Australia Pacific LNG Project

Volume 5: Attachments

Attachment 19: Marine Ecology Technical Report - Transmission Pipeline

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Executive summary

Australia Pacific LNG Limited proposes a project which comprises the development of coal seam gas (CSG) fields, the construction of a gas pipeline, together with the construction of a liquefied natural gas (LNG) plant and associated facilities to export the gas to international markets. This report focuses on the construction of the pipeline in the marine environment. The pipeline is proposed to cross the wetlands of Targinie Creek on the mainland and then across 'The Narrows' to a landing on Curtis Island just south of Laird Point.

The proposed pipeline corridor identified by the government for LNG proponents traverses the Great Barrier Reef World Heritage Area, and in part a habitat protection zone of the *Great Barrier Reef Coast Marine Park*. The objectives of the habitat protection zone are to provide for the conservation of the areas of the marine park within the zone through the protection and management of sensitive habitats that are generally free from potentially damaging activities, and to provide opportunities for reasonable use of the areas.

This report describes the marine environmental values in Port Curtis and assesses the potential impact of constructing the pipeline on the marine environment.

Broadly, the key features of the marine environment in Port Curtis are:

- Extensive saltpan/saltmarsh, seagrass and mangrove habitats that provide important nursery habitat for juvenile fish and prawns, and support fisheries production. The seagrass is also a food source for dugong.
- Nesting and feeding habitats for marine turtles.
- Habitat for inshore dolphin species including the endemic Australian snubfin dolphin, the Indo-Pacific humpback dolphin and the inshore form of the bottlenose dolphin.
- Although the seabed is dominated by unvegetated sedimentary environments, natural rocky reef habitat occurs, and there is artificial hard substrata including jetty piles and rock walls.
- An assemblage of macrobenthic infauna that is dominated by filter feeding organisms, with species richness and abundance that is lowest on fine muddy substrates in intertidal areas, and greatest in the coarse sandy sediments that predominate in the deeper channels of the estuary.
- Utilisation for commercial and recreational fishing.
- Water quality that is generally high but influenced by tidal state and input from river systems. It is identified the Fitzroy River catchment is a source of elevated dissolved metals (nickel and to a lesser extent copper) that occur in The Narrows.

The proposed pipeline crossing traverses saltpan/saltmarsh habitat that drains into Targinie Creek before entering The Narrows in the vicinity of Friend Point. The foreshore in this area is mangrove fringed with extensive intertidal flats. The sub-tidal area of the proposed pipeline route is unvegetated.

There are three proposed methods for constructing the pipeline crossing of the marine environment. Horizontal Directional Drilling (HDD) is the preferred method. The other two methods involve constructing a trench across The Narrows using dredging equipment – the flotation method and the bottom pull method. The volume of dredging necessary is estimated to be between 90,000 and 150,000m^3 with the likely period of dredging estimated to be 60 days.

All three methods involve disturbing and fragmenting saltpan/saltmarsh and mangrove habitat including the potential for changing local patterns of hydrology which may impact saltmarsh plants and

mangroves. To mitigate impact, construction activities should be undertaken to minimise the area of disturbance and hydrodynamic changes across the saltpan/saltmarsh habitat.

Dredging will result in a turbidity plume. Turbidity plumes can decrease the ambient light levels that extend through to the seabed which can affect photosynthesis through the water column and impact vegetated habitats on the seabed such as seagrass and algae. When a turbidity plume settles out it can also smother benthic assemblages. While increases in turbidity are a natural event, the duration of elevated turbidity plumes from the proposed dredging program are much longer than those that occur naturally. Elevated turbidity from the dredge plume in The Narrows and Graham Creek will persist for between ten days and one month after dredging activities have ceased. The dredge plume is likely to overlap spatially with the seagrass beds in the vicinity of North Passage Island.

To minimise the turbidity plume of dredging and the potential transport of a turbidity plume from within the materials offloading facility (MOF) area during material placement, the following measures are recommended:

- Where practical, Australia Pacific LNG will deploy silt curtains to prevent migration of turbidity plumes.
- Dredging will only operate within safe weather conditions (as defined by the Harbour Master) to minimise spillage of dredged material and hence minimise the magnitude of the turbidity plume generated.

The mitigation measures serve to potentially limit both the spatial scale and the magnitude of the impact from dredging activities.

Dredging and HDD will both generate underwater noise that has the potential to impact the local distribution and behaviour of dolphins and dugong. This impact will not persist beyond the construction phase. It is recommended that monitoring the usage of the area at and adjacent to the pipeline area by cetaceans and dugong will be undertaken prior, during and after construction.

Bentonite is proposed to be used as the principal drilling fluid and it is possible that some of this material will directly or indirectly enter the marine environment. While bentonite is a natural clay compound, its physical properties can potentially result in significant environmental impacts.

To mitigate potential impacts from the use of bentonite, it is recommended that no deliberate discharge of drilling fluid to the marine environment be undertaken and all drilling fluid should be disposed of off-site. It is also recommended that in the event of a potential or actual spill of drilling fluid, the pumping of drilling fluid and the drilling activity should cease immediately until remedial action is taken.

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1. Introduction

This report addresses potential environmental issues and impacts to the marine ecology from the proposed Australia Pacific LNG Project, specifically those related to the pipeline crossing of 'The Narrows' and the associated wetlands.

Australia Pacific LNG Pty Limited (APLNG) proposes to develop a project which enables the creation of a world scale, long-term industry in Queensland, utilising APLNG's substantial coal seam gas resources in Queensland. APLNG holds significant interests in less developed areas across the Walloons Fairway in the Surat Basin, which together with the Talinga coal seam gas fields constitutes the Walloons gas field's development area. The gas will be conveyed via a pipeline to the proposed liquefied natural gas (LNG) plant on Curtis Island.

The LNG plant will include up to four LNG trains with an installed capacity of 16-18Mtpa and associated wharf and materials off-loading facilities to be located at Laird Point within the Curtis Island Industry Precinct of the Gladstone State Development Area. The LNG plant will utilise ConocoPhillips' proprietary Optimised Cascade® technology.

This report describes:

- The existing marine environment in the vicinity of the pipeline crossing, including relevant matters of national environmental significance as identified in the *Environment Protection and Biodiversity Conservation Act 1999.*
- Potential impacts on the marine environment from the construction and operation of the pipeline.
- Options for mitigation and management of these impacts.

2. Existing environment

Biogeographically, Port Curtis falls within the Shoalwater Coast bioregion, as defined in the Interim Marine and Coastal Regionalisation for Australia (IMCRA Technical Group 1998), which includes the coastal and island waters from Mackay south to Baffle Creek. This inshore coastal region comprises large bays with very large tidal ranges (up to six metres), large coastal islands, mostly sedimentary substrates, and relatively low rainfall.

2.1 Marine parks, wetlands and World Heritage areas

It is proposed that the pipeline will cross The Narrows from the mainland in the vicinity of Friend Point to just south of Graham Creek (Laird Point on Curtis Island). This crossing is situated within the Gladstone Port Limits. However, all of the Port waters below the mean low water mark lie within the Great Barrier Reef World Heritage Area. The World Heritage values of the Great Barrier Reef World Heritage Area are described in Appendix A.

Prior to 2004, four Queensland marine parks existed in the Great Barrier Reef Region: the Mackay/Capricorn Marine Park, Townsville/ Whitsunday Marine Park, Trinity Inlet/ Marlin Coast Marine Park, and the Cairns Marine Park. In 2004, these marine parks were amalgamated into the Great Barrier Reef Coast Marine Park with additional areas of marine park added. It now includes the rivers, creeks and mangrove areas that formed parts of these four marine parks, together with intertidal areas of the coastline that border the Great Barrier Reef Marine Park.

The Narrows area was previously included as part of the Mackay/Capricorn Marine Park but is now included in the Great Barrier Reef Coast Marine Park (in Schedule 3 of the *Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004* as area QI HP-22-01). The Narrows is zoned as a habitat protection zone, with the southern boundary of this forming a straight line across The Narrows at latitude 23°45.000' (Figure 2.1). The objectives of the habitat protection zone are:

- To provide for the conservation of the areas of the marine park within the zone through the protection and management of sensitive habitats that are generally free from potentially damaging activities.
- To provide opportunities for reasonable use of the areas.

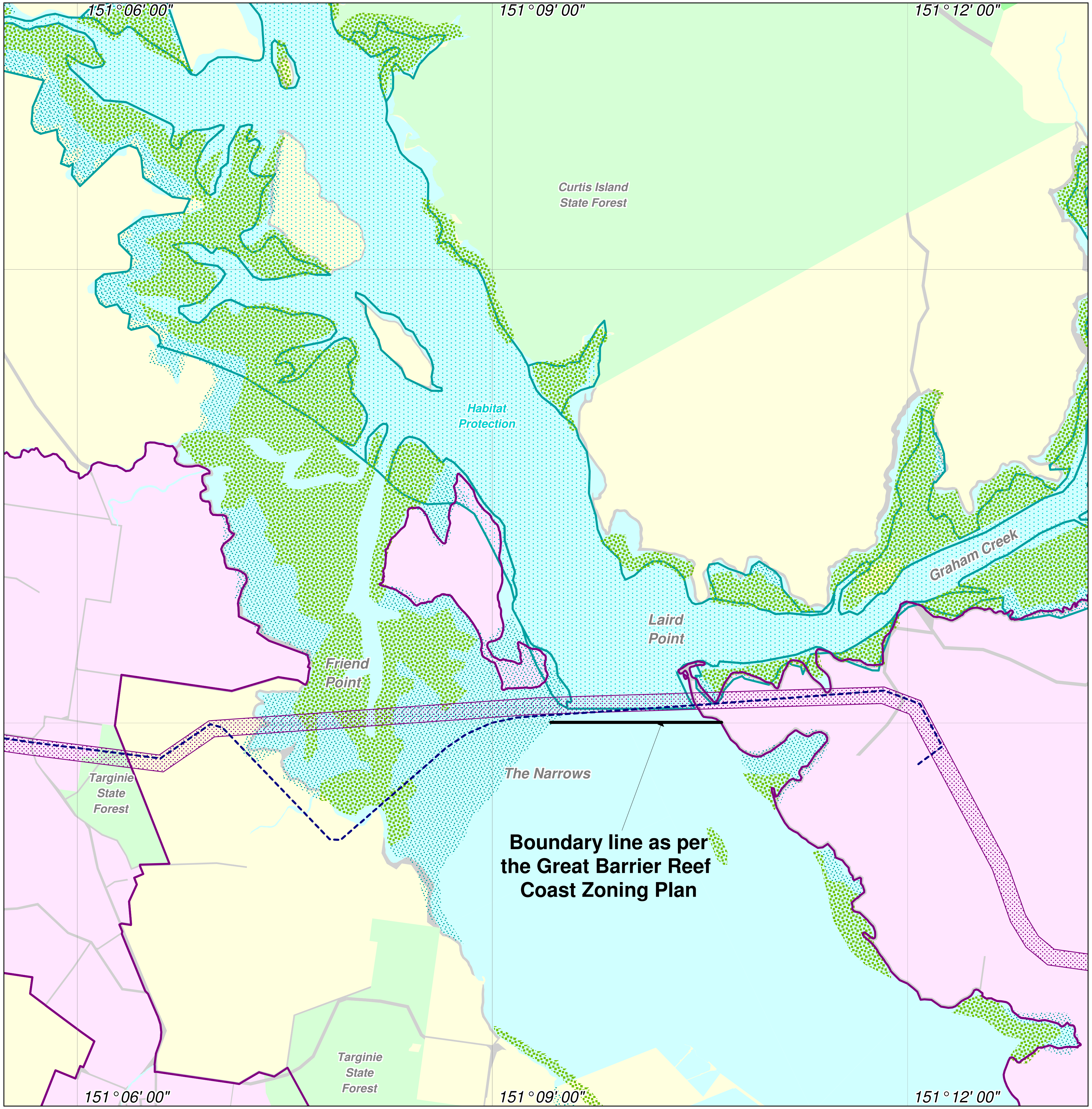
The proposed pipeline route in part traverses the Great Barrier Reef Coast Marine Park.

Ramsar wetlands are not located within or adjacent to the proposed development site. The closest Ramsar wetlands are Corio Bay and Shoalwater Bay, which are approximately 150km north of the site. The area of the pipeline crossing is within the Curtis Island Nationally Important Wetland (QLD019).

The nearest declared fish habitat areas are in the Fitzroy River, which includes large parts of the northern and north-western parts of Curtis Island (FHA-072), Colosseum Inlet (FHA-037) and Rodds Harbour (FHA-036). These are approximately 23km, 35km and 50km, respectively, from the proposed pipeline crossing.

Wetlands that will be disturbed as part of the proposed project are “Areas of state significance (natural resources)” under the State Coastal Plan. The following matters are relevant to the conservation and management of Queensland’s coastal wetlands, including land within 100m of a coastal wetland:

- Maintenance of an area between the wetland and any adjacent use or activity, of a width and with characteristics that will safeguard the functions of the wetland and allow for natural fluctuations of location
- Minimising any modification of the natural characteristics of the wetland, including the topography, groundwater hydrology, water quality, and plant and animal species
- Minimising any adverse impact on coastal wetland values from proposed access
- Any adverse impact on the wetland as a result of proposed or potential pest insect control;
- The appropriate management of acid sulfate soils
- Maintaining the role of wetlands in providing protection from coastal hazards, including any impacts from potential changes in sea level rise
- Minimising potential changes in fire regimes that may have adverse impacts on the coastal wetland
- The need to retain the values and functionality of saltflats, to assist in the maintenance of estuarine system viability
- The need to maintain the coastal wetland functions to provide habitat for rare, threatened and migratory species
- The potential for a proposal to introduce plant or animal species non-native to the local area that may have or are likely to have adverse impacts on the coastal wetland ecosystem
- Minimising impacts on the sustainability of economic productivity, including critical inshore habitat for fisheries-related species
- The need to restore and rehabilitate degraded coastal wetlands, and
- Any long-term maintenance and management implications, particularly for government agencies.



LEGEND

- Gas pipeline route
- Gladstone State Development Area
- Gladstone State Development Area corridor
- State marine park management areas

Protected Areas

- State forest

Waterbodies

- Mangrove flats
- Saline coastal flats

0 1 2km

SCALE - 1 : 50,000 (at A3)

Latitude / Longitude
Geocentric Datum of Australia 1994

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Figure 2.1 Marine Park Boundary - Curtis Island

Project No: 301001-00448	Figure: 00448-00-EN-DAL-0431	Rev: 0

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2.2 Extent and condition of marine habitats

The primary marine environmental features of interest in the vicinity of the proposed pipeline crossing are the seagrass meadows, mangroves and saltmarsh areas. These vegetated habitats contribute significantly to the high primary productivity of estuarine areas. They also provide structurally complex nursery habitats that maximise food availability and minimise predation for fish, prawns and crabs (Halliday and Young 1996, Thomas and Connolly 2001, Heck et al. 2003).

Rocky intertidal and subtidal environments also exist in the study area and these are important foraging areas for various fish species. Extensive unvegetated intertidal banks also occur in the area around Laird Point, and these banks provide foraging opportunities for fish at high tide and shorebirds at low tide.

Field investigations undertaken as part of the EIS provided additional information on intertidal and subtidal habitats.

2.2.1 Seagrass

The seagrass beds of the Port Curtis region have been extensively investigated and mapped by Rasheed et al. (2003), Taylor et al. (2007) and Chartrand et al. (2009). Approximately 20% of the intertidal (7,246 hectares) and sub-tidal area (6,332 hectares) of Port Curtis is covered by seagrass. Generally, the area of the seagrass bed and seagrass biomass peaks in late spring and summer and is lowest over winter (McKenzie 1994, Lanyon and Marsh 1995). The seagrass surveys are undertaken when the area and biomass of the seagrass beds in Port Curtis is approaching, or at the seasonal maximum.

Table 2.1 describes the key parameters (area and above ground biomass) of the main seagrass beds in the northern part of Port Curtis and the location of these beds are described in Figure 2.2. Ongoing monitoring of six of the seagrass meadows between 2002 and 2008 has shown that the area of intertidal seagrass beds has generally remained the same, while the area of the two subtidal seagrass beds that are the subject of regular monitoring (Western Basin 2 and South of Fisherman’s Landing 2) both showed significant variations. In particular, the area of subtidal seagrass at the South of Fisherman’s Landing 2 site fell significantly in 2007 before showing some sign of recovery in 2008, and the area of subtidal seagrass beds at the Western Basin 2 site fell significantly in 2005 before showing clear signs of recovery over the next three years (Figure 2.3).

The principal driver of seagrass change in Port Curtis is local climate conditions. High rainfall events and high inflows of freshwater may result in seagrass declines as a result of inputs from nutrients, sediment, herbicides and reduced salinity. These declines are generally reversed with the associated nutrient inputs enhancing seagrass growth (Waycott et al. 2007).

Seagrass distribution digitized from: Rasheed, M.A., Thomas, R., Roelofs, A.J., Neil, K.M. and Kerville, S.P. 2003. Port Curtis and Rodds Bay seagrass and benthic macro-invertebrate community baseline survey, November/December 2002. QDPI Information Series QI03058 (DPI, Cairns).

Satellite imagery (GeoEye-1 on 24 March 2009) AAM Hatch 2009

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Figure 2.2 - Seagrass Distribution

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Table 2.1 Description of seagrass beds in the northern part of Port Curtis (modified from Rasheed et al. 2003)

General location	Seagrass species and general description	Biomass (g/dw/m-2)	Seagrass area (hectares)
Laird Point (30)[1]	Aggregated patches of *Zostera capricorni* of light cover	2.9 ± 1.5	14.9 ± 1.3
South of Laird Point (32)	Isolated patches of *Z. capricorni* of light cover	N/A	2.4 ± 0.3
Passage Islands 1 (31)	Aggregated patches of *Z. capricorni* of light cover with *Halophila ovalis*	0.9 ± 0.2	40.0 ± 2.6
Passage Islands 2 (35)	Aggregated patches of *Z. capricorni* of light cover with *H. ovalis*	0.7 ± 0.2	22.1 ± 2.0
Passage Islands 3 (33 and 34)	Aggregated patches of moderate *H. ovalis* with *Z. capricorni*	1.0 ± 0.5	10.1 ± 0.8
Western Basin 1 (including Friend Point) (8)	Aggregated patches of *Z. capricorni* of light cover with *H. ovalis*, *Halophila spinulosa* and *Halophila decipiens*	2.1 ± 0.3	269.1 ± 11.3
Western Basin 2 (9)	Aggregated patches of *H. decipiens* with *H. ovalis*.	0.9 ± 0.3	268.3 ± 14.9
South of Fisherman's Landing 1 (6)	Aggregated patches of *Z. capricorni* of light cover with *H. ovalis*, *H. decipiens* and *H. spinulosa*	1.1 ± 0.1	464.0 ± 12.9
South of Fisherman's Landing 2 (7)	Aggregated patches of *H. decipiens*	0.9 ± 0.2	72.6 ± 11.3
Wiggins Island 1 (4)	Aggregated patches of *Z. capricorni* of light cover with *H. ovalis*	0.8 ± 0.4	35.8 ± 1.7
Wiggins Island 2 (5)	Aggregated patches of *Z. capricorni* of light cover with *H. ovalis* and *H. uninervis*	1.4 ± 0.3	149.8 ± 2.5

[1] The number in parentheses corresponds to the meadow number in the report by Rasheed et al. (2003).

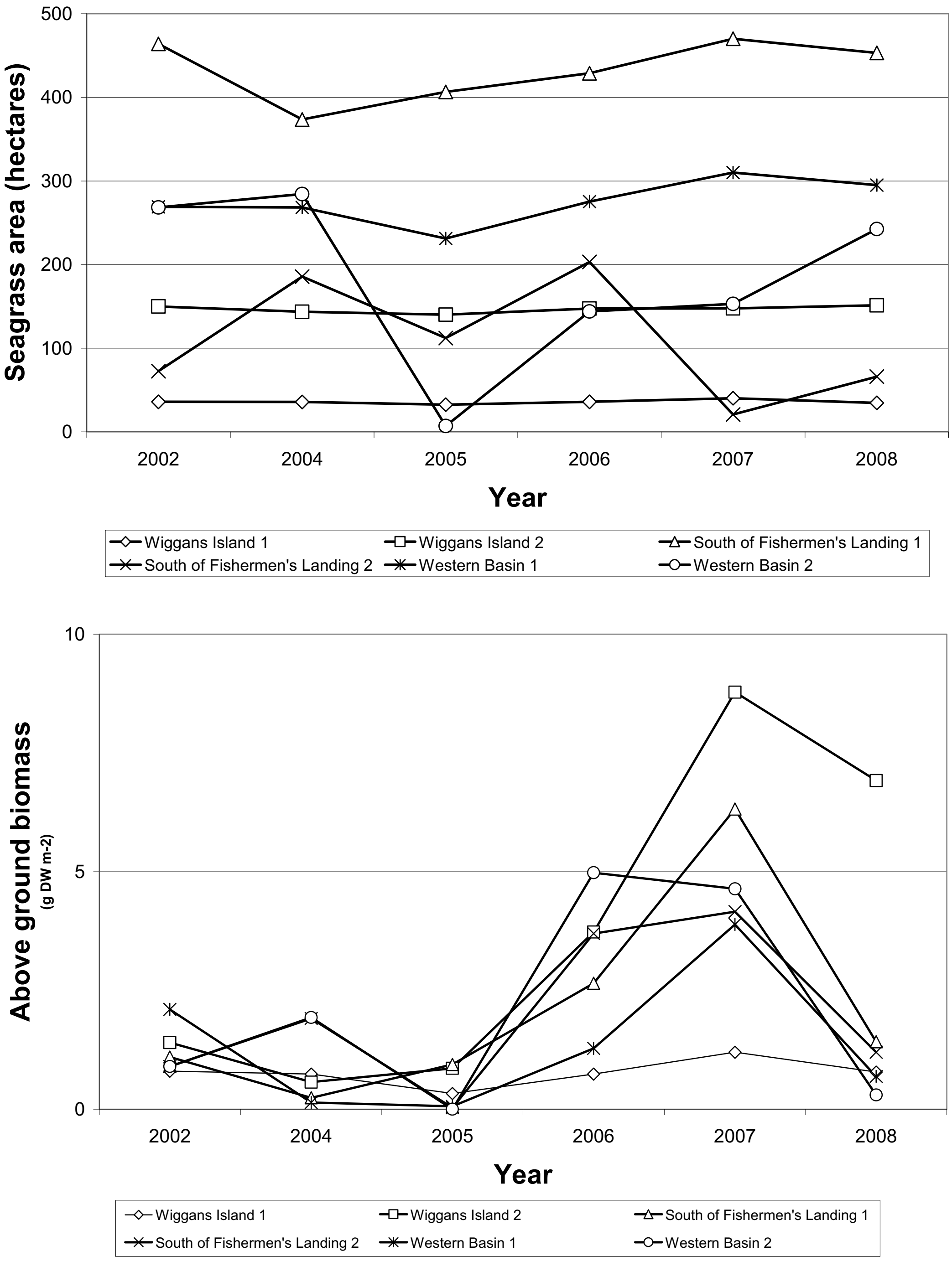


Figure 2.3 Seagrass area (top) and above ground biomass (below) of six seagrass beds in the northern Port Curtis area between 2002 and 2008 (modified from Chartrand et al. 2009)

2.2.2 Mangroves and saltmarsh

Mangroves provide a structurally complex habitat that offers food and protection for juveniles. They are also a source of carbon that may be exported by the tide to other areas and contribute to the food web elsewhere in a region (Manson et al. 2005, Meynecke et al. 2008). Extensive mangroves extend along the coastline from the Gladstone city precinct and into The Narrows and these have been surveyed by Danaher et al. (2005). Within the Gladstone region it is estimated that there are 3,875

patches of mangroves with an area of 203km^2 with a perimeter of 4,855km (Manson et al. 2005). However, Duke et al. (2003) reported a regional loss of almost 40% of mangrove area in Port Curtis between 1941 and 1999. Fourteen species of mangroves are reported from the Port Curtis region (Saenger 1996):

- Club mangrove (*Aegialitis annulata*)
- River mangrove (*Aegiceras corniculatum*)
- Orange mangrove (*Bruguiera exaristata*);
- Large-leafed orange mangrove (*Bruguiera gymnorrhiza*)
- Blind-your-eye mangrove (*Excoecaria agallocha*)
- Black mangrove (*Lumnitzera racemosa*)
- Myrtle mangrove (*Osbornia octodonta*)
- Red mangrove (*Rhizophora stylosa*)
- Cannonball mangrove (*Xylocarpus granatum*)
- Cedar mangrove (*Xylocarpus moluccensis*)
- Yellow mangrove (*Ceriops tagal*)
- Grey mangrove (*Avicennia marina*)
- Mangrove fern (*Acrostichum speciosum*)
- Holly leaf mangrove (*Acanthus ilicfolius*).

Port Curtis represents the southern limit of the distribution of two of these mangrove species (orange mangrove and cedar mangrove). The mangrove assemblage in Port Curtis, while diverse, is dominated by red mangrove with lesser amounts of yellow mangrove and grey mangrove also present. Red mangrove tends to dominate the seaward edge of the assemblage while yellow mangrove and grey mangrove are generally more abundant on the landward edge. The mangrove assemblage is considered to be in a healthy state at the proposed development site and in Port Curtis generally.

Also present in the Curtis Coast region are salt pans which are largely bare, but contain patches (or isolated plants) of salt marsh species such as *Sueda* spp. (sea blite), *Sarcocornia quinqueflora* (common samphire), and *Sporobolus virginicus* (salt couch). While saltmarsh habitats receive only intermittent tidal inundation, fish can extend many hundreds of metres into salt marsh habitats on spring tides, and their importance for fisheries production is well documented. Important commercial and recreational fish species, such as yellowfin bream (*Acanthopagrus australis*) and various species of mullet are well known to frequently utilise salt marsh habitat in Queensland as juveniles (Morton et al. 1987, Thomas and Connolly 2001, Sheaves et al. 2007) and this is discussed in more detail in Section 2.8.

2.2.3 Rocky reefs and rocky shores

Intertidal rocky shores occur at several locations in the Port Curtis region including in the vicinity of Laird Point on Curtis Island. These rocky shores are best described as a ‘rubble field’ with significant oyster cover. They also contain other macro-invertebrates that associate with oyster cover, in particular the oyster borer (*Morula marginalba*). These rubble fields offer little vertical relief.

Rasheed et al. (2003) also identified rubble reef areas in the deep channel area in the vicinity of Graham Creek to Fisherman's Landing. These contained medium density cover (>15% of the area surveyed) of bivalves, ascidians, bryozoans and hard corals. Other such areas of reef environment are located in the vicinity of Hamilton Point (URS 2009).

2.3 Marine habitats within the proposed development footprint

2.3.1 Intertidal habitat

Field investigations of habitats within the area of the proposed pipeline were undertaken during June 2009. Intertidal areas were visually inspected and described and a drop video camera was systematically deployed at a number of pre-determined locations across the development footprint (Figure 2.9)

The proposed project requires disturbance of intertidal areas in the vicinity of Friend Point and an area on Curtis Island just south of Graham Creek. Friend Point contains an extensive mangrove forest, dominated by the red mangrove, and intertidal flats. The intertidal flats are principally mudflats although areas of rubble field are also present (Figure 2.4).

The area of the proposed pipeline landing on Curtis Island consists of a sandy beach with isolated mangrove trees that extends into an area of saltpan. The latter contains saltmarsh plants including salt couch, common samphire and seablite (Figure 2.5 and Figure 2.6).

Figure 2.4 Friend Point showing areas of rocky shore and mudlflats

Figure 2.5 Area in the vicinity of the proposed pipeline landing on Curtis Island

Figure 2.6 Examples of saltmarsh plants - the common samphire (top and bottom) and marine couch (top) in the vicinity of the proposed pipeline landing on Curtis Island

2.3.2 Subtidal habitat

An Outland Technology Inc. video and video recording system was used at selected sites along the proposed pipeline route to provide visual information on typical seabed features along the crossing of The Narrows. The location of these sampling points is shown in Figure 2.9. The proposed route is principally bare sedimentary area with a high amount of unconsolidated shell and rubble material present at many of the survey sites sampled. Some macroalgae was found attached to shell and rubble at a number of locations. Evidence of bioturbation was largely absent. No hard coral was present and there was no reef structure that afforded any vertical relief, although isolated epifauna individuals (for example, gorgonians) were present. Selected pictures from the seabed are shown in Figure 2.7 and Figure 2.8.

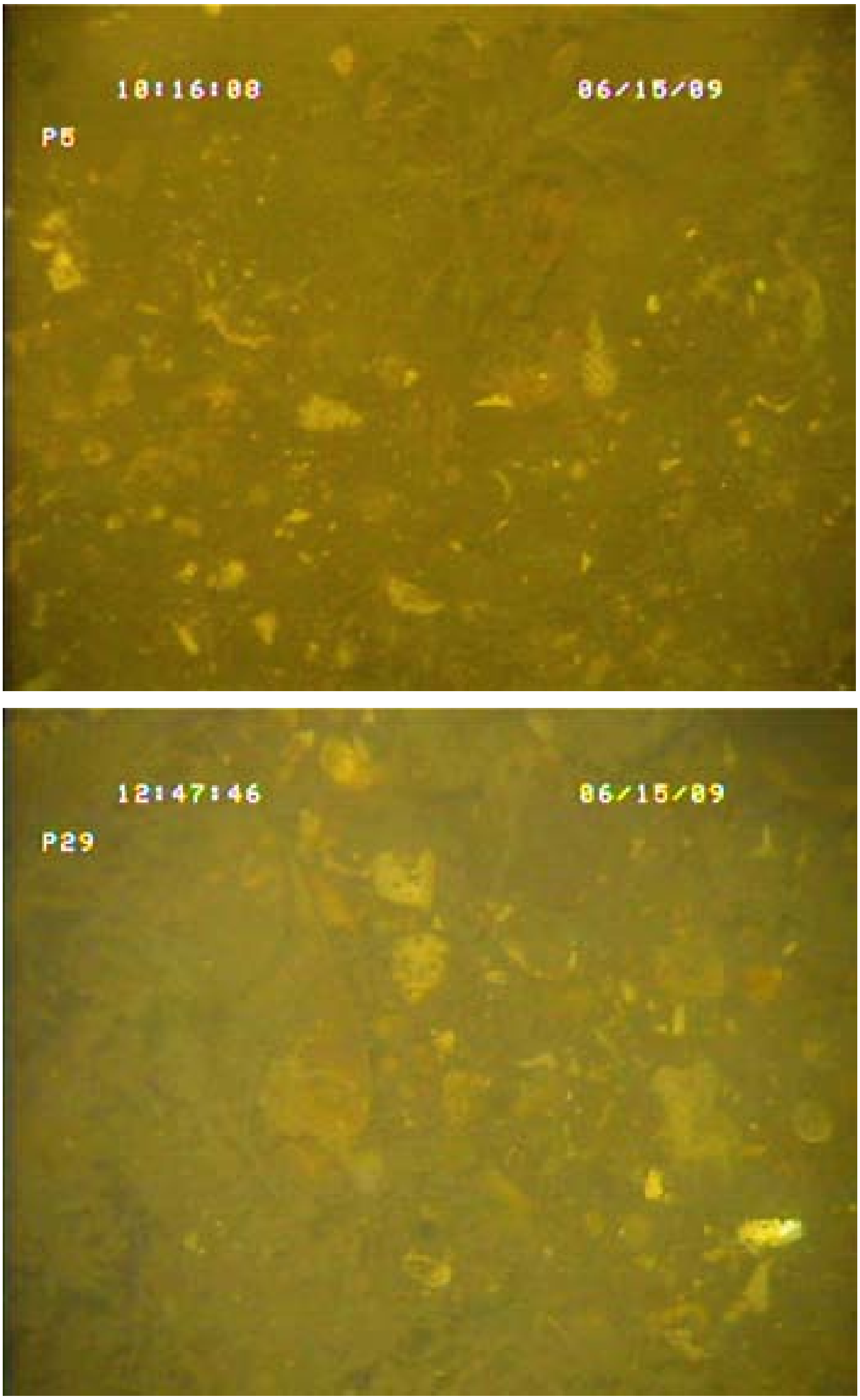


Figure 2.7 Predominantly bare sediment showing a significant amount of shell material

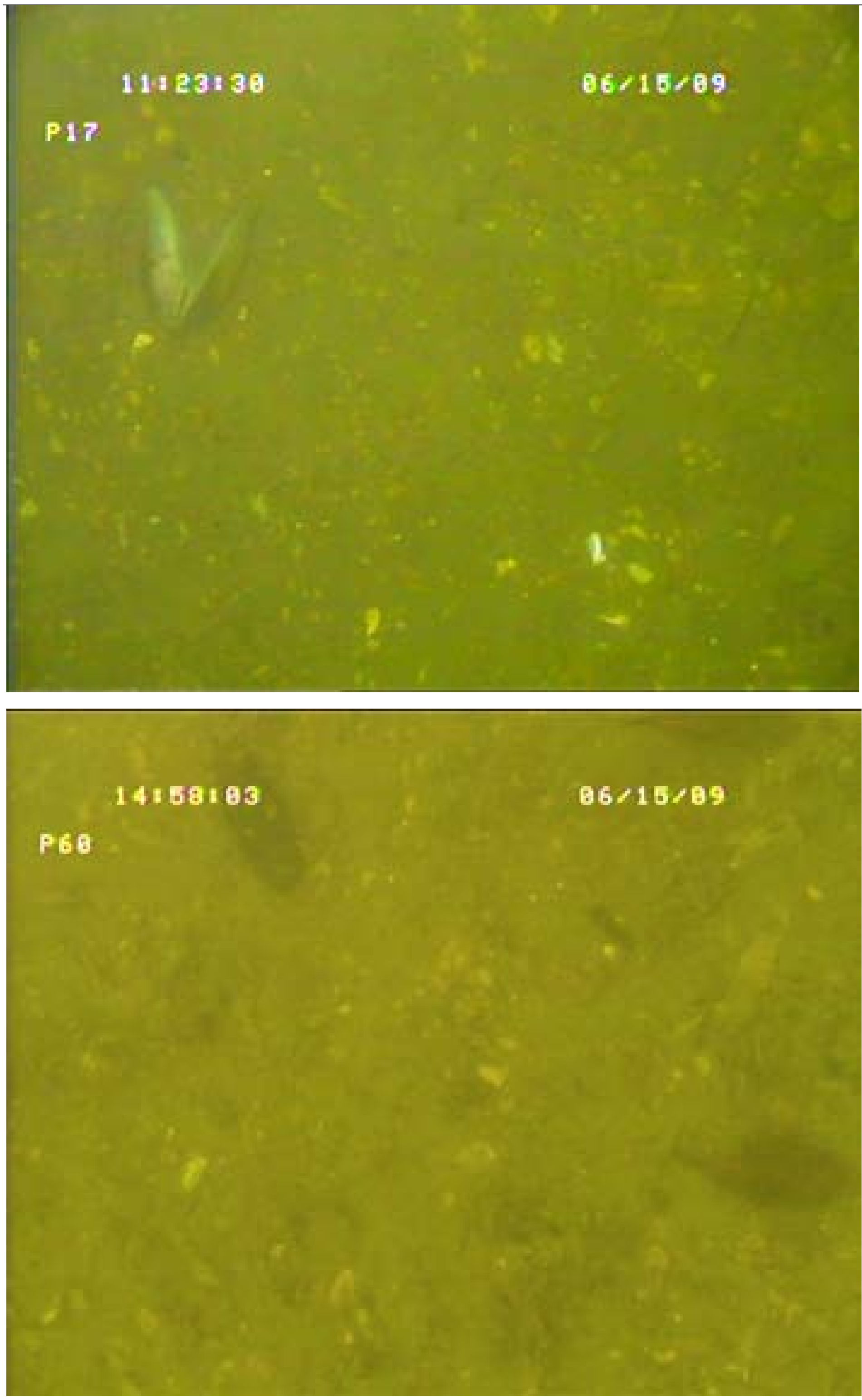
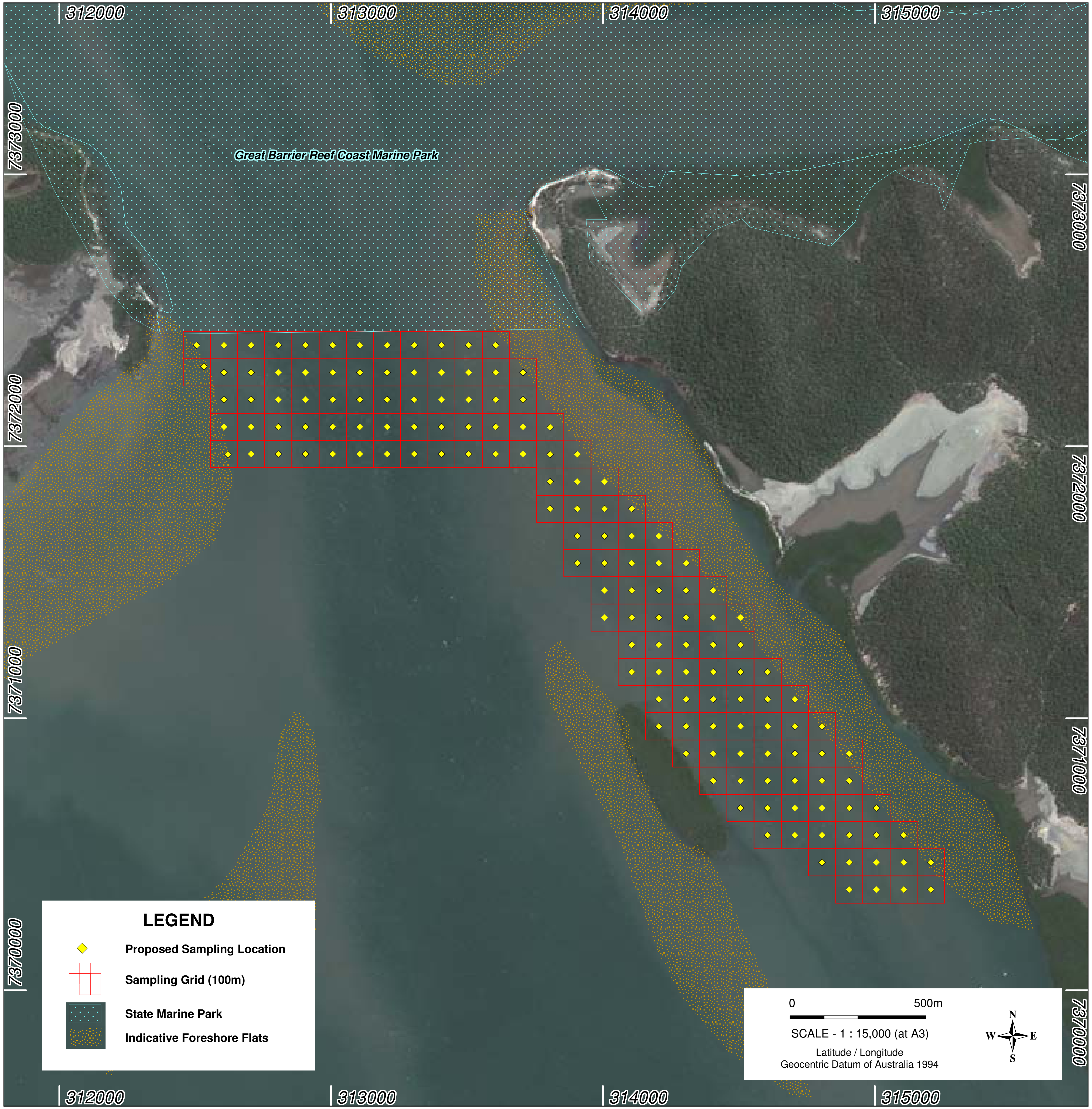


Figure 2.8 Predominantly bare sediment showing a significant amount of shell material



Satellite imagery (GeoEye-1 on 24 March 2009) AAM Hatch 2009

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Figure 2.9 - Proposed Benthic Survey Location
Pipeline Crossing and Laird Point Facility

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2.4 Water quality

Port Curtis is recognised as a well mixed estuary and traditionally assumed to be well flushed and readily dispersed to the offshore environment. A study by Apte et al (2006) showed that while water circulation within the Port Curtis estuary is strong, material had difficulty discharging from the estuary. It was found that the time for the total mass of material to decrease to approximately one-third of its original mass is approximately 19 days. Although metal contaminants are currently below regulation guidelines, the limited flushing of the estuary may potentially have important implications over time. For example, marine organisms in the estuary are exposed to higher metal concentrations compared to those in pristine environments and show evidence of bioaccumulation of these contaminants (Andersen et al. 2005, Apte et al. 2005, Jones et al. 2005).

Water quality studies in Port Curtis have been generally consistent in identifying that water quality within Port Curtis is generally high although strongly influenced by tidal state (BMT WBM 2009): low tides generally exhibit lower water quality. The physiochemical water quality parameters are described in Table 2.2.

Table 2.2 Physicochemical water quality parameters (EPA data 1996-2006)

	Minimum	20th percentile	Median	80th percentile	Maximum
Temperature °C	17.7	22.5	26.2	29.2	33.9
Conductivity mS/cm	29.9	52.7	55.0	56.6	60.5
Salinity[1] ppt	18.5	34.7	36.5	37.6	40.6

[1] Derived from temperature and conductivity (note conductivity @ 25ºC), ppt = parts per thousand.

Many of the nutrients and metals at these tidal states were associated with particulate (rather than dissolved) phases. Salinities in the Port Curtis estuary, including The Narrows, closely resemble that of ocean water and in some areas can be higher, possibly due to a combination of low freshwater inputs, evaporative losses and limited discharge to coastal waters (Apte et al. 2006, BMT WBM 2009). Generally, pH and temperature levels are uniform throughout depth within the Port Curtis estuary (BMT WBM 2009). However, elevated temperatures (with a maximum differential of 8.2°C) occur in the cooling water discharge of the Gladstone Power Station which discharges into the Calliope River (Saenger et al. 1982).

Within the estuary, common contaminants that have been assessed include various metals, fluoride, cyanide and tributyltin (TBT). Metals within the Port Curtis estuary have consistently been recorded as occurring below ANZECC/ARMACANZ (2000) guidelines (Apte et al. 2005, Jones et al. 2005). However, metal concentrations, particularly dissolved copper, nickel, lead and zinc are elevated in comparison with pristine coastal water sites in Australia (Apte et al. 2005). In particular copper and nickel have elevated concentrations in The Narrows and elevated concentrations of lead and zinc are present in Port Curtis. Apte et al. (2005) provide a comparison of metal concentrations from the Port Curtis estuary with those at various locations in nearby marine waters. Table 2.3 compares metal concentrations from the Port Curtis estuary with those at various locations around the world.

Apte et al. (2005) concluded that, based on the distribution of copper and nickel concentrations in The Narrows, these contaminants are likely to be representative of naturally occurring concentrations. In comparison, lead and zinc concentrations in Port Curtis are considered most likely to be influenced by anthropogenic inputs.

Water from the Fitzroy River is a source of dissolved metals to the region and, under certain conditions, may flow into The Narrows and ultimately Port Curtis. Of particular note, is that the Fitzroy River contains elevated concentrations of nickel, and to a lesser extent copper, which may significantly influence the observed metal concentrations reported in The Narrows (Apte et al. 2005). The Narrows was, until recently, thought to be a relatively pristine area. Given the results of recent sampling, which have indicated elevated metal concentrations, it has been hypothesised that The Narrows may potentially act as a source of contaminants into Port Curtis (Apte et al. 2005).

TBT is a contaminant of concern in Port Curtis and has been identified as occurring in concentrations above trigger levels within the water column, particularly around Fisherman's Landing and the mid and southern harbour (Jones et al. 2005). However, in comparison, levels are much lower than reported in ports around Australia (Andersen 2004). TBT has been found to have bio-accumulated in the biota of Port Curtis (oysters, mud whelks and mud crabs), but is expected to decrease over the coming years, as TBT continues to be phased out as an anti-foulant on ships worldwide.

Table 2.3 Concentration of trace metals in waters in nearby marine waters (from Apte et al. 2005)

Location	Metal concentration, ng/L				
	Cadmium (Cd)	Copper (Cu)	Nickel (Ni)	Lead (Pb)	Zinc (Zn)
Port Curtis (average)	6	496	407	76	163
The Narrows (average)	7	512	536	21	124
Central Queensland Coastal waters (average)	1	42	147	13	34
Lower Fitzroy River (saline)	8	672	1030	21	118
NSW coast	2.4	31	180	9	<22

2.4.1 Level of ecosystem protection

For the purposes of describing water quality, Port Curtis can be described as 'slightly to moderately' disturbed. ANZECC/ARMCANZ (2000) guidelines for toxicants in aquatic ecosystems commonly apply a 95 percent protection level to ecosystems that are classified as slightly to moderately disturbed. Furthermore, the Guidelines recommend that trigger values for 'slightly to moderately' disturbed systems also be applied to highly disturbed ecosystems wherever possible. This addresses the reality of the 'continuum of disturbance' whereby the specified levels of protection are essentially arbitrary classifications and their application can be such that they can be used to set 'aspirational targets'.

2.4.2 Water quality guidelines

The ANZECC/ARMCANZ (2000) guidelines allow for a broad scale assessment of water quality condition, but where applicable, locally relevant guidelines should be adopted. In Queensland, discharges to the marine environment are regulated by the Department of Environment and Resource Management (DERM), formerly the Environment Protection Agency (EPA). In the current instance, given that there are only limited relevant environmental values (EVs) or water quality objectives (WQOs) established for Port Curtis, in accordance with EPP (Water) 1997, the Queensland Water

Quality Guidelines (QWQG; DERM 2009) shall be adopted for assessing potential impacts from the brine discharge to Port Curtis. The QWQG have been drafted to address the need for more locally specific water quality guidelines by:

- Providing guideline values (numbers) that are tailored to Queensland regions and water types.
- Providing a process/framework for deriving and applying local guidelines for waters in Queensland (i.e. more specific guidelines than those in the QWQG).

The spatial limits of the marine waters of Queensland to which the QWQG apply are taken to be the three nautical-mile limit. The QWQG have been derived for specific areas throughout Queensland, where every effort has been made to ensure that there are seamless boundaries with any regional guidelines derived for adjacent Commonwealth waters.

The QWQG are technical guidelines, primarily for the protection of Queensland aquatic ecosystems. The guidelines include locally and regionally relevant water quality data for fresh, estuarine and marine waters. The DERM has been collecting water quality data from reference (unimpacted or minimally impacted) waterways since 1992. The EPA has used these data, together with data collected throughout Queensland by a range of government agencies, tertiary institutions and other organisations, to derive the QWQG. Any future water quality monitoring should rely on these guidelines, and the default trigger values which protect 95% of species, as defined by ANZECC/ARMCANZ (2000), where applicable.

The QWQG water quality objectives for the Central Coast Queensland Region (DERM, 2009) and the default trigger values for physical and chemical stressors for slightly disturbed ecosystems in marine waters of tropical Australia (ANZECC/ARMCANZ, 2000) are presented in Table 2.4.

Table 2.4 Water quality objectives for tropical marine waters near Gladstone.

	QWQG (DERM, 2009)	ANZECC/ARMCANZ (2000)
Ammonia N (µg/L)	8	1 – 10
Oxidised N (µg/L)	3	2 - 8
Organic N (µg/L)	180	
Total N (µg/L)	200	100
Filterable P (µg/L)	6	5
Total P (µg/L)	20	15
Chlorophyll-a (µg/L)	2.0	0.7 – 1.4
DO (% saturation). Upper	100	ND
DO (% saturation). Lower	90	90
Turbidity (NTU)	6	1 – 20
Secchi (m)	1.5	ND
Suspended solids (mg/L)	15	ND
pH. Upper	8.4	8.4
pH. Lower	8.0	8.0
Conductivity (µS/cm)	n/a	ND

2.5 Marine species of conservation significance

2.5.1 Dugong

Dugongs are more closely related to elephants than to other marine mammals such as whales and dolphins, but their closest living aquatic relatives are the manatees. The dugong is listed as vulnerable to extinction under the Queensland *Nature Conservation Act 1992* (NC Act 1992) and vulnerable by the International Union for the Conservation of Nature (IUCN).

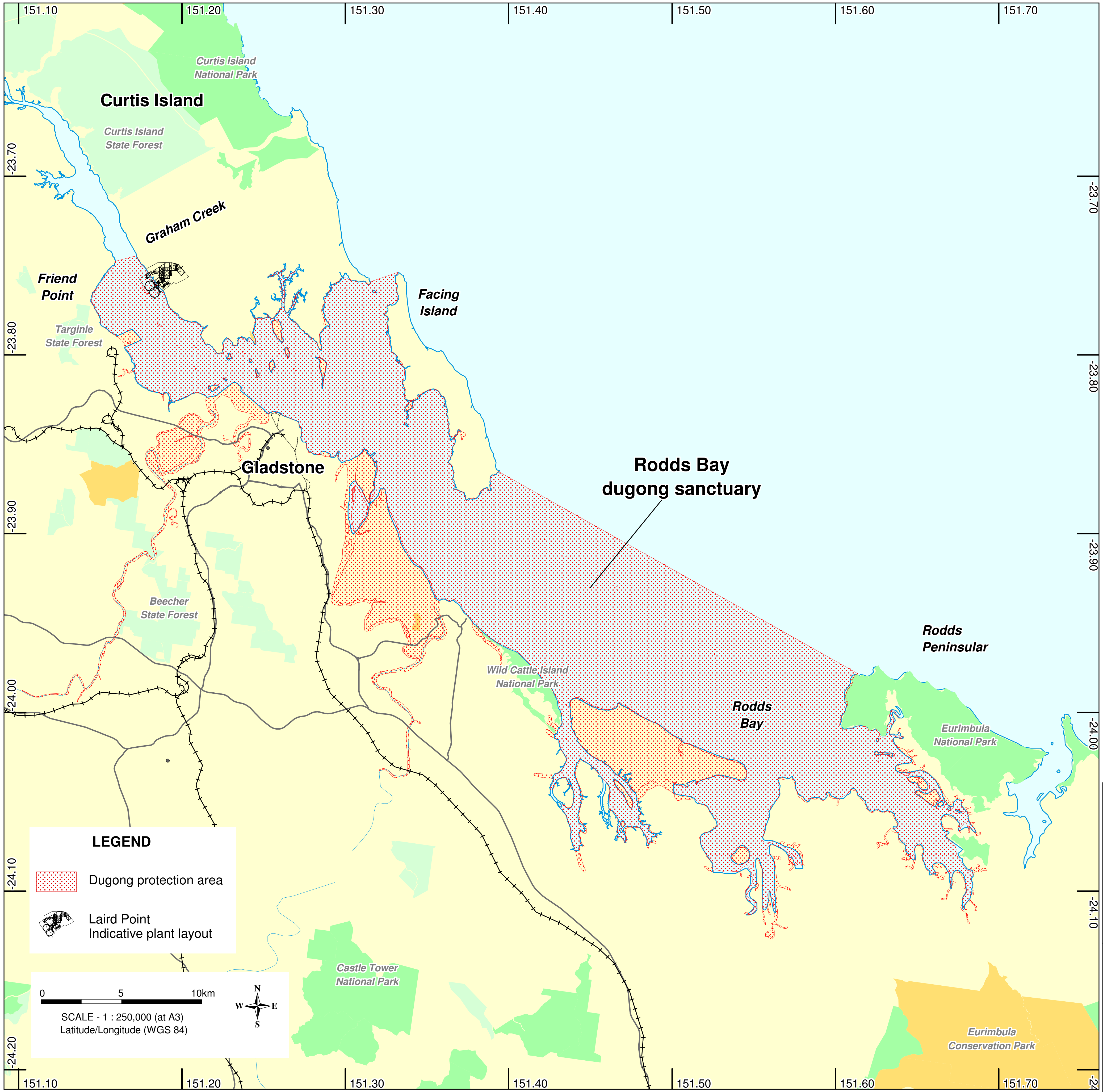
There is a significant and long-term decline in the population of dugong along the Queensland urban coast (Dobbs et al. 2008). Dugong numbers in the Great Barrier Reef along the urban coast of Queensland have fallen by 97 per cent since the 1960s (Marsh et al. 2001). Dugong are long-lived (up to 70 years) with low levels of reproductive output. After a gestation period of between 13 and 15 months, a female produces a single calf with calving intervals between three and seven years. Their slow breeding rate and long life span mean that dugongs are particularly susceptible to factors that threaten their survival, and population recovery even when impacting processes are removed is slow.

Anthropogenic impacts on dugong include traditional hunting, incidental capture in large meshed commercial fishing nets, the shark control program, boat strike and destruction of, and alienation from seagrass habitat.

Sixteen Dugong Protection Areas are declared under the NC Act 1992, and as Special Management Areas under the *Great Barrier Reef Marine Park Regulations 1983* and the *Great Barrier Reef Marine Park Zoning Plan 2003*. The Great Barrier Reef Marine Park Authority's primary management intent for dugong conservation in the Great Barrier Reef Marine Park is to facilitate the recovery of dugong populations such that they fulfil their ecological role within the Great Barrier Reef ecosystem (GBRMPA 2007).

The Rodds Bay/Port Curtis area, including the area adjacent to the proposed development site, is designated a Dugong Protection Area B. Dugong Protection Areas are a two-tiered management scheme where Dugong Protection Area A represents the most significant dugong habitat in the southern Great Barrier Reef, while Dugong Protection Area B represents less significant but still important habitat. The main difference in management arrangements between Dugong Protection Areas A and B relate to commercial mesh netting fishing regulations.

As with all other marine mammals, dugongs must surface to breathe. However, unlike other marine mammals such as some whales and dolphins, dugongs cannot hold their breath under water for very long. Dives generally last for only a few minutes. Dugongs have poor eyesight but acute hearing. They almost solely consume seagrass, although in Moreton Bay large amounts of ascidians (sea squirts) may be consumed (Preen 1995). Dugong (*Dugong dugon*) are associated with seagrass beds in the Port Curtis region, but the region is not identified as supporting large populations of these animals. The nearest large populations of dugong occur in Shoalwater Bay to the north and Hervey Bay to the south. The dugong that do occur in the Port Curtis region are centred around the Rodds Bay area (Lawler and Marsh 2001), but they are recorded using seagrass beds in the northern part of Port Curtis such as those near Wiggins Island (Taylor et al. 2007, Chartrand et al. 2009).



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Rev	Date	Revision Description	ORIG	CHK	ENG	APPD
1	09/02/2010	Re-issued for use	KM	MZ		RB
0	17/02/2010	Issued for use	NA	MZ		RB

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Figure 2.10 - Dugong Proptection Areas

Project No: 301001-00448 | Figure: 00752-00-EN-DAL-0433 | Rev: 1

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Table 2.5 Dugong population estimates in Dugong Protection Areas in Central and Southern Queensland from 1999 (from Lawler and Marsh 2001)

Rodds Bay	Hervey Bay/ Great Sandy Straits	Shoalwater Bay	Hinchinbrook Channel	Cleveland Bay	Repulse Bay	Upstart Bay
55 ± 37	1,673 ± 521	452 ± 132	725 ± 436	362 ± 157	90 ± 57	25 ± 26

2.5.2 Marine turtles

The conservation status of marine turtle species found in Australian waters is identified in Table 2.6. Currently, there is a recovery plan in place under the *Environment Protection and Biodiversity Conservation Act 1999* for all marine turtle species in Australia.

Table 2.6 The conservation status of marine turtles found in Australian waters

Species name	Conservation status		
	IUCN	EPBC Act	NC Act
Green turtle (*Chelonia mydas*)	Endangered	Vulnerable	Vulnerable
Hawksbill turtle (*Eretmochelys imbricata*)	Critically endangered	Vulnerable	Vulnerable
Flatback turtle (*Natator depressus*)	Data deficient	Vulnerable	Vulnerable
Olive Ridley turtle (*Lepidochelys olivacea*)	Vulnerable	Endangered	Endangered
Leatherback turtle (*Dermochelys coriacea*)	Critically endangered	Endangered	Endangered
Loggerhead turtle (*Caretta caretta*)	Endangered	Endangered	Endangered

Key: IUCN = International Union for the Conservation of Nature, EPBC Act = Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, and the NC Act = *Queensland Nature Conservation Act 1992*.

Marine turtles are long-lived and late maturing with maturity reached at between 30 and 50 years of age (Miller 1996). Foraging habitats and preferred food items for marine turtles are identified in Table 2.7. Marine turtles nest on mainland coastal beaches and offshore islands. They do not routinely nest in estuarine areas such as Port Curtis. Figure 2.11 through to Figure 2.13 describe the recorded nesting areas for the six marine turtle species in eastern and northern Australia.

Female marine turtles emerge from the water, generally at night, and move up the shoreline to select a nesting location. Most females do not nest in consecutive years. However, they may lay several clutches of eggs per year (Limpus et al. 1984, Miller 1996). Nesting marine turtles generally demonstrate fidelity to a nesting beach and return to nest on their natal beach with a high degree of precision (Limpus et al. 1984). The process by which turtles select nesting sites along a beach have not been clarified (Miller 1996). However, light regime is considered to have a significant impact on the emergence of female marine turtles from the ocean.

Marine turtles may also emerge from the water and return without attempting to excavate a nest or lay eggs – a phenomenon known as a ‘false crawl’ – and the frequency of false crawls can be influenced by anthropogenic factors such as coastal development and the presence of humans on the beach during nesting activities. Nesting generally occurs between the high water mark and the foredune, but nests may also be laid below the high tide mark (Whiting et al. 2007). If a nest is significantly inundated, it becomes unviable.

The sex ratio of turtle hatchlings depends on the temperature of incubation which is a function of sand colour. Nests in darker sand incubate at higher temperatures and produce more females (Hays et al. 2001).

Once hatched, lighting cues have been identified as critical for hatchlings to move from the beach to the ocean – a behaviour known as sea-finding. In simple terms, where there are no anthropogenic light sources hatchlings move away from the dark silhouetted shoreline towards the brighter ocean horizon. Brightness in this context is a term that encompasses wavelength and intensity (Witherington and Martin 1996). Further, the heterogeneity of the light regime can also act as a cue: that is, hatchlings may orientate away from a horizon that has spatial patterns of light and shadow, which in practical terms would see them orientate away from the shore and head towards the more homogenous light environment of the ocean horizon (Godfrey and Barreto 1995, Witherington and Martin 1996). Changes to lighting regime can impact hatchlings if light sources are at the nesting beach, on the foreshore adjacent to the nesting beach, or offshore. Lights at a nesting beach can result in turtle hatchlings heading inland rather than into the ocean, with subsequent mortality. Lights adjacent to nesting beaches can result in hatchlings entering the ocean safely, only to re-emerge closer to the light source.

It is known that the endemic flatback turtle (*Natator depressus*) nests on the eastern beaches of Curtis Island, Facing Island and Hummock Hill Island (Limpus et al. 2002; 2006, Hodge 2006). The South End area of Curtis Island is the key flatback nesting area in the region and it is identified nationally as a medium density rookery (Limpus et al. 2006). Nesting activity reaches a peak in late November – early December and ceases by about late January. Hatchlings emerge from nests during early December until about late March, with a peak of hatchling activity in February (Limpus 2007).

Green turtles (*Chelonia mydas*) and loggerhead turtles (*Caretta caretta*) may also nest sporadically in similar areas. However, important rookeries for the species lie elsewhere: the Carpicorn Bunker Group of Islands for green turtles and the Bundaberg Coast for loggerhead turtles. Leatherback turtles (*Dermochelys coriacea*) and Hawksbill turtles (*Eretmochelys imbricata*) do not nest adjacent to the proposed pipeline location (Limpus and McLachlan 1994).

Foraging habitats and preferred food items for marine turtles are identified in Table 2.7.

Table 2.7 Foraging habitats and preferred food items of the various marine turtle species

Turtle species	Foraging habitats	Preferred food items	Reference
Green turtle (*Chelonia mydas*)	Shallow coastal area, in particular seagrass beds	Seagrass and seaweeds although juveniles are also carnivorous	Brand-Gardner et al. (1999)
Hawksbill turtle (*Eretmochelys imbricata*)	Rocky reef and coral reef habitats	Algae, seagrass and sponges	Limpus (2009a)
Flatback turtle (*Natator depressus*)	Shallow coastal environments including rocky reef and sedimentary habitats	A wide variety of soft bodied animals including soft corals, sea pens, sea cucumbers, jellyfish and other large plankton	Limpus (2007)
Loggerhead turtle (*Caretta caretta*)	A wide range of intertidal and subtidal habitats including coral and rocky reefs, seagrass meadows, and unvegetated sand or mud areas.	Although their diet is diverse, typical items include bivalve and gastropod molluscs and crabs	Limpus (2008a)

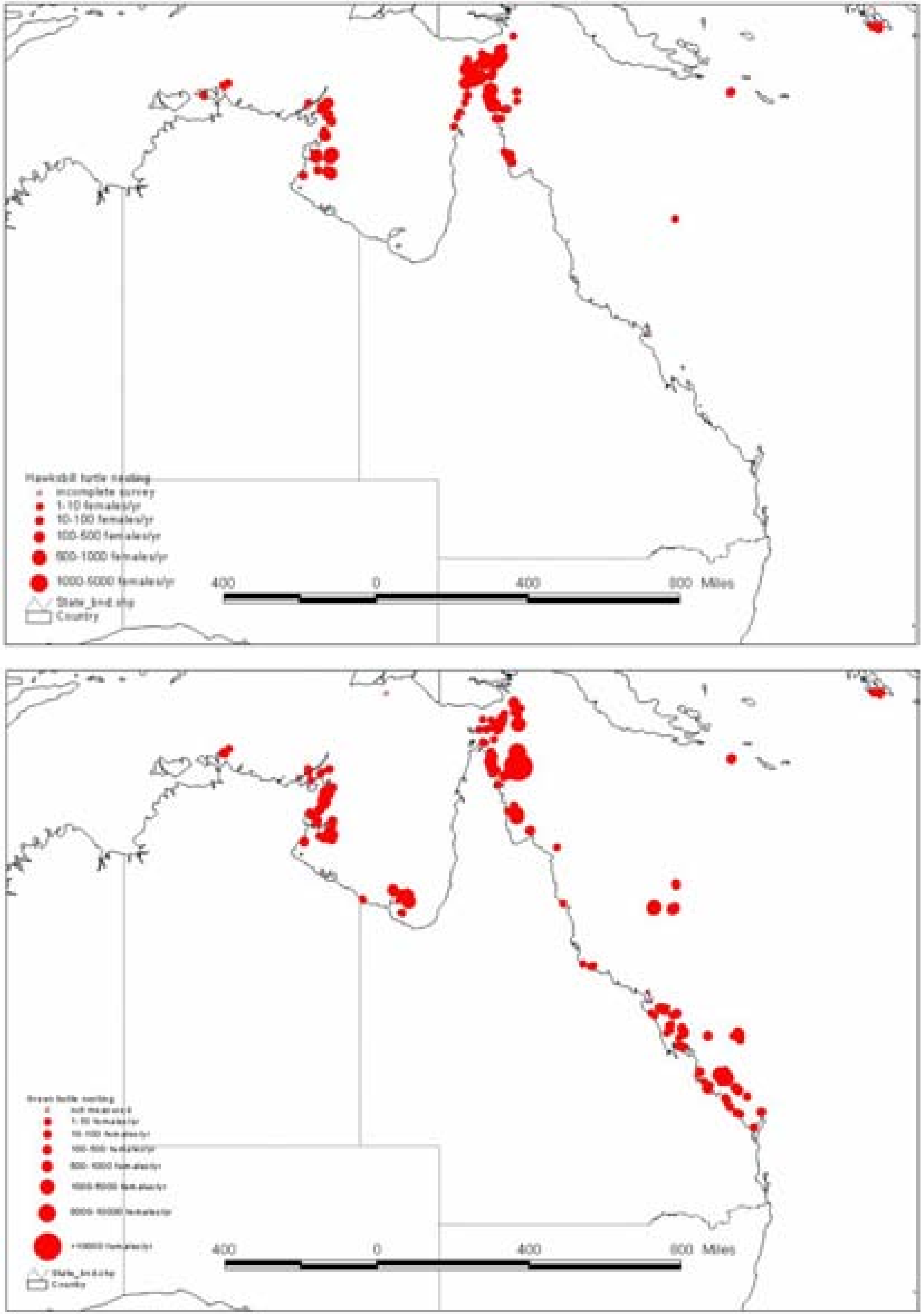


Figure 2.11 Nesting locations in northern and eastern Australia for hawksbill turtles (top) and green turtles (bottom) (from Limpus and Miller 2008)

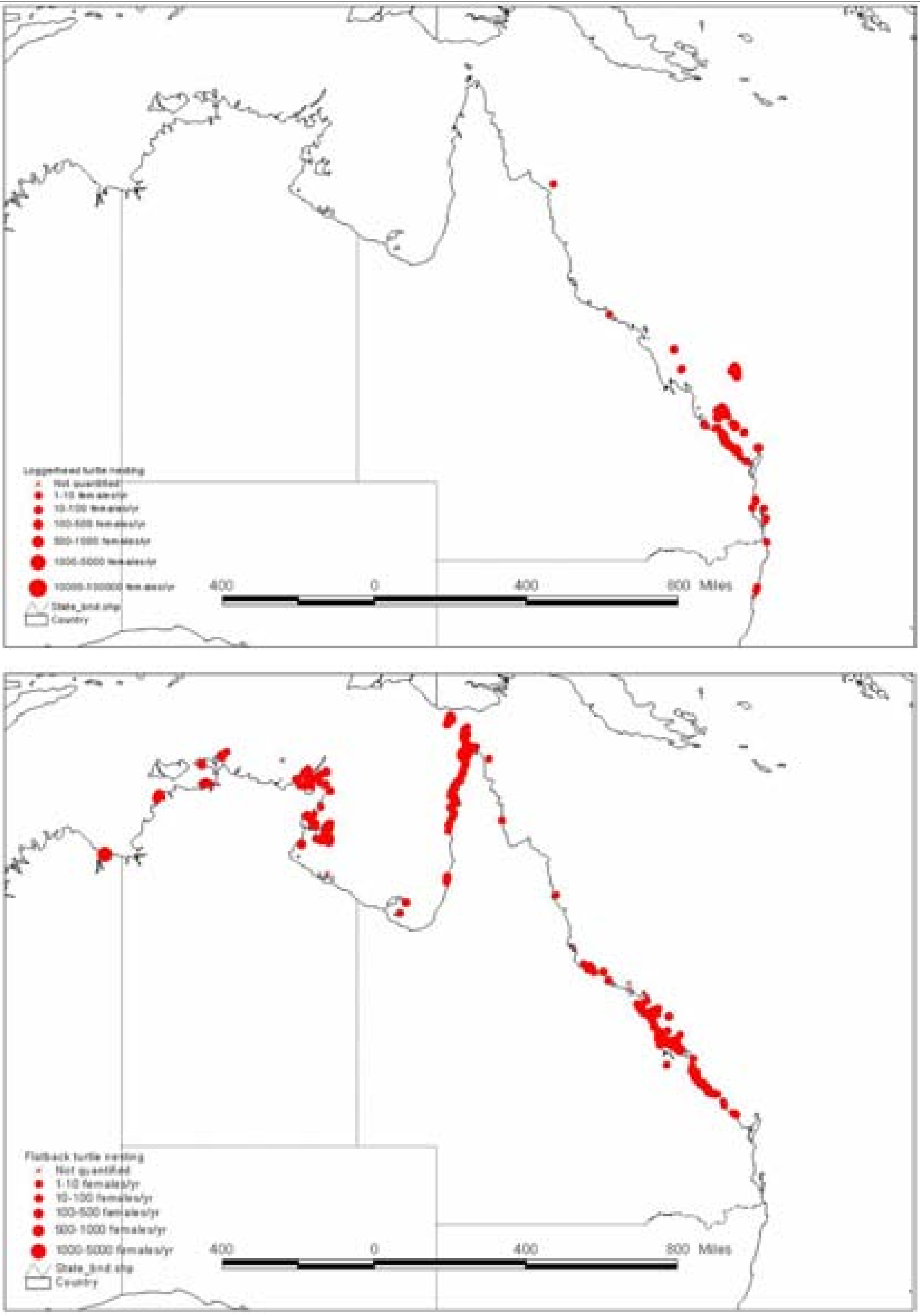


Figure 2.12 Nesting locations in northern and eastern Australia for loggerhead turtles (top) and flatback turtles (bottom) (from Limpus and Miller 2008)

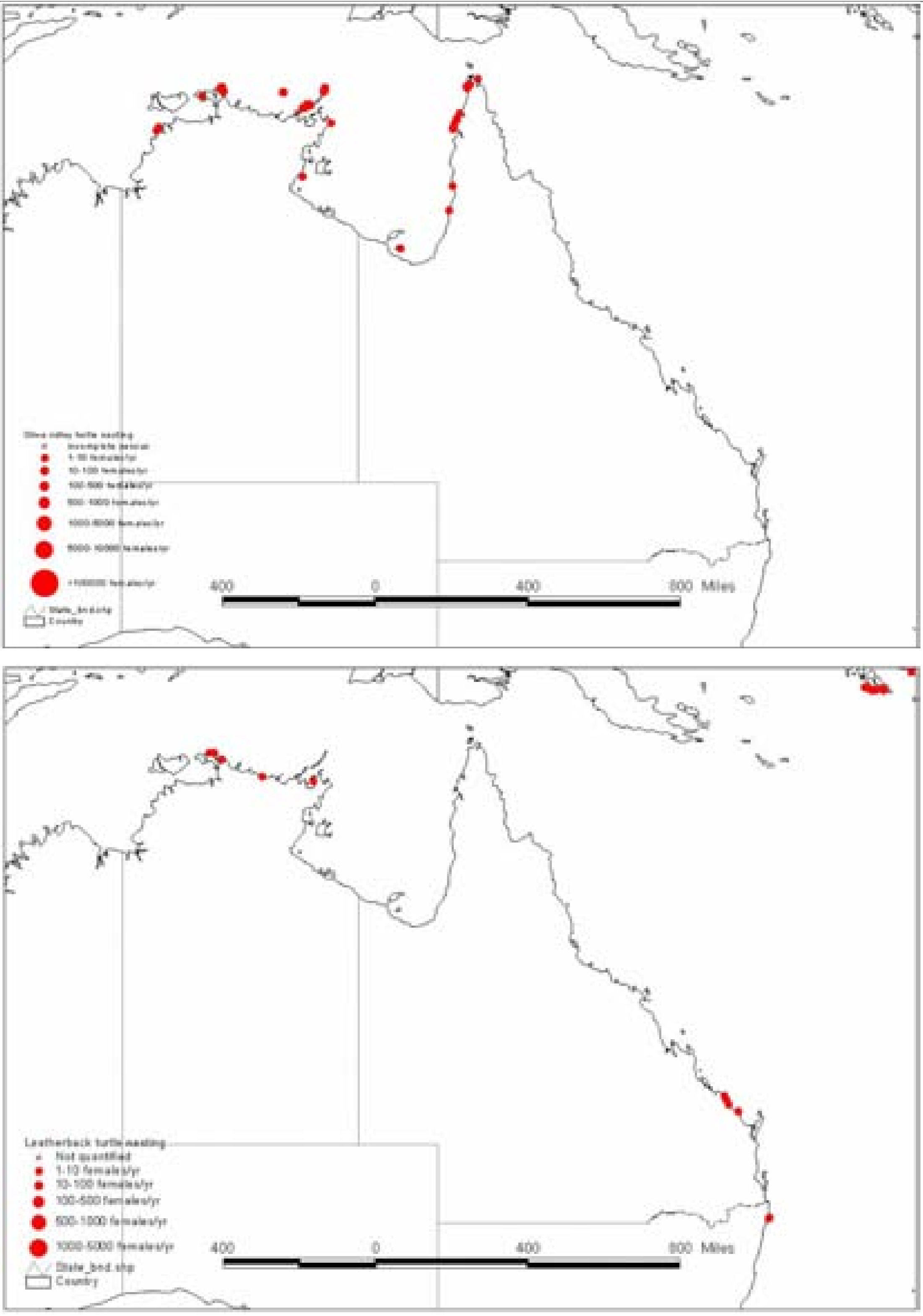


Figure 2.13 Nesting locations in northern and eastern Australia for olive Ridley turtles (top) and leatherback turtles (bottom) (from Limpus and Miller 2008)

2.5.3 Cetaceans - whales and dolphins

The Environment Protection and Biodiversity Conservation (EPBC) Protected Matters Database identified 10 cetacean species that may occur in the Port Curtis region including offshore areas. Of these, the Indo-Pacific humpback dolphin (*Sousa chinensis)*, the Australian snubfin dolphin (*Orcaella heinsohni*) and the bottlenose dolphin (*Tursiops aduncus* and *Tursiops truncatus*) are known to occur adjacent to the proposed development locations.

Both the Australian snubfin dolphin and the Indo-Pacific humpback dolphins usually inhabit shallow coastal waters of less than 20m depth and are often associated with rivers and estuarine systems, enclosed bays and coastal lagoons (Corkeron et al. 1997, Hale et al. 1998; Parra 2006). There are no estimates of dolphin abundance in Port Curtis. The Australian snubfin dolphin is endemic to Australia but may also occur in Papua New Guinea (Beasley et al. 2005). Previously, the Australian snubfin dolphin was identified as the widely distributed Irrawaddy dolphin (*Orcaella brevirostris*). Recent genetic studies on Indo-Pacific humpback dolphins indicate Australian populations may also represent a different species, only found in Australia (Frère et al. 2008).

Parra (2006) examined habitat use of both Australian snubfin dolphins and Indo-Pacific humpback dolphins in Cleveland Bay (Townsville). While there was significant overlap in habitat use by the two species, differences were also found. Australian snubfin dolphins preferred slightly shallower (1m–2m) waters than humpback dolphins (2m–5 m). Shallow areas with seagrass ranked high in the habitat preferences of snubfin dolphins, whereas humpback dolphins favoured dredged channels.

The diet of both Australian snubfin dolphins and Indo-Pacific humpback dolphins has been examined by Parra and Jedensjö (2009). The Australian snubfin dolphin consumes fish, cephalopods (squid and cuttlefish), bivalves and decapod crustaceans (prawns). The fish families consumed most frequently by the Australian snubfin dolphin were the Sciaenidae, Leiognathidae, Sillaginidae, Haemulidae, Apogonidae and Synodontidae. The Indo-Pacific humpback dolphin consumed cephalopods, bivalves and decapod crustaceans less frequently than Australian snubfin dolphins. The fish families consumed most frequently by the Australian snubfin dolphin were Apogonidae, Mugilidae, Clupeidae, Sciaenidae and Haemulidae.

Due to the inshore nature of the site, the following cetacean species identified in the EPBC Protected Matters search are *not* considered to occur at or adjacent to the proposed development location as they are principally oceanic species: minke whale (*Balaenoptera acutorostrata*)*,* humpback whale (*Megaptera novaeangliae*)*,* Bryde's whale (*Balaenoptera edeni*), Risso's dolphin (*Grampus griseus*), spotted dolphin (*Stenella attenuata*), common dolphin (*Delphinus delphis*) and the killer whale (*Orcinus orca*).

2.5.4 Estuarine crocodile

The southern most range of the estuarine crocodile (*Crocodylus porosus*) is generally recognised as the Fitzroy River although individuals straggle as far south as Colosseum Inlet and Seven Mile Creek. While it is plausible that the estuarine crocodile may be sited near the proposed LNG Facility, the area does not represent key habitat for the species. The key area for estuarine crocodile populations in Queensland is the north western Cape York Peninsula, particularly parts of the Wenlock River and the Lakefield National Park (Read et al. 2004).

2.5.5 Sea snakes

An EPBC Protected Matters Database search identified that there were 12 species of sea snakes that may occur in the region of the proposed development. The species are as follows:

- Horned seasnake (Acalyptophis peronii)
- Dubois' seasnake (*Aipysurus duboisii*)
- Spine-tailed seasnake (*Aipysurus eydouxii*)
- Small headed seasnake (*Hydrophis mcdowelli*)
- Olive seasnake (*Aipysurus laevis*)
- Stokes seasnake (*Astrotia stokesii*)
- Spectacled seasnake (*Disteria kingii*)
- Olive-headed seasnake (*Disteria major*)
- Turtle-headed seasnake (*Emydocephalus annulatus*)
- Elegant seasnake (*Hydrophis elegans*)
- Spine-bellied seasnake (*Lapemis hardwickii*)
- Yellow-bellied seasnake (*Pelamis platurus*).

There are clear and significant knowledge gaps with respect to the distribution and abundance of sea snakes in Australia. However, the following sea snake species are considered to prefer inshore waters with sandy/muddy substrata and moderate turbidity: elegant seasnake, spine-bellied seasnake and the small headed seasnake (Heatwole and Cogger 1993). As such, these are the sea snake species most likely to occur in the vicinity of the pipeline crossing. Coral reef, inter-reefal habitats or the open ocean are likely to be preferred habitats for the remaining species (Heatwole and Cogger 1993, Marcos and Lanyon 2004, Lukoschek *et al.* 2007).

2.5.6 Pipefish and seahorses

Pipefish and seahorses are listed marine species under the EPBC Act (section 248). An EPBC Protected Matters Database search identified that there were 33 species of syngnathids (pipefish and pipehorses) that may occur in the region of the proposed development locations:

- Hairy pygmy pipehorse (*Acentronura tentaculata*)
- Tryon's pipefish (*Campichthys tryoni*)
- Pacific short-bodied pipefish (*Choeroichthys brachysoma*)
- Brown-banded pipefish (*Corythoichthys amplexus*)
- Yellow-banded pipefish (*Corythoichthys flavofasciatus*)
- Reef-top pipefish (*Corythoichthys haematopterus*)
- Banded pipefish (*Corythoichthys intestinalis*)
- Ocellated pipefish (*Corythoichthys ocellatus*)
- Paxton's pipefish (*Corythoichthys paxtoni*)

- Schultz's pipefish (*Corythoichthys schultzi*)
- Blue-stripe pipefish (*Doryhamphus excisus*)
- Girdled pipefish (*Fetucalex cincatus*)
- Tiger pipefish (*Filicampus tigris*)
- Duncker's pipefish (*Halicampus dunckeri*)
- Mud pipefish (*Halicampus grayi*)
- Glittering pipefish (*Halicampus nitidis*)
- Spiny-snout pipefish (*Halicampus spinirostris*)
- Blue-spotted pipefish (*Hippichthys cyanospilos*)
- Madura pipefish (*Hippichthys heptagonus*)
- Beady pipefish (*Hippichthys penicillus*)
- Pygmy seahorse (*Hippocampus bargibanti*)
- Dpotted seahorse (*Hippocampus kuda*)
- Glat-face seahorse (*Hippocampus planifrons*)
- Zebra seahorse (*Hippocampus zebra*)
- Javelin seahorse (*Lissocampus runa*)
- Shortnose pipefish (*Micrognathus andersoni*)
- Thorn-tailed pipefish (*Micrognathus brevirostris*)
- Painted pipefish (*Nannocampus pictus*)
- Pipehorse (*Solegnathus hardwickii*)
- Robust ghost pipefish (*Solegnathus cyanopterus*)
- Ornate ghost pipefish (*Solegnathus paradoxus*)
- Double-ended pipefish (*Syngnathoides biaculeatus*)
- Short-tailed pipefish (Trachyrhamphus bicoarctatus).

Currie and Connolly (2004) identified the presence of an unidentified species of seahorse (*Hippocampus* sp. 1) and an unidentified species of pipefish (*Sygnathidae* sp. 1). Although information gaps exist, it is known that many species of pipefish prefer shallow inshore habitat, including both bare sand/mud and seagrass habitat, which are in the vicinity of the pipeline crossing.

2.6 Soft sediment macrobenthic infaunal assemblages

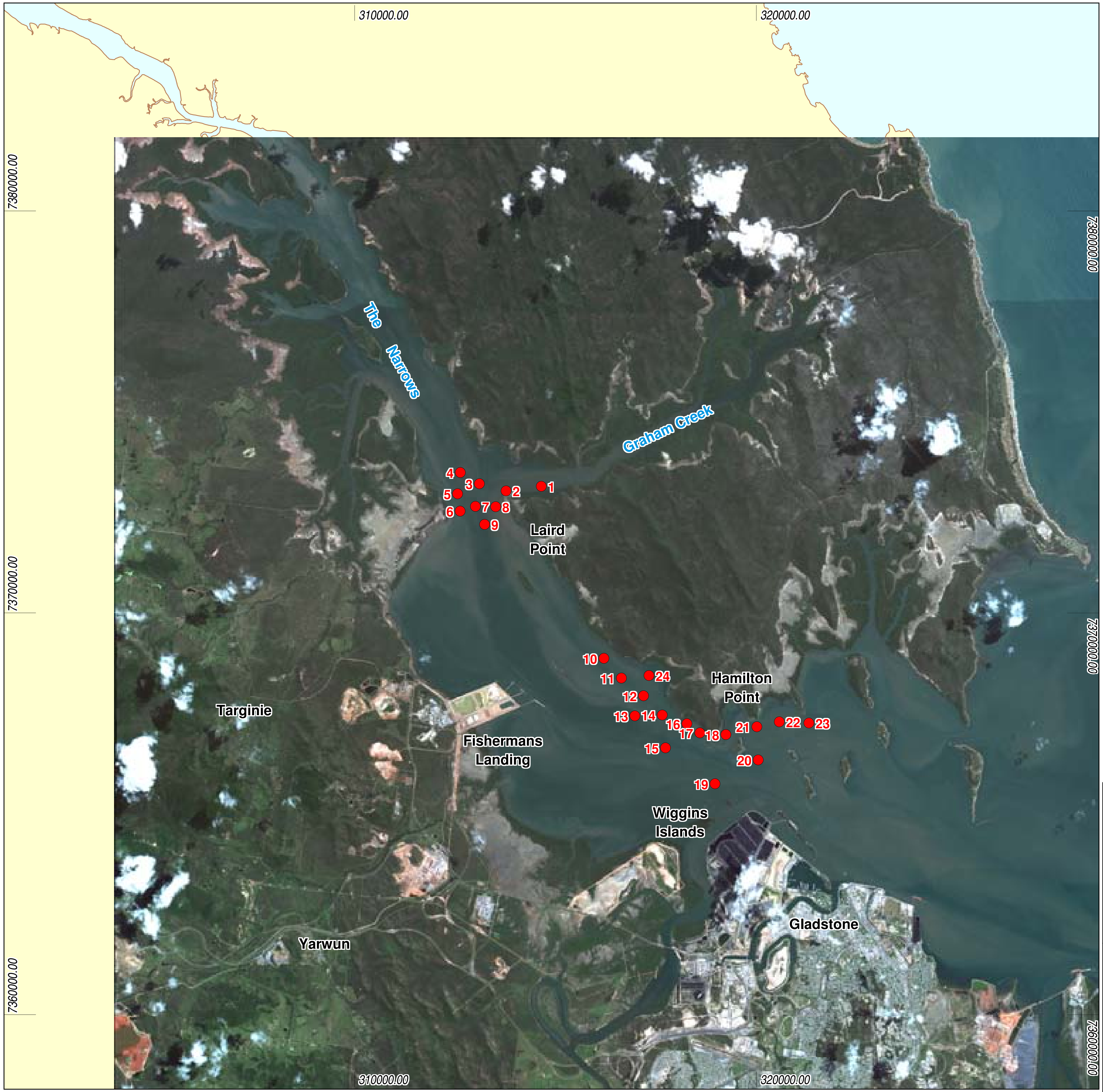
Through a variety of processes (for example, bioturbation, feeding and excretion), macrobenthic infauna regulate physical and chemical conditions at the sediment-water interface, and promote the decomposition of organic matter and recycling of nutrients required by plants for photosynthesis. Macrobenthic infauna also form important prey items for many large invertebrates and fish species (including species of direct fisheries significance) and are therefore an important linkage in the transfer of energy through the coastal food web.

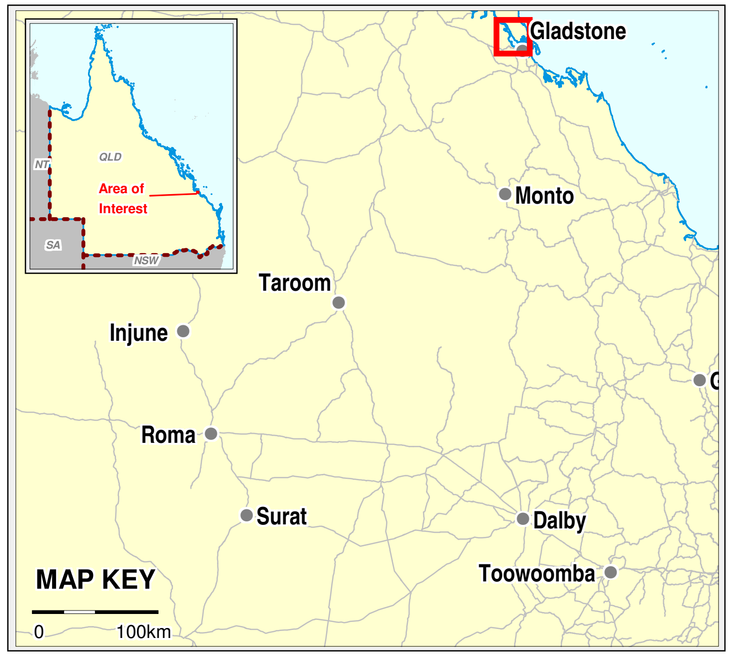
Currie and Small (2005, 2006) undertook a comprehensive assessment of the macrobenthic infaunal assemblage of Port Curtis over a six year period. Alquezar (2008) carried out additional work, in part, in the area of interest for the proposed project. Overall, the assemblage sampled by Currie and Small (2005, 2006) throughout the Port Curtis region is dominated by filter feeders which accounted for more than 50% of the total abundance and nearly 30% of the total species richness. The bivalve mollusc *Carditella torresi* was the most abundant species, accounting for more than 14% of the total abundance. The ascidian *Ascidia sydneiensis* was the second most abundant species accounting for less than 4% of the total abundance. A further eight species – including five bivalves (*Corbula tunicata*, *Mimachlamys gloriosa*, *Leionuculana superba*, *Mactra abbreviata* and *Placamen tiara*), one ascidian (*Ascidiacea* sp.), one polychaete worm (*Eunice vittata*) and one caridean shrimp (*Alpheus* sp.) – each contributed between 2 and 3% of the total abundance. The majority of organisms (98% of the species) were collected infrequently and individually contributed less than 2% of the total abundance. The species richness of the macrobenthic infaunal assemblage was generally lower than in higher latitude embayments elsewhere in Australia (for example, Moreton Bay).

In terms of spatial variability of the macrobenthic infaunal assemblage, species richness and abundance were found to be lowest on fine muddy substrates in intertidal areas and greatest in coarse sandy sediments that predominated in the deeper channels of the estuary. The pattern of freshwater flow was identified as the principal source of temporal variation in the assemblage, with regional rainfall and freshwater inflow positively correlated with macrobenthic infaunal abundance.

Some information presented by Currie and Small (2006) can be disaggregated into a smaller spatial scale. Sampling stations closest to the proposed pipeline crossing had a macrobenthic infaunal assemblage which was low density and numerically dominated by the deposit feeding bivalve *Leionuculana superba* and the predatory polychaetes *Eunice* species 1, *Nephtys* species 1 and *Leanira* sp 1.

Alquezar (2008) sampled 24 sites within Port Curtis, seven of which are in the vicinity of the proposed pipeline crossing between Laird Point and Friend Point (sites three to nine) and a further two were in Graham Creek (sites one and two) (Figure 2.14). Results for the total average abundance, taxa richness, taxa diversity (Shannon-Weaver Index) and evenness per replicate per site are summarised in Table 2.8. One of the sites near the proposed pipeline route (Site 9) had the highest sampled diversity and abundance of macrobenthic infauna.





LEGEND

Survey Sites extracted from Macroinvertebrate and Sediment Assessment for the Curtis Island Gas Pipeline EIS, Alquezar (2008).

Satellite imagery (GeoEye-1 on 24 March 2009) AAM Hatch 2009

0 2.5 5km

N W E S

SCALE - 1 : 100,000 (at A3)
Latitude/Longitude (WGS 84)

Rev	Date	Revision Description	ORIG	CHK	ENG	APPD
1	09/03/2010	Re-issued for use	GSB	MZ		RB
0	17/02/2010	Issued for use	NA	MZ		RB

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Figure 2.14 - Macroinvertebrate Survey Sites in Port Curtis used by Alquezar (2008)

Project No: 301001-00448 | Figure: 00448-00-EN-DAL-0435 | Rev: 1

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Table 2.8 Univariate attributes of the macrobenthic infaunal assemblage at 24 sites in Port Curtis (modified from Alquezar 2008)

Site no.	Total average abundance per replicate	Taxa richness per replicate	Taxa diversity	Evenness
1*	6.6	4.6	1.1	0.9
2*	3.3	2.7	0.9	0.8
3*	7.0	6.0	1.7	0.8
4*	12.0	6.7	1.5	0.6
5*	6.3	4.6	1.5	0.8
6*	1.6	1.7	0.5	1.0
7*	6.3	5.3	1.2	0.9
8*	6.3	5.6	1.7	0.9
9*	37.0	16.0	2.4	0.3
10	11.0	9.0	2.1	0.7
11	14.0	9.0	1.9	0.6
12	18.0	11.0	2.1	0.6
13	18.0	5.6	0.9	0.3
14	2.3	2.3	0.7	1.0
15	7.0	5.0	1.4	0.7
16	6.6	4.0	1.2	0.6
17	2.3	2.0	0.6	0.9
18	4.3	3.6	3.6	0.8
19	18.0	9.3	9.3	0.5
20	4.6	3.3	3.3	0.8
21	1.0	1.0	1.0	0.6
22	2.3	1.0	1.0	0.1
23	17.0	11.0	11.0	0.5
24	2.6	2.3	2.3	0.9

* Denotes sites within or adjacent to proposed development

2.7 Plankton

Plankton consists of phytoplankton (floating plants) and zooplankton (floating animals).

Phytoplankton is an important source of primary production in coastal waters and is recognised as an important indicator of environmental health. In particular, phytoplankton is a good indicator of nutrient enrichment from anthropogenic sources. Phytoplankton concentrations are measured by assessing the concentration of chlorophyll *a* in the water column. Chlorophyll *a* is the principal photosynthetic pigment possessed by phytoplankton. Prediction of chlorophyll *a* winter levels in the Port of Gladstone range from 0.6µg/L to 3.2µg/L and are between 2.05µg/L and 2.28µg/L in waters adjacent to Curtis Island. These values are below the relevant ANZECC guideline (2000) trigger value of 4.0µg/L (Currie and Small 2006).

Zooplankton is further divisible into holoplankton (animals that spend their whole life cycle as plankton) and meroplankton (animals that spend only part of their life cycle as plankton). Meroplankton includes larvae of sessile benthic organisms (for example, oysters) as well as fish and prawn larvae including those of commercial and recreational significance. Zooplankton includes animals that graze on phytoplankton as well as carnivores that consume other zooplankton. Both phytoplankton and zooplankton are key components of the food web of coastal waters.

With the exception of Moreton Bay, inshore plankton assemblages in Queensland are not well studied and the research in Moreton Bay is not directly transferable to the Port Curtis region. Although the majority of plankton is microscopic, the most visible component of the planktonic assemblage is the large scyphozoan jellyfishes, such as *Catostylus mosaicus*, which occur in Port Curtis.

2.8 Fish and nektobenthic invertebrates

All sub-tropical inshore fish assemblages are temporally and spatially variable at many different scales. Components of the fish assemblage in the Port Curtis region support regionally important commercial and recreational fisheries. Although information gaps exist, Currie and Connolly (2006) provide data on the structure of the inshore fish assemblage in the Port Curtis region. Their study utilised small trawl gear over sedimentary habitats, thereby limiting its use for describing the presence and abundance of larger species and those that associate with rock or reef habitat.

The fish assemblage of shallow, nearshore, sedimentary parts of the Port Curtis area was found to be diverse with 88 species present but was dominated by two small schooling species. This is typical of fauna recorded in inshore areas elsewhere in Queensland (see, for example, Hyland 1988, Blaber et al. 1989, Reid and Campbell 1998, Thomas and Connolly 2001, McPhee and Skilleter 2005). In the case of Port Curtis, the numerically dominant species were ponyfish (*Leiognathus equulus*) and herring (*Herklotsichthys castelnaui*), which in combination comprised approximately 50% of the total abundance.

The structure of the subtidal fish assemblage at inshore sites in the vicinity of pipeline crossing of The Narrows was found to be similar to most other inshore sites surveyed in Port Curtis. The major components of this inshore group of sites surveyed were: common ponyfish (*Leiognathus equulus*), finny scad (*Megalapsis cordyla*), herring (*Herklotsichthys castelnaui*), yellow perchlet (*Ambassis marianus*), happy moments (*Siganus rivulatus*), large-scaled grinner (*Saurida undosquamis*), striped cardinalfish (*Apogon fasciatus*), yellow-fin tripod fish (*Tripodichthys angustifrons*), large-toothed flounder (*Pseudorhombus arsius*), and diver whiting (*Sillago maculata*). All of these species are common, widely distributed and typical of inshore habitats in sub-tropical Australia.

Saltmarsh and saltpan habitats tend to have lower species richness than other inshore habitats such as mangroves and seagrass (Sheaves et al. 2007). Nonetheless, these provide important habitat for fish species, including those of recreational and commercial significance. Although fish utilisation of saltmarsh in the Gladstone region is not well studied, Sheaves et al. (2007) presents information on the saltmarsh fish assemblage for Munduran Creek which drains into The Narrows approximately 15km from the proposed development location. The species recorded and their abundances are listed in

Table 2.9. A similar suite of species are likely to occur within the saltmarsh to be disturbed by the proposed project.

Thomas and Connolly (2001) have also undertaken relevant work looking at the fish utilisation of saltmarsh habitat elsewhere in Queensland. Fish can extend many hundreds of metres into saltmarsh habitats on spring tides. For example, at Meldale in Pumicestone Passage and Theodolite Creek in Hervey Bay, fish were recorded 413m and 201m respectively from subtidal water. The relative importance of saltmarsh habitat, in terms of its use as a fisheries resource, is generally considered to decrease with decreasing depth. This parameter is often related to distance from mangroves (if present) or the water's edge – however, local habitat heterogeneity may confound this relationship. For two salt marshes (Meldale and Theodolite Creek), Thomas and Connolly (2001) identified consistent fish density across the first 200m of the salt marsh (from the water's edge), with reduced densities farther on to the saltmarsh.

Table 2.9 The abundance of fish species in salt pan areas in Munduran Creek (modified from Sheaves et al. 2007)

Species	Abundance
Liza subviridis (greenback mullet)	273
Gerres filamentosus (whipfin silverbiddy)	125
Mugil cephalus (sea mullet)	30
Leiognathus equulus (common ponyfish)	23
Valamugil sehali (bluespot mullet)	21
Herklotsichthys castelnaui (Castelnaui's herring)	16
Leiognathus decorus (decorated ponyfish)	14
Acanthopagrus australis (yellowfin bream)	10
Ambassis spp. (perchlet)	10
Nematalosa come (bony bream)	10
Valamugil sp. A. (mullet)	9
Selenatoca multifasciata (southern butterfish)	8
Sillago sihama (northern whiting)	5
Thryssa hamiltoni (Hamilton's anchovy)	3
Lutjanus argentimaculatus (mangrove jack)	3

Species	Abundance
Gerres erythrourus (deep-bodied silverbiddy)	3
Chanos chanos (milkfish)	2
Lates calcarifer (barramundi)	2
Gobid sp. A (goby)	1
Monodactylus argenteus (butter bream)	1
Scatophagus argus (spotted scat)	1
Siganus lineatus (striped rabbitfish)	1
Zenarcopterus buffonis (Buffon's river-garfish)	1
Terapon jarbua (Jarbua terapon)	1

Although specific information is lacking, the rock and reef habitat within Port Curtis is likely to be utilised by a range of adult and juvenile fish species including yellowfin bream (*Acanthopagrus australis*), sweetlip (principally *Lethrinus fletus*), estuary cod (*Epinephelus coides*), and blubber-lip bream (*Plectorhincus* spp.).

In terms of fish species of conservation significance, whale sharks occur in oceanic waters east of Facing and Curtis islands. They are therefore unlikely to occur in an estuarine environment such as Port Curtis, and highly unlikely to occur in the area adjacent to the LNG Plant study area. The green sawfish (*Pristis zijsron*) has been recorded in shallow inshore coastal environments including estuaries. However, detailed records of the occurrence of the species from 1912 to 2004 show that no individuals of the species have been recorded in the Gladstone region during that period (Stevens et al. 2005). The estuary stingray (*Dasyatis fluviorum*) is ranked as a high priority species by the DERM "Back on Track species prioritisation framework" which prioritises Queensland's native species to guide conservation, management and species recovery. The estuary stingray utilises a range of shallow inshore habitats and is likely to occur frequently within the area of the proposed development.

Nektobenthic invertebrates refers to large, more mobile benthic invertebrates (such as crabs, prawns and lobsters) that are typically absent or significantly underestimated in standard benthic sampling gear such as grabs or sleds. Nektobenthic invertebrates are frequently important for fisheries. Although a comprehensive analysis is lacking, the Port Curtis area provides habitat for various portunid crabs including the blue swimmer crab (*Portunus pelagicus*), juvenile penaeid prawns (including tiger prawns (*Penaeus semisulcatus* and *Penaeus esculentus*), eastern king prawns (*Penaeus plebejus*) and banana prawns (*Penaeus merguiensis*)), and mud crabs (*Scylla serrata*) (Walker 1997).

2.9 Fisheries resources

2.9.1 Commercial fisheries

Net and mud crab fisheries are the principal commercial fisheries operating in the Port Curtis area, although beam trawling also occurs (Walker 1997). Net and crab fishers that operate in Port Curtis are also permitted to operate anywhere on the east coast where these fishing activities are permissible. Commercial fishers that are endorsed to beam trawl in the Port Curtis area are only permitted to operate in Port Curtis and The Narrows, the mouth of the Fitzroy River and Keppel Bay.

Commercial fisheries in Queensland are monitored through a compulsory logbook program administered by the Queensland Primary Industries and Fisheries (QPI&F). Data collated from the program is available via the Coastal Habitat and Resource Inventory System (CHRISweb) database[2] which is also administered by the QPI&F. A key consideration when interpreting information from the database is the spatial resolution, which is very coarse. Commercial net and crab fishers record spatial information on catch and effort in 30 minute grid squares. In the current area of interest, this scale includes all of the Gladstone Port Area and The Narrows area as well as a significant area of offshore waters east of Curtis Island (Grid S30 in Figure 2.15). Further, catches within a reporting grid are only publicly available where five boats or more have accessed that particular grid in a given year.

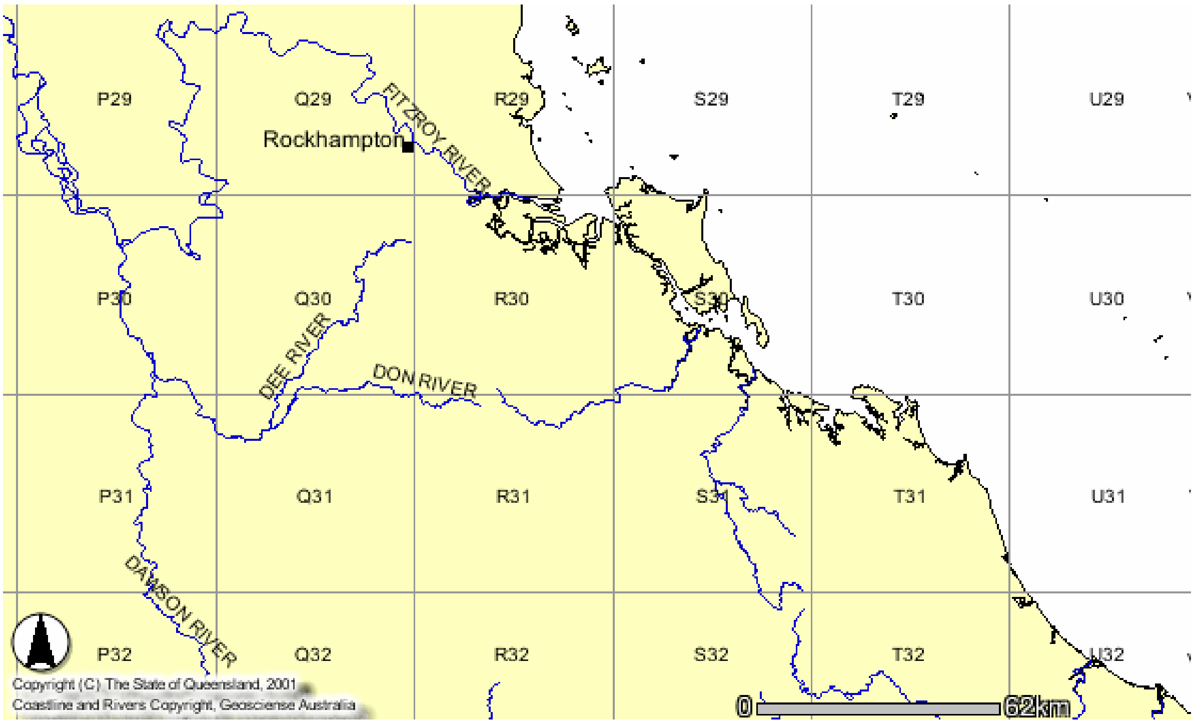

Figure 2.15 Map of the 30minute grids for recording commercial fishing catch and effort in the Port Curtis region.

The annual volume and value of the catch for the commercial net and crab fishery in the Gladstone Port area (grid S30) between 1988 and 2005 is shown in Figure 2.17. Both the volume and value of the catch in the net and crab fishery has tended to increase over time with a more rapid increase since 2003, particularly for the net fishery. No data is currently publicly available post 2005. The crab fishery in the region is almost solely focussed on the mud crab (*Scylla serrata*). Most of the commercial mud crab fishery is concentrated in The Narrows and the creeks that drain into this body of water (for example, Graham Creek, D.McPhee pers. obs). By volume and value, key target species in the net fishery include various species of shark (principally *Carcharinus* spp), blue threadfin salmon (*Eleutheronema tetradactylum*), mullet (*Mugil* spp.), barramundi (*Lates calcarifer*), and grey mackerel (*Scoberomorus semifasciatus*). A large range of other species are also captured and retained in the net fishery.

[2] http://chrisweb.dpi.qld.gov.au/chris/

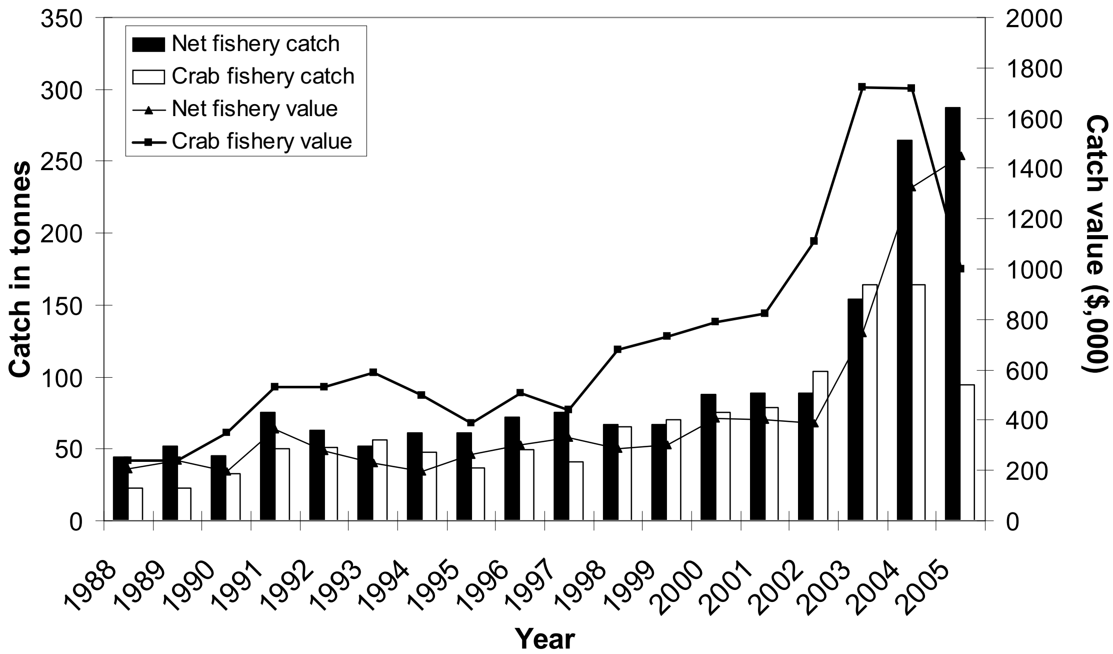

Figure 2.16 The annual volume and value of the commercial net and crab fishing catch between 1988 and 2005 in grid S30 which includes the Gladstone Port area.

The beam trawl fishery targets various species of prawns with banana prawns (*Penaeus merguiensis*), school prawns (*Metapenaeus macleayi*) and greasyback prawns (*Metapenaeus bennettae*) dominating the catch. The beam trawl fishery within the Port Curtis/Fitzroy River/Keppel Bay area contributes approximately 15% of the Queensland beam trawl catch. However, while the Port Curtis region is within the area that can be accessed by the fishery, it is rarely done so in practice.

The beam trawl fishery is consistently dominated by catches taken from the mouth of the Fitzroy River (reporting grid R29, Figure 6) and Keppel Bay (reporting grid R30, Figure 6). Beam trawl catch in reporting grid S30 has only been reported five times in 17 years and volumes during these five years have been low (Table 2.10). In the years where no catch has been recorded, it is possible that beam trawl vessels did access the fishery, but the number of vessels that did so was less than five. Nonetheless, the available logbook data indicates that reporting grid S30, which contains the location of the proposed development, is not an important area for the beam trawl fishery.

Table 2.10 Annual volume of prawn catch (tonnes) in the reporting grids that cover the Port Curtis/Fitzroy Beam trawl fishery (from CHRISweb)

Year	Grid R29	Grid R30	Grid S30	Grid T30	Grid T31
1988	22.1	15.0	-	4.5	1.8
1989	6.4	16.0	1.7	-	-
1990	5.8	19.3	-	-	-
1991	8.9	12.5	-	-	-
1992	7.0	20.2	-	4.7	3.6
1993	5.1	19.1	-	-	5.2

Year	Grid R29	Grid R30	Grid S30	Grid T30	Grid T31
1994	5.2	26.7	-	-	7.5
1995	-	28.1	-	5.6	6.9
1996	5.2	27.1	1.7	-	5.2
1997	7.4	47.9	-	-	-
1998	5.3	42.4	-	-	-
1999	8.5	33.7	-	-	1.7
2000	10.7	28.7	-	-	-
2001	18.1	39.3	-	-	-
2002	10.5	29.9	-	-	-
2003	32.6	52.5	4.4	-	-
2004	29.5	30.1	-	-	-
2005	21.9	31.9	7.0	-	-

2.9.2 Recreational fisheries

Statewide, recreational fishing surveys were undertaken in 1997, 1999, 2002, and 2005 and, like the information on commercial fishing, can be accessed via CHRISweb. These surveys report catch and effort information at a broad spatial scale – the statistical division that a fisher resides in. The relevant statistical division in relation to the proposed development is the Fitzroy Region and this is a large region comprising 13 local government areas with a total area of 122,972km^2 and includes Rockhampton, Gladstone, Emerald, and Biloela. The rank of importance of the various inshore and estuarine fish species for anglers residing in the Fitzroy statistical division in 2005 from the CHRISweb database is displayed in Table 2.11. This information demonstrates that whiting, mullet and bream are the three dominant taxa harvested.

Platten et al. (2007) provide information on the levels of boat-based fishing effort through central Queensland including Gladstone. From 1985 to 2005, boat registrations in the Gladstone region increased 110% from 2,171 to 4,581, with the vast majority of these boats used for recreational fishing. It was estimated that between June 2005 and May 2007, approximately 16,395 boating trips commenced from the Gladstone Boat ramp (adjacent to Gladstone Volunteer Marine Rescue VMR), which is the main public boat ramp in the region.

Platten (2006) provides additional information on fishing club catches of finfish at a finer spatial scale for the main fishing club that targets inshore species. The species composition of the catch is displayed in Figure 2.17. Platten (2006) clearly shows that whiting are the numerically dominant taxa captured, but catches by fishing clubs are not necessarily indicative of the broader recreational fishing public (McPhee 2008).

As well as the targeting of finfish, extensive mud crabbing by recreational fishers occurs in The Narrows and the creek systems that drain into it.

Table 2.11 The rank of numerical importance of recreationally harvested finfish in the Fitzroy Statistical Division in 2005 (from CHRISweb database)

Rank	Taxa	Rank	Taxa
1	Whiting	11	Spotted mackerel
2	Mullet	12	Fingermark
3	Bream	13	Mangrove jack
4	Dart	14	Barramundi
5	School mackerel	15	Moses perch
6	Garfish	16	Shark
7	Grunter	17	Grey mackerel
8	Threadfin salmon (blue & king)	18	Queenfish
9	Flathead	19	Rays
10	Tailor	20	-

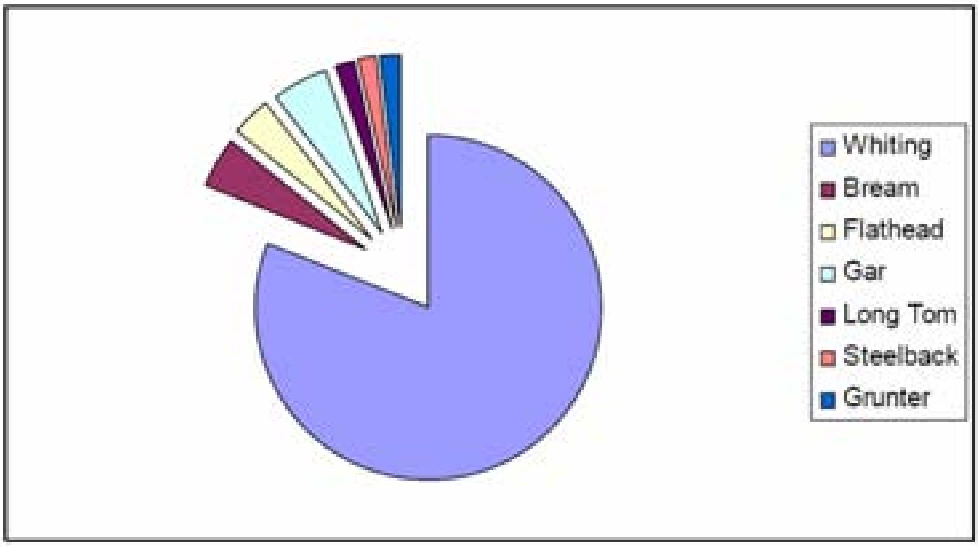

Figure 2.17 The catch composition of catches by the Wanderers Fishing Club in the Port Curtis region between 1997 and 2000 (from Platten 2006)

3. Impact assessment

The construction of the pipeline across the wetlands on the mainland and The Narrows has the potential to cause environmental impacts. The chosen construction method significantly influences the nature and magnitude of the potential impacts. Two habitat types are affected by pipeline construction including, intertidal areas including saltmarsh, saltpan, mangroves and intertidal mudlflats; and the subtidal sedimentary habitats in The Narrows. The exact alignment for the pipeline crossing across the wetlands on the mainland and The Narrows is not currently finalised, however an indicative route is available. The route as currently defined, in part, traverses the Habitat Protection Zone of the Great Barrier Reef Coast Marine Park as described in Schedule 2 of the Marine Parks (Declaration) Regulation 2006.

Three methods are being considered for constructing a high pressure gas pipeline across The Narrows, as follows:

- Flotation method
- Bottom pull method
- Horizontal Directional Drilling (HDD)

The first two methods require a dredged trench in which the pipeline is to be laid before backfilling. The HDD method does not require the dredging of a trench.

Flotation method

The flotation method requires assembling the complete pipe section for the crossing at the bank and covering it with a concrete coat to resist buoyancy effects. Transfer of the pipe from the shoreline to the pre-dredged underwater trench is undertaken by using floating plant and cranes. The flotation method is more applicable for waterway crossings where current velocities are low as manoeuvring floating plant into position becomes more difficult with increasing tidal currents. The dredging plant extracts the marine sediments to a hopper barge that transits to a designated material placement area, which in this case is proposed to be the reclamation area north of Fisherman's Landing. Due to the length of the crossing (approximately 1.8km) and the moderate to high current velocities encountered, the flotation method is the least favoured from an operational perspective.

Bottom pull method

The bottom pull method is employed to cross waterways that exhibit strong currents and where the seabed is dominated by sedimentary habitat. The method involves assembling a pipeline string so that its entire length is set out on the shore in the extended axis of the planned crossing route. Following assembly, it is pulled into the open dredged trench using an anchored winch located on the opposite bank of the waterway. If the site is too small to produce one continuous section for the length of the crossing, a series of pipe strings are made as long as possible to reduce the number of weld seams necessary to connect the sections. Due to the length of the crossing of The Narrows a large anchored winch to deal with the pulling force is required for such a large length of pipe.

If either of the above methods (that require dredging) are utilised, a cutter suction dredge or a backhoe dredge is the most suitable. The volume of dredging required for the pipeline trench is between 90,000m^3 and 150,000m^3. The duration required for the dredging activity is approximately two months.

Horizontal Directional Drilling

The potential impact to the marine environment is much less than the other described methods because there is no underwater trenching. However, there is potential for the disturbance of wetland areas at both sides of the waterway during construction activities. The typical workspace for drill rigs using HDD operations is about 50x70 metres. A construction pad, from which the plant operates, involves clearing space and creating a graded level. Additionally, access roads are also required that will in part traverse the wetland area to the drill rig location. Management of drilling fluid required of the drill hole is also required from an environmental perspective. The drilling fluid is usually a mixture of freshwater and bentonite. Bentonite is a naturally-occurring clay that is extremely hydrophilic – that is, it has swelling characteristics. Certain polymers may also be used to enhance the drilling fluid.

Disturbance of acid sulphate soils are also likely to occur and this addressed in Volumes 2, 3, 4, within Chapters 6 of the EIS.

For the two options involving dredging, the following details are impacting processes that will, or may, impact the marine environment:

- Disturbance of the sub-tidal seabed at the dredge location
- Creation of a turbid plume that is transported from the dredge location to elsewhere in Port Curtis
- Underwater noise generated by dredging activities
- Disturbance, including fragmentation of the mangrove and wetland areas during construction of the pipeline across the intertidal areas.

For the HDD option, the following details are impacting process that will, or may, impact the marine environment:

- Disturbance including fragmentation of the mangrove and wetland areas during construction of the pipeline across the intertidal area, in particular the clearing and grading of a workspace
- Underwater noise generated by drilling activities
- Potential for loss of drilling fluid directly or indirectly into the marine environment.

3.1 Impact assessment methodology

Impact assessment involves assessing the potential impacts of the impacting processes to the existing environment. This was undertaken through a risk-based approach. The use of such an approach is widely adopted in environmental impact assessments and assessment of the anthropogenic impacts to the environment in general (Fletcher 2005, Thomas and Elliott 2005, Astles et al. 2006).The Australia Pacific LNG Risk Tools were used for the marine environment impact assessment.

3.2 Potential dredging impacts

The potential dredging impacts from the flotation method and the bottom pull method are similar and will be discussed in unison.

3.2.1 Direct disturbance to subtidal habitat

Dredging will result in the direct disturbance to subtidal habitat and the removal of the animals contained in the sediment within the dredged area. Field investigations identified that the proposed dredge footprint was devoid of seagrass and structure forming organisms.

Following dredging, there are a number of factors that influence the rate and trajectory of recolonisation of the macrobenthic infaunal assemblages, including the:

- Level and frequency of natural disturbance (storm events, river flows, and wave environment)
- Scale and timing of the dredging operation
- Changes to the sedimentary environment.

The processes involved in recolonisation including the following:

- The direct return of organisms following survival of entrainment and release in discharge waters
- Passive recolonisation, via erosion of the pit wall
- Active recolonisation as animals move into the disturbed area
- Larval recruitment.

Some larger and more robust animals such as molluscs may survive entrainment in discharge waters and may facilitate recolonisation by adults of the dredged location (Van Der Veer et al. 1985). Changes to the physical or chemical characteristics of the sediment caused by dredging can have large implications for the recovery potential of the assemblage as it influences the suitability for larval recruitment (Snelgrove and Butman 1994, Kenny and Rees 1996).

There is no method to accurately predict the recovery dynamics of the assemblage once disturbed. In the present case, the assemblage that recolonises the area will also be influenced by the material that is used to infill and cap the pipeline trench. If rock is used to cap the trench then a rocky reef assemblage would replace the current soft sediment assemblage. The area to be disturbed is also small and the lack of a requirement for maintenance dredging means that disturbance is not ongoing.

Overall the risk to the benthic assemblage from physical disturbance during dredging activities is identified as ‘low’ (consequence = minor (1), likelihood = highly unlikely (5)). Beyond minimising the area to be disturbed by dredging activities, no specific mitigation measures are possible to ameliorate the impacts.

3.2.2 Turbidity impacts from dredging

A turbid plume can decrease the ambient light levels that reach the seabed and can affect photosynthesis through the water column and vegetated habitats on the seabed, such as seagrass and algae. When suspended sediments within a turbid plume settle out, the material can also smother benthic organisms. While increases in turbidity naturally occur, the duration of elevated turbidity plumes from the proposed dredging program are much longer than those that occur naturally.

Should dredging be required for pipeline construction, the spatial extent of the turbidity plume generated by dredging is described in Attachment 12: Coastal Environment – LNG Plant and Gas Pipeline. The sediment plume will extend into The Narrows and Graham Creek, with elevated turbidity persisting for ten days to one month after the dredging activity has ceased. The dredge plume is likely to overlap spatially with the seagrass beds in the vicinity of North Passage Island.

Erftemeijer and Lewis (2006) reviewed the environmental impacts of dredging on sea grass and identified critical thresholds of light availability for a range of seagrass species around the world. Significant differences were found between species within the respective critical levels and duration tolerances. Variation between different seagrass species and the ability to tolerate and recover from periods of reduced light is related to differing morphological and physiological characteristics. These characteristics represent different strategies for survival in response to stress or disturbance. Smaller, short-lived species (e.g. several *Halophila* spp.) do not survive for long once environmental conditions are outside a species' environmental tolerance however, the species tend to recolonise rapidly following an impact. Conversely, largely seagrass species, including *Z. capricorni,* survive longer during periods of low light due to greater stored reserves, which can be mobilised to sustain the plant. Larger species tend to be slow growing, live longer and therefore represent a resilience strategy that is more resistant to short-term to medium-term disturbances. However, if the impact persists to the point where the seagrasses have exhausted the stored reserves, the seagrass would die and recover slowly or not at all.

Overall the risk to the benthic assemblages and seagrass beds from a turbidity plume generated during dredging activities is identified as 'low' (consequence = minor (1), likelihood = highly unlikely (2)).

To minimise the turbidity plume of dredging and the potential transport of a turbid plume, the following measures are recommended:

- Where practical, Australia Pacific LNG will deploy silt curtains to prevent migration of turbidity plume
- Dredging will only operate within safe weather conditions (as defined by the Harbour Master) to prevent spills.

The mitigation measures serve to potentially limit both the spatial scale and the magnitude of the impact from dredging activities.

3.2.3 Underwater noise

Activities associated with construction in the marine environment and operations have the potential to displace dugong and cetaceans from critical habitat and interrupt critical behaviours through the creation of underwater noise. Such behavioural disturbance is the mildest form of marine noise impact on fauna and may involve alienation of animals from habitat or changes to foraging efficiency (Richardson and Würsig 1996, Würsig et al. 2000, Würsig and Greene Jr. 2002, Ng and Leung 2003, Tyack 2008, Jefferson et al. 2009).

While noise and vibration in the marine environment is also considered in the Noise and Vibration Report, this section provides additional interpretation drawn from peer reviewed literature.

A number of marine mammal species, particularly cetaceans, have sensitive hearing and rely heavily upon sound for communicating, navigation and locating prey (Gordon and Moscrop 1996). Marine mammals have been found to avoid some human sound sources for ranges of several kilometres, temporarily avoiding valuable habitat in the process (Ng and Leung 2003, Tyack 2008, Jefferson et al. 2009). The behavioural response of marine mammals to human-made underwater noise however, is highly context-specific, depending on the significance of the noise to the subject mammal and the prior experience of the subject mammal to the given noise event (Richardson and Würsig 1996).

Noise generated by construction activities, including dredging, can also change the behaviour of dugong and result in alienation from important habitat. Potential energetic costs of disturbance to

dugongs include a reduction in energy intake; the energy expended while moving and the possible cost of moving to a different patch on the seagrass beds (Hodgson and Marsh 2007). Disturbed dugongs may be forced to spend time searching for alternative feed patches and may be forced to feed on less desirable patches with lower nutritional value (Hodgson and Marsh 2007). However, if animals can move to suitable nearby habitat then this may largely mitigate impacts from disturbance (Gill et al. 2001). In the case of Port Curtis, existing high value dugong (seagrass) habitat occurs in areas away from the area which would be dredged, if dredging a trench was required.

Overall the risk to the dugong and cetaceans from underwater noise generated during dredging activities is identified as 'low' (consequence = moderate (2), likelihood = highly unlikely (2)). The impact will only persist during the two months of dredging operations.

3.2.4 Disturbance and fragmentation of wetlands

The pipeline will be constructed across saltpan/saltmarsh habitat that drains into Targinie Creek on the mainland and across foreshore flats on the mainland and on Curtis Island. The saltpan/saltmarsh area is only inundated during the spring tides. The area of mangrove, saltpan/saltmarsh and intertidal flats in Port Curtis is extensive. Mangroves cover 6,736 hectares, saltpan/saltmarsh covers 4,573 hectares and seagrass covers 4,501 hectares. The spatial scale of disturbance from pipeline construction will be approximately 3km long and 25m wide, which represents 0.16% of the saltpan/saltmarsh habitat within Port Curtis. However, the disturbance during construction will also result in fragmentation of the habitat, including locally altered tidal flows. These altered tidal flows can impact saltmarsh plants and mangroves and potentially lead to localised dieback (Arnold 1995). Therefore, there is a clear potential for impacts to be greater than the area directly disturbed by construction.

Construction activities should be undertaken to minimise the area of disturbance and hydrodynamic changes across the saltpan/saltmarsh habitat; ensuring that no 'ponding' occurs. Without mitigation, the risk posed by pipeline disturbance to intertidal habitats during the construction phase is identified as 'moderate' (consequence = serious (3), likelihood = highly unlikely (5)). With effective mitigation that utilises adaptive management to address the impacts, the risk would be reduced to 'low' (consequence = moderate (2), likelihood (2) = highly unlikely).

3.3 Potential HDD impacts

3.3.1 Underwater noise

Like dredging activities, the application of horizontal directional drilling (HDD) to construct the pipeline crossing will generate underwater noise that may potentially impact the distribution and behaviour of dugong and cetaceans during the period the noise is generated. However, as Jefferson et al. (2009) identify there is little information about how noise from pipe-laying activities affects cetaceans and no existing information about any potential impacts to dugong. In the case of HDD, there is no direct generation of noise within the water column.

Overall the risk to the dugong and cetaceans from underwater noise generated during HDD activities is identified as 'low' (consequence = moderate (2), likelihood = highly unlikely (2)). The impact will only persist during construction activities.

3.3.2 Bentonite

Bentonite is proposed to be used as the principal drilling fluid and it is possible that some of this material will directly or indirectly enter the marine environment. While bentonite is a natural clay

compound, its physical properties can potentially result in significant environmental impacts through elevated turbidity levels that can persist as a result of a re-suspension, smothering of benthic assemblages and reduced recruitment of benthic animals as a result of physical changes to the seabed (Smit et al. 2008). The 50% hazardous concentrations (HC50) for suspended bentonite, based on 50% effect concentrations (EC50s) were 1,830mg/L.

Without mitigation, the risk posed by drilling fluid to the marine environment during the construction phase is identified as ‘moderate’ (consequence = serious (3), likelihood = unlikely (3)). It is recommended that no deliberate discharge of drilling fluid to the marine environment be undertaken and all drilling fluid should be disposed of off-site. It is also recommended that in the event of a potential or actual unintentional release of drilling fluid, the pumping of drilling fluid and the drilling activity should cease immediately until remedial action is taken. With remedial measures in place, the risk is reduced to ‘low’ (consequence = minor (1), likelihood (1) = remote).

3.4 Disturbance and fragmentation of wetlands

Regardless of the construction method used to cross The Narrows, disturbance and fragmentation of wetland habitat will occur during the construction phase of the project. The pipeline will be constructed across saltpan/saltmarsh habitat that drains into Targinie Creek on the mainland and across foreshore flats on the mainland and on Curtis Island. The saltpan/saltmarsh area is only inundated during the spring tides. The area of mangrove, saltpan/saltmarsh and intertidal flats in Port Curtis is extensive. Mangroves cover 6,736 hectares, saltpan/saltmarsh covers 4,573 hectares and seagrass covers 4,501 hectares. The spatial scale of disturbance from pipeline construction will be approximately 3km long and 25m wide, which represents 0.16% of the saltpan/saltmarsh habitat within Port Curtis. However, the disturbance during construction will also result in fragmentation of the habitat, including locally altered tidal flows. These altered tidal flows can impact saltmarsh plants and mangroves and potentially lead to localised dieback (Arnold, 1995). Therefore, there is a clear potential for impacts to be greater than the area directly disturbed by construction.

Construction activities should be undertaken to minimise the area of disturbance and hydrodynamic changes across the saltpan/saltmarsh habitat; ensuring that no ‘ponding’ occurs. Without mitigation, the risk posed by pipeline disturbance to intertidal habitats during the construction phase is identified as ‘moderate’ (consequence = serious (3), likelihood = highly unlikely (5)). With effective mitigation that utilises adaptive management to address the impacts, the risk would be reduced to ‘low’ (consequence = moderate (2), likelihood (2) = highly unlikely).

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Appendix A Great Barrier Reef World heritage Values

Great Barrier Reef World heritage value

The Great Barrier Reef was inscribed on the World Heritage List in 1981. The World Heritage criteria against which the Great Barrier Reef was listed remain the formal criteria for this property. The World Heritage criteria are periodically revised and the criteria against which the property was listed in 1981 are not necessarily identical with the current criteria.

Criteria

Outstanding example representing a major stage of the earth's evolutionary history

The Great Barrier Reef is by far the largest single collection of coral reefs in the world. The World Heritage values of the property include:

- 2904 coral reefs covering approximately 20,055km squared
- 300 coral cays and 600 continental islands
- Reef morphologies reflecting historical and on-going geomorphic and oceanographic processes.
- Processes of geological evolution linking islands, cays, reefs and changing sea levels, together with sand barriers, deltaic and associated sand dunes.
- Record of sea level changes and the complete history of the reef's evolution are recorded in the reef structure.
- Record of climate history, environmental conditions and processes extending back over several hundred years within old massive corals.
- Formations such as serpentine rocks of South Percy island, intact and active dune systems, undisturbed tidal sediments and 'blue holes'.
- Record of sea level changes reflected in distribution of continental island flora and fauna.

Outstanding example representing significant ongoing geological processes, biological evolution and man's interaction with his natural environment

Biologically, the Great Barrier Reef supports the most diverse ecosystem known to man and its enormous diversity is thought to reflect the maturity of an ecosystem, which has evolved over millions of years on the north-east Continental Shelf of Australia. The World Heritage values include:

- The heterogeneity and interconnectivity of the reef assemblage.
- Size and morphological diversity (elevation ranging from the sea bed to 1142m at Mt. Bowen and a large cross-shelf extent encompass the fullest possible representation of marine environmental processes).
- Ongoing processes of accretion and erosion of coral reefs, sand banks and coral cays, erosion and deposition processes along the coastline, river deltas and estuaries and continental islands.
- Extensive Halimeda beds representing active calcification and sediment accretion for over 10,000 years.
- Evidence of the dispersion and evolution of hard corals and associated flora and fauna from the 'Indo-West Pacific centre of diversity' along the north-south extent of the reef.

- Inter-connections with the Wet Tropics via the coastal interface and Lord Howe Island via the East Australia current.
- Indigenous temperate species derived from tropical species.
- Living coral colonies (including some of the world's oldest).
- Inshore coral communities of southern reefs.
- Five floristic regions identified for continental islands and two for coral cays.
- The diversity of flora and fauna, including:
  - Macroalgae (estimated 400-500 species)
  - Porifera (estimated 1500 species, some endemic, mostly undescribed)
  - Cnidaria: Corals - part of the global centre of coral diversity and including:
    - Hexacorals (70 genera and 350 species, including 10 endemic species).
    - Octocorals (80 genera, number of species not yet estimated).
  - Tunicata: Ascidians (at least 330 species)
- Bryozoa (an estimated 300-500 species, many undescribed)
- Crustacea (at least 1330 species from 3 subclasses)
- Worms:
  - Polychaetes (estimated 500 species)
  - Platyhelminthes - include free-living Tubelleria (number of species not yet estimated), polyclad Tubelleria (up to 300 species) and parasitic helminthes (estimated 1000s of species, most undescribed).
- Phytoplankton (a diverse group existing in two broad communities)
- Mollusca (between 5000-8000 species)
- Echinodermata (estimated 800 extant species, including many rare taxa and type specimens)
- Fishes (between 1200 and 2000 species from 130 families, with high species diversity and heterogeneity; includes the Whale Shark *Rhynchodon typus*).
- Seabirds (between 1.4 and 1.7 million seabirds breeding on islands).
- Marine reptiles (including six sea turtle species, 17 sea snake species, and one species of crocodile).
- Marine mammals (including 1 species of dugong (*Dugong dugon*), and 26 species of whales and dolphins).
- Terrestrial flora: see ‘Habitats: Islands’
- Terrestrial fauna, including:
  - Invertebrates (pseudoscorpions, mites, ticks, spiders, centipedes, isopods, phalangids, millipedes, collembolans and 109 families of insects from 20 orders, and large over-wintering aggregations of butterflies).

  - Vertebrates (including seabirds (see above), reptiles: crocodiles and turtles, 9 snakes and 31 lizards, mammals)
- The integrity of the inter-connections between reef and island networks in terms of dispersion, recruitment, and the subsequent gene flow of many taxa.
- Processes of dispersal, colonisation and establishment of plant communities within the context of island biogeography (e.g. dispersal of seeds by air, sea and vectors such as birds are examples of dispersion, colonisation and succession).
- The isolation of certain island populations (e.g. recent speciation evident in two subspecies of the butterfly *Tirumala hamata* and the evolution of distinct races of the bird *Zosterops* spp).
- Remnant vegetation types (hoop pines) and relic species (sponges) on islands.
- Evidence of morphological and genetic changes in mangrove and seagrass flora across regional scales.
- Feeding and/or breeding grounds for international migratory seabirds, cetaceans and sea turtles.

Contain unique, rare and superlative natural phenomena, formations and features and areas of exceptional natural beauty

The Great Barrier Reef provides some of the most spectacular scenery on earth and is of exceptional natural beauty. The World Heritage values include:

- The vast extent of the reef and island systems which produces an unparalleled aerial vista.
- Islands ranging from towering forested continental islands complete with freshwater streams, to small coral cays with rainforest and unvegetated sand cays.
- Coastal and adjacent islands with mangrove systems of exceptional beauty.
- The rich variety of landscapes and seascapes including rugged mountains with dense and diverse vegetation and adjacent fringing reefs.
- The abundance and diversity of shape, size and colour of marine fauna and flora in the coral reefs.
- Spectacular breeding colonies of seabirds and great aggregations of over-wintering butterflies.
- Migrating whales, dolphins, dugong, whale sharks, sea turtles, seabirds and concentrations of large fish.

Provide habitats where populations of rare and endangered species of plants and animals still survive

The Great Barrier Reef contains many outstanding examples of important and significant natural habitats for in situ conservation of species of conservation significance, particularly resulting from the latitudinal and cross-shelf completeness of the region. The World Heritage values include:

- Habitats for species of conservation significance within the 77 broad-scale bioregional associations that have been identified for the property and which include:
  - Over 2900 coral reefs (covering 20 055km^2) which are structurally and ecologically complex.
  - Large numbers of islands, including:

    - 600 continental islands supporting 2195 plant species in 5 distinct floristic regions.
    - 300 coral cays and sand cays.
    - Seabird and sea turtle rookeries, including breeding populations of green sea turtles and Hawksbill turtles.
    - Coral cays with 300-350 plant species in 2 distinct floristic regions.
  - Seagrass beds (over 5000km squared) comprising 15 species, two endemic.
  - Mangroves (over 2070km squared) including 37 species.
  - *Halimeda* banks in the northern region and the unique deep water bed in the central region.
- Large areas of ecologically complex inter-reefal and lagoonal benthos.
- Species of plants and animals of conservation significance.