Heritage value of the GBRWHA, or the notable damage, degradation and/or modification of other World Heritage values of the GBRWHA.

9.26 Matters of national and State environmental significance

This section provides an overall summary of the likely impacts on MNES and MSES as a result of the Project. The information provided in Table 9.85 and Table 9.86 is summarised from information detailed in this chapter (nature conservation) and the relevant appendices (i.e. Appendix I1, Appendix I3 and Appendix I4).

9.26.1 Matters of national environmental significance

The MNES assessed in this section (and the applicable sections of the EPBC Act) include:

- World heritage properties (Sections 12 and 15A)
- National heritage places (Sections 15B and 15C)
- Wetlands of international importance (Ramsar wetlands) (Sections 16 and 17B)
- Nationally threatened species and ecological communities (Sections 18 and 18A)
- Migratory species (Sections 20 and 20A)
- Commonwealth marine areas (Sections 23 and 24A)
- Great Barrier Reef Marine Park (Sections 24B and 24C).

A summary of the MNES located in the Project impact areas is provided in Table 9.85, including the relevant sections of the EPBC Act. The table outlines where controlling provisions under the EPBC Act are not relevant to the Project activities (e.g. nuclear actions).

9.26.2 Matters of State environmental significance

The purpose of the MSES assessment is to identify MSES listed in Schedule 2 of the Offset Regulation which are either confirmed or highly likely to occur within the Project EIS database search area (refer Figure 9.1), including the Project impact areas.

A summary of the MSES located in the Project impact areas, and a summary of the likelihood of significant impacts occurring as a result of the Project is provided in Table 9.86.

Table 9.85 Matters of national environmental significance and their relevance to the Project

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of the Project impacts and significant impact assessment
World Heritage properties (Sections 12 and 15A) and National Heritage places (Sections 15B and 15C)		
The areas to be dredged (including the channel duplication and barge access channel), location of new navigational aids, the WBE reclamation area and BUF are situated within the boundaries of the GBRWHA which is both a World Heritage property and a National Heritage place (i.e. Project activities below the LAT within the Port are located within the GBRWHA)	Section 9.25 provides a summary of the local expression of the OUV of the GBRWHA within the Port of Gladstone, and that are therefore relevant to the Project. The 2012 *Statement of Outstanding Universal Value for the Great Barrier Reef World Heritage Area* establishes that the GBRWHA meets all four natural heritage criteria of the current Operational Guidelines, all of which are considered to be present within the Port of Gladstone. These are: ▪ Criterion vii – contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance ▪ Criterion viii – be outstanding examples representing major stages of earth's history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiographic features ▪ Criterion ix – be outstanding examples representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, freshwater, coastal and marine ecosystems and communities of plants and animals ▪ Criterion x – contain the most important and significant natural habitats for in situ conservation of biological diversity, including those containing threatened species of OUV from the point of view of science or conservation	**No significant impacts are expected** The Project activities have the potential to have impacts on several values that contribute to the OUV of the GBRWHA, including: ▪ Loss of seagrass meadows as a result of the establishment of the WBE reclamation area, equating to approximately 4.86% of the total area of coastal seagrass recorded in Port Curtis in 2017 surveys ▪ Potential impacts on marine fauna (including dugong and other marine mammals) through direct loss of habitat and indirect impacts such as underwater noise, temporary impacts on water quality including the suspension and resuspension of fine sediments, vessel strike and direct contact with dredging equipment ▪ Potential impacts on migratory shorebirds through direct loss of foraging habitat and potential indirect impacts associated with establishment of the WBE reclamation area and BUF (e.g. noise and dust impacts) The Project is therefore likely to have an impact on the expression of GBRWHA values at the local-level (i.e. Port Curtis), however it is unlikely that this would result in the loss or significant diminishment of the local expression of these values in Port Curtis. With the implementation of the Dredging EMP (refer Appendix Q1) and the Project EMP (refer Appendix Q2), it is unlikely that the Project will result in the notable loss, damage, degradation and/or modification of values of the GBRWHA.
Wetlands of international importance (Ramsar wetlands) (Sections 16 and 17B)		
No Ramsar wetlands are located within close proximity to the Project impact areas. Shoalwater and Corio Bay Ramsar wetlands are located approximately 98km to the north of the WBE reclamation area	▪ These wetlands are located outside of the Project impact areas and will not be impacted by the Project	**No significant impacts are expected** The Project will not impact on Ramsar wetlands.
Nationally threatened species and ecological communities (Sections 18 and 18A)		
Subtropical and Temperate Coastal Saltmarsh TEC is known to occur in Project indirect impact areas	▪ There will be no direct loss of this TEC as a result of the Project activities, however this TEC is located within the Project indirect impact areas as it is situated approximately 200m to 300m west of the WBE reclamation area	**No significant impacts are expected** As this TEC is located more than 200m from the nearest direct impact area (i.e. the WBE reclamation area), the Project will not result in the direct loss of this TEC. With the implementation of the Dredging EMP (refer Appendix Q1) and the Project EMP (refer Appendix Q2), it is unlikely that the Project will significantly impact on the Coastal Saltmarsh TEC.
Suitable habitat for threatened flora species occurs in Project indirect impact areas	▪ No threatened flora species were identified during Project EIS field investigations and no species are known to occur within the direct impact areas as identified during previous and Project EIS studies ▪ Potentially suitable habitat identified within Project potential indirect impact areas, approximately 200m west of the WBE reclamation area	**No significant impacts are expected** Potential suitable habitat for threatened flora species was identified through database searches as occurring approximately 200m west of the WBE reclamation area. With the implementation of the Dredging EMP (refer Appendix Q1) and the Project EMP (refer Appendix Q2), it is unlikely that the Project will significantly impact on threatened flora species or potentially suitable habitat for threatened flora species.

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of the Project impacts and significant impact assessment
Marine turtle species are known to forage and nest within Port Curtis, and foraging habitat is present within the Project impact areas (direct and potential indirect impact areas)	▪ Flatback turtle known to nest regularly in Port Curtis ▪ Green turtle known to occur in Port Curtis on a regular basis (only occasionally for nesting) ▪ Loggerhead turtle occasionally nests in Port Curtis ▪ Hawksbill turtle occasionally migrates through Port Curtis	**No significant impacts are expected** The Project will not result in direct or significant impacts on known marine turtle nesting beaches in the Port Curtis region. The establishment of the WBE reclamation area and BUF, and dredging activities will result in the direct removal and permanent loss of seagrass, algae and benthic habitats which provide potential foraging resources for marine turtle species. The inshore region of Port Curtis provides habitat for juvenile and sub-adult Green turtles in the form of foraging grounds and food sources such as seagrass meadows (including species *Z. muelleri*, *Halodule* and *Halophila*) along with mangroves and macroalgae (Limpus 2008a). The total area of seagrass meadows mapped at WBE reclamation area footprint was 156.41ha in 2017, which represents approximately 4.33% to 5.53% of coastal seagrass mapped in Port Curtis in 2017 (Chartrand et al. 2018). There were no seagrass meadows mapped within the Project dredging footprint recorded during 2017 surveys. The loss of seagrass meadows within the Project impact areas is not anticipated to affect the overall abundance of Green turtles in Port Curtis, given that *H. ovalis* and *Z. muelleri* are the dominant seagrass species in coastal meadows in Port Curtis. Any impacts to seagrass meadows as a result of increased turbidity through dredging activities, including the suspension and resuspension of fine sediments, is expected to be temporary and managed through an adaptive Dredging EMP and Project EMP (refer Appendices Q1 and Q2, respectively). The Project has the potential to result in impacts on marine turtles as a result of noise and artificial light sources during dredging and piling activities, however these potential impacts will be short term and contained in extent. The Project potential impacts are not considered to have a significant impact on the marine turtle lifecycle, including breeding activities; or on the availability of suitable foraging habitat.
Marine mammal species are known to occur within Port Curtis	▪ Humpback whale known to occur in Port Curtis ▪ Other marine mammals occur within Port Curtis, however are not listed as threatened species under the EPBC Act (refer to assessments for migratory species below)	**No significant impacts are expected** Several whale species can be can be found seasonally migrating in coastal waters around the Port Curtis region, and Humpback whales are occasionally seen within Port of Gladstone. However, it is unlikely that the Project impacts will result in significant direct impacts on this species or important habitat for this species.
Threatened migratory shorebirds are known from the Port Curtis, and foraging and roosting habitat is located within Project impact areas	The Project impact areas include known foraging and roosting habitat for threatened migratory shorebirds including: ▪ Western Alaskan bar-tailed godwit ▪ Curlew sandpiper ▪ Eastern curlew ▪ Great knot ▪ Northern Siberian bar-tailed godwit ▪ Red knot ▪ Greater sand plover ▪ Lesser sand plover	**Potentially significant impact** Project activities will involve the direct disturbance of migratory shorebird foraging habitat, including disturbance within and adjacent to areas of important migratory shorebird habitat (i.e. important roost sites). Project activities also have the potential to result in noise and dust impacts and may disturb migratory shorebird foraging and are anticipated to increase the level of noise and dust in areas of adjacent shorebird habitat. This may result in the potential to disturb roosting and/or foraging behaviours of migratory shorebirds. Disturbance of migratory shorebirds can result in reduced food intake and increased energy expenditure, and has the potential to result in reduced use or abandonment of preferred feeding and roosting areas (Geering et al. 2008). Disturbances resulting in increased time spent in alarm flight, can adversely impact shorebird energy reserves required for migration, and can alter the selection of roosting and foraging sites, and has the potential to ultimately affect the survival of migratory shorebirds (Collop et al. 2016; Lilleyman et al. 2016). Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of migratory shorebird habitat loss at the WBE reclamation area (refer Section 9.27). Shorebird behaviour will be monitored during establishment of the WBE reclamation area and BUF with adaptive management strategies implemented where activities are likely to result in a significant impact on migratory shorebird species in important habitats. The Dredging EMP and Project EMP (refer Appendices Q1 and Q2, respectively) include mitigation measures to minimise the potential to disturb migratory shorebirds as a result of noise and dust impacts associated with Project activities.

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of the Project impacts and significant impact assessment
Threatened migratory seabirds have a moderate potential to occur within the Project impact areas	The Project impact areas include potential habitat for threatened migratory seabirds including: ▪ Black-browed albatross ▪ Campbell albatross ▪ Chatham albatross ▪ Fairy prion (southern) ▪ Kermadec petrel (western) ▪ Salvin's albatross ▪ Shy albatross ▪ Southern giant-petrel ▪ White bellied storm petrel	**No significant impacts are expected** The Project is not considered likely to destroy an area of important habitat or cause significant disruption to an ecologically significant area of habitat for migratory seabird species. There are no known areas of breeding habitat for migratory seabird species situated within the direct or potential indirect Project impact areas. Migratory seabird species exhibit a broad range of diets and foraging behaviours (DSEWPaC 2011), and thus are not reliant on specific habitat requirements to facilitate foraging activities. The migratory seabird species subject to this assessment feed predominantly on fish, however also eat crustaceans, insects, annelids and molluscs (Garnett and Crowley 2000). Migratory seabird species are not considered to be reliant on specific microhabitats or prey resources to facilitate foraging activity. With consideration to the species capacity for long range movements, all waters within Australian jurisdiction can be considered to constitute foraging habitat for albatross and giant petrel species. Critical foraging habitat for albatross and giant petrel species is considered to occur in waters south of 25 degrees latitude, due to the closer proximity of these waters to nesting locations (DSEWPaC 2011). It is unlikely that the Project activities will result in significant impacts on the potential migratory seabird foraging habitat located in the Project impact areas, and it is therefore unlikely that the Project would impact on migratory seabird populations. Potential impacts on foraging habitat will be minimised through the implementation of mitigation measures in the Project EMP (refer Appendix Q2) and Dredging EMP (refer Appendix Q1).
Potentially suitable habitat for two threatened fauna species occurs within terrestrial and intertidal Project impact areas	Potential habitat for the following threatened species occurs in the Project indirect impact areas: ▪ Koala ▪ Water mouse	**No significant impacts are expected** There is no habitat for the Koala within the direct impact areas, and the areas of modelled potential habitat for the Water mouse (based on known habitat requirements) do not extend into the direct impact areas. Potential habitat for both species has been mapped within the Project indirect impact areas, near the WBE reclamation area. Project activities are not likely to result in impacts on the Koala or potentially suitable habitat for this species, as the Project impact areas are situated in intertidal and subtidal environments. Potential habitat for the Water mouse is located in the Project indirect areas associated with the mangrove and coastal saltmarsh communities along the coastline to the west of the WBE reclamation area. There is potential for indirect impacts on areas adjacent to potential habitat as a result of minor predicted changes in erosion, siltation and tidal velocities due to the establishment of the WBE reclamation area and BUF. However, areas of vegetation along the coastline will be monitored prior to, during and post construction of the reclamation area to identify potential adverse impacts. In the event that adverse impacts are identified on these vegetation communities (and associated potential Water mouse habitat), adaptive management strategies will be implemented. The Project activities may also result in short term declines in water quality, noise and dust impacts, however, with the implementation of the Dredging EMP (refer Appendix Q1) and the Project EMP (refer Appendix Q2), these potential impacts are not likely to have a significant impact on the Water mouse, or on potential habitat mapped for this species.
Migratory species (Sections 20 and 20A)		
Migratory marine fish species are confirmed or have a moderate likelihood of occurring in the Project impact areas	The Project impact areas provide suitable habitat for: ▪ Five shark species ▪ Two manta ray species	**No significant impacts are expected** The establishment of the WBE reclamation area will result in the direct and permanent loss of potential habitat for the Estuary stingray, however this species is not listed as migratory under the EPBC Act. The WBE reclamation area is not considered to be habitat for other migratory Chondrichthyan species listed under the EPBC Act. Dredging activities will result in the temporary loss of potential habitat for Chondrichthyan species (including species listed as migratory under the EPBC Act) associated with the duplication of the shipping channels the BUF and the barge access channel. This temporary loss is not expected to result in significant impacts on these species as the areas to be dredged are not known to be ecologically significant or important habitat. The Project activities may also result in underwater noise impacts and short term declines in water quality, however, with the implementation of the Dredging EMP (refer Appendix Q1) and the Project EMP (refer Appendix Q2), these potential impacts are not likely to impact on the size of a population, area of occupancy or important habitat for Chondrichthyan species.

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of the Project impacts and significant impact assessment
Migratory reptiles are known to occur or have a moderate likelihood of occurring within the Project impact areas	▪ Four marine turtles (refer assessment for marine turtles above)	**No significant impacts are expected** Refer to assessments provided above for threatened marine turtles.
	▪ Saltwater crocodile (*Crocodylus porosus*)	**No significant impacts are expected** Preferred nesting habitat of the Saltwater crocodile includes elevated, isolated freshwater swamps that do not experience the influence of tidal movements. The Project is not considered to directly impact key nesting habitat for the Saltwater crocodile. The primary feed sources for the Saltwater crocodile are defined by common and widespread species, including crustaceans, insects and mammals. The Project will have a potential impact on intertidal foraging resources within the WBE reclamation area and BUF, however with respect to the non-specific nature of the foraging resources and the mobility of the Saltwater crocodile and that the works will not isolate species movement, the Project is not anticipated to have a significant impact on the foraging resources for the Saltwater crocodile. The Dredging EMP and Project EMP (refer Appendices Q1 and Q2, respectively) include specific mitigation measures to be implemented during Project activities to minimise any potential for direct and indirect impacts on the Saltwater crocodile and areas of potential habitat.
Migratory marine mammal species are confirmed or have a moderate likelihood of occurring in the Project impact areas	▪ Humpback whale known to occur in Port Curtis ▪ Australian humpback dolphin known to occur in Port Curtis, and has been recorded in the Project impact areas ▪ Dugong known to occur in Port Curtis and foraging habitat is present within Project impact areas	**No significant impacts are expected for whales** Refer to assessment provided above for threatened marine mammals, including the Humpback whale. **No significant impacts are expected for dugong and the Australian humpback whale** The establishment of the WBE reclamation area and BUF, and dredging activities will result in the direct removal and permanent loss of seagrass, algae and benthic habitats which provide potential foraging resources for dugong and the Australian humpback dolphin. Establishment of the WBE reclamation area and BUF will result in the direct and permanent loss of potential habitat for dugong and the Australian humpback dolphin, including the loss of 156.41ha of seagrass mapped during 2017 surveys. This area represents approximately 4.33% to 5.53% of coastal seagrass mapped in Port Curtis in 2017 (Chartrand et al. 2018). There were no seagrass meadows mapped within the Project dredging footprint recorded during 2017 surveys. Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of habitat loss at the WBE reclamation area and BUF. Given the availability of similar habitat in the surrounding areas, the potential habitat associated with the WBE reclamation area and BUF is not considered to be 'important habitat for a migratory species'. The Project has the potential to result in adverse impacts on dugong and the Australian humpback dolphin as a result of noise associated with dredging and piling activities, however these potential impacts will be short term and contained in extent, and will be managed through the implementation of the Dredging EMP (refer Appendix Q1). During dredging activities, a short term decline in water quality is expected to occur in the form of increased turbidity caused by sediment resuspension, predominantly concentrated in and around the areas to be dredged (referred to as the 'zone of high impact'). Increased turbidity has the potential to impact important dugong and dolphin habitat at seagrass meadows through temporarily decreasing benthic light conditions and smothering through sediment deposition. The Dredging EMP will be implemented during dredging activities which will minimise and mitigate potential impacts to water quality from dredging activities (refer Appendix Q1). These plans include adaptive management measures to be adopted during dredging activities which will focus on minimising impacts at key sensitive receptors such as seagrass meadows (e.g. by focussing on benthic light thresholds). Mitigation measures to minimise water quality impacts are provided in Section 9.27 and the Dredging EMP (refer Appendix Q1). With the implementation of the Dredging EMP and Project EMP (refer Appendices Q1 and Q2, respectively) it is unlikely that the Project will have a significant impact on the Australian humpback dolphin or the dugong.
Migratory bird species are confirmed or have a moderate likelihood of occurring in the Project impact areas	▪ Sixty migratory bird species are confirmed or have a moderate likelihood of occurrence within in the Project impact areas, this includes migratory shorebirds and migratory seabirds ▪ Including populations which have exceeded approximately 0.1% of the flyway population on at least one occasion for the following species: – Eastern curlew – Grey-tailed tattler – Terek sandpiper – Lesser sand plover – Ruddy turnstone	**Potentially significant impact for migratory shorebirds** **No significant impacts are expected for migratory seabirds** Refer to assessments provided above for threatened shorebird and seabird species.

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of the Project impacts and significant impact assessment
Commonwealth marine areas (Sections 23 and 24A)		
Commonwealth marine areas include any part of the sea, including the waters, seabed and airspace, within Australia's exclusive economic zone and/or over the continental shelf of Australia. Commonwealth marine areas stretch from 3 to 200 nautical miles from the coast The Project impact areas are not located within Commonwealth marine areas, with the nearest Commonwealth marine areas situated more than 9km from the area to be dredged and the new navigational aids	Not applicable to the Project	Not applicable to the Project
Great Barrier Reef Marine Park (Sections 24B and 24C)		
The GBRMP boundary is situated on the open coastal waters side of Curtis and Facing Islands, with the closest Project impact area located more than 2km southwest of the boundary (i.e. the areas to be dredged, near the southern end of Facing Island)	▪ The GBRMP is located outside of the Project direct impact areas (i.e. nearest direct impact area is approximately 2km from the GBRMP boundary) ▪ Indirect impacts associated with dredging are likely to result in short term declines in water quality within the GBRMP boundary	**No significant impacts are expected** The Project dredging activities have the potential to result in increased turbidity and sedimentation including the suspension and resuspension of fine sediments, within the local area, which may also extend into the GBRMP. Hydrodynamic modelling predicts zones of impact extending into the GBRMP along the eastern side of Facing Island. These zones are predominantly low impact zones, with some localised areas of moderate to high impact. Any declines in water quality in the GBRMP will be temporary in nature and within a contained extent. With the implementation of the Dredging EMP (refer Appendix Q1) and the Environmental Monitoring Procedure (refer Appendix Q3), it is unlikely that the Project will have a significant impact on the GBRMP.
Nuclear actions (including uranium mining) (Sections 21 and 22A)		
Not relevant to the Project	Not applicable to the Project	Not applicable to the Project
A water resource, in relation to coal seam gas development and large coal mining development (Sections 24D and 24E)		
Not relevant to the Project	Not applicable to the Project	Not applicable to the Project

Table 9.86 Matters of State environmental significance and their relevance to the Project

MSES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of Project impacts and identification of significant residual adverse impacts
Regulated vegetation		
Regulated vegetation mapped within the WBE reclamation area, BUF and barge access channel potential indirect impact area	▪ No regulated vegetation is mapped within the Project direct impact areas ▪ 111.67ha of remnant vegetation is mapped within 500m of the WBE reclamation area and BUF (i.e. indirect impact area)	**No significant residual adverse impacts are expected** As the Project activities will not involve the direct disturbance of Prescribed REs, no significant residual adverse impacts are expected to occur as a result of the Project activities. Project activities are not expected to result in high or significant impacts to regulated vegetation within the indirect impact area.
Connectivity areas		
Connectivity value of regulated vegetation	▪ There are no core remnant areas occurring within the WBE reclamation area and BUF. The percent change of core remnant areas at a local scale following Project impact is 0%	**No significant residual adverse impacts are expected** The EHP Landscape Fragmentation and Connectivity Tool analysis determined that any Project impact on connectivity areas is not significant. The analysis is specific to the terrestrial connectivity values of regulated vegetation.
Wetlands and watercourses		
MSES HES Wetlands mapped within the Project potential direct and indirect impact areas	▪ 48.62ha mapped within the WBE reclamation area (direct impact area) ▪ 60.86ha mapped within the WBE reclamation area and BUF potential indirect impact area ▪ 0ha mapped within the areas to be dredged, or within the potential indirect impact area	**Significant residual adverse impact is likely to occur** The establishment of the WBE reclamation area will result in the direct disturbance of approximately 48.62ha of mapped HES wetlands. The loss of these HES wetlands is also likely to have an adverse impact on wetland fauna species, in particular, resident and migratory shorebirds that are known to roost and forage within close proximity to the WBE reclamation area. Project activities have the potential to have an indirect adverse impact on HES wetlands which are situated within proximity to the Project impact areas. Approximately 109.49ha of HES wetlands are mapped within a 500m radius of the WBE reclamation area and BUF. Project activities are unlikely to result in adverse impacts as a result of impacts on water quality, changes in hydrodynamic regimes, increased marine debris, spread of pest and weed species and the accidental release of contaminants. Mitigation measures outlined in Section 9.27, the Project EMP (refer Appendix Q2), and the Dredging EMP (refer Appendix Q1) will be implemented to reduce the potential impacts on wetlands.
Designated precinct in a strategic environment area		
The Project impact areas are not situated within a strategic environmental area	▪ There are no strategic environmental areas mapped within the Project direct or potential indirect impact areas	**No significant residual adverse impacts are expected** The Project activities are not expected to have a significant impact on any mapped strategic environmental areas.
Protected wildlife habitat		
Protected Dugong habitat mapped within the Project impact areas	▪ The areas to be dredged, the BUF, barge access channel and the WBE reclamation area are located within the Rodds Bay DPA Zone B ▪ The area which extends from Friend Point, at the base of The Narrows, to the bottom of Rodds Bay was declared the 'Rodds Bay DPA Zone B' to recognise the importance of the seagrass communities present as important habitat for the Dugong	**Significant residual adverse impact is likely to occur for dugong** Project activities are not considered to have a significant impact on dugong as assessed in accordance with the MNES migratory impact criteria (refer Table 9.87). However, as the establishment of the WBE reclamation area will result in the direct loss of seagrass communities which have the potential to reduce the extent of occurrence of local dugong populations. The Project is considered to have a potential significant impact on local dugong populations in accordance with the MSES significant impact guidelines for protected wildlife habitat (EHP 2014a).
Other threatened marine mammals known to occur in Port Curtis	▪ Humpback whale known to occur in Port Curtis ▪ Australian humpback dolphin known to occur in Port Curtis, and has been recorded in the Project impact areas	**No significant residual adverse impacts are expected for the Humpback whale or the Australian humpback dolphin** Refer to assessments provided above for the Humpback whale and Australian humpback dolphin in Table 9.87.

MSES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of Project impacts and identification of significant residual adverse impacts
	▪ The Beach stone curlew was recorded within the Project indirect impact areas during Project EIS field investigations, and the Saltwater crocodile has the potential to occur in Project impact areas	**Significant residual adverse impact is likely to occur for Beach stone curlew** The Beach stone curlew is a largely sedentary species (EHP 2013c). The species was recorded within the indirect impact areas associated with the WBE reclamation during the Project EIS field investigations (i.e. approximately 200m from the reclamation area footprint). The exposed mudflats and saltmarsh communities within the WBE reclamation area direct impact area likely provide suitable foraging habitat for the species. The mangrove communities within the WBE reclamation area indirect impact area provide suitable high tide roosting habitat for the species. The Beach stone curlew constructs nests in mangroves, estuaries, coral ridges or amongst short grass and scattered casuarinas. No nests for the Beach stone curlew were identified within the Project impact area during EIS field investigations, however the mangrove communities within the WBE reclamation area indirect impact area do provide potential breeding habitat for the species. The removal of foraging habitat for the species at the WBE reclamation area may potentially impact on an ecologically significant location for the Beach stone curlew. Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of shorebird habitat loss at the WBE reclamation area (including potential foraging habitat for the Beach stone curlew). Project activities may also have impact on the Beach stone curlew as a result of potential noise and dust impacts associated with the establishment of the WBE reclamation area. Shorebird behaviour will be monitored during establishment of the WBE reclamation area, with adaptive management strategies implemented where activities are likely to result in a significant impact on shorebird species (refer Section 9.27). The Dredging EMP and Project EMP (refer Appendices Q1 and Q2, respectively) include mitigation measures to minimise the potential to disturb migratory shorebirds as a result of noise and dust impacts associated with Project activities.
Marine turtle species are known to forage and nest within Port Curtis, and foraging habitat is present within the Project impact areas (direct and potential indirect impact areas)	▪ Flatback turtle known to nest regularly in Port Curtis ▪ Green turtle known to occur in Port Curtis on a regular basis (only occasionally for nesting) ▪ Loggerhead turtle occasionally nests in Port Curtis ▪ Hawksbill turtle occasionally migrates through Port Curtis	**No significant residual adverse impacts are expected** Refer to assessments provided above for threatened marine turtles in Table 9.87.
The Estuary stingray is likely to utilise habitat within the Project impact areas	The Project impact areas associated with the WBE reclamation area provide suitable habitat for the Estuary stingray	**No significant residual adverse impacts are expected** Refer to assessment provided above for migratory marine fish species in Table 9.87.
Threatened migratory shorebirds, and migratory shorebirds and seabirds listed as special least concern species are known from areas adjacent to the Project impact areas and potential habitat is located within the Project impact areas	The Project impact areas include potential habitat for threatened migratory shorebirds including: ▪ Western Alaskan bar-tailed godwit ▪ Curlew sandpiper ▪ Eastern curlew ▪ Great knot ▪ Northern Siberian bar-tailed godwit ▪ Red knot ▪ Greater sand plover ▪ Lesser sand plover The Project impact areas include potential habitat for a range of special least concern migratory shorebirds and seabirds (refer Sections 9.16 and 9.17).	**No significant impacts are expected for migratory seabirds** Refer to assessments provided above for threatened migratory seabirds in Table 9.87. **Potentially significant impacts for migratory shorebirds** Refer to assessments provided above for threatened migratory shorebirds in Table 9.87.

MSES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of Project impacts and identification of significant residual adverse impacts
Habitat for several endangered and vulnerable species is known or predicted to occur within the Project impact areas	Essential habitat is mapped within the Project indirect impact areas associated with the WB and WBE reclamation areas including: ▪ 258.34ha of Essential Habitat for the Coastal sheathtail bat ▪ 14.81ha of Essential Habitat for the Koala ▪ 5.17ha of Essential Habitat for the Water mouse	**No significant residual adverse impacts are expected for Coastal sheathtail bat, Koala, Water mouse or Saltwater crocodile** Refer to the summary provided in Table 9.87 for a summary of the potential impacts for Water mouse, Koala and Saltwater crocodile. Essential habitat is mapped for the Coastal sheathtail within the WBE reclamation area indirect impact area. These areas of habitat are considered likely to provide potential foraging habitat for the species. The Coastal sheathtail bat is associated with a large variety of habitats close to the sea, including mangroves, coastal sand dunes, Melaleuca swamps, rainforest and any other habitats within foraging range of the species roosts. The Coastal sheathtail bat is not considered to have specialised or specific resources for foraging. During the Project EIS field investigations, no roost sites (i.e. sea caves) for the Coastal sheathtail bat were identified within the Project direct or indirect impact areas. The Project is not anticipated to impact on ecologically significant locations for the Coastal sheathtail bat. Given the broad habitat requirements of this species, their highly mobile nature, availability of suitable habitat in the broader region, and the predominantly intertidal and subtidal nature of the Project activities, it is unlikely that the Project will have a significant residual adverse impact on this species.
Protected areas		
There are no protected areas, under the provisions of the NC Act, present within the Project impact areas	▪ There are no protected areas mapped under the provisions of the NC Act within the Project impact areas	**No significant residual adverse impacts are expected** The Project activities are not expected to have an impact on protected areas listed under the provisions of the NC Act.
Highly protected zones of State marine parks		
The GBRMP boundary is situated on the open coastal waters side of Curtis and Facing Islands, with the closest Project impact area located more than 2km southwest of the boundary (i.e. the areas to be dredged, near the southern end of Facing Island)	▪ There are no highly protected areas of a Queensland marine park within the Project impact areas ▪ The nearest highly protected zones are located more than 15km to the south of the Project impact areas near Rodds Peninsula	**No significant residual adverse impacts are expected** The Project activities are not expected to have an impact on highly protected zones within the GBRMP.
Fish habitat areas		
There are no declared FHA present within the Project direct impact areas	▪ Declared FHA 'Colosseum Inlet', 'Rodds Harbour' and 'Dē-răl-lĭ (Calliope River)' are located outside of the Project impact areas	**No significant residual adverse impacts are expected** There are no FHAs in the Project direct impact areas. The nearest FHA to the Project impact areas is the Dē-răl-lĭ (Calliope River) FHA which is situated approximately 15km to the east of the areas to be dredged for the barge access channel. There may be potential impacts associated with dredging activities that extent into the Calliope River (i.e. short term declines in water quality as a result of minor increases in turbidity). However, these impacts are not expected to have an adverse impact on the FHA as predicted by water quality modelling. The Project is unlikely to have adverse impacts on the FHAs located within and surrounding Port Curtis.
Waterway providing for fish passage		
Project area contains a tidal waterway providing for fish passage	▪ The WBE reclamation area is situated within an area considered to be a tidal waterway providing for fish passage	**Impacts to be determined during detailed design** The requirement for temporary and/or permanent waterway barriers will be determined during detailed design. A significant residual adverse impact assessment will be undertaken during detailed design.

MSES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of Project impacts and identification of significant residual adverse impacts
Marine plants		
Marine plant species are present within the Project impact areas	▪ Seagrass and macroalgae communities are present within the Project impact areas ▪ Marine plant communities are also present within the Project impact areas (e.g. mangroves, macroalgae, coastal saltmarsh communities)	**Significant residual adverse impact is likely to occur** The Project involves the direct loss of seagrass meadows from the WBE reclamation area. This includes the direct disturbance of seagrass communities recorded during 2017 seagrass surveys: ▪ Approximately 7.67ha within the WBE reclamation area (southern area) ▪ Approximately 114.66ha within the WBE reclamation area (northern area) ▪ Approximately 34.08ha within the areas adjoining the WBE reclamation area. The historic extent of seagrass meadows within and adjoining the WBE reclamation area and BUF is 375.06ha. This area represents almost all of the WBE reclamation area (i.e. approximately 99% of the reclamation area) and half of the BUF. The historic seagrass mapping indicates all of the locations where seagrass has been previously recorded (i.e. not necessarily all at one point in time). The historic extent of seagrass meadows within the area to be dredged for the channel duplication is 35.65ha, however no seagrass has been recorded in the channel duplication footprint since 2002. Baseline surveys will be undertaken prior to commencement of the Project to confirm the area of marine plant species present within the Project direct impact areas. The Project has the potential to result in short term declines in water quality as a result of dredging activities including the suspension and resuspension of fine sediments. Seagrass has been previously recorded within the area to be dredged for the duplication of the channels (i.e. in 2002, but has not been recorded since). There is potential for impacts on potential seagrass meadows in areas directly adjacent to the areas to be dredged. Therefore, prior to the commencement of the Project, baseline surveys will be undertaken to map the location of marine plants within and directly adjacent to the areas to be dredged. The dredging activities are unlikely to have a significant residual adverse impact on seagrass meadows due to the temporary nature of the dredge plume, the ability to modify dredging locations/durations, and the small areas of seagrass meadows in the high and moderate zones of impact (as shown on the historic seagrass mapping). The establishment of the WBE reclamation expansion area will result in the fragmentation of approximately 34.08ha of seagrass mapped in the area between the northern and southern WBE reclamation areas and between the WBE reclamation area and the main land (i.e. based on the 2017 seagrass survey). There is potential for hydrodynamic impacts on this area of seagrass once the WBE reclamation area has been established, as a result of predicted changes in tidal velocity, erosion and siltation. Seagrass adjacent to the WBE reclamation area will be monitored following construction to identify actual impacts, or to determine if it persists following construction. Baseline surveys will be undertaken prior to commencement of the Project to map areas of marine plants that are likely to be impacted by Project activities. This will further inform the assessment of fragmentation of marine communities, including seagrass meadows. No fragmentation impacts are expected to occur for the mangrove and coastal saltmarsh communities on the coastline adjacent to the WBE reclamation area (i.e. no clearing is required). These communities are located more than 200m from the Project direct impact areas. With the implementation of mitigation measures outlined in the Dredging EMP (refer Appendix Q1) and the Project EMP (refer Appendix Q2), it is unlikely that the Project will result in impacts on the mangrove and saltmarsh communities on the coastline adjacent to the WBE reclamation area.
Legally secured offset areas		
There are no legally secured offset areas situated within the Project impact areas	▪ There are no strategic environmental areas mapped within the Project impact areas	**No significant residual adverse impacts are expected** The Project activities are not expected to have an impact on any mapped strategic environmental areas.

9.27 Mitigation measures

9.27.1 Overview

As detailed throughout this chapter, there is the potential for impacts to a range of marine, intertidal and terrestrial values as a result of the Project activities. The mitigation measures set out in Table 9.87 will be implemented to minimise the potential for Project activities to impact on ecological values. The measures relate to the following broad management themes:

- Pest and weed management
- Vegetation management
- Fauna management
- Noise and vibration management
- Air quality management
- Waste management.

The measures included in this section are also included in the Project EMP (refer Appendix Q2), the Dredging EMP (refer Appendix Q1), and the Environmental Monitoring Procedure (refer Appendix Q3). Ecological mitigation measures to be implemented during the Project dredging activities are provided in the Dredging EMP (refer Appendix Q1), while the ecological mitigation measures to be implemented during the establishment of the WBE reclamation area and BUF, installation of the navigational aids and stabilisation and maintenance activities are provided in the Project EMP (refer Appendix Q2).

The ecological mitigation measures include measures to be implemented in several phases, including during the detailed design phase of the Project (refer Section 9.27.2 for an overview of these measures), prior to construction, during construction (including adaptive management measures outlined in Section 9.27.3), and during stabilisation and maintenance.

9.27.2 Adaptive design measures

During detailed design, adaptive design measures will be implemented to reduce the potential impacts of the Project on ecological values within and adjacent to the Project impact areas. The detailed design phase will avoid impacts on ecological values in the first instance. Where impacts are unavoidable, the design of structures, systems and/or ancillary works will seek to minimise potential impacts on ecological values. Examples of how adaptive design measures will be implemented during the detailed design phase of the Project include:

- Design of stormwater management systems associated with the reclamation area to appropriately locate discharge points away from sensitive ecological receptors, such as seagrass meadows
- Design of the reclamation area discharge points to prevent fauna entering the reclamation area and potentially becoming stranded/trapped, and to enable any fauna within the reclamation area safe egress into the marine/intertidal environment
- Location of construction compounds, site offices, storage or stockpiling areas in consideration of existing ecological values. These will be located within existing disturbed areas where suitable, and with adjacent ecological values and potential for indirect impacts on these values considered during detailed design and siting.

9.27.3 Adaptive management measures

The implementation of adaptive management measures will act to ensure dredging-related plumes do not cause long term harm to sensitive ecological receptors, including corals and seagrass. Ongoing water quality and BPAR monitoring will be conducted at a range of sites that are within the expected range of sediment plumes generated by the Project dredging activities. This will allow for adaptive management relating to both the extent of potential sedimentation impacts on corals, and potential light impacts (as a result of increased turbidity) on seagrass meadows (i.e. including coastal and deep water seagrass meadows).

The Project baseline water quality monitoring data were used to determine appropriate trigger levels and to establish thresholds for when adaptive measures will be implemented. To develop trigger levels for coral sedimentation, a conservative approach was applied based on biological tolerances for the most sensitive coral species. Light thresholds for all species of seagrass in both deep water and coastal environments were identified to establish maximum allowable levels in turbidity before adaptive management measures are required to be implemented. These light thresholds were established for seagrass located in high, moderate, and low impact zones taking into account the expected conditions over different periods of time (e.g. neap or spring tides, low or high winds, wave heights).

Management processes and procedures have been developed in the event that turbidity or BPAR levels exceed identified trigger levels over respective alert timeframes (refer Appendix Q3). The primary response involves performing an internal investigation (initiated within 24 hours) into the likely cause(s) of the exceedance of a trigger level. The internal investigation will include such activities as:

- Inspection of monitoring equipment to ensure the data received is accurate
- Analysis and comparison of the data with background levels and predicted dredge plume modelled data
- Identification of other anthropogenic activities occurring within Port Curtis at the time that may be contributing to the exceedance
- Identification of the sites where exceedances are recorded, relative to the location of the dredger
- Consideration of any elevated turbidity levels from natural events.

In the event that the internal investigation determines that dredging activities are the likely cause of the trigger level exceedance, adaptive management measures will be implemented. Adaptive management measures may include:

- Decreasing the rate of dredging unloading and/or placement of dredged material
- Assessment of the material being dredged at the time of the exceedance and relocating the dredger (where practical) to dredge material with greater coarseness
- Reducing the overflow rate by the barges or temporarily ceasing work in overflow mode
- Relocating dredging equipment to other sections of the channel duplication area to be dredged based on tidal movements.

If there is a continuous exceedance of trigger levels for a 24 hour period (i.e. an External Notification Level exceedance), DoEE, DES, and DTRP will be notified and a further investigation will be conducted. All necessary management strategies will then be implemented accordingly. If levels remain above the threshold levels for a 48-hour period, an environmental investigation will be undertaken, the outcomes of which will be discussed at a DTRP meeting. Additional relevant management measures will then be implemented. If these are determined to be ineffective, a second meeting will be held where additional measures and the severity of the exceedance(s) and its potential impacts will be discussed. If all management measures prove to be ineffective in stabilising turbidity and BPAR levels, all dredging activities will cease until acceptable levels are restored. A report will then be provided to DES and DoEE (within a month) describing the outcomes of the External Notification Level exceedance, the management measures that were implemented, and recommended amendments to the Dredging EMP.

Table 9.87 Relevant mitigation measures management plans

Mitigation measures	Pre-construction of WBE reclamation area	Construction of WBE reclamation area	Preconstruction for dredging	Dredging and dredged material placement	Installation of navigation aids	Stabilisation and maintenance on WBE reclamation area	Maintenance dredging
Pest and weed management plan							
A pre-construction baseline pest and weed survey will be undertaken to identify high risk species (location and abundance) within the Project direct impact areas. This survey will be used as a baseline to enable assessment against performance indicators during the construction phase. The survey will be conducted within the intertidal and terrestrial environments associated with the: ▪ WB and WBE reclamation areas and construction compounds (terrestrial and intertidal areas) ▪ BUF ▪ Quarry and haul route. This survey will target both flora and fauna pest species.	✓						
The PWMP will be updated using site specific detail obtained during the baseline pest and weed survey.	✓						
Prior to construction high risk areas will be identified (i.e. areas containing prohibited or restricted matters as defined by the Biosecurity Act) within the Project direct impact areas. Vehicle wash/blow-down facilities and procedures will be established for these areas to reduce the risk of the transport and potential spread of weed species and/or their propagules.	✓						
The Dredging Contractor will prepare a Ballast Water Management Plan (BWMP) in accordance with the *Australian Ballast Water Management Requirements* (Version 7) (Commonwealth Government 2017) (or the most recent revision). This management plan will include contingency measures that include: ▪ Information on instances where immediate notification to DAWR/DES/MSQ is required ▪ Ballast water management measures ▪ Corrective actions (i.e. immediate investigation strategies, holding the balance of ballast on board, transferring the balance between tanks, examining ship to shore transfer options, etc.) ▪ Reporting/liaison requirements.			✓				
All dredging plant will be required to conform with the BWMP and DAWR Guidelines to minimise the risk of the introduction of any introduced marine species.			✓	✓			✓
All vehicles and machinery will be visually inspected by an appropriately skilled person, prior to entering the Project impact areas.		✓		✓		✓	
All vehicles entering areas known to contain pest or weed species (high risk areas) will be washed down prior to entering a low risk area (i.e. areas free of pest or weed species).		✓		✓		✓	
Signs will be erected at entrance points, prompting the wash-down of all vehicles prior to entering low risk areas.		✓		✓		✓	
All high-risk materials (e.g. imported soil) will be certified as 'free of weeds and pests' prior to acceptance into Project impact areas.		✓		✓		✓	
Regular inspections will occur within the terrestrial Project impact areas to identify and record any sightings of pest fauna species. Appropriate mitigation measures will be developed and implemented for pest fauna species to avoid and/or minimise potential impacts on native fauna species and their habitats (e.g. migratory shorebirds and roosting/foraging habitat).		✓		✓		✓	
Any sightings of any terrestrial pest fauna species will be maintained in a log and reported back to the Contractor's Environmental Manager		✓		✓		✓	
Soil and fill material from high risk areas will not be transported to low risk areas.		✓		✓		✓	
All declared prohibited or restricted plant matter (as defined by the Biosecurity Act) detected within Project impact areas will be controlled in accordance with the specific herbicide application procedure/s, outlined in the PWMP.		✓		✓		✓	
Vehicle movement will be restricted to existing roads and temporary tracks, wherever practicable.		✓		✓		✓	
Food scraps will be removed from the Project impact areas every day so as to limit the potential for pest fauna species to enter Project impact areas.		✓		✓			
The use of herbicides and pesticides within and adjacent to intertidal/marine areas and drainage lines will be avoided and/or minimised. Products that are specifically formulated for use in environmentally sensitive areas will be used in these locations where required.		✓		✓		✓	
Major incidents resulting in a significant spread of weeds and/or pests will be reported to GPC, and the appropriate regulatory agency (e.g. DAWR, DES, MSQ)		✓		✓	✓	✓	
In the event that marine pests are introduced/spread as a result of Project activities, the BWMP contingency measures will be implemented in accordance with the Australian Ballast Water Management Requirements.				✓	✓		✓

Mitigation measures	Pre-construction of WBE reclamation area	Construction of WBE reclamation area	Preconstruction for dredging	Dredging and dredged material placement	Installation of navigation aids	Stabilisation and maintenance on WBE reclamation area	Maintenance dredging
Vegetation management plan							
If terrestrial vegetation clearing is required within areas mapped as a 'high risk' area on the flora survey trigger map, a vegetation survey will be undertaken by a suitably qualified person in accordance with the *Flora Survey Guidelines – Protected Plants* guideline (version 2.0, 2016) (or the most recent revision). This survey is required to determine if there are protected plant species within the Project impact areas that have the potential to be impacted by Project activities. In the event that protected flora species are located, and are likely to be impacted as a result of Project activities, an Impact Management Plan (IMP) will be developed which will include species-specific mitigation measures. All relevant permits must be obtained prior to clearing in accordance with the *Flora Survey Guidelines – Protected Plants* guideline (version 2.0, 2016) (or the most recent revision).	✓						
A pre-construction baseline mangrove and seagrass meadow survey will be undertaken in the Project indirect impact area (where there is the potential for impacts as a result of Project activities), in accordance with the DES *Monitoring and Sampling Manual 2018: Environment Protection (Water) Policy 2009, Version February 2018 – Biological assessment: Monitoring mangrove forest health* (or the most recent revision).	✓						
A Bushfire Management Plan (BMP) will be developed and implemented and will include measures to minimise the risk of fire on areas of native vegetation.	✓	✓		✓		✓	
The BMP will identify measures to minimise potential ignition sources associated with Project activities, including all earth-moving equipment will be fitted with fire arrestors.	✓						
The construction compound and other laydown areas will be located within existing cleared and/or disturbed areas that are considered to be of low ecological value, where practical.		✓		✓			
The design of the Project works will aim to reduce impacts on adjacent intertidal vegetation and marine plants (e.g. seagrass meadows and mangroves), where practical, and will reduce potential fragmentation impacts as a result of Project activities.	✓						
All necessary permits and approvals will be obtained prior to undertaking relevant works. Any vegetation clearing or removal of marine plants will be carried out in accordance with all relevant approval conditions.	✓		✓				
The clearing or removal of terrestrial, intertidal or marine vegetation (where unavoidable) will be restricted to the minimum required to enable the safe construction and maintenance of the Project, including minimising disturbance to ecologically sensitive areas.		✓					
The clearing of vegetation and grubbing works (if required) will employ techniques that leave the root ball intact and minimise the disturbance of soil/sediments, where practical (e.g. cut the tree at the base and leave the root structure *in situ*).		✓					
Cleared vegetation will be stockpiled and mulched for use within the reclamation works area. Stockpiles will be placed in areas of low ecological value (i.e. existing cleared and/or disturbed areas), where practical.		✓					
Parking of vehicles, stockpiling, or storage of plant/equipment will not be permitted within areas of native vegetation. Tree protection zones will be established where Project impact areas are within/adjacent to vegetated areas, as identified by a suitably qualified person (e.g. arborist, ecologist, environmental officer/manager).		✓		✓		✓	
The condition of mangrove habitats will be monitored every 6 months within areas that have the potential to be impacted by Project activities, in accordance with the DES *Monitoring and Sampling Manual 2018: Environment Protection (water) Policy 2009, Version February 2018 – Biological assessment: Monitoring mangrove forest health* (or future versions). This will be undertaken for the duration of the Project activities, and for a 2 year period following the completion of Project activities.		✓		✓		✓	
The health and extent of seagrass meadows, benthic macroalgae and the condition of coral reefs will be monitored within areas potentially impacted by Project activities as detailed within the Environmental Monitoring Procedure (refer Appendix Q3). This will include surveys during dredging and post dredging to assess the extent of these communities at multiple sites located within the low and moderate impact zones, and the zone of influence established for water quality parameters (outlined in the Environmental Monitoring Procedure).	✓	✓	✓	✓			
Dredging and dredged material placement works will be restricted to the extent necessary to enable the safe construction and maintenance of the Project, including minimising the disturbance to ecologically sensitive areas (i.e. adjacent habitats and seagrass communities).				✓			
Turbidity and Benthic Photosynthetically Active Radiation (BPAR) will be monitored during dredging activities, and adaptive management measures will be implemented where there is an exceedance of trigger values outlined in the Environmental Monitoring Procedure for sensitive ecological values (e.g. seagrasses and coral reefs).				✓			
The hydrodynamic model for the reclamation area will be validated following completion of construction to determine actual sedimentation and erosion impacts. Management measures will be revised, if required, to reduce the potential for impacts on sensitive ecological receptors (e.g. seagrass meadows, water quality).		✓					
Fauna management plan							
The detailed design of the Project works will take into account fauna impacts, with residual adverse impacts offset through the provision of suitable offsets in accordance with legislative requirements.	✓		✓				

Mitigation measures	Pre-construction of WBE reclamation area	Construction of WBE reclamation area	Preconstruction for dredging	Dredging and dredged material placement	Installation of navigation aids	Stabilisation and maintenance on WBE reclamation area	Maintenance dredging
A pre-construction fauna habitat survey will be conducted by a suitably qualified and experienced person, to detect and record details of animal breeding places (as defined under Schedule 5, Section (1) of the NC Reg) within the Project direct impact area and surrounds, and obtain additional site-specific information to supplement existing fauna data. The survey extent will include the Project direct impact areas associated with the WB and WBE reclamation areas, BUF and construction compounds, including a 100m buffer (note: where additional impact areas are required, this mitigation measure will apply). Where required, a Species Management Plan (SMP) will be developed in accordance with the requirements of the *Nature Conservation (Wildlife Management) Regulation 2006*, and approvals to operate under the SMP will be obtained as required, and in accordance with Section 88 of the NC Act, and pursuant to Section 332 of the NC Reg, to authorise any unavoidable interference with animal breeding places (as defined under the NC Reg). Where breeding habitats, such as hollow-bearing trees or nests, are located within the Project impact areas, or where they have the potential to be impacted, measures to protect or appropriately manage these habitats will be developed in accordance with the *Nature Conservation (Wildlife Management) Regulation 2006.* These measures will be included in the Fauna Management Plan (FMP) prior to construction or impacting activities being undertaken, and will address the following: ▪ Potential impacts to native terrestrial and intertidal animal breeding places, resulting from Project activities ▪ Site-specific and practical management actions to avoid or minimise both the potential immediate and long-term impact/s of removing an animal breeding place ▪ Monitoring and reporting requirements that demonstrate how management actions will be effectively implemented and will produce the intended results.	✓						
The FMP will be finalised prior to construction using site-specific detail obtained during pre-construction fauna habitat surveys. The FMP will incorporate the mitigation measures to avoid or minimise potential impacts to native terrestrial and intertidal fauna, within areas that have the potential to be impacted by Project activities.	✓		✓				
The survey for and management of wildlife will be undertaken by suitably qualified personnel with the appropriate permits and licences (e.g. fauna spotter catchers to have appropriated damage mitigation permits).	✓						
Wildlife load reduction measures will be implemented and conducted by a suitably qualified ecologist.	✓						
Where practicable, the construction of the WBE reclamation area bund wall that is nearest to the coastline will be scheduled to occur from March to September (i.e. outside of the critical migratory bird visitation periods for the majority of species visiting Port Curtis) (as presented in Appendix 3 (Timing of Migration) of the *Gladstone Ports Corporation Report for Migratory Shorebird Monitoring Port Curtis and the Curtis Coast Annual Summer Survey 2016*). Migratory birds are still likely to be present in the area outside of the March to September period, therefore measures relating to migratory shorebirds and their habitat will be implemented as required during the construction period (i.e. not restricted to these months).	✓						
During pre-construction activities, all personnel operating vehicles will be made aware of the potential to encounter native fauna, including conservation significant species, and be trained in the implementation of the relevant mitigation measures including all requirements for reporting injured/trapped fauna.	✓		✓		✓		
Appropriate signage will be installed, to promote driver awareness and provide safety for fauna crossing or inhabiting the area. Reduced speed zones will be established within proximity to sensitive areas, to be determined prior to construction by a suitably qualified person (e.g. ecologist, fauna spotter catcher).	✓		✓			✓	
If required, tree clearing activities will be undertaken in the presence of a suitably qualified and experienced fauna spotter catcher, in accordance with the FMP and other approvals and legislative requirements.	✓						
Any works occurring within sensitive habitats (e.g. shorebird habitat) will be conducted in the presence of a fauna spotter catcher.		✓					
The fauna spotter catcher will have the authority to initiate a 'stop-work' order within the buffer zone of an active breeding place (i.e. 50m for all raptor, owl, and conservation significant species; 30m for all other species). In this event, the spotter catcher will determine the appropriate management of the breeding place in accordance with the management measures included in the FMP (as developed following the pre-construction survey) and in accordance with all relevant permits and approvals.		✓					
The fauna spotter catcher will relocate any displaced fauna to a suitable recipient site, in the event that the animal is not injured. All injured animals (native or introduced) will be taken to receive immediate veterinary attention.		✓					
If an animal is injured during construction activities, works in the immediate area of the animal will cease immediately and will not recommence until rescue actions have been taken. A review of construction activities will be undertaken following the event, to minimise the risk of the event reoccurring. The results of the review will be communicated to the relevant personnel, including the requirement to adapt alternative construction methods and/or additional mitigation measures.		✓		✓			
Speed limits will be enforced for all Project activities to prevent injuries to native fauna.		✓		✓			
Where night lighting is required (i.e. cannot be avoided), the lights will be directional to avoid light spill into adjacent marine, intertidal and terrestrial areas, and appropriate bulbs will be selected and used to reduce potential impacts on marine fauna (e.g. to avoid impacts on marine turtle orientation).		✓		✓			
If fauna exclusion fencing is determined to be required as a result of the pre-construction fauna surveys, a detailed summary of exclusion fencing will be prepared and included in the FMP.	✓						
A marine species emergency response/notification plan will be developed to allow for the rapid and effective handling (e.g. capture and release) of marine fauna in the event that an incident occurs within Project impact areas.			✓		✓		
Where practicable, all vessels will be fitted with propeller guards to reduce potential impacts on marine fauna as a result of propeller strike.				✓	✓		
Dredger heads will be fitted with fauna exclusion devices, including turtle deflectors. This equipment will be appropriately serviced and inspected prior to commencement of dredging activities to ensure it is in good working order.				✓			✓

Mitigation measures	Pre-construction of WBE reclamation area	Construction of WBE reclamation area	Preconstruction for dredging	Dredging and dredged material placement	Installation of navigation aids	Stabilisation and maintenance on WBE reclamation area	Maintenance dredging
All vessel operators will be made aware of the potential for native fauna species, including conservation significant species, to occur within the Project impact areas, prior to construction				✓	✓		✓
During construction of the WBE reclamation area and BUF, migratory shorebirds will be monitored by a suitably qualified person (e.g. fauna spotter catcher, ecologist) to determine if adaptive management of Project activities is required. This will include monitoring impacts in response to a range of construction-related activities, including potential noise and dust impacts; vehicle movements; and the potential introduction and/or spread of pest species (e.g. foxes, wild dogs). Works will cease and mitigation measures developed where the suitably qualified person identifies that the Project activities are resulting in frequent alarm or flight responses, or avoidance of the area. The results of the monitoring will be reported and will include the identification of adaptive management measures to be implemented to avoid or reduce impacts on these species.		✓					
Noise spot checks will be conducted at nearby shorebird roosts during construction (i.e. Friend Point shorebird roost) and compared to the following guidelines for migratory shorebirds. Works will cease and mitigation measures developed as appropriate where noise spot checks determine that 'moderate impacts on habitat use', or 'avoidance of area' disturbance has or is likely to occur.		✓					

Disturbance effect	Steady or continuous noise sources LA_{eq} (15min)(dBA)	Episodic (single event or short-term) noise sources LA_{max} (dBA)	Typical bird activities potentially impacted
Occasional (Alert) – **minor impacts** on habitat use for most species	50 to 65	45 to 60	Nesting
Frequent (Alarm or Flight) – **moderate impacts** on habitat use	65 to 85	60 to 80	Nesting Roosting
Avoidance of area – by most of the population of some species	≥85	≥80	Nesting Roosting Foraging

Note:

- Masking impacts, particularly on smaller songbirds, may occur at noise levels of approximately the alert threshold right up until the point of avoidance
- LA_{max} limits have been specifically set below the LA_{eq} limits in recognition of considerations related to startle response

Appropriate signage will be erected in prominent positions to promote awareness of marine fauna present within the Project impact areas.		✓		✓	✓		
A marine fauna spotter will be present on all moving vessels larger than 7m in length, at all times and will conduct a pre-start search for marine fauna prior to the commencement of dredging, and will to continue to spot for marine fauna throughout dredging activities (i.e. continual observations during dredging). All fauna observations will be recorded and reported, as per the relevant approval requirements.				✓	✓		
Immediately prior to the commencement of dredging activities, a search for marine megafauna will be conducted by a suitably qualified and experienced marine fauna spotter, in accordance with the relevant management plans and permits, approvals, and legislative requirements.			✓				
Dredging works will be stopped in the event that the marine fauna spotter (or operator) observes a marine turtle or marine mammal (e.g. dolphin, dugong or whale) within 50m of the operation. Dredging will not recommence until the animal(s) have moved beyond 50m or until 15 minutes has passed and the animal(s) have not been observed within 50m of the operations during that time. The vessel may move to another area and recommence work provided that the 50m separation distance is maintained.				✓			
Vessel speed limits will be enforced within the Project impact areas to reduce the potential for injury to marine fauna. Go slow zones will be established in shallow areas, less than 5m in depth.				✓	✓		
A bund wall closure plan will be prepared to manage potential impacts on marine and intertidal fauna species. This plan will include the following measures: - When construction of the WBE reclamation area and BUF reaches the stage where the bund/sheet piling wall is to be closed, a suitably qualified and experienced marine spotter will be present to minimise the risk of marine fauna being stranded within the WBE reclamation area and BUF - If there are any instances of overflow into the reclamation area or BUF once it has been closed, the area within the reclamation area or BUF bund will be immediately inspected for any stranded fauna - Fish capture/salvage techniques will be implemented, as provided in the Fish Salvage Guidelines (DPIF 2004), if required - All personnel involved in the capture and salvage of fauna will be appropriately inducted and trained - Fauna exclusion measures will be installed on the seaward facing side of all discharge points to prevent fauna entering into the reclamation area via the discharge points. Exclusion measures will allow fauna within the reclamation area to leave and re-enter the marine environment (e.g. one-way gates).	✓	✓					

<table>
<tr><th>Mitigation measures</th><th>Pre-construction of WBE reclamation area</th><th>Construction of WBE reclamation area</th><th>Preconstruction for dredging</th><th>Dredging and dredged material placement</th><th>Installation of navigation aids</th><th>Stabilisation and maintenance on WBE reclamation area</th><th>Maintenance dredging</th></tr>
<tr><td>The bund wall/sheet piling wall closure plan will contain details on the following:
■ Qualifications and training of personnel undertaking the capture and salvage and the methods to be used
■ Details of the relevant permits under which the bund wall closure activities will be undertaken
■ Overview of the bund/sheet piling wall closure schedule, including pre-closure meetings and checks
■ Monitoring and reporting requirements.</td><td>✓</td><td>✓</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Hazardous substances with the potential to impact fauna and associated habitat will be stored within suitably contained and bunded areas, and located an appropriate distance from waterbodies and/or sensitive habitats.</td><td></td><td>✓</td><td></td><td>✓</td><td></td><td></td><td></td></tr>
<tr><td>An exclusion/safety zone will be created around the perimeter of the navigational aid impact piling. During the works, a suitably qualified marine fauna spotter will be present to ensure that navigational aid impact piling will not be carried out while:
■ Dugongs, turtles or other protected marine species are within 150m of piling activities
■ Migratory birds are within 25m of piling activities
Activities will be placed on hold for the period of time it takes the animal to leave the safety zone of its own accord.
The following fauna safety shut-down zones will also be implemented for continuous impact piling durations using the fauna spotter:
<table>
<tr><th colspan="2">Noise exposure threshold based on cumulative SEL (within a 24-hour period)</th><th>Observation zone</th><th>Shut-down zone</th></tr>
<tr><td>Duration with continuous piling
@ 100 strikes / min</td><td>Cumulative SEL
< 198dB re 1µPa^2·S</td><td></td><td></td></tr>
<tr><td>≤ 1 min</td><td>≤ 50m</td><td>1.0km</td><td>50m</td></tr>
<tr><td>10 min</td><td>310m</td><td>1.0km</td><td>310m</td></tr>
<tr><td>60 min</td><td>1.4km</td><td>2.0km</td><td>1.4km</td></tr>
</table></td><td></td><td></td><td></td><td></td><td>✓</td><td></td><td></td></tr>
<tr><td>Impact piling activities will be avoided during the following times:
■ When marine mammals are likely/observed to be breeding, calving, feeding or resting in nearby biologically important habitats (i.e. times may vary depending on species)
■ Humpback whale migration season from June to September (ie June to August for northward migration to breeding grounds, and around September for the southward migration)
■ During marine turtle peak nesting activity period from November to December.</td><td></td><td>✓</td><td></td><td></td><td>✓</td><td></td><td></td></tr>
<tr><td>■ Standard operating procedures will be required to be undertaken by contractors during impact piling activities, and will include pre-start, soft start, normal operation, stand-by operation, and shut-down procedures, as follows:
– Pre-start monitoring – the presence of marine turtles and marine mammals will be visually monitored by a suitably trained crew member for at least 30 minutes before piling commences using a soft start procedure
– Soft start – if marine turtles and marine mammals have not been observed inside the shut-down zone during the pre-start observations, soft start will commence with piling impact energy gradually increased over a 10-minute time period. A soft start will also be used after long breaks of more than 30 minutes in piling activity.
– Normal piling – if marine turtles and marine mammals have not been observed inside the shut-down or observation zones during the soft start, piling at full impact energy will commence. Visual observations will continue throughout piling activities
– Stand-by – if a marine turtle or marine mammal is sighted within the observation zone during the soft start or normal operation piling, the operator of the piling rig will be placed on stand-by to shut down the piling rig, while visual monitoring of the animal continues.
– Shut-down – if a marine turtle or marine mammal is sighted within or are about to enter the shut-down zone, piling activity will be stopped immediately. If the animal is observed to move outside the zone again, or 30 minutes have elapsed with no further sightings, piling activities will recommence with the soft start procedure. If a marine turtle or marine mammal is detected in the shut-down zone during a period of poor visibility, operations will stop until visibility improves.</td><td></td><td>✓</td><td></td><td></td><td>✓</td><td></td><td></td></tr>
</table>

Mitigation measures	Pre-construction of WBE reclamation area	Construction of WBE reclamation area	Preconstruction for dredging	Dredging and dredged material placement	Installation of navigation aids	Stabilisation and maintenance on WBE reclamation area	Maintenance dredging
▪ Where noise-related incidents occur while implementing standard operating procedures, validation of the effectiveness of the following noise mitigation measures will be undertaken (via site acoustic testing): ▪ Lower piling duration/piling strike number per day ▪ Use of additional piling noise attenuation measure: – Air bubble curtains. Air bubble curtains are designed to infuse the water column surrounding the pile with air bubbles, generating a bubble screen that attenuates the sound propagation from the piling. For the mid-sized steel pile proposed for the Project (with a dimension greater than 24 but less than 48 inches), an air bubble curtain is expected to provide about 10 dB of noise reduction. – Isolation casings. Isolation casings are hollow casing slightly larger in diameter than the pile to be driven. The casing is inserted into the water column and bottom substrate, and then dewatered so that the work area is isolated from the surrounding water column in order to attenuate the sound propagation. Dewatered isolation casings are expected to provide attenuation that is at least as great as the attenuation provided by air bubble curtains. – Cushion blocks. Cushion blocks consist of blocks of material atop a pile during piling to minimise the noise generated during impact hammering. Materials typically used for cushion blocks include wood, nylon and micarta blocks. The noise reduction is expected to be from a few dB to over 20 dB. This measure can be used in conjunction with air bubble curtains or isolated casings as described above.		✓			✓		
Water quality management plan (including erosion and sediment control)							
An Erosion and Sediment Control Plan (ESCP) will be prepared and approved by a Certified Professional in Erosion and Sediment Control (CPESC) prior to construction commencing. The ESCP will be implemented and audited monthly during the wet season (December through to March), as well as after heavy rainfall events.	✓	✓		✓			
Bund wall and sheet pile wall design and construction will mitigate the risk of erosion and sedimentation by implementing the following measures: ▪ The seaward bund walls will be designed to 100 year average recurrence interval (ARI) immunity and the detailed design will include allowances for storm surge, sea level rise (i.e. 0.2m), wave climate, and flood levels ▪ Fine material of < 12 mm diameter will be removed from bund wall construction material prior to use ▪ A Stormwater Management System will form part of the detailed design of the reclamation area and BUF, which will include drainage systems and stormwater treatment measures to manage runoff and minimise discharge of sediment laden and turbid waters into the marine environment.	✓	✓					
Water quality monitoring will be undertaken according to the Environmental Monitoring Procedure. This procedure includes testing for pH, turbidity and other contaminants as well as other monitoring requirements for the Project activities.	✓	✓	✓	✓			
Key construction personnel will be provided mandatory training in the control procedures for erosion and sedimentation, including the timing of the implementation of such measures		✓		✓		✓	
Refuelling of heavy vehicles hauling material for the construction of the WBE reclamation area and BUF will not occur at the WB or WBE reclamation areas but within an appropriately sized bunded area within the construction compound, or alternative external site.		✓		✓			
Refuelling at the WB and WBE reclamation areas for plant located on site will occur by mobile fuel truck in a bunded area appropriately sized for the application.		✓		✓			
No refuelling will occur within 50m of a watercourse or the Gladstone Harbour.		✓		✓			
Temporary storage of hydrocarbons will occur in bunded areas that are appropriately sized for the application with design storage capacity maintained (i.e. kept free of rain water).		✓		✓			
Should an oil spill or hazardous substance spill into marine waters immediate clean up procedures will be implemented and GPC will be contacted immediately. The GPC first strike oil spill response plan will take effect if required.		✓		✓	✓	✓	
Contaminants required to be stored on site will be stored appropriately and contained within a bunded area. Should contaminants of any kind spill into marine waters immediate clean up procedures will be implemented and GPC will be notified.		✓		✓			
If water quality monitoring determines turbidity reaches above recommended levels, the source of erosion will be determined and remediation will commence immediately. The ESCP will provide detailed information on remediation actions to be implemented.		✓		✓			
Design specifications will require that disturbance of marine and terrestrial surface and subsurface soils will be avoided where practical. Where disturbance is unavoidable, the design specification will aim to minimise the disturbance footprint.	✓						
A specific geotechnical investigation will be undertaken during the detailed design phase of the reclamation area to determine if paleo channels are likely to occur within the footprint of the WBE reclamation area and BUF. If paleo channels are identified, appropriate design and construction methodologies will be implemented to minimise the potential for piping under the bund walls and wave erosion on the outside of the walls.	✓	✓					
The WBE reclamation area construction contractor will prepare an emergency plan which will include procedures to address severe climatic events such as cyclones and minimise, where practicable, the potential environmental impacts from the reclamation works. This will be consistent with the requirements detailed within the GPC emergency response procedure.	✓	✓					

Mitigation measures	Pre-construction of WBE reclamation area	Construction of WBE reclamation area	Preconstruction for dredging	Dredging and dredged material placement	Installation of navigation aids	Stabilisation and maintenance on WBE reclamation area	Maintenance dredging
Where practicable, the majority of works (that have the potential to result in erosion and sedimentation) will be scheduled to occur during the dry season (generally May to September) to prevent runoff of material and fines from the bund walls.		✓					
Where practicable, works will be staged to minimise sediment disturbance and sediment migration within the marine environment. For example, works that are likely to generate sediment plumes will be scheduled to avoid periods of high flow and/or high tidal variation, which may result in the migration of sediments into a broader area.		✓					
A stockpile of armour material will be held at the quarry, sufficient to cover any exposed core material if a cyclone were to approach Gladstone.		✓					
Geotextile material will be placed against the inner face of seaward bund walls, at all placement areas and the BUF, to minimise the migration of dredged material fines through the bund walsl to the marine environment. The geotextile liner material type, placement and restraint method will be specified during the detailed design phase of the reclamation bund walls, and will meet industry best practice and recognised industry standards, taking into account the findings and recommendations of the *Gladstone Bund Wall Independent Review* (Australian Government 2014).		✓					
Armour material will be established next to the core material as soon as practicable after the placement of core material to prevent the spread of fines within the marine environment. The entire bund walls will be protected by armour material within 28 days of bund wall completion.		✓					
No greater than 100m of unprotected core material along the bund walls will be exposed at any given time during construction.		✓					
Decant water will be managed in dewatering ponds constructed within the WB and WBE reclamation areas. All decant water will be managed to meet the water quality levels outlined in the Environmental Monitoring Procedure prior to being released at the licenced discharge point.				✓			
No decant water will be discharged prior to water monitoring in accordance with the Environmental Monitoring Procedure and the ASSMP.				✓		✓	
The internal dewatering cells will be designed to ensure the surface area and volume is large enough, and the detention time sufficient, to meet the required decant water quality licenced discharge limits.	✓		✓				
Progressive installation of stormwater management measures will occur on the final reclamation surfaces as they are completed.				✓		✓	
Where practicable, undertake progressive rehabilitation of areas that are no longer needed for on-going construction (e.g. construction compound), throughout construction.				✓		✓	
At the completion of filling of the WB and WBE reclamation areas, large stormwater ponds will be retained to manage dust and stormwater quality runoff from the final surfaces.				✓		✓	
WB and WBE reclamation area surface stabilisation works will include capping the final surfaces with material of an appropriate grade, and revegetation of the reclamation surfaces.				✓		✓	
Noise and vibration management plan							
General management measures for construction noise (i.e. not including maintenance dredging) will be implemented to manage construction noise emissions, particularly for all construction works outside standard daytime hours of 6.30 am to 6.30 pm Monday to Saturday: ▪ Selection of the quietest plant and equipment that can economically undertake the work ▪ All equipment will be turned off when not in use ▪ Regular maintenance of equipment to ensure that it remains in good working order ▪ During site inductions and toolbox talks, all site personnel (including subcontractors and temporary workforce) will be made aware of the hours of construction and how to apply practical, feasible and reasonable measures to minimise noise and vibration when undertaking construction activities.		✓		✓			
Mobile plant such as excavators, front end loaders and other diesel-powered equipment will be fitted with residential class mufflers to minimise potential noise impacts on sensitive receptors, including ecological receptors such as shorebirds.		✓		✓			
Broadband reversing alarms will be used instead of tonal reversing alarms where sensitive receptors (including ecological receptors such as shorebirds) are within 1 km of proposed construction works. This is particularly relevant to contractors working outside of standard day time hours (6.30 am to 6.30 pm Monday to Saturday), and this measure will be a contractual requirement.		✓		✓			
Where work is proposed within at least 1km of residences, the community will be notified at least 3 days prior to the commencement of works. Notifications will describe the potential noise and vibration levels and the proposed management measures to control environmental impacts.		✓		✓	✓		
The site manager will provide a community liaison phone number and permanent site contact so that any noise and/or vibration-related complaints, can be received and addressed in a timely manner.		✓		✓	✓		
Prior to using the impact piling rig within 1km of terrestrial sensitive receptors (ie Facing island residents at Gatcombe Head) undertake impact trials to determine the minimum required drop height to install the piles. Noise control measures will be adopted with respect to the control of underwater noise (refer to Fauna Management Plan above).		✓			✓		

Mitigation measures	Pre-construction of WBE reclamation area	Construction of WBE reclamation area	Preconstruction for dredging	Dredging and dredged material placement	Installation of navigation aids	Stabilisation and maintenance on WBE reclamation area	Maintenance dredging
Where noise-related incidents from impact piling occur while implementing standard operating procedures, validation of the effectiveness of additional noise mitigation measures will be undertaken (via site acoustic testing) which may include: ▪ Lower piling duration/piling strike number per day ▪ Use of additional piling noise attenuation measures such as cushion blocks, air bubble curtains, and isolation casings (refer to Fauna Management Plan above for further detail).		✓			✓		
Noise and vibration measures specifically for dredging will be implemented as per the Dredging EMP (refer Appendix Q1). Including: ▪ Fitting of noise suppression devices on dredge and pump equipment, where practicable ▪ In accordance with Australian Standards, noisy plant or equipment will be acoustically treated or housed as necessary ▪ All equipment on the dredge will be operated and maintained in a safe and efficient manner to ensure that generated noise complies with manufacturer specifications.				✓			
Air quality management plan							
Watering of material being dozed or graded will be undertaken to supress dust and reduce emissions.		✓		✓		✓	
Suppressants (non-toxic) will be used to reduce dust from material haulage over completed sections of bund walls.		✓		✓			
Watering of the reclamation areas will be undertaken following dewatering of the dredged material to reduce windblown dust.		✓		✓			
Wheel wash stations and/or vibration grids will be used at both ends of the haul route from the quarry to the WBE reclamation area and BUF to reduce the potential for wheel generated dust emissions into areas adjacent to the haul route.		✓		✓			
Exhaust emissions from diesel generators will be released at a point that is 2.5 times higher than any buildings, or structures within 10 stack heights of the exhausts		✓		✓			
Greenhouse gas emissions generated by the transport of quarry material to the reclamation area for bund wall construction and the BUF will be minimised by: ▪ Fuel efficiency of machinery and vehicles will be matched to the delivery requirements where possible ▪ Appropriate equipment maintenance ▪ Optimisation of transport of materials through load optimisation and delivery scheduling.		✓					
All marine plant and equipment will be maintained to minimise the discharge of noxious fumes and pollutants.				✓	✓		
Vessels will be registered and in survey as required by Australian law and to meet International Maritime Organisation (IMO) guidelines.				✓	✓		✓
The potential for the use of bio-diesel will be considered and evaluated by GPC during the detailed design phase of the Project.	✓		✓				
Waste and vegetation will not be disposed of by burning.		✓		✓			
Vehicle movement will be restricted to existing roads and tracks to reduce the potential for dust generation, wherever practicable.		✓		✓		✓	
Dust suppression will be undertaken on the access road into the WB and WBE reclamation areas (when in use) to reduce the potential for dust generation.		✓		✓			
Speed limits on unsealed haulage routes will be enforced to minimise dust generation.		✓		✓			
Air quality measures specifically for dredging will be implemented as per the Dredging Environmental Management Plan.				✓			

Mitigation measures	Pre-construction of WBE reclamation area	Construction of WBE reclamation area	Preconstruction for dredging	Dredging and dredged material placement	Installation of navigation aids	Stabilisation and maintenance on WBE reclamation area	Maintenance dredging
Waste management plan							
Prior to the commencement of construction, a Waste Management Plan (WMP) will be prepared using Project-specific detail relating to construction and maintenance activities, to establish suitable waste management requirements. The WMP will include the following information: ▪ An inventory of solid, liquid (including wastewater and sewerage) and gaseous wastes to be generated (on land and at sea) during the construction and maintenance phases of the Project ▪ Waste management processes and their associated waste systems (i.e. waste outputs: solid, liquid and gaseous), including opportunities for waste avoidance, reuse and recycling, as well as treatment and disposal efforts, during construction and maintenance phases ▪ Procedures for waste avoidance, reuse, recycling, treatment and disposal, with regard to best practice waste management strategies and the EP (Waste) Policy ▪ Procedures for collection, handling, and transport of waste material ▪ Information on the variability, composition and generation rates of waste produced ▪ Natural resource use efficiency (e.g. energy and water), integrated processing design, co-generation of power and by-product reuse ▪ Proposed location, site suitability, dimensions and volume of any solid waste disposal facility, including method of construction ▪ Origin, quality, volume and chemical analysis of wastewater, and any immiscible liquid waste originating from the Project ▪ Market demand for recyclable waste, where practicable.	✓		✓		✓		
During the pre-construction phase, suitable material storage arrangements will be determined to minimise damage from weather or machinery, eliminating the need for the purchase of replacement materials, and unnecessary waste generation.	✓		✓				
Where practicable, suppliers will be instructed to avoid the use of excessive packaging, and be requested to collect packaging and unused materials (e.g. pallets).		✓		✓	✓		
Where practicable, the use of non-biodegradable/non-recyclable plastics will be avoided or reduced, particularly in proximity to marine areas.		✓		✓	✓		
Where practicable, prefabrication of construction components off-site will be encouraged to avoid waste generation within the Project impact areas.		✓		✓	✓		
Collection and disposal of waste material will be conducted by a licenced contractor, and disposed of at a licenced waste disposal facility, using appropriate tracking documentation.		✓		✓	✓		
Regulated wastes will be contained and controlled in a manner that prevents environmental harm.		✓		✓	✓		
Absorbent material used to clean up hydrocarbon spills will be stored in an appropriate container marked ‘regulated waste’.		✓		✓	✓		
All bunding will be appropriately sized for the application and capacity maintained (e.g. kept free of rain water).		✓		✓			
Appropriate waste disposal facilities will be present on-site throughout construction to maintain segregation and maximise economic reuse and recycling.		✓		✓			
Food scraps will be removed from the Project impact areas daily.		✓		✓			
To prevent unnecessary waste, materials will be purchased cut-to-size, where practicable.		✓		✓			
No waste, other than reclamation decant water, is will be released into the marine environment or adjacent vegetation communities.		✓		✓		✓	
No major maintenance work to plant or machinery will occur at the WB or WBE reclamation areas. Minor maintenance of plant or machinery conducted at the WB and WBE reclamation areas* will be conducted on a bunded cement pad appropriately sized for the application.		✓		✓		✓	
Waste management measures specifically for dredging will be implemented as per the Dredging EMP (refer Appendix Q1).				✓			

9.28 Project offset framework

9.28.1 Commonwealth offsets

The EPBC Act Offsets Policy states: 'offsets provide environmental benefits to counterbalance the impacts that remain after avoidance and mitigation measures. These remaining, unavoidable impacts are termed 'residual impacts'.

Offsets will be required to compensate for the significant residual adverse impacts on MNES as a result of the Project.

A 'significant impact' is defined as 'an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts' (DoE 2013).

Residual impacts are those impacts that remain after the successful implementation of the avoidance hierarchy and mitigation measures (refer Section 9.27). The significance of residual impacts reflects the effectiveness of the proposed mitigation but allows for the identification of areas where further management measures may be required.

Although terrestrial and aquatic ecological receptors will be avoided where practicable and potential impacts will be minimised and mitigated to the greatest extent practicable, in some instances the magnitude and significance ratings may remain unchanged following the implementation of the mitigation measures. However, in many instances, a reduction in the magnitude of impacts will result in a reduction of impact significance following the application of mitigation measures.

The establishment of the WBE reclamation area will result in a permanent impact upon migratory shorebird foraging habitat, including for threatened migratory shorebirds, even after the implementation of all Project mitigation measures. In this case, the significant residual adverse impacts on the MNES, will require an offset in accordance with the EPBC Act Matters of National Environmental Significance Significant Impact Assessment (DoE 2013).

Project dredging activities have the potential to introduce additional fine sediment into the marine environment that was not previously available for resuspension by natural processes. During the preparation of the Project offset management strategy and delivery plan, GPC will consider the need and possibility for the Project to offset fine sediment generated by the Project, and the potential options on how this may be delivered in consultation with the DoEE.

9.28.2 Queensland Government Offsets Policy

As stated in Section 9.3.4, impacts to prescribed environmental matters that are considered to constitute significant residual impacts will need to be offset in accordance with the Offsets Act. The Offset Act places limits on when an environmental offset condition may be imposed and provides for the subsequent assessment, delivery, and compliance with offset conditions once imposed. The Offsets Act also identifies provisions for offsetting protected matters of MNES under the EPBC Act, however Section 15 of the Offsets Act also restricts the State from imposing an offset condition for a matter which relates to an area for which there is an existing Commonwealth condition.

The Offsets Regulation and associated *Queensland Environmental Offsets Policy 2017* (Offsets Policy), provides guidance related to the offsets related to MSES. The purpose of the Offsets Policy is to provide a decision-support tool to enable administrating agencies the ability to assess offset proposals to ensure that they meet the requirements of the Offsets Act.

The establishment of the WBE reclamation area will result in a permanent impact upon seagrass, HES wetlands, migratory shorebird foraging habitat, including for threatened migratory shorebirds, and Beach stone curlew, even after the implementation of all Project mitigation measures. In this case, the significant residual adverse impacts on the MSES, will require an offset in accordance with the Offsets Act and Offsets Policy.

GPC proposes to provide its offset obligation post EIS, during the detailed design phase of the Project. This approach is generally consistent with Offsets Policy and the likely Government EIS offset approval conditions.

9.28.3 Outline of Project offset management strategy and delivery plan

The ecological values included in Table 9.87 will be incorporated into the Project offset management strategy and delivery plan. Prior to the development of a Project offset management strategy and delivery plan, there are several tasks to be undertaken to confirm matters requiring offsets and to confirm the preferred strategy and delivery plan for the provision of offsets for the Project. These tasks include:

- Undertake a 'lessons learnt' workshop with GPC and key stakeholders involved in the development and implementation of the BOS and ERMP for the WBDDP. The purpose of this workshop will be to identify any areas for improvement as well as areas for integration with or continuation of the BOS and ERMP projects undertaken for WBDDP.
- During detailed design and prior to commencement of the Project, there will be a review and reassessment of the significant residual adverse impact assessments for MNES and MSES in accordance with the relevant guidelines/policies. Reassessment will be required where additional ecological information becomes available, or where the detailed design results in changes to the direct and/or indirect impact areas (i.e. the footprint of the WBE reclamation area and BUF is redesigned).
- Review of Project approval conditions, particularly where the impact assessment for ecological values has changed (i.e. as above), where matters requiring offset have been amended, or where the conditions require alteration to reflect current ecological conditions.

While the Project offset management strategy and delivery plan will be developed post EIS, during the detailed design phase of the Project, the strategy and delivery plan may contain a combination of the below offset types.

- Land/intertidal-based offset options will be investigated
- Direct Benefit Management Plan offsets, including priority actions to address threats to, and provide substantial benefits for the MNES and MSES values outlined in Table 9.87
- Funding for further research and long term ecosystem health assessment within the Port of Gladstone and adjoining areas. Specific research may include studies that further the understanding of the MNES and MSES values outlined in Table 9.87.
- Financial settlement offset in accordance with the Offsets Policy.

9.29 Summary

9.29.1 Terrestrial and intertidal flora

The establishment of the WBE reclamation area will not result in the direct and permanent loss of Coastal Saltmarsh TEC, mangrove communities and terrestrial vegetation communities. Proposed works associated with the BUF, dredging activities, the removal and installation of navigational aids, and stabilisation and maintenance works on the final Project landform will not result in the direct and permanent loss of these flora values.

Potential indirect impacts from Project activities may occur adjacent to the WBE reclamation area. The introduction and spread of weed and/or pest species, as a result of material transport associated with the bund wall construction, can have negative impacts on native wildlife, including increased competition for resources, physical harm and decreased habitat value. Flora values also have the potential to be indirectly impacted by erosion, sedimentation and decreased water quality in adjacent TEC areas as a result of sediment transport from disturbed areas within the WB and WBE reclamation areas as well as changes in marine water velocities, and minor erosion and siltation of intertidal environments.

9.29.2 Wetland values

The Port Curtis DIWA wetland is listed as a nationally important wetland due to its important ecological and hydrological role within the Port of Gladstone. The Port Curtis wetland supports a range of flora and fauna species that are dependent on wetlands for all, or part, of their life cycle, it contains important habitat for species of conservation significance, and it is of historical and cultural significance (DoEE 2018a).

There are HES wetlands mapped within the Project impact areas, including 48.62ha mapped within the WBE reclamation area. These wetlands are protected under the provisions of the Planning Act with respect to maintaining the ecological values and ecosystem function of important wetlands.

The construction of the WBE reclamation area and BUF will result in the permanent loss of 278ha, or 0.89% of the mapped Port Curtis DIWA wetland area and the permanent loss of 48.62ha, or 0.16% of the mapped Queensland HES wetlands within Port Curtis. Potential indirect impacts from Project activities may occur adjacent to the WB and WBE reclamation areas during construction, including short term declines in water quality, and the potential for accidental release of contaminants and waste/debris into the marine environment. However, these impacts are expected to be contained in extent and are not expected to result in significant impacts on wetland values within Port Curtis.

Dredging activities are expected to have a temporary impact on water quality in Port Curtis wetlands, as a result of the dredging plumes and through accidental contaminant release, with the potential to impact on a range of marine flora and fauna species.

9.29.3 Seagrass

The most notable potential impact to seagrass meadows from the Project is the direct and permanent loss of seagrass meadows as a result of the WBE reclamation area as well as indirect impacts from areas adjoining the WBE reclamation area (i.e. 156.41ha of coastal seagrass habitat as per the 2017 surveys). This loss of seagrass represents approximately 4.33% to 5.53% of the total area of coastal seagrass recorded in Port Curtis in the 2017 survey.

During dredging activities, a short term decline in water quality is expected to occur in the form of increased turbidity caused by sediment suspension and resuspension predominantly concentrated in and around the areas to be dredged (referred to as the ‘zone of high impact’). Increased turbidity has the potential to impact seagrass meadows through temporarily decreasing benthic light conditions and smothering through sediment deposition. Hydrodynamic modelling and the implementation of adaptive management measures within the Dredging EMP predicts dredging activities will not result in a wide-reaching zone of high impact. It is therefore unlikely that dredging activities will have long term impacts on seagrass meadows as a result of turbidity and sedimentation impacts.

9.29.4 Reef communities

Port Curtis supports a range of reef communities, including fringing, inshore turbid and coral reefs which are recognised as contributing to the local expression of the OUV of the GBRWHA, and are considered to have high sensitivity ratings compared to other reef communities such as rock/rubble reefs considered to have a moderate sensitivity.

The establishment of the WBE reclamation area and BUF will not result in the loss of known reef communities. There is the potential for short term declines in water quality to impact on reef communities, however these impacts are not expected to be significant.

The predominant potential indirect impact on ecological values from Project dredging activities will be a short term decline in water quality from an increase in turbidity and sedimentation including the suspension and resuspension of fine sediments. The impacts of dredging activities on reef communities are represented by zones of impact from the hydrodynamic model. The modelling predicts that the reef communities fall within the zone of low impact or within the zone of influence therefore indicating that Project dredging activities will not result in any long term decline in reef communities.

9.29.5 Fish and marine reptiles (excluding marine turtles)

The Project impact areas, include intertidal and subtidal environments which provide potential habitat for species of conservation significance, including Chondrichthyan fish species (e.g. sharks and rays) as well as significant fisheries resources (e.g. nursery grounds, foraging resources and a variety of fish habitats).

Port Curtis is important in terms of its commercial and recreational fisheries, and contains ecologically important fisheries habitats including the declared FHAs located at Colosseum Inlet, Rodds Harbour, and the upper reaches of the Calliope Creek. In addition, areas of significant inshore fish habitat in the form of seagrass meadows, mangrove communities, estuaries and coral reef communities are present within the Port.

The FHAs are not located in the Project direct impact areas, and are not expected to be significantly impacted as a result of the Project activities. The nearest FHA to Project impact areas is the Dē-răl-lĭ (Calliope River) FHA which is situated approximately 15km to the east of the areas to be dredged for the barge access channel.

Whilst the direct loss of inshore habitat from the establishment of the WBE reclamation area and BUF has the potential to impact on fisheries values, this direct loss of inshore habitat will not result in any significant impacts on Port Curtis fisheries due to the extent of other seagrass meadows, mangrove communities and inshore areas identified as having fisheries importance within Port Curtis.

Short term declines in water quality generated by dredging activities and increased turbidity have the potential to impact on fish, fisheries values and other marine reptiles, either directly through exposure to contaminants, or indirectly through habitat loss. Given the location of the zones of high or moderate impact, the temporary nature of the dredge plume, and the highly mobile nature of fish species, it is not expected that the water quality impacts will have a significant or long term impact on fish, other marine reptiles and fisheries values.

9.29.6 Soft sediment habitats and benthic macroinvertebrates

The soft sediment habitats and benthic macroinvertebrate communities of Port Curtis are not considered to be unique or rare to the region, and are considered representative of those present in similar environments across Queensland.

Project direct disturbance areas will result in the permanent loss of soft sediment habitat and benthic macroinvertebrate assemblages. Dredging activities will result in a temporary loss and mobilisation of benthic macroinvertebrates from within the dredging footprint, with benthic macroinvertebrates anticipated to recolonise the deepened channel footprint.

9.29.7 Migratory shorebirds

The WBE reclamation area will result in permanent loss of approximately 275.37ha of migratory potential shorebird foraging habitat (99.74% of the direct disturbance area). The habitat within the WBE reclamation area is foraging habitat in close proximity to a number of important roosting habitats for migratory shorebird species, and is therefore likely important foraging habitat for birds utilising these roosts.

Loss of foraging habitat due to establishment of the WBE reclamation area has the potential to impact on migratory shorebirds via the potential to cause disruption to roosting and foraging behaviour. As a result, adverse impacts on the survival of migratory shorebirds and their breeding success may potentially occur if shorebirds are unable to find suitable alternative foraging sites within close proximity to current suitable roosting sites.

During the establishment of the WBE reclamation area bund wall and BUF and dredged material unloading and placement, migratory shorebirds have the potential to be disturbed (e.g. noise, dust and vehicle movements). Potential noise impacts have the potential to cause alert responses and sometimes an alarm or flight reaction in shorebirds. It is likely that shorebirds will avoid areas of vehicle movements.

Dredging activities are unlikely to have a significant impact on migratory shorebirds or migratory seabirds. Hydrodynamic modelling predicts that dredging activities associated with the licenced dewatering discharge from the WB and WBE reclamation areas will not result in a wide-reaching zones of high and moderate impact. It is therefore unlikely that dredging activities will have significant direct or indirect impacts on migratory shorebirds or migratory seabirds.

Other Project activities (e.g. establishment of the BUF, removal and installation of navigational aids and maintenance activities on the reclamation area) are not expected to have significant impacts on migratory shorebirds, migratory seabirds, or their habitat.

9.29.8 Intertidal and terrestrial fauna

The WBE reclamation area direct impact area includes exposed mudflats that provide suitable foraging habitat for resident shorebird species, including the Beach stone curlew, a species of conservation significance. There are no areas of woody vegetation, including mangroves or terrestrial vegetation communities, present within the WBE reclamation area direct impact area.

The mangrove and saltmarsh communities present adjacent to the WBE reclamation area provide foraging and roosting habitat for resident shorebird species, including the Beach stone curlew. The mangrove and saltmarsh communities adjacent to the WBE reclamation area also provide potential habitat for intertidal species, including the Water mouse and Coastal sheathtail bat, both of which are species of conservation significance.

The establishment of the WBE reclamation area and BUF will not involve the direct and permanent loss of terrestrial vegetation, mangroves or coastal saltmarsh vegetation. The establishment of the WBE reclamation area, including the placement of dredged material, will result in the permanent loss of exposed mudflats and benthic habitats which provide foraging habitat for resident shorebird species and intertidal fauna species.

The new navigational aids and the areas to be dredged are located offshore and these activities will not result in the direct and permanent loss of intertidal or terrestrial habitats.

9.29.9 Marine turtles

The Project impact areas include intertidal and subtidal environments which provide potential habitat for marine turtle species of conservation significance, most notably Green turtles and Flatback turtles. Other marine turtle species are occasionally recorded in the Port Curtis region such as Loggerhead turtles (which occasionally nest in the region) and Hawksbill turtles, while Olive ridley turtles and Leatherback turtles are rarely encountered (Limpus et al. 2013).

The most notable potential impact to marine turtles from the Project is the direct and permanent loss of coastal seagrass habitat as a result of the WBE reclamation area.

Short term declines in water quality generated by dredging activities and increased turbidity have the potential to impact on important Green turtle habitat at seagrass meadows through temporarily decreasing benthic light conditions and smothering through sediment deposition. These potential impacts to water quality are short term and will not significantly impact the availability of seagrass habitat for marine turtles.

Vessel movements associated with dredging activities pose a potential risk to marine turtles in Port Curtis. The Port of Gladstone currently experiences a high volume of commercial and recreational vessel traffic. The nature, scale and volume of Project vessel movements are considered minor compared to the existing Port vessel movements.

Underwater noise impacts from navigational aid impact piling activity is expected to have the largest impact on marine turtles with a single strike having potential to cause mortal injury within 35m from piling locations, avoidance of source at up to 600m and behavioural changes exhibited within 2km from piling locations.

The Project will not result in direct impacts on marine turtle nesting beaches within the Port Curtis. The disruption of nesting and hatchling activity through increases in artificial lighting are unlikely given the location of Project activities and the low levels of light to be produced, particularly when compared to the artificial light generated by the surrounding industries of Port Curtis.

9.29.10 Marine mammals

The Port Curtis and Rodds Bay regions provide suitable habitat for dugongs in the form of extensive coastal and deep water seagrass meadows. The Port Curtis and surrounding regions also provide suitable habitat and food resources for inshore and coastal dolphin species. Several whale species can be can be found seasonally migrating in coastal waters around the Port Curtis region, and Humpback whales are very occasionally seen within Port of Gladstone.

The most notable potential impact to marine mammals from the Project is the direct and permanent loss of coastal seagrass habitat as a result of the establishment of the WBE reclamation area.

Short term declines in water quality generated by dredging activities and increased turbidity have the potential to impact on dugong and inshore dolphin habitat at seagrass meadows through temporarily decreasing benthic light conditions and smothering through sediment deposition. Hydrodynamic modelling predicts that dredging activities associated with the licenced dewatering discharge from the WB and WBE reclamation areas will not result in a wide-reaching zone of high impact.

The establishment of the WBE reclamation area and BUF, and dredging activities associated with the Project are not expected to result in any significant adverse noise impacts on marine mammal species due to the low levels of noise emissions being emitted. Behavioural changes may occur in marine mammal species in response to underwater noise generated by the Project, however it is unlikely that temporary or permanent hearing trauma to marine mammals will result from these activities.

The installation of navigational aids has the potential to result in mortal injuries to dugong within a 160m radius of piling activities and potential behavioural displacement responses by dugong have the potential to occur within a 2km radius of the activity. Zone of impact for potential behavioural changes are predicted to be up to 3.4km from piling locations.

9.29.11 World Heritage values

The OUV of the GBRWHA that have the potential to be impacted by the Project at the local level (i.e. local expression of OUV) include marine water quality, dugong, seagrass meadows, shorebirds and migratory birds. Of these locally expressed values, only the local expression of shorebirds and migratory birds contributes significantly to the overall OUV of the GBRWHA.

The Project has the potential to impact on the local expression of the OUV attributes within the Port of Gladstone, however it is not likely that these impacts will result in the loss of the local expression of the value, or the value overall.

The Project will not result in the loss of one or more World Heritage and National Heritage values, and these values will not be notably altered, modified, obscured or diminished by Project activities.

9.29.12 Environmental management

The Project will implement mitigation measures provided in the Dredging EMP and Project EMP (refer Appendices Q1 and Q2, respectively), and associated management plans to reduce the likelihood and magnitude of potential Project impacts on ecological values. The real time adaptive management steps incorporated into the Dredging EMP will ensure that Project generated turbidity, sedimentation and other emissions do not impact on the long term survival of the ecological values of Port Curtis.

9.29.13 Significant residual adverse impact assessments

Significant residual adverse impact assessments have been conducted to identify if the Project will, or is considered likely to have a significant residual adverse impact on ecological values which are defined as a MNES or a MSES. Table 9.88 summarises the Project activities that are likely to result in a significant residual adverse impact on MNES and/or MSES.

Table 9.88 Summary of Project activities likely to result in a significant residual adverse impact on MNES and/or MSES

Project activity and disturbance footprint	Ecological value
Establishment of the WBE reclamation area	**MNES** ▪ Migratory shorebird foraging habitat, including for threatened migratory shorebirds (direct loss of 275.37ha) **MSES** ▪ Seagrass (direct loss of 156.41ha) and associated dugong habitat ▪ HES wetlands (direct loss of 48.62ha) ▪ Migratory shorebird foraging habitat, including for threatened migratory shorebirds (direct loss of 275.37ha) ▪ Beach stone curlew (resident shorebird) foraging habitat (direct loss of 275.37ha)
BUF and areas to be dredged	No significant residual adverse impact expected
Installation of navigational aids	No significant residual adverse impact expected
Maintenance activities on the WB and WBE reclamation areas	No significant residual adverse impact expected