8 MARINE ECOLOGY

The marine ecology assessment of the LNG Component of the Queensland Curtis LNG (QCLNG) Project includes the development, construction, operation and decommissioning of the LNG Facility and associated Marine Facilities.

Marine Facilities associated with the LNG Facility are located within the bounds of the Port of Gladstone as defined in Queensland *Transport Infrastructure (Ports) Regulation 2005*[1]. The bounds of the Port of Gladstone are shown in *Volume 2, Chapter 9, Figure 2.9.10*.

The Port of Gladstone and approved shipping zones within the Great Barrier Reef Marine Park (GBRMP) will be used for the Project's shipping activities.

8.1 DESCRIPTION OF PROJECT ENVIRONMENTAL OBJECTIVES

The overall Project environmental objective for marine ecology is: to undertake Project activities such that impacts on abundance and distribution of marine flora, fauna and ecological communities are minimised.

8.2 METHODOLOGY

The following key activities were undertaken to complete the Marine Ecology Impact Assessment section for the Project.

Existing Environmental Values

This section provides a detailed description of the marine ecological environment in which the proposed LNG Facility and its associated infrastructure will be located. The description of the existing environment in the vicinity of the development area and wider region is based on relevant information from desktop studies, baseline information previously identified and reviewed in a Marine Facilities Scoping Report completed in early 2009 and additional information from the following sources:

- hydrodynamic modelling of channel dredging and dredge spoil disposal
- data from the Port Curtis Integrated Monitoring Program (PCIMP) (for managing the ecosystem health of the Port of Gladstone)
- dispersion modelling of point source water discharges from LNG facilities.

---

1 Queensland Government (2005) Transport Infrastructure (Ports) Regulation

Impact Assessment, Mitigation and Management Measures

The assessment methodology employed comprises the following phases:

- Phase 1: Scoping
  - information gathering
  - hazard identification
- Phase 2: Risk Assessment
- Phase 3: Risk Management and Feedback.

In Phase 1 potential marine environmental impacts identified in conjunction with the Project design were used in a scoping workshop to create a comprehensive matrix identifying potential interactions with marine environmental receptors.

This assessment involved a two-part process which included:

- identifying which relevant aspects, whether their interaction with the receiving environments would likely result in positive, negative or neutral impacts (by virtue of, for example, their nature, extent or duration)
- determining which receptors would potentially be affected by the interacting activity and the likely magnitude of such an impact.

Phase 2 applied a risk-based approach to the impact assessment process. The previously identified impacts were further evaluated to determine the probable significance of potential impacts and the prioritisation of these impacts in relation to the EIS process.

In Phase 3, the significance and probability of the potential impacts were assessed to determine the level of mitigation and management appropriate, such that the proposed facilities can be constructed and operated in an environmentally acceptable manner. The methodology for determining this is detailed in *Volume 1.*

8.3 EXISTING ENVIRONMENT

8.3.1 Physical Environment

8.3.1.1 Location and Setting

The Port of Gladstone is located on the Central Queensland coast and forms an integral part of the City of Gladstone about 525 km north of Brisbane at Latitude of 23°49.61'S, Longitude 151°34.6'E. Port land and facilities are located at various sites within the port precinct. A total of 4,321 ha of land falls under control of the Gladstone Ports Corporation (GPC), encompassing more than 700 ha of reclaimed land[2]. The region falls within the Northeast Marine Bioregion as defined in the Integrated Marine and Coastal Regionalisation for Australia (IMCRA) Guidelines (refer to *Figure 5.8.1*). It is also located within the Great Barrier Reef World Heritage Area (GBRWHA) (refer to *Figure* 5.8.2).

The Port of Gladstone is situated in a subtropical region comprising a flat coastal plain bordered by a range of mountains of up to 630 m elevation. Sediments supplied by rivers and offshore sources are slowly infilling the valleys[3]. The Port of Gladstone is classified as an embayment (or drowned river valley), which normally occurs along hard coasts, where they appear as topographic depressions or indentations in the country rock, that have not been significantly infilled by terrigenous or marine sediment[4]. Embayments represent transitional environments between true estuarine and marine environmental conditions (such as salinity, temperature, turbidity, and energy) and thus typically contain an abundant and highly variable biota.[5] [6] [7]

The region is characterised by extensive areas of tidal flats that become exposed at low tide and large areas of mangroves fringing the estuary which act as a storage buffer for water at high tide. These mangroves and tidal flats have ecological significance, being home to numerous aquatic fauna and flora (refer to *Volume 5, Section 8.3.2*). The outer series of barrier islands (Curtis and Facing) protect enclosed waters allowing these estuarine environments to establish. Most of these estuaries receive a limited supply of fresh water from a narrow coastal hinterland.

8.3.1.2 Climate

The Port of Gladstone experiences a subtropical, maritime climate. The average minimum and maximum ambient air temperatures for the area range from 22.8°C to 28.9°C in summer, and 11.4°C to 20.9°C in winter. The majority of Gladstone's annual average 876 mm rainfall is received during the summer months. Evaporation rates are high and generally exceed rainfall, with the average annual evaporation rate for Gladstone being 1,752 mm. Relative humidity for Gladstone's 9am and 3pm annual averages is 67 per cent and 59 per cent respectively[8].

---

2 Commonwealth of Australia (2006) A Guide to the Integrated Marine and Coastal Regionalisation of Australia Version 4.0

3 Queensland Department of Environment and Heritage [QDEH] (1994) Curtis Coast Study Resource Report

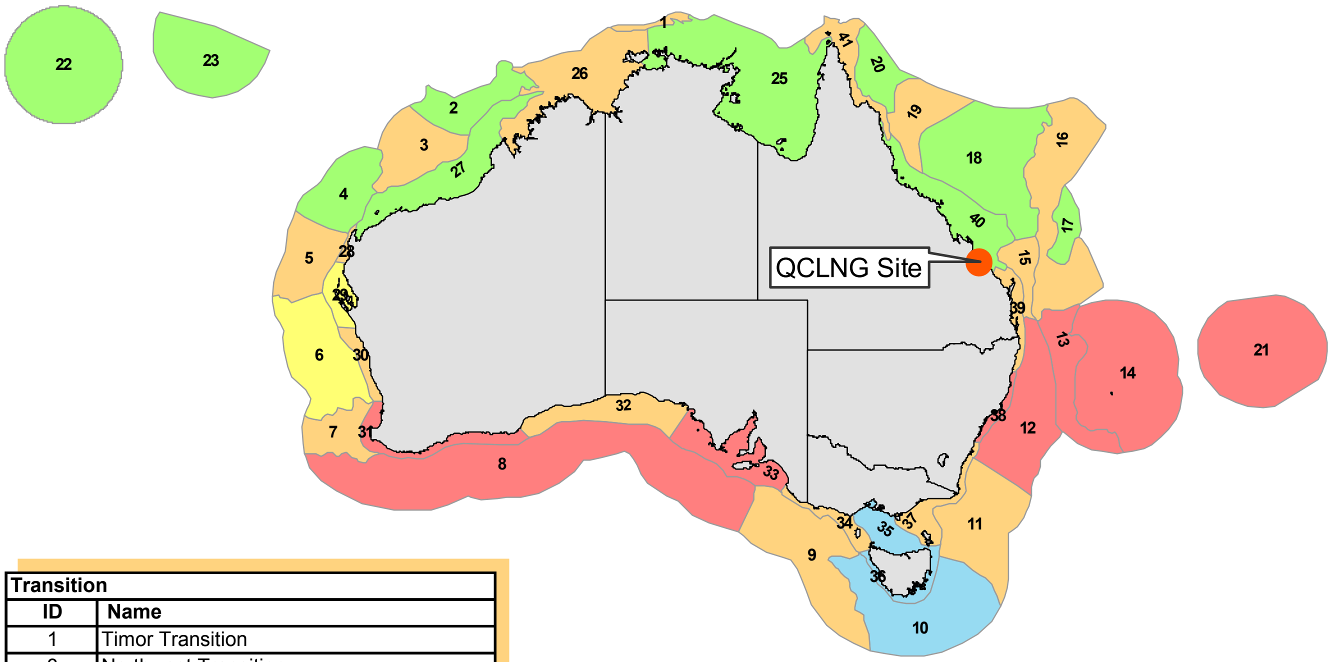
4 Ryan D A, Heap A D, Radke L & Heggie D T (2003) Conceptual models of Australia's estuaries and coastal waterways: applications for coastal resource management

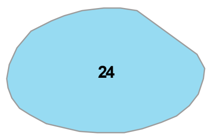
5 Dethier M N (1992) Classifying marine and estuarine natural communities: an alternative to the Cowardin system

6 Rainer S F and Fitzhardinge R C (1981) Benthic communities in an estuary with periodic deoxygenation

7 Roy P S, Williams R J, Jones A R, Yassini R, Gibbs P J, Coates B, West R J, Scanes P R, Hudson J P and Nichol S (2001) Structure and function of southeast Australian estuaries

8 Bureau of Meterology (2008)





Transition	
ID	**Name**
1	Timor Transition
3	Northwest Transition
5	Central Western Transition
7	Southwest Transition
9	West Tasmania Transition
11	Southeast Transition
15	Central Eastern Transition
16	Kenn Transition
19	Northeast Transition
26	Northwest IMCRA Transition
28	Central Western IMCRA Transition
30	Southwest IMCRA Transition
32	Great Australian Bight IMCRA Transition
34	Western Bass Strait IMCRA Transition
37	Central Eastern IMCRA Transition
39	Central Eastern IMCRA Transition
41	Northeast IMCRA Transition

Tropical Waters	
ID	**Name**
2	Timor Province
4	Northwest Province
17	Kenn Province
18	Northeast Province
20	Cape Province
22	Cocos (Keeling) Island Province
23	Christmas Island Province
25	Northern IMCRA Province
27	Northwest IMCRA Province
40	Northeast IMCRA Province

Subtropical Waters	
ID	**Name**
6	Central Western Province
29	Central Western IMCRA Province

Warm Temperate Waters	
ID	**Name**
8	Southern Province
12	Central Eastern Province
13	Tasman Basin Province
14	Lord Howe Province
21	Norfolk Island Province
31	Southwest IMCRA Province
33	Spencer Gulf IMCRA Province
38	Central Eastern IMCRA Province

Cold Temperate Waters	
ID	**Name**
10	Tasmania Province
24	Maquarie Island Province
35	Bass Strait IMCRA Province
36	Tasmanian IMCRA Province

Legend

IMCRA 4.0 Provincial Bioregions

- Cold Temperate Waters
- Subtropical Waters
- Transition
- Tropical Waters
- Warm Temperate Waters

Source Note:

IMCRA 4.0 provincial bioregions reproduced from data sourced from Department of the Environment, Water, Heritage and the Arts, 2006.

Projection: UTM MGA Zone 56

Datum: GDA 94

0 375 750 1,500 km

N

QUEENSLAND CURTIS LNG

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Environmental Resources Management Australia Pty Ltd

Project	**Queensland Curtis LNG Project**		
Client	**QGC - A BG Group business**		
Drawn	JB	**Volume 5**	**Figure 5.8.1**
Approved	GB	File No:	0086165b_EIS_ME_GIS014_F5.8.1
Date	11.05.09	Revision	1

Title **IMCRA 4.0 Provincial Bioregions**

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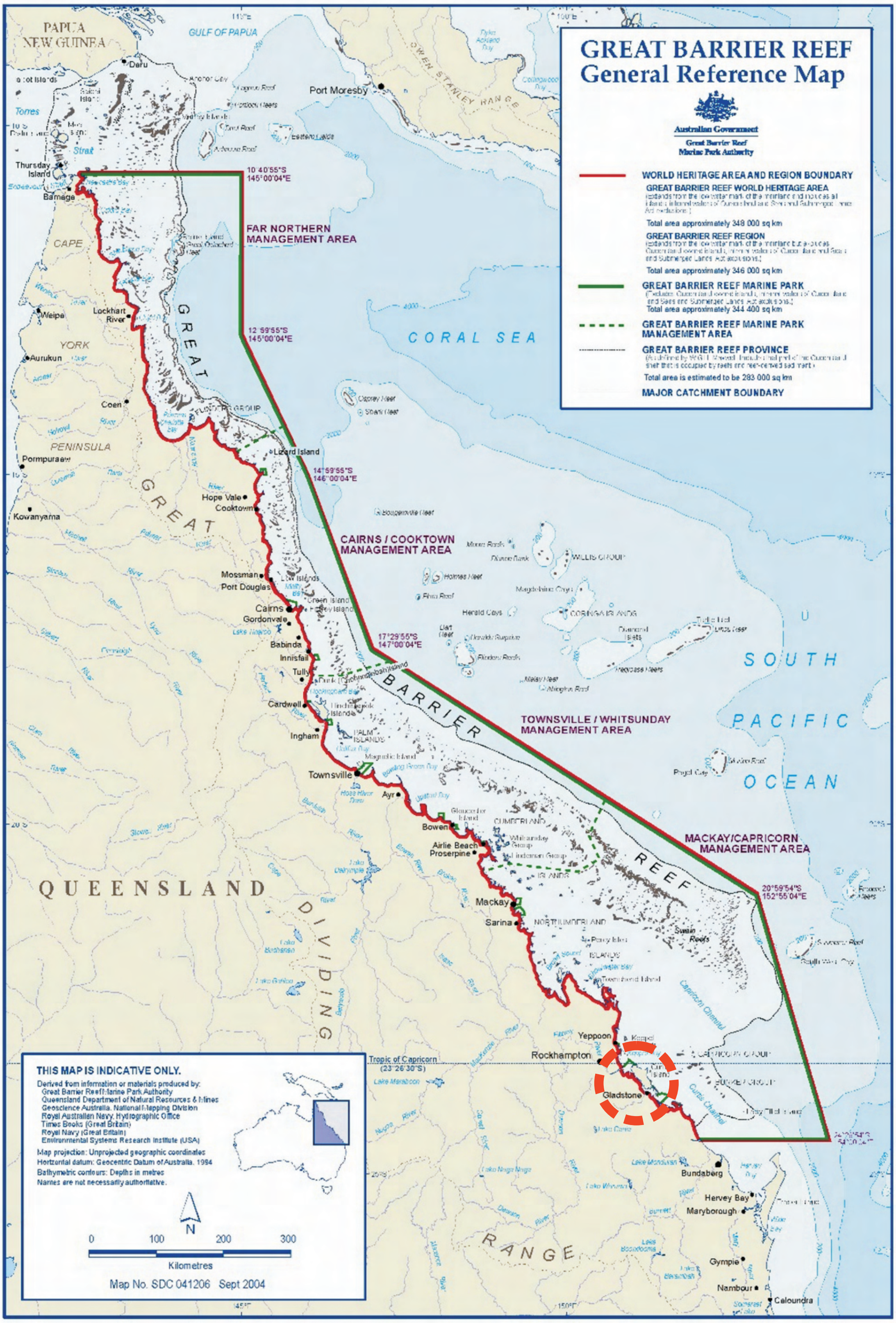


Legend

Site Location

Source Note:
Australian Govenment
Great Barrier Reef Marine Park Authority 2004
Ref: SDC 041206

N

QUEENSLAND CURTIS LNG A BG Group business	Project: Queensland Curtis LNG Project		Title: Great Barrier Reef World Heritage Areas
	Client: QGC - A BG Group business		
ERM Environmental Resources Management Australia Pty Ltd	Drawn: JF/JB	Volume 5 — Figure 5.8.2	Disclaimer: Maps and Figures contained in this Report may be based on Third Party Data, may not to be to scale and are intended as Guides only. ERM does not warrant the accuracy of any such Maps and Figures.
	Approved: GB	File No: 0086165b_EIS_ME_CDR002_F5.8.2	
	Date: 01/06/09	Revision 1	

The tropical cyclone season runs from 1 November to 30 April, with most occurring between December and April. On average, about 10 cyclones per year develop over Australian waters, and around six cross the coast. In Queensland, the most commonly affected coastal area is between Port Douglas and Maryborough where the Port of Gladstone is located. For 101 years from 1906 to 2006 there were six tropical cyclones within 50 km of the Project and 14 tropical cyclones within 100 km of the Project.

Further detail on local climate is provided in *Volume 5, Chapter 2*.

8.3.1.3 *Oceanographic Conditions*

Tides are semi-diurnal with the highest astronomical tide (HAT) of 4.69 m at Gladstone, rising to 6 m in The Narrows and a mean spring tide range of 3.3 m in the Gladstone area[9]. The interchange of tidal waters between the estuary and the ocean varies greatly between extreme neap and extreme spring tides. In the area between Curtis Island and Facing Island large tidal flats become exposed at low water. For very low tides, the whole area between the islands reduces to several narrow meandering channels connecting to North Entrance and to Facing Channel, and the water surface area reduces to about 20 per cent of the area at mean water/tide level.

Many of the estuaries have multiple entrances, so tidal circulation patterns are complex[10]. Results from hydrodynamic modelling of the Port of Gladstone region[11] demonstrated that the currents in the estuary are predominantly driven by the effects of the tide. Strong tidal currents and a 5 m tidal range also have major influences on the area's marine and intertidal ecosystems. These large tides can generate very strong currents, with current velocities reaching up to 2 metres per second (m/s) in the vicinity of North Channel[12] producing scouring of seabed and sediment transport.

Water depths in the Port of Gladstone are up to 12.5 m and mean wave height is 0.83 m with maximum wave height of 3.2 m. The area surrounding the Project area is sheltered from offshore waves, and the adjacent port waters are open to only a very limited fetch (6 km) along the main direction of wind energy from the south-east sector. A longer east south-east fetch, approximately 15 km, extends in the direction of the main channel but is restricted in width by islands and shoals and the width of the channel itself. Consequently, the waves from this direction lose energy quickly through diffraction and refraction processes along the channel.

The large tides ensure that the water column is vertically well mixed most of the time, and are also responsible for significant re-suspension of fine

9 Maritime Safety Queensland (2004) ***The official tide tables and boating safety guide.***

10 Queensland Department of Environment and Heritage [QDEH] (1994) ***Curtis Coast Study Resource Report***

11 Herzfeld M, Parslow J, Andrewartha J, Sakov P and Webster IT (2004) ***Hydrodynamic Modelling of the Port Curtis Region – Project CM2.11*** *CRC for Coastal Zone, Estuary and Waterway Management Technical Report.*

12 Witt C and C Morgan (1999) ***Stuart oil shale project, stage 2 EIS marine water quality and flow modeling***

sediment. Combined with very large deposits of silt from the hinterland in times of flood, the estuary maintains a highly turbid character.

Minor storm surges in the Port of Gladstone are not uncommon phenomena. Less intense tropical cyclone activity and extra-tropical low-pressure systems produce surges that would most likely go unnoticed when combined with the lower tide ranges. Long-term average statistics indicate that approximately one to four cyclones pass within 500 km of the Port of Gladstone each year and around 10 cyclones have passed with 100 km.

Nevertheless, these can alter normal currents and water levels from their predicted or forecast values and in these situations higher turbidity of coastal waters can be expected in addition to the transport of water mass. Any marine pollutants, if present, can be transported with the abnormal circulation patterns caused by the meteorological conditions.

Water temperatures in the region vary from 18°C in winter to 29°C in summer.

8.3.1.4 Water Quality

A range of water quality studies has been undertaken in the area of the Port of Gladstone from 1998 to 2008. A number of data sources were reviewed and relevant data analysed to provide an account of the condition of water quality in the Port of Gladstone. A summary of these data sources is provided below, in *Table 5.8.1*.

Table 5.8.1 Summary of Water Quality Data Sources Reviewed

Source	Year	Location	Description
Department of Environment and Heritage/ Department of Natural Resources	1992–1996	Calliope River	Broadscale physicochemical monitoring
Environmental Protection Agency	2002–2008	Calliope River	Physicochemical monitoring
National Land and Water Resources Audit (NLWRA)	1998 2001	Calliope River Fitzroy River Boyne River	Physicochemical and nutrients
Connell Hatch	2006	Calliope River	Physicochemical and nutrients
Geoscience Australia	1998	Port of Gladstone	Turbidity, tidal regime, sediments, bedforms, seagrasses and biota
Port Curtis Integrated Monitoring Programs (PCIMP)	2005 2006 2007	Port of Gladstone	Pilot program conducted in 2005, expanded in 2006; monitored range of water quality indicators in nine major zones of the Port of Gladstone
Cooperative Research	2003-	Port of Gladstone	Contaminants, spatial interpolation of water quality parameter distributions,

Source	Year	Location	Description
Centre (CRC)	2006		remote sensing, biomonitors, Diffuse Gradient in Thin Films (DGT), and oyster metals accumulation
BMT WBM Pty Ltd	1999 2001 2008	Port of Gladstone	Review of existing water quality data Water quality profiles every two months from 1998 to 2000 Hand-held physical water quality profiles and water quality grab samples

BMT WBM Pty Ltd (BMT WBM) undertook an extensive review in 2009 and assessed the marine water quality aspects of the proposed LNG Marine Facilities[13]. The five sites sampled in the BMT WBM baseline water quality program on 20 November 2008 were in the vicinity of proposed works adjacent to Curtis Island (refer to *Figure 5.8.3*). Unless otherwise stated, the following information is sourced from the BMT WBM (2009) report.

When comparing the baseline water quality data from the studies listed in *Table 5.8.1* with water quality guidelines, such as the EPA *2006 Queensland Water Quality Guidelines*, the water quality in the Port of Gladstone is generally good, though variable.

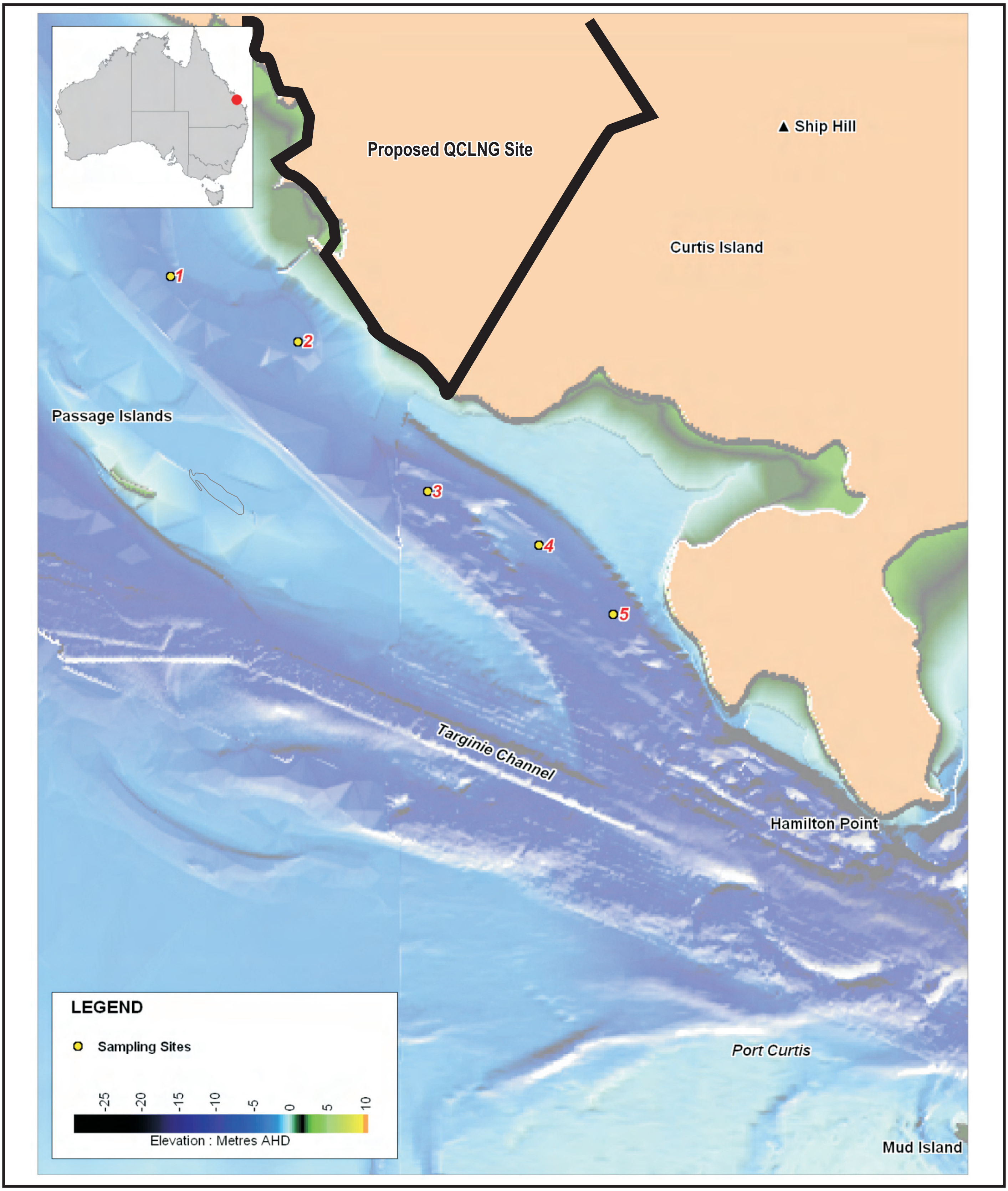
The marine flora and fauna of this area would be adaptable to such variable ambient conditions. Water quality appears to be relatively strongly correlated with tidal state and hence sediment bedload re-suspension. In particular, low tides exhibit generally inferior water quality compared to high tides, with the majority of nutrient and metal species at these times being associated with particulate (rather than dissolved) phases.

Salinity

- The estuarine waters in the Port of Gladstone are generally close to seawater. Salinities are often only slightly below that for oceanic seawater (35.5 g/L) and can sometimes be slightly higher.
- Salinities are higher in the north of the Port of Gladstone than in the surrounding coastal waters. This could reflect evaporation losses in these more sheltered areas where water circulation is restricted[14].
- Salinity appears to be responsive to rainfall and associated inflow events, although it is not clear whether local or remote inflows (or a combination of both) dominate in this regard.

13 BMT WBM Pty Ltd 2009 ***Proposed BG LNG Facility EIS Marine Water Quality Assessment***.

14 Apte S C, Andersen L E, Andrewartha J R Angel B M, Shearer D, Simpson S L., Stauber J L & Vicente-Beckett, V (2006) ***Contaminant pathways in Port Curtis: final report***.



Source Note:
BMT WBM 2008
Ref. WQU_079_081115_WQSites.wor
Figure not to scale.

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QUEENSLAND CURTIS LNG A BG Group business	Project: Queensland Curtis LNG Project Client: QGC - A BG Group business	Title: WBM Water Quality Sampling Locations (November 2008)
ERM Environmental Resources Management Australia Pty Ltd	Drawn: JF/JB; Volume 5; Figure 5.8.3 Approved: GB; File No: 0086165b_EIS_ME_CDR004_F5.8.3 Date: 01/06/09; Revision 1	Disclaimer: Maps and Figures contained in this Report may be based on Third Party Data, may not to be to scale and are intended as Guides only. ERM does not warrant the accuracy of any such Maps and Figures.

pH (Acidity)

- Water column pH was lowest in The Narrows region and is most likely related to acid inputs from the adjacent mangrove regions[15].
- pH and temperature are relatively uniform with depth, with evidence of only slight thermal stratification.
- Lower pH and higher turbidity were noted by PCIMP in the shallow mangrove-lined upper estuaries.
- A salinity and pH gradient is evident from low tide to high tide and north to south, where salinity and conductivity is highest and pH is lowest at low tide in the northern reaches of the Port of Gladstone. Salinity and conductivity decreases and pH increases further south and as the tide rises.

Turbidity

- Turbidity increases with depth and tidal velocity, most likely due to bottom sediment re-suspension.
- Water clarity as defined by Secchi disc visibility is generally poor, being less than 2 m. Turbidity in-situ measurements in the Port range from 30 to 40 Nephelometric Turbidity Units (NTU) for spring tides and 1 to 5 NTU for neap tides[16].
- Primary variations in spatial distribution and nature of Coloured Dissolved Matter, Total Suspended Matter (TSM) and Secchi depth appear to be controlled by tidal stage and stream flow of major rivers flowing into Gladstone harbour[17].
- Low chlorophyll *a* concentrations were noted throughout the Port of Gladstone[18].

Nutrients

- The Port of Gladstone is the receiving environment for sewage and diffused nitrogen sources from a small number of settlements fringing the Port as well as nitrogen discharges from industrial sources[19].
- Nutrient, total organic carbon and biochemical oxygen demand concentrations appear generally low and consistent with high quality estuarine water[20].

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15 Apte S C, Andersen L E, Andrewartha J R Angel B M, Shearer D, Simpson S L., Stauber J L & Vicente-Beckett, V (2006) ***Contaminant pathways in Port Curtis: final report***.

16 BMT WBM Pty Ltd (2009) ***Proposed BG LNG Facility EIS Marine Water Quality Assessment***.

17 Dekker A G and Phinn S (2005) ***Port Curtis and Fitzroy River Estuary Remote Sensing Tasks***.

18 Dekker A G and Phinn S (2005) ***Port Curtis and Fitzroy River Estuary Remote Sensing Tasks***.

19 Melzer A. and Johnson R (2004) ***Stable isotopes of nitrogen as potential indicators of nitrogen contamination in Port Curtis- a pilot study***.

20 BMT WBM Pty Ltd (2009) ***Proposed BG LNG Facility EIS Marine Water Quality Assessment***.

Contaminants

- The Port of Gladstone is a well-connected estuary which allows dissolved material to be dispersed evenly, however material does not as readily leave the estuary to the offshore environment[21]. This reduced flushing time is likely to contribute to the anomalous bioaccumulation of some metals in biota of the Port of Gladstone[22].
- Elevated metal concentrations exist in the harbour. The Narrows region has the highest concentrations of dissolved copper and nickel which may be attributable to natural geological sources.
- The Fitzroy River is a source of dissolved metals to the local coastal region. In particular, the Fitzroy River contains elevated dissolved nickel concentrations. Under some flow conditions, the Fitzroy River plume may enter The Narrows region and supply dissolved metals to the Port of Gladstone. Trace metal distributions in the Port of Gladstone are likely to reflect a subtle mixture of metal inputs including industrial and other anthropogenic discharges, inputs from unidentified sources in The Narrows and the Fitzroy River plume.
- Trace metal inputs to the Port of Gladstone which contribute to dissolved metal concentrations are most likely to be delivered in solution form and not by release of metals from particulates[23].
- Aluminium and iron concentrations can be significantly higher than those for oceanic seawater.
- Concentrations of other major elements (e.g. boron, fluoride, manganese) appear to be consistent with those of oceanic seawater.
- Trace element, cyanide and phenol concentrations do not appear to be elevated above typical seawater or the Australia and New Zealand Environment and Conservation Council (ANZECC) 2000 guideline concentrations.
- Inner harbour PCIMP sampling sites had significantly higher copper levels than oceanic reference sites[24].
- PCIMP oceanic reference sites had highest cadmium concentrations compared to harbour zones[25].

21 Herzfeld J, Parslow J, Andrewartha P, Sakov and. Webster I T (2004) ***Hydrodynamic Modelling of the Port Curtis Region***

22 Anderson L, Revill A and Storey A (2005) ***Metal bioaccumulation through food web pathways in Port Curtis.***

23 Apte S C, Andersen L E, Andrewartha J R Angel B M, Shearer D, Simpson S L., Stauber J L & Vicente-Beckett, V (2006) ***Contaminant pathways in Port Curtis: final report*.**

24 Anderson, L E, Melville F, Steinberg, A.N, Teasdale A W, and Fabbro L D (2008) ***PCIMP Biomonitoring 2007****: Port Curtis Integrated Monitoring Program*

25 Anderson L E, Melville,F, Steinberg A. N, Teasdale P R, Storey A. W, and Fabbro L D (2007) ***PCIMP Biomonitoring 2006****: Port Curtis Integrated Monitoring Program*.

Biomonitoring

- PCIMP biomonitoring survey in 2007 used two complimentary time-integrated techniques, Diffuse Gradients in Thin Films DGT (passive samplers) and transplanted oysters as biomonitor measurements.
- The monitoring identified a consistent estuarine influence for cobalt, nickel and manganese, with elevated nickel found particularly in The Narrows area, which is within the Project area especially the Bridge and Pipeline crossing[26].

A decreasing gradient of cobalt, manganese and nickel from The Narrows to the oceanic sites was identified in 2006 and 2007 surveys, suggesting a natural geological estuarine influence.

8.3.1.5 *Bathymetry and Seabed Features*

The dominant underlying geology for the Curtis Island area is the Wandilla Formation of the Curtis Island Group consisting of mudstone, quartz greywacke, and pale grey chert. Three distinct geological units are identifiable from the Port of Gladstone area outlined in the Gladstone Special 1:100,000 Geological Map, 2006. These are:

- quaternary alluvial sediments deposited by the Calliope River
- quaternary coastal sediments associated with estuarine channels and banks, supratidal flats, mangroves and coastal grasslands
- late Devonian/Early Carboniferous Curtis Island Group meta sediments which form the basement or bedrock.

Previous geotechnical and geochemical surveys of the marine sediments have been undertaken in the Port as part of planning for dredging and marine infrastructure developments. A comprehensive survey was conducted of the main shipping channel at Wiggins Island Coal Terminal in 2006 which found the general characteristics of the sediments in that part of the Port to be a mixture of gravels, sands, silts and clays.

Surface sediments in high current areas were typically found to be coarser, as finer particles were likely to be swept away with the currents. While in the shallower intertidal areas the sediments were a mixture of sands and silts, with soft silts dominating in the low-current, low-wave energy areas. The fine sediments which typify the intertidal areas highlight the potential for sediment transport in the system[27].

Bottom sediments in the Port of Gladstone estuary are variable over small distances (less than 1.5 km), and median-size classes ranged from silt and mud, through sand, to coarse-sand and gravel. Median-grain size increases

26 Anderson, L E, Melville F, Steinberg, A.N, Teasdale A W, and Fabbro L D (2008) ***PCIMP Biomonitoring 2007**: Port Curtis Integrated Monitoring Program*

27 Connell Hatch (2006 *Wiggins Island Coal Terminal Environmental Impact Statement*.

significantly with depth. Consequently spatial patterns in sediments broadly reflect patterns in the Port bathymetry[28]. *Table 5.8.2* describes sediment type and associated location.

Table 5.8.2 Sediment Types of the Port of Gladstone [29]

Sediment Type	Description	Location/Extent
Silts and muds	<63 mm diameter	Protected intertidal flats in inner harbour
Fine sands	0.06 mm–0.25 mm diameter	Shallow banks between Curtis and Facing Islands
Medium sands	0.25 mm–0.5 mm diameter	Channels through the inner harbour, shelving waters through the outer harbour
Coarse sands and gravels	>0.5 mm diameter	Scour holes of arterial channels and entrances, fringing reefs east of Facing Island

The bathymetry in the harbour has been modified by the development of shipping channels, land reclamation and coastline armouring. The maintenance dredging of the shipping channels occurs regularly, with the dredged material being disposed of ashore or deposited at a location approximately 9 km south-east from Facing Island.

Deepwater benthic habitats in the Port of Gladstone and nearby Rodds Bay (approximately 20 km south-east) have been mapped as comprising of open rubble and reef substrates[30]. The water depth in the Port of Gladstone at low tide ranges from zero to 12.5 m and from 15 m 50 18 m at Hamilton Point (refer to *Figure 5.8.4).* The water depth of the proposed Pipeline crossing at Friend Point is approximately 12 m.

8.3.1.6 Sediment Quality

In a study conducted between 2003 and 2005[31], benthic sediments and sediment cores from the Port of Gladstone were analysed for metals and polycyclic aromatic hydrocarbons (PAHs). The study confirmed that intertidal (mangrove) sediments tended to collect fine sediments, which contained higher levels of metals and PAHs than did estuarine sediments.

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28 Currie D R and Small K J. (2006) *The influence of dry-season conditions on the bottom dwelling fauna of an east Australian sub-tropical estuary*.

29 Currie D R and Small K J. (2006) *The influence of dry-season conditions on the bottom dwelling fauna of an east Australian sub-tropical estuary*.

30 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.*

31 Vincente-Beckett Vicky and Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management (Australia) 2006 ***Metal and polycyclic aromatic hydrocarbon contaminants in benthic sediments of Port Curtis***. Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management, Indooroopilly, Qld

The top 28 cm of subsurface sediments at intertidal or subtidal sites were estimated to have been deposited since 1958 in the Port of Gladstone, which is roughly the start of Gladstone's industrialisation. The rate of sediment deposition was at least 0.6 cm a year. The sediment depositional zones were demonstrated to be largely at the intertidal (mangrove) sites, particularly at the northern end of The Narrows, lower Calliope River and Boyne River areas.

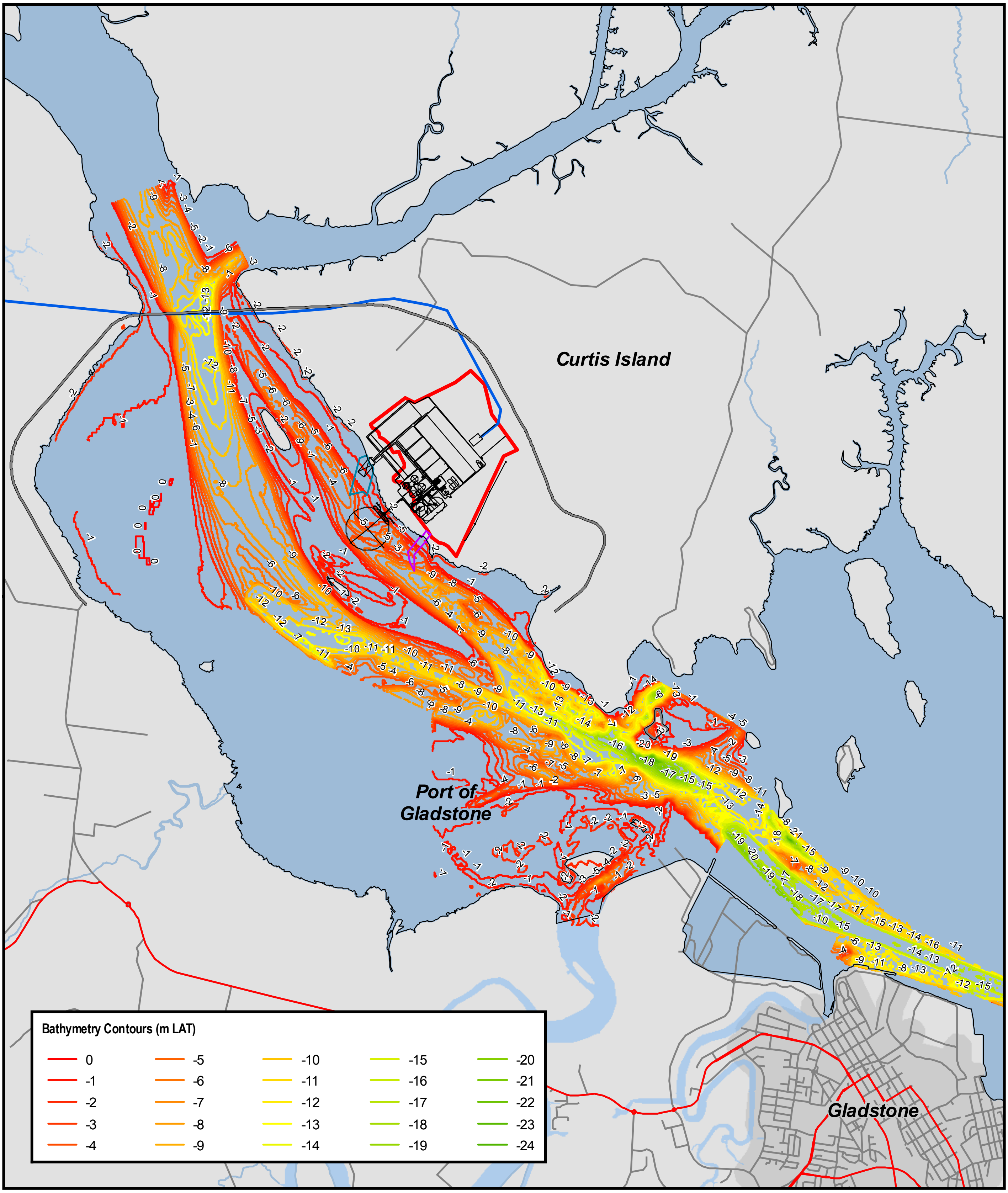
The study also concluded that concentrations of nickel, arsenic and chromium appeared to be related to local geology and not to contamination by anthropogenic sources. Natural levels of nickel, arsenic and chromium were confirmed to be fairly close to their respective ANZECC (2000) trigger values.

PAHs from combustion or pyrolytic sources were dominant around intertidal sites along the industrial area of Gladstone, particularly at the Clinton Coal Facility, Queensland Alumina Limited's (QAL) Red Mud Dam outlet, Auckland Creek, Calliope River near the NRG Gladstone Power Station and at the Gladstone marina. Perylene, a naturally-occurring PAH, dominated sediments in the northern end of The Narrows area. Naphthalene levels were below 5 µg/kg, in contrast to high levels (exceeding the ANZECC 2000 guideline of 160 µg/kg) reported in a previous study in 2000[32].

An extensive sediment study is currently being undertaken in the Port of Gladstone area. This study will characterise the sediments for GPC's proposed dredging program and determine the level of contaminants to approximately 14.5 m below lowest astronomical tide (reported in metres (m) LAT). It will also include the assessment of potential acid sulfate soils.

The objective of the dredging assessment program is to determine sediment characteristics and the level of contaminants present in the harbour. In addition, QGC will use this information in relation to the dredging assessment for the LNG Facility, as outlined in *Volume 6* .

32 Apte, SC, Andersen, LE, Andrewartha, JR, Angel, BM, Shearer, D, Simpson, SL., Stauber, JL & Vicente-Beckett, V (2006) ***Contaminant pathways in Port Curtis: final report***. CRC for Coastal Zone, Estuary and Waterway Management, Brisbane.



Legend

- Proposed QCLNG Site Boundary
- QCLNG Footprint Plant Layout
- Possible Curtis Island Road/Bridge Corridor
- Proposed Export Pipeline
- Rock Dock Approach Channel
- MOF Dredge Pocket

Source Note:

Bathymetric Data - Gladstone Ports Corporation
Rock Dock Approach Channel - Adapted from Bechtel K0-1T00-00001_00A
MOF Approach Channel - Adapted from Bechtel K0-1T00-00001_00A
StreetPro Australia, Pitney Bowes MapInfo
Curtis Island Road/Bridge Corridor - Connell Wagner

Projection: UTM MGA Zone 56 Datum: GDA 94

0 0.5 1 2 km

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Project	Queensland Curtis LNG Project		
Client	QGC - A BG Group business		
Drawn	JF/JB	Volume 5	Figure 5.8.4
Approved	JC	File No:	0086165b_EIS_ME_GIS021_F5.8.4
Date	03/06/09	Revision	2

Title **Bathymetry Map of Port of Gladstone**

8.3.1.7 *Underwater Noise*

Ambient or background noise levels are the product of a number of oceanic sources, including natural and distant man-made sources. Natural underwater noise includes physical sources, such as wind, waves and tectonic activity (e.g. sub-sea volcanoes and earthquakes); and biological sources, such as cetacean and fish vocalisations. Man-made sounds include shipping, fishing and tourism vessels, and industrial activities. Sound is transmitted more efficiently through water, compared to air, and can therefore be detected at much greater distances from the source.

In the Port of Gladstone, current sources of man-made noise primarily come from vessel activities. For example, in 2007 there were 1,363 vessel movements into the Port of Gladstone. Noise from vessels results from the propellers, machinery and hull passage through the water. Most shipping has a low-frequency range less than 1 kilohertz (kHz). However, small leisure craft may generate sound from 1 kHz up to 50 kHz[33].

The ambient sound level in the Port of Gladstone will vary with natural factors such as time of day, season and meteorological and oceanographic conditions; and also with anthropogenic factors such as the level of shipping or other noise-producing activities. Underwater noise levels have not been measured directly in the Port of Gladstone region. Instead, a summary of frequencies produced by different shipping vessels and their source levels is listed in *Table 5.8.3* indicating the types of anthropogenic noise that may be present in the Port.

Table 5.8.3: Summary of Sound Frequencies Produced by Shipping Traffic and their Source Levels[34]

Type of vessel	Frequency (kHz)	Source level (dB re 1µPa)	Reference
650 cc jetski	0.8–50.0	75–125	Evans and Nice 1996
Rigid inflatable	6.3	152	Malme *et al.* 1989
7 m outboard motor boat	0.63	156	Malme *et al.* 1989
Fishing boat	0.25–1.0	151	Greene 1985
Fishing trawler	0.1	158	Malme *et al.* 1989
Tug pulling empty barge	0.037	166	Buck and Chalfant 1972
	1.0	164	Miles *et al.* 1989
	5.0	145	

33 Simmonds M, Dolman S, and Weilgart L (2004) *Oceans of Noise 2004.*

34 Simmonds M, Dolman S, and Weilgart L (2004) ***Oceans of Noise 2004.***

Type of vessel	Frequency (kHz)	Source level (dB re 1μPa)	Reference
Tug pulling loaded barge	1.0	170	Miles *et al.* 1989
	5.0	161	
34 m (twin diesel engine) workboat	0.63	159	Malme *et al.* 1989
Tanker (135 m)	0.43	169	Buck and Chalfant 1972
Tanker (179 m)	0.06	180	Ross 1976
Supertanker (266m)	0.008	187	Thilele and Ødengaard 1983
Supertanker (340 m)	0.007	190	
Supertanker (337 m)	0.007	185	
Containership (219 m)	0.033	181	Buck and Chalfant 1972
Containership (274 m)	0.008	181	Ross 1976
Freighter (135 m)	0.041	172	Thilele and Ødengaard 1983

8.3.2 Biological Environment

A summary of the extent of various intertidal and subtidal habitats present in the Port of Gladstone area is provided in *Table 5.8.4*.

Table 5.8.4 Summary of Intertidal and Subtidal Habitat in the Port of Gladstone Area [35] [36]

Habitat Type	Area (ha)	% Area of Total	Prominent Location(s)
Exposed mud and sandbanks	5,144	9	• Eastern side of Curtis Island • Western side of Facing Island
Exposed Rocky substrate	297	0.52	• Curtis, Facing, Tide and Picnic Islands
Seagrass (coastal)	7,246	12.7	• Pelican Banks/Quoin Island • Fisherman's Landing area
Seagrass (deepwater)	6,332	11.1	• Facing Island • Seal Rocks • West and East Banks
Benthic Open	9,876	17.3	• Outside Facing Island from Curtis

35 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***

36 Danaher K, Rasheed M A and Thomas R (2005) ***The Intertidal Wetlands of Port Curtis.***

Habitat Type		Area (ha)	% Area of Total	Prominent Location(s)
macro-invertebrate communities (including coral)	substrate, occasional individual			Island to East Bank
				• North-west of Seal Rocks
				• Entrance to Rodds Bay
	Low density	8,606	15	• Throughout the Port of Gladstone/Rodds Bay area
	Medium Density	4,099	7.2	• Southern and northern side of Seal Rocks
				• Deep channel area from mouth of The Narrows at Graham Creek to Fisherman's Landing
	High Density	4,189	7.3	• Narrow strip in channel from Fisherman's Landing to inside Facing Island and East Bank
Saltmarsh		4,572	8	• Throughout the Port of Gladstone/Rodds Bay area
Mangroves		6,736	11.8	• Curtis Island coastline from Graham Creek to Hamilton point
Total		**57,097**	**100**	

8.3.2.1 *Plankton*

Plankton can be divided into two categories, phytoplankton and zooplankton. Phytoplankton is the food base that supports, either directly or indirectly, primary production in marine and estuarine waters. Plankton biomass is strongly influenced by nutrient availability, temperature and light.

Plankton communities in Great Barrier Reef (GBR) waters are comprised of oceanic, coastal and benthic taxa. Phytoplankton biomass is overwhelmingly dominated (50 per cent and 80 per cent) by very small phototrophic picoplankton (less than 2 μm) such as *Prochlorococcus* and *Synechoccus*. Chlorophytes dominate in oceanic and outer waters, giving way to cyanobacteria in the coastal zone.[37]

Chlorophyll *a* concentrations are an indicator of phytoplankton abundance and biomass in coastal and estuarine waters. They can be an effective measure of trophic status, are potential indicators of maximum photosynthetic rate (P-max), and are commonly used to measure water quality[38] Chlorophyll *a* concentrations will naturally fluctuate, however high levels often indicate poor

37 Brando V, Dekker A, Marks A, Qin Y, Oubelkheir K (2006) Chlorophyll and suspended sediment assessment in a macrotidal tropical estuary adjacent to the Great Barrier Reef: spatial and temporal assessment using remote sensing.

38 Great Barrier Reef Marine Park Authority (GBRMPA) (2001)

water quality and in particular the long-term persistence of elevated levels can be a problem. For this reason, annual median chlorophyll *a* concentrations are more useful indicators of the waterway health.

Prediction of chlorophyll *a* winter levels in the Port of Gladstone range from 0.6 micrograms per litre (µg/L) to 3.2 µg/L and are between 2.05 µg/L and 2.28 µg/L in waters adjacent to Curtis Island[39]. Concentrations in the inner harbour were generally lower compared to the shallow near-shore waters to the south-east of the eastern entrance. The ANZECC guidelines (2000) trigger level for a tropical estuary is 4.0 µg/L of chlorophyll. Studies have found chlorophyll *a* concentrations in the Port of Gladstone were uncorrelated with macrobenthic diversity and richness, and that phytoplankton may not be the dominant source for benthic productivity within the estuary[40].

Nutrient release from suspended sediments during storm events stimulates phytoplankton growth during subsequent days[41]. Therefore, phytoplankton concentrations are likely to be elevated in the Port of Gladstone following a storm or cyclone. Chlorophyll *a* concentration, is used as an integrative parameter to monitor nutrient concentrations in the GBRWHA[42,43].

8.3.2.2 *Seagrass and Algal Communities*

Benthic Primary Producer Habitat (BPPH) refers largely to marine plants such as seagrass, macroalgae and mangroves, but also includes scleractinian coral species. BPPH plays a major role in marine ecosystem functioning including acting as a substrate and providing shelter and food for organisms, as well as providing physical stability of the coastline and seafloor.

Seagrasses are true flowering plants found between intertidal and subtidal habitats. Seagrasses are highly productive and form the basis for many complex grazing and detrital food webs. They are essential food sources for a variety of marine and estuarine organisms including dugongs, turtles, fish and macroinvertebrates[44].

Within Queensland waters 15 species of seagrass have been recorded. Within

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39 Currie D R and Small K J (2006) The influence of dry-season conditions on the bottom dwelling fauna of an east Australian sub-tropical estuary.

40 Currie D R and Small K J (2005) Macrobenthic community responses to long-term environmental change in an east Australian sub-tropical estuary.

41 Walker T A and O'Donnell G (1981) Observations on nitrate, phosphate and silicate in Cleveland Bay, northern Queensland.

42 Brodie J E, Furnas M, Steven A D L, Trott L A, Pantus F and Wright M (1997) Monitoring chlorophyll in the Great Barrier Reef lagoon: trends and variability, in Proceedings of the 8th International Coral Reef Symposium, Panama, June 24–29 1996, eds H.A. Lessios and I.G. Macintyre, Smithsonian Tropical Research Institute, Balboa, Republic of Panama, pp. 797–801.

43 Steven A D L, Pantus F and Brooks, D (1998) Long-term chlorophyll monitoring in the Great Barrier Reef agoon: Status report 1, 1993–1995. GBRMPA Research Publication No. 55, Great Barrier Reef Marine Park Authority, Townsville

44 Alquezar R, Small K and Hendr R (2007) Port Curtis Biomonitoring programme: macroinvertebrate, mangrove and seagrass surveys November 2006.

the Port of Gladstone the following six seagrass species were identified:

- *Halodule uninervis*
- *Halophila ovalis*
- *Halophila decipiens*
- *Halophila minor*
- *Halophila spinulosa*
- *Zostera capricorni*.

Within the Port or Gladstone region, seagrass monitoring has been regularly undertaken by the Department of Primary Industries and Fisheries (DPIF) Marine Ecology Group in collaboration with GPC. This regular monitoring expands on a baseline study conducted in 2002, and in 2007 was included as an annual monitoring theme in the PCIMP[45]. The monitoring sites in comparison to the 2002 baseline survey are outlined in *Figure 5.8.5.*

A 2002 baseline study included a seagrass and macrobenthos survey of the Port of Gladstone – Rodds Bay Dugong Protection Area (DPA)[46] (refer to *Figure 5.8.9*). The Port of Gladstone – Rodds Bay seagrass communities are of regional significance as the next nearest meadows are located at Hervey Bay 170 km to the south and Shoalwater Bay 170 km to the north. Much of the Port of Gladstone – Rodds Bay area is relatively well protected from southeasterly winds by Rodds Peninsula and from northerly winds by Curtis and Facing Islands. The extensive seagrass distribution within the area is considered in part to be as a result of these sheltered conditions.

A total of 7,246 ha of intertidal seagrass beds were identified within the Port of Gladstone – Rodds Bay DPA with an additional 6,332 ha in deepwater areas (greater than 5 m mean sea level) identified to the east and south of Facing Island[47]. Within the Port the majority of the seagrass communities were located in the Pelican Banks/Quoin Island area between The Narrows and the Calliope River mouth and southern Port limits. These communities are located close to a number of industrial activities within the Port, including shipping channels, the RG Tanna Coal Terminal (RGTCT), QAL and Fisherman's Landing.

No deepwater seagrass (greater than 5 m below mean sea level) communities are known to occur within the inner Port area. It is noted that the studies have not been focused in the intertidal/subtidal areas to the west of Curtis Island.

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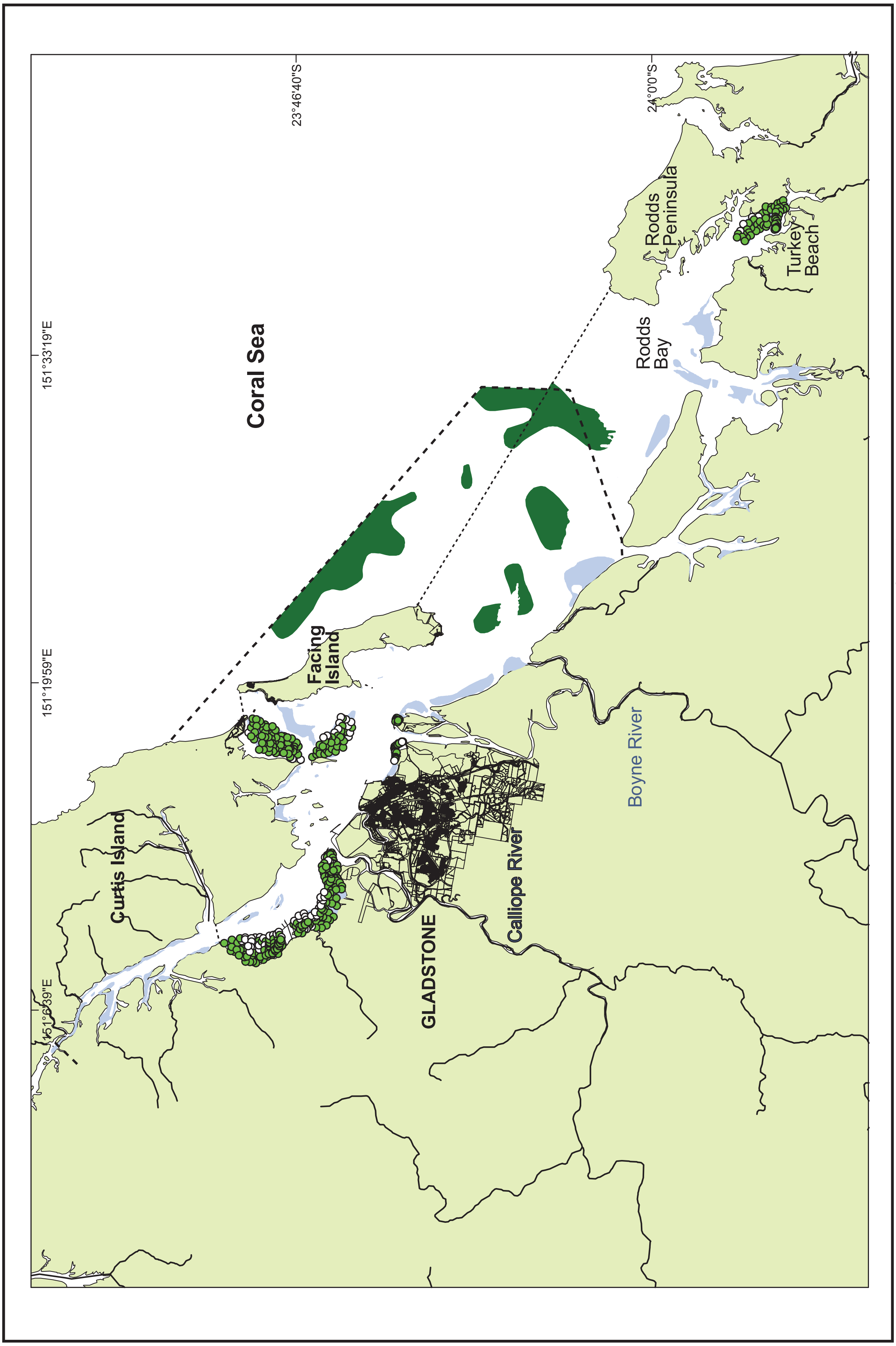
45 Storey A W, Andersen L E, Lynas J, and Melville F (2007). ***Port Curtis Ecosystem Health Report Card***.

46 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*.**

47 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*.**



0 5 10 km

N

Source Note:
Rasheed, M.A, McKenna, S.A., Taylor, H.A. and Sankey, T. 2007. Long term seagrass monitoring in Port Curtis and Rodds Bay, Gladstone - October 2007. DPI&F Publication PRO7-3271 (DPI&F, Cairns) 32pp.
Port Curtis Integrated Monitoring Program and the State of Queensland through the Department of Primary Industries and Fisheries.
Founded by the Port Curtis Integrated Monitoring Program and the Queensland Department of Primary Industries and Fisheries.
Produced by the Marine Ecology Group, Queensland Department of Primary Industries and Fisheries, Northen Fisheries Centre, Cairns, 2008.

Legend
- Coastal seagrass from 2002 baseline
- Deepwater seagrass from 2002 baseline
- Port Curtis limits
- Rodds Bay dugong protection area
- Sites without seagrass
- Sites with seagrass

QUEENSLAND CURTIS LNG A BG Group business	Project: Queensland Curtis LNG Project Client: QGC - A BG Group business	Title: **Location of 2007 Monitoring Seagrass Sites compared to 2002 Baseline Survey**
ERM Environmental Resources Management Australia Pty Ltd	Drawn JF/JB · Volume 5 · Figure 5.8.5 Approved GB · File No: 0086165b_EIS_ME_CDR001_F5.8.5 Date 02/06/09 · Revision 1	Disclaimer: Maps and Figures contained in this Report may be based on Third Party Data, may not to be to scale and are intended as Guides only. ERM does not warrant the accuracy of any such Maps and Figures.

Therefore, there is limited information in the proposed area of the Materials Offloading Facility (MOF) and the associated LNG Facilities. There is significant information for the north and south of the Fisherman's Landing area, which has been proposed as a future reclamation area for the disposal of dredge spoil as part of the Port of Gladstone dredging program (refer to *Volume 6*).

Seagrass meadows most commonly occur on intertidal mud and sand substrates. There were only 12 coastal seagrass meadows that were completely subtidal and these were generally small *Halophila*-dominated meadows immediately adjacent to mud and sand banks[48].

In 2007 seagrasses in the Port of Gladstone were in the healthiest condition recorded since the inception of the monitoring program[49]. Most of the monitoring meadows were at or near their highest-recorded density and area. The changes observed in the monitoring program appear to be largely linked to a combination of climate factors and tidal exposure and the natural resilience and capacity for recovery in individual seagrass meadows.

Changes observed were consistent between seagrasses within the Port infrastructure area and at reference sites in nearby Rodds Bay as well as other Queensland locations where seagrasses are monitored.

During a recent long-term seagrass monitoring program (2002 to 2007) shifts in the community structure and composition were not uncommon. Seagrass meadows varied significantly in percentage of cover, biomass and species composition among sampling sites and years[50].

The healthy *Zostera capricorni* communities identified in the 2007 monitoring are likely to provide an important refuge for fish and crustacean species and are recognised as key nursery areas for many commercial species. Evidence of dugong activity in the Port of Gladstone seagrass meadows has been consistently observed throughout the monitoring program. The seagrass meadows around Wiggins Island in particular appear to be heavily utilised by dugongs, as feeding trails were found at a majority of sites sampled in 2007, and have been recorded in all previous surveys.

Further evidence of feeding activity was observed in South Trees, Quoin Island and Fisherman's Landing. Green sea turtles were also regularly observed within the seagrass meadows, particularly on Pelican Banks where they were often stranded at low tide.

The presence of seagrass meadows and dugong activity in intertidal areas

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48 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***.

49 Rasheed M A, McKenna S A, Taylor H.A. and Sankey T L (2008). ***Long term seagrass monitoring in Port Curtis and Rodds Bay, Gladstone – October 2007***.

50 Alquezar R, Small K,, Hendry R (2007) ***Port Curtis Biomonitoring programme: macroinvertebrate, mangrove and seagrass surveys November 2006.*** A report to Queensland Energy Resource Limited (QERL). Centre for Environmental Management, Central Queensland University, Gladstone Queensland.

adjacent to Port facilities and infrastructure has implications for Port management. Some of the most utilised seagrass meadows also appear to be those closest to major Port infrastructure and proposed areas of expansion.

Water quality parameters (temperature, turbidity and light) were recorded at selected seagrass-monitoring sites as part of the long-term seagrass water quality monitoring program by PCIMP. The *in situ* collection of these parameters provides information on the natural water quality conditions experienced by seagrass meadows during autumn and winter[51].

Macroalgae are only a minor component of the benthic communities in the Port of Gladstone region. Macroalgae cover is generally low and does not form distinctive macroalgae community regions. However, while significant areas of macroalgae in coastal areas are absent, coastal seagrass meadows have been observed with a relatively high percentage cover of filamentous green algae[52].

Microalgae live in the sediment and form part of the local and regional fish production cycle. In the Port of Gladstone area microalgae occur in lagoons, estuaries, sandbanks, mudbanks, saltmarshes and soft seabeds.

8.3.2.3 Mangroves

At a regional scale, the distribution of mangrove species is determined by a number of factors including temperature, rainfall, catchment area and tidal inundation. In Queensland, mangrove species diversity generally decreases with increasing latitude. For example, 36 species have been recorded from Cape York, 14 from the Curtis Coast region, and only nine species from south-east Queensland[53].

Fourteen species of mangroves are reported from the Port of Gladstone region and three species (*Acanthus ilicifolius*, *Bruguiera exaristata* and *Xylocarpus moluccensis*) are at the southern limit of their distribution. The mangrove assemblage is dominated by *Rhizophora stylosa* with lesser amounts of *Ceriops tagal* and *Avicennia marina* also present, generally on the landward edge of the assemblage. The mangrove assemblage is considered to be in a healthy state. Mangroves are dominant in the mid-to-upper intertidal zones, fringing much of the mainland and Curtis Island coasts between mean sea level and mean high water springs.

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51 Wilson S P,, Andersen L E and Melville F (2008) ***Port Curtis Seagrass Water Quality Data Report: December 2007 – April 2008***.

52 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.

53 Duke N C (1992) Mangrove floristics and biogeography. In: Robertson A I and Alongi D M (eds) Tropical Mangrove Ecosystems. American Geophysical Union, Washington DC, pp. 63–100.

Extensive mangroves extend along the Curtis Island coastline from Graham Creek to Hamilton Point to the south beyond the Project area[54]. Intertidal mangrove habitat comprises 31.7 per cent of all habitat types in the Port of Gladstone covering an area of 6,736 ha (refer to *Figure 5.8.6*). Areas of mangrove (*Rhizophora* closed forest) are found along the coastline of Curtis Island close to the proposed LNG Marine Facilities and also adjacent, south and north and on Passage Islands (refer to *Figure 5.8.6*).

Recent monitoring of mangroves in the Port of Gladstone for the PCIMP[55] identified five mangrove species among the surveyed sites: *Rhizophora stylosa*, *Avicennia marina*, *Aegiceras corniculatum*, *Ceriops tagal* and *Osbornia octodonta*. The highest number of species found in any one sampling zone was four, with The Narrows, Boat Creek, Auckland Creek, South Trees South and Oceanic Reference zones containing the highest species diversity (refer to *Figure 5.8.7*[56]).

Species diversity was found to be similar across two years of monitoring (2006 and 2007). *Rhizophora stylosa* was the dominant mangrove species, with the Graham Creek, Wiggins Island, Inner Harbour and South Trees North zones only containing this species. Total tree density varied significantly among the zones, with density at Graham Creek (0.2 trees/m² in 2007) significantly lower than in the Calliope River (0.9 trees/m² in 2007) and Auckland Creek (1.5 trees/m² in 2007). In addition, density at Auckland Creek was significantly higher than at mid harbour, Fisherman's Landing and Boat Creek zones (0.3 to 0.4 trees/m² in 2007).

8.3.2.4 Other Benthic Habitats

The deep-water harbour of the Port of Gladstone is protected by a low island to the east called Facing Island and to the north by Curtis Island. These two islands provide a barrier, allowing estuarine environments to establish within the harbour. A number of benthic habitats exist within the harbour and provide important habitat for a wide range of species.

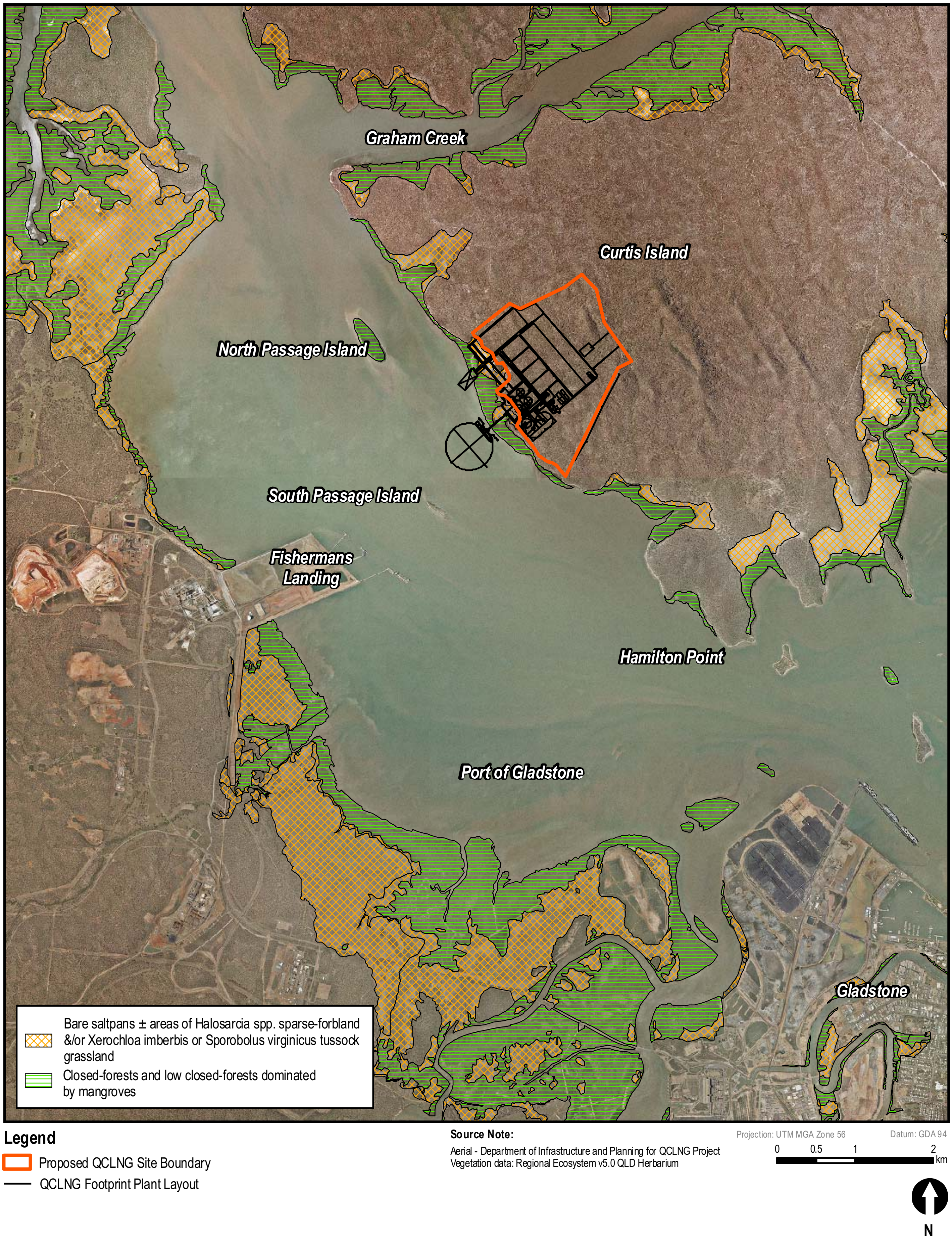
The predominant subtidal benthic habitats consist of:

- winding channels of the tidal creek systems which drain the mudflats and hinterland in the Port of Gladstone and The Narrows, plus the deeper channels of the lower Calliope River
- the relatively turbid and tidally dominated water column that overlies the soft silty sediments of the Port of Gladstone (0–10 m lowest astronomical tide (LAT) depth range, extending to 15 m–18 m LAT near Hamilton Point)

54 Danaher K, Rasheed M A and Thomas R (2005) ***The Intertidal Wetlands of Port Curtis.***

55 Melville F and Anderson L (2008) *PCIMP* ***Intertidal Monitoring 2007: North Harbour Zones***.

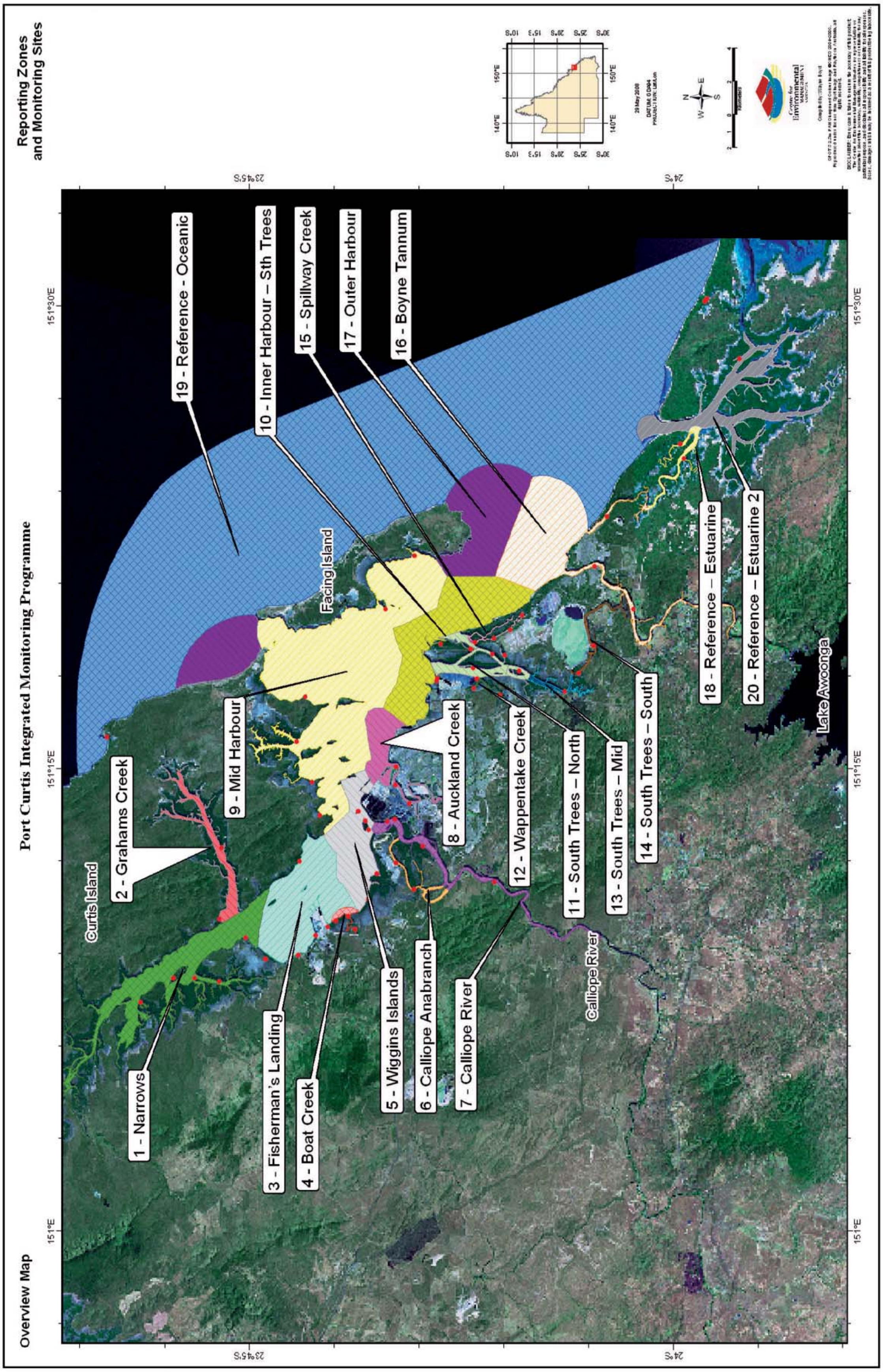
56 Melville, F. and Anderson, L (2008). ***PCIMP Intertidal Monitoring 2007: North Harbour Zones***.



QUEENSLAND CURTIS LNG
A BG Group business

ERM
Environmental Resources Management Australia Pty Ltd

Project	Queensland Curtis LNG Project	Title	Coastal Wetland Vegetation (Mangroves and Saltmarsh)
Client	QGC - A BG Group business		
Drawn JF/JB	Volume 5	Figure 5.8.6	Disclaimer: Maps and Figures contained in this Report may be based on Third Party Data, may not to be to scale and are intended as Guides only. ERM does not warrant the accuracy of any such Maps and Figures.
Approved JC	File No: 0086165b_EIS_ME_GIS022_F5.8.6		
Date 10.06.09	Revision 1		



Source Note:
Figure sourced from Melville, F. and Anderson, L. (2008).
PCIMP Intertidal Monitoring 2007: North harbour Zones.
Centre for Environmental Management, Central Queensland University.

Legend
- Mangrove Monitoring Site

QUEENSLAND CURTIS LNG A BG Group business	Project	Queensland Curtis LNG Project	Title **Mangrove Monitoring Sites for 2007 Port Curtis Integrated Monitoring Programme**
	Client	QGC - A BG Group business	
ERM Environmental Resources Management Australia Pty Ltd	Drawn JF/JB	Volume 5 Figure 5.8.7	Disclaimer: Maps and Figures contained in this Report may be based on Third Party Data, may not to be to scale and are intended as Guides only. ERM does not warrant the accuracy of any such Maps and Figures.
	Approved GB	File No: 0086165b_EIS_ME_CDR003_F5.8.7	
	Date 02/06/09	Revision 1	

- limited areas of rocky substrate restricted to small headlands and drop-offs off Curtis and Facing Islands and some of the smaller islands south of Curtis Island, including Tide and Picnic Islands
- the dredged shipping channel leading to the swing area and berths at Fisherman's Landing (7 m–15 m LAT) with mixed, variable and often coarse substrate dominated by cobbles, silty sandy gravel and shelly, silty sand
- shelly, gravely sand and silt substrates of the nearshore shallow and subtidal zone, bare or colonised by macroalgae.

Approximately one-third of the estuary is intertidal. These habitats are most extensive in the protected waters of the inner harbour, and typically occur as gently sloping nearshore mudflats. Nearshore gradients in the outer harbour are, by comparison, much steeper and intertidal habitats here are generally represented by narrow sandy beaches and occasionally small rocky outcrops.

Both of these intertidal substrates support minimal algal growth, probably reflecting higher wave exposure. Shallow sub-tidal sandbanks (less than 5 m depth) comprise a further third of the estuary. The remainder of the estuary consists of channels of a wide depth range (5 m–18 m)[57]. These axial channels are generally shallowest in the upper reaches of the estuary, and become progressively deeper towards the eastern entrance. In the outer harbour, sandbanks gradually slope offshore towards the north-east, the deepest part of the estuary.

Mudflats/Sandbanks

A number of small islands are located within the Port of Gladstone ranging from non-vegetated mud banks to islands colonised with stands of mangroves. Exposed mud and sandbanks are the most common intertidal habitat. These intertidal habitats of exposed mud and sandbanks total approximately 5,144 ha within the Port of Gladstone area[58] and may be non-vegetated sand or mud or colonised by seagrass or algal beds.

These banks are primarily a feature of the outer harbour, and extend through much of the waters to the east of the eastern entrance. The banks present a significant natural barrier to prevailing south-easterly swells, and provide a degree of protection for inshore waters and coastal mangroves on the mainland side of the entrance. Large areas of exposed mud and sand are found for example on the eastern side of Curtis Island (Pelican Banks) and the western side of Facing Island (Shoal Bay).

Mudflats and sandbanks are often considered to be relatively unproductive compared to fish habitats with seagrass meadows or mangroves. These bare-fish habitats support microalgae on and below the surface which is

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57 Currie D R and Small K J (2006) The influence of dry-season conditions on the bottom dwelling fauna of an east Australian sub-tropical estuary.

58 Danaher K, Rasheed M A and Thomas R (2005) The Intertidal Wetlands of Port Curtis.

important to the marine environment. Intertidal mudflats constitute an important habitat that support a high biodiversity and biomass of benthic invertebrates, sustain productive fisheries and are likely to provide important feeding grounds for migratory shorebirds listed under the *Environment Protection and Biodiversity Conservation Act (EPBC Act) 1999*[59] (Cth).

Saltmarsh

Also present in the Curtis Coast region are saltpans which are largely bare, but contain patches of saltmarsh species such as *Sueda* spp., *Sarcocornia quinqueflora* and *Sporobolus virginicus*. Approximately 40 saltmarsh species have been recorded[60]. Although biodiversity within this habitat type is generally low compared to other wetland types, saltmarsh communities support a range of invertebrates, which are an important food source for a wide range of fish species.

Waterbirds/shorebirds may also utilise this habitat for feeding. Saltmarsh habitat comprises 4,572 ha and occurs along the landward edge of the intertidal zone in a saline environment that is only inundated by the spring tides (refer to *Figure 5.8.6*). Areas of saltmarsh are found along the coastline of Curtis Island close to the LNG Marine Facilities and also adjacent, south and north (refer to *Figure 5.8.6*).

Rocky Substrate

Rocky foreshores provide a hard substrate for the attachment of algal flora as well as the long-term attachment of sedentary invertebrates (such as barnacles, oysters and tube worms). Exposed rocky substrate totalling approximately 297 ha is found in the Port of Gladstone area and occurs along the seaward edge of the intertidal zone and are inundated every tide[61].

Rocky substrate in subtidal areas is restricted to small headlands and drop-offs of Curtis and Facing Islands and some of the smaller islands south of Curtis Island, including Tide and Picnic Islands. Brown algae has been reported to be the predominant macroalgae on these substrates. Coral habitat is restricted to sites between Facing and Curtis Islands[62].

A field survey on the south side of Picnic Island in 2006[63] found that the reefal benthos comprised primarily of soft corals, anemones, fan worms, sponges and tunicates. A few small, isolated hard corals were found, but did not provide adequate structure (height and extent) for significant reef habitat

59 Erftemeijer P L A and Lewis R R (1999) Planting mangroves in intertidal mudflats: habitat restoration or habitat conversion? Paper presented at the ECOTONE-VIII Seminar 'Enhancing coastal ecosystem restoration for the 21st century. Ranong and Phuket, 23–28 May 1999.

60 Saenger P (1996) Ecology of mangroves of Port Curtis: regional biogeography, productivity and demography. In: Mangroves – a resource under threat? (eds D Hopley & L Warner). Australasian Marine Science Consortium, James Cook University, Townsville (pp. 23-36).

61 Danaher K, Rasheed M A and Thomas R (2005) *The Intertidal Wetlands of Port Curtis*.

62 Queensland Department of Environment and Heritage [QDEH] (1994) *Curtis Coast Study Resource Report*.

63 URS. (2006) *Gladstone Pacific Nickel Project. Environmental Impact Statement, 2006*.

associated species.

8.3.2.5 Invertebrates

Coral Communities

The Port of Gladstone is located in proximity to the southern end of the Great Barrier Reef Marine Park (GBRMP) and within the GBRWHA. The GBR is the largest coral reef system in the world, stretching for 2,600 km off the coast of Queensland. The GBR's high productivity and topographic complexity supports a diversity of marine life, including more than 1,500 species of fish, 5,000 species of mollusc, six species of turtle and 400 species of coral[64].

The nearest coral reefs of significance to the Project area are associated with the offshore islands of the Capricorn and Bunker Groups, approximately 60 km north-east of Gladstone. In this region the reefs consist of a series of isolated platform reefs, many of which surround small vegetated islands. A total of 244 species of hard coral has been recorded from the Capricorn Group reefs and the reefs of the Bunker Group to the south[65].

Deepwater benthic macro-invertebrate communities previously identified[66] in the Port of Gladstone were divided into regions based on density of individuals and community composition. Two regions (98 ha and 158 ha) of low, coral reef bommies and associated mixed coral reef communities, interspersed with bare substrate, were identified on the seaward side of Facing Island. Hard and soft corals were also associated with a number of benthic communities throughout the survey area (refer to *Figure 5.8.8*).

Developed hard coral assemblages are supported on the rocky reef substrate sites between Facing and Curtis Islands[67],[68] and north of Targinie Creek in rocky parts of The Narrows[69]. Reefal benthos on the south side of Picnic Island is comprised primarily of soft corals, anemones, fan worms, sponges and tunicates[70]. A few small, isolated hard corals occur (mostly *Favidae* and *Goniopora*), but these do not combine or provide adequate structure (height and extent) to form significant reef habitat for reef associated species[71].

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64 CRC Reef Research Centre (2008) Reef Facts: Plants and Animals on the Great Barrier Reef.

65 Great Barrier Reef Marine Park Authority (GBRMPA) (2004) The Status of the Great Barrier Reef Report: Corals.

66 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.

67 URS (2007) Gladstone Nickel Project Environmental Impact Statement. Public EIS report prepared on behalf of Gladstone Pacific Nickel by URS Australia Pty Ltd, Brisbane, Queensland.

68 Dames and Moore (1998) Comalco Alumina Project Gladstone: Impact Assessment Study – Environmental Impact Statement. Public EIS report produced by Dames and Brisbane (now URS Australia Pty Ltd), Brisbane, Queensland.

69 URS (2007) Gladstone Nickel Project Environmental Impact Statement. Public EIS report prepared on behalf of Gladstone Pacific Nickel by URS Australia Pty Ltd, Brisbane, Queensland.

70 URS (2007) Gladstone Nickel Project Environmental Impact Statement. Public EIS report prepared on behalf of Gladstone Pacific Nickel by URS Australia Pty Ltd, Brisbane, Queensland.

71 URS (2007) Gladstone Nickel Project Environmental Impact Statement. Public EIS report prepared on behalf of Gladstone Pacific Nickel by URS Australia Pty Ltd, Brisbane, Queensland.

Table 5.8.4 summarises prominent locations and areas of coral community habitat.

Invertebrate communities

The strong tidal regime in the Port of Gladstone gives rise to naturally high turbidity levels and as such, the species found within this location are well adapted to high sediment loads and scour within/from the water column. Because of their dynamic physical nature, the faunal composition of an estuary may vary considerably at spatial scales of metres to kilometres, and temporal scales of days to years.[72 73]

Infaunal communities inhabiting the soft sediments of the Port of Gladstone are well studied, both spatially and temporally. It has been found that filter-feeding organisms dominate the infaunal communities and account for more than 50 per cent of the total abundance and nearly 30 per cent of total species richness[74]. Deposit-feeding organisms were also common (greaterthan 25 per cent of total abundance and nearly 35 per cent of total species diversity). Polychaete worms, molluscs and crustaceans together accounted for more than 86 per cent of the individuals and 83 per cent of the species collected. Other less common taxa identified included echinoderms; cnidarians; sea spiders; and ribbon, round, peanut and flatworms. The bivalve mollusc (*Carditella torresi*) was the most abundant species and accounted for more than 14 per cent of the total infaunal abundance, principally within subtidal sites. Few other species could be considered numerically dominant.

Species abundance data revealed strong ecological gradients that were principally driven by depth and sediment grain size. Depth-related differences in infaunal species assemblages were most pronounced between the subtidal and intertidal zones, and total abundance and richness were both significantly lower in the intertidal. Total abundance and richness were also found to be significantly lower in sediments that were either extremely coarse or extremely fine. This broad ecological gradient was retained throughout the duration of the study period, despite apparent seasonal and interannular changes in species dominance.

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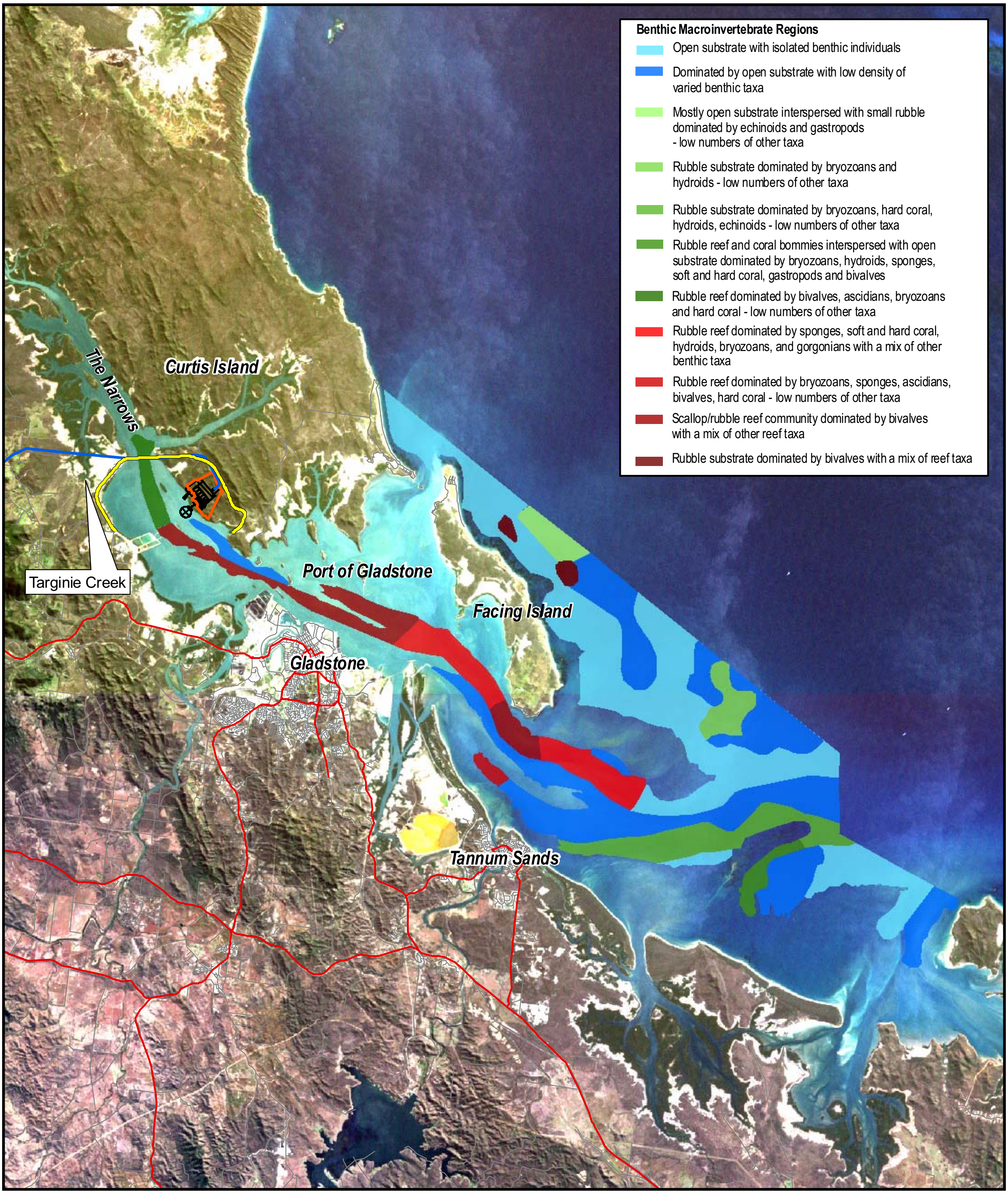
72 Morrisey D J, Howitt L, Underwood A J, Stark J S, (1992a) ***Spatial variation in soft-sediment benthos***. Marine Ecology Progress Series 81, 197-204.

73 Morrisey D J, Underwood A J, Howitt L, Stark J S, (1992b) ***Temporal variation in soft-sediment benthos.*** Journal of Experimental Marine Biology and Ecology 164, 233-245.

74 Currie D R and Small K J (2005) ***Macrobenthic community responses to long-term environmental change in an east Australian sub-tropical estuary***. Estuarine, Coastal and Shelf Science, 63: 315-331.



Legend

- Proposed QCLNG Site Boundary
- QCLNG Footprint Plant Layout
- Possible Curtis Island Road/ Bridge Corridor
- Proposed Export Pipeline
- Major Roads
- Local Roads

Source Note:
Benthic macro-invertebrate data adapted from Rasheed et al 2003.
Landsat ETM+ Image source: USGS 2009. Aquired May 2000.
Curtis Island Road/bridge Corridor - Connell Wagner
StreetPro Australia - Pitney Bowes MapInfo

Projection: UTM MGA Zone 56   Datum: GDA 94

0 2 4 8 km

N

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Project	Queensland Curtis LNG Project		
Client	QGC - A BG Group business		
Drawn JF/JB	Volume 5	Figure 5.8.8	
Approved JC	File No: 0086165b_EIS_ME_GIS012_F5.8.8		
Date 11.05.09	Revision 1		

Title **Deep Water Benthic Macro - Invertebrate Regions in Port of Gladstone and Rodds Bay, November/December 2002**

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A diverse range of benthic macro-invertebrate communities have been previously identified[75]. Benthic macro-invertebrates occurred throughout the areas surveyed (refer to *Figure 5.8.8*). Communities identified in the survey were divided into regions based on density of individuals and community composition. Communities were dominated by filter-feeding species such as sponges, gorgonians and bivalves that tend to thrive in high-current environments.

High-density benthic communities were mostly located in a narrow strip running in the channel from Fisherman's Landing to inside Facing Island and East Bank. The high-density communities generally consisted of rubble reef dominated either by sponges, soft coral, hard coral, hydroids, bryozoans and gorgonians with a mix of other benthic taxa; or dominated by large numbers of scallops but otherwise with a similar mix of reef taxa.

Medium-density benthic communities in the deep channel area from the mouth of The Narrows at Graham Creek to Fisherman's Landing consisted of rubble reef dominated by bivalves, ascidians, bryozoans and hard corals with low numbers of other taxa. *Table 5.8.4* summarises prominent locations and areas of macro-invertebrate community habitat.

A 2006 survey of benthic invertebrates in 17 arbitrary zones in the Port of Gladstone (refer to *Figure 5.8.7* for location of zones) similarly found molluscs and crustaceans dominate in most zones[76]. Polychaetes were the next most abundant organism. The highest total macroinvertebrate abundance was found at Fisherman's Landing (279 organisms/m^3) while the lowest abundance was found at the Anabranch (54 organisms/m^3). Polychaetes provided the highest proportion of individual species in the majority of zones, while mollusc and crustacean species richness was also high.

Highest species richness was found at Fisherman's Landing (31 species/m^3) while the lowest richness was found at the Estuarine Reference (13 species/m^3).

Spatial variation in intertidal macroinvertebrate abundance, species richness, species diversity and evenness across the zones was not significant. This is primarily due to the large amount of variation within each zone. This indicates that a range of diverse macroinvertebrate communities are found throughout the intertidal areas of the Port of Gladstone. Macroinvertebrate parameters did not appear to be impacted by sediment contaminant concentrations, but seemed to be more dependent on sediment physical properties, such as particle size.

75 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*****.** DPI Information Series Q103058 (DPI, Cairns), 47pp.

76 Melville F and Anderson L (2008). ***PCIMP Intertidal Monitoring 2007: North Harbour Zones***. Centre for Environmental Management, Central Queensland University.

8.3.2.6 Fish

The fish assemblage in the Port of Gladstone is considered to be diverse with 180 species recorded from the Port of Gladstone and Calliope River including a number of regulated species and species of commercial and recreational value[77]. A survey of demersal fish species of the estuarine and marine environments of the Port of Gladstone identified 88 species of fish, dominated by two small-schooling species[78].

The numerically dominant species identified in the Port of Gladstone, were Ponyfish (*Leiognathus equulus*) and Herring (*Herklotsichthys castelnaui*) which in combination comprised approximately 50 per cent of the total catch by trawl-netting fisheries[79]. This is typical of the fauna recorded in inshore areas elsewhere in Queensland (e.g.[80] [81] [82] [83] [84]). A study of recreational angler catches found that the most common species caught in the Port of Gladstone was whiting (largely *Sillago ciliato*)[85].

Five fish assemblage types have been defined in the Port of Gladstone, reflecting the differences in habitat type and depth[86]. The fish assemblage associated with seagrass communities illustrates the importance of this habitat type as a fish nursery/habitat. Seagrass habitats are further discussed in *Section 8.3.2.2*.

Although specific information of the structure of the fish assemblage immediately adjacent to the proposed Marine Facilities is not available, the assemblage is considered to be similar to most other inshore sites surveyed in the Port of Gladstone[87]. The major components of this inshore grouping of

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77 Connell Hatch (2006) ***Wiggins Island Coal Terminal Environmental Impact Statement***, prepared by Connell Hatch on behalf of the Central Queensland Ports Authority and Queensland Rail.

78 Connolly R, Currie D, Danaher K, Dunning M, Melzer A, Platten J, Shearer D,, Stratford P, Teasdale P, & Vandergragt, . (2006) ***Intertidal Wetlands of Port Curtis Ecological Patterns and Processes and their Implications***.

79 Connolly R, Currie D, Danaher K, Dunning M, Melzer A, Platten J, Shearer D,, Stratford P, Teasdale P, & Vandergragt, (2006) ***Intertidal Wetlands of Port Curtis Ecological Patterns and Processes and their Implications***.

80 Hyland S J (1988) ***The Moreton Bay Beam Trawl Fishery. Queensland:***

81 Blaber S J M,, Brewer D T and Salini J P, (1989) '***Species composition and biomasses of fishes in different habitats of a tropical northern Australian estuary: their occurrence in the adjoining sea and estuarine dependence'***

82 Reid C R M and Campbell H F (1998) ***Bioeconomic analysis of the Queensland Beam Trawl Fishery***.

83 Thomas B E and Connolly R M (2001) ***Fish use of subtropical saltmarshes in Queensland, Australia: relationships with vegetation, water depth and distance onto the marsh***.

84 McPhee D P and Skilleter G A (2005) ***The set pocket (stow) net prawn fishery of the Mary River (Queensland, Australia) and its by-catch***. Proceedings of the Royal Society of Queensland. 112:39- 46.

85 Connolly R, Currie D, Danaher K, Dunning M, Melzer A, Platten J, Shearer D,, Stratford P, Teasdale P, & Vandergragt .(2006) ***Intertidal Wetlands of Port Curtis Ecological Patterns and Processes and their Implications***.

86 Connolly R, Currie D, Danaher K, Dunning M, Melzer A, Platten J, Shearer D,, Stratford P, Teasdale P, & Vandergragt .(2006) ***Intertidal Wetlands of Port Curtis Ecological Patterns and Processes and their Implications***.

87 Connolly R, Currie D, Danaher K, Dunning M, Melzer A, Platten J, Shearer D,, Stratford P, Teasdale P, & Vandergragt .(2006) ***Intertidal Wetlands of Port Curtis Ecological Patterns and Processes and their Implications***.

sites surveyed for the Port of Gladstone area are listed in *Table 5.8.5*. All of these species are common, widely distributed and typical of inshore habitats in subtropical Australia.

Table 5.8.5 Inshore Fish Species Typically Found in the Port of Gladstone

Common Name	Scientific Name
Ponyfish	*Leiognathus equulus*
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*
Diver Whiting	*Sillago maculata*

Under the *Fisheries Act 1994* (Qld) and the DPIF Operational Policy (FHMOP 008[88]) on Waterway Barrier Works, the construction of infrastructure that would impede waterways and therefore impact on fish passage, would require approval.

The Project will comply with applicable requirements of the *Fisheries Act* and associated operational policies and guidelines, although the construction and operation of the LNG Facility marine infrastructure is not anticipated to significantly restrict fish movement.

Two threateneid fish species, whale shark (*Rhincodon typus*) and the green sawfish (*Pristis zijsron*) are listed as vulnerable under the *EPBC Act* and have potential to occur within or migrate through the area (refer to *Annex 5.3*). The whale shark is also listed as migratory under the *EPBC Act* as well as being classified as vulnerable on the International Union for Conservation of Nature (IUCN) Red List (2008). It may utilise the region for migration and foraging. However, this species is typically an offshore species and not expected to utilise the Port of Gladstone or areas immediately adjacent to the Project.

Green sawfish are northern Australian marine/estuarine species having a preference for muddy, soft-bottom habitats such as the upper reaches of estuaries and turbid river systems[89]. In Australian waters, green sawfish have historically been recorded in the coastal waters off Broome, Western Australia, around northern Australia and down the east coast as far as Jervis Bay in New South Wales. On the east coast of Australia, green sawfish are now only found north of Cairns and are most commonly known from the Gulf of Carpentaria[90]. Therefore, it is highly unlikely that the Port of Gladstone will

88 Peterken, C. (2001) Waterway Barrier Works Approvals and Fishway Assessments: Departmental Procedures, Queensland Department of Primary Industries Fish Habitat Management Operational Policy FHMOP 008

89 Department of Environment Water Heritage and the Arts DEWHA 2008 (http://www.environment.gov.au/index.html).

90 Stevens,J D, Pillans R D and Salini J (2005). Conservation assessment of *Glyphis* sp. A (speartooth shark), Glyphis sp. C (northern river shark), Pristis microdon (freshwater sawfish and Pritis zijsron (green sawfish).

provide important habitat for green sawfish.

A total of 33 syngnathids (seahorse and pipefish) were identified in *EPBC Act* Protected Matters Report (19 February 2009) (refer to *Annex 5.3*) and have the potential to inhabit the inshore environment of the Port of Gladstone. Syngnathids are occasionally associated with marine structures and potentially inhabit the seagrass communities within the Port of Gladstone.

8.3.2.7 Marine Mammals

One species of marine mammal, the Humpback whale *(Megaptera novaeangliae)* is listed as vulnerable and migratory under the *EPBC Act* and may potentially occur in or around the development area. A further five migratory marine mammal species and six cetacean species are listed under the *EPBC Act* and potentially occur in the region. *Table 5.8.6* lists the results of searches from the *EPBC Act* Protected Matters database (19 February 2009) (refer to *Annex 5.3*), the *Queensland Nature Conservation Act 1992 (NC Act)* and the IUCN Red List 2008.

***Table 5.8.6* EPBC Act *and* Nature Conservation Act *(Qld) Threatened, Migratory and Listed Marine Mammal Species*[91]**

Species name	Status	Type of Presence (EPBC definition)	Likelihood of presence in the Port of Gladstone
Humpback whale *(Megaptera novaeangliae)*	*EPBC Act*: Vulnerable and Migratory *NC Act*: Vulnerable *IUCN Category*: Least Concern	Breeding known to occur within area	Unlikely (known to aggregate offshore from the Port of Gladstone)
Bryde's whale *(Balaenoptera edeni)*	*EPBC Act*: Migratory *NC Act*: No Listing *IUCN Category*: Data Deficient	Species or species habitat may occur within area	Unlikely (may migrate occasionally through the area)
Dugong *(Dugong dugon)*	*EPBC Act*: Migratory *NC Act*: Vulnerable *IUCN Category*: Vulnerable	Species or species habitat likely to occur within area	Highly likely (DPA in the Port of Gladstone)
Snubfin dolphin (*Orcaella heinsohni*) (previously listed as Irrawaddy dolphin, *Orcaella brevirostris)*	*EPBC Act*: Migratory *NC Act*: Rare *IUCN Category*: Vulnerable	Species or species habitat may occur within area	Likely (may migrate through the area)
Killer whale, orca *(Orcinus orca)*	*EPBC Act*: Migratory *NC Act*: No Listing *IUCN Category*: Data Deficient	Species or species habitat may occur within area	Highly unlikely (oceanic species - may migrate occasionally through the area)
Indo-Pacific Humpback dolphin *(Sousa chinensis)*	*EPBC Act*: Migratory *NC Act*: Rare *IUCN Category*: Near	Species or species habitat may occur within area	Likely (may migrate through the area)

91 Area search of the EPBC Protected Matters database on 19 February 2009

Species name	Status	Type of Presence (EPBC definition)	Likelihood of presence in the Port of Gladstone
	Threatened		
Common dolphin *(Delphinus delphis)*	*EPBC Act*: Cetacean *NC Act*: No Listing *IUCN Category*: Least Concern	Species or species habitat may occur within area	Unlikely (may migrate occasionally through the area)
Risso's dolphin *(Grampus griseus)*	*EPBC Act*: Cetacean *NC Act*: No Listing *IUCN Category*: Least Concern	Species or species habitat may occur within area	Unlikely (may migrate occasionally through the area)
Spotted dolphin *(Stenella attenuate)*	*EPBC Act*: Cetacean *NC Act*: No Listing *IUCN Category*: Least Concern	Species or species habitat may occur within area	Unlikely (may migrate occasionally through the area)
Indian Ocean Bottlenose dolphin, Spotted Bottlenose dolphin *(Tursiops aduncus)*	*EPBC Act*: Cetacean *NC Act*: No Listing *IUCN Category*: Data Deficient	Species or species habitat likely to occur within area	Likely (may migrate through the area)
Bottlenose dolphin (*Tursiops truncates s. str.)*	*EPBC Act*: Cetacean *NC Act*: No Listing *IUCN Category*: Least Concern	Species or species habitat may occur within area	Likely (may migrate through the area)

Cetaceans

There are known to be two populations of migratory Humpback whales in Australia, a west coast and an east coast population. The population estimate for the Humpback whale on the east coast of Australia was around 8,000 in 2006[92]. Every year the whales migrate north to the subtropical calving grounds from June to August, with peak migration in July, and south to the feeding grounds of the Southern Ocean from September to November (refer to

Figure 5.8.12*).* The northward migration is generally offshore and the majority of whales probably pass to the east of Stradbroke Island and Moreton Island, approximately 600 km from the Port of Gladstone, during which time the migration may pass as close as 50 km from the shore.

The closest aggregation area to the Port of Gladstone is approximately 400 km south in the area surrounding Hervey Bay[93]. The GBR is a critical habitat used as calving (between 14°S and 27°S) and resting grounds during the annual migration. Given the offshore nature of this species and the known distances from the Port of Gladstone area, this species is not expected to be a key sensitive receptor for this Project.

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92 Department of Environment and Water Resources (DEWR) (2007). ***The Humpback Whales of Eastern Australia***. [Accessed: 03-Feb-2009].

93 Chaloupka M., Osmond M. and Kaufman G. (1999*)* ***Estimating seasonal abundance trends and survival rates of humback whales in Hervey Bay (east coast of Australia***).

Due to the inshore nature of the site it is considered that Bryde's whale *(Balaenoptera edeni*) and the Killer whale *(Orcinus orca)* both identified as migratory (refer to *Annex 5.3*), do not occur at or adjacent to the Port of Gladstone itself as they are principally oceanic species.

Two dolphin species may occur in the Port of Gladstone region, the Snubfin dolphin (*Orcaella heinsohni)* (previously listed as Irrawaddy dolphin, *Orcaella brevirostris)* and the Indo–Pacific Humpback dolphin *(Sousa chinensis)*. The Indo–Pacific Humpback dolphin usually inhabits shallow coastal waters of less than 20 m depth and are often associated with rivers and estuarine systems, enclosed bays and coastal lagoons[94].

Previous studies have shown that the Indo–Pacific Humpback dolphin co-exist with coastal development such as in Cleveland Bay, Townsville[95] The Snubfin dolphin (*Orcaella heinsohni*) is endemic to Australia and is known to occur close to rivers mouths in Australian waters[96]. Their preference for near-shore, estuarine waters is likely related to the productivity of these tropical coastal areas[97]. Currently there is no published information available for either species in the Port of Gladstone region.

Dugongs

The Australian population comprises of two genetically distinct groups. One group ranges from Moreton Bay in southern Queensland to Western Australia. The other has a more restricted distribution, ranging from Moreton Bay to the Northern Territory[98]. Although dugongs are not considered to be under threat in most parts of Australia, their numbers have declined along the Queensland coast[99]. The IUCN has listed dugongs as vulnerable to extinction due to the global decline of populations.

Dugongs feed predominately on seagrass but supplement their diet with invertebrates such as polychaete worms, seasquirts and shellfish. The value of the large seagrass meadows identified in the coastal areas within the Port of Gladstone[100] to the dugong population has resulted in declaration of the Rodds Bay DPA (refer to *Figure 5.8.9*).

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

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

96 Parra G J, Azuma C, Preen A R, Corkeron P J and Marsh H (2002) **Distribution of Irrawaddy Dolphins, Orcaella brevirostris, in Australian waters**. Raffles Bulletin of Zoology, Supplement10, pp 141-154.

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

98 Lawler I, Marsh H, McDonald B and Stokes T. (2002) ***Current State of Knowledge: Dugongs in the Great Barrier Reef***. CRC Reef Research Centre, Townsville.

99 Lawler I, Marsh H, McDonald B and Stokes T. (2002) ***Current State of Knowledge: Dugongs in the Great Barrier Reef***. CRC Reef Research Centre, Townsville.

100 Coles R G, Lee Long W J, Squire B A, Squire L C and Bibby J M (1987) ***Distribution of seagrasses and associated juvenile commercial penaeid prawns in north-eastern Queensland waters***. Aust J Mar Freshwater Res, 38: 103–119.

The Narrows, south of Graham Creek and east to Facing Island, encompassing the majority of Southern Curtis Island waters, comprise the Rodds Bay DPA. The area has been classified as Zone B, with boat speed restricted and mesh netting practices subject to more restrictions than those outside the DPA.

Recent studies suggest that dugong numbers are now stable at the scale of the whole urban coast and over a timeframe of two decades[101]. However, dugong populations fluctuate at the level of individual bays and over shorter time periods, probably largely due to natural changes in seagrass habitats.

A survey was conducted in November 2005 which estimated that there were 183 (±66) dugongs in the Port of Gladstone area. *Figure 5.8.10* shows the aerial survey transects with location and size of dugong groups sighted[102]. In a long-term monitoring program of seagrass in the Port of Gladstone, dugongs were consistently observed to be actively feeding, especially around Wiggins Island (approximately 6 km south-east of the Project site)[103].

Dugong feeding activity was also observed on the majority of intertidal seagrass meadows surveyed during a study of benthic habitats in the Port[104]. The highest density of dugong feeding trails was observed at Wiggins Island west with dugong feeding trails recorded at 58 per cent of sampling sites. Dugong feeding trails were also observed at Quoin Island, Wiggins Island, Pelican Banks, South Trees and the intertidal meadows to the north and south of Fisherman's Landing[105].

8.3.2.8 Marine Reptiles

A search of the *EPBC Act* protected matters database on 19 February 2009 (refer to *Annex 5.3*) found that two species of marine turtle listed as endangered and migratory and four species listed as vulnerable and migratory under the *EPBC Act* may potentially occur in or around the Project area (refer to *Table 5.8.7*). The database also indicated that two species are known to breed in the area. The Estuarine crocodile is listed as migratory under the *EPBC Act* and potentially occurs in the area.

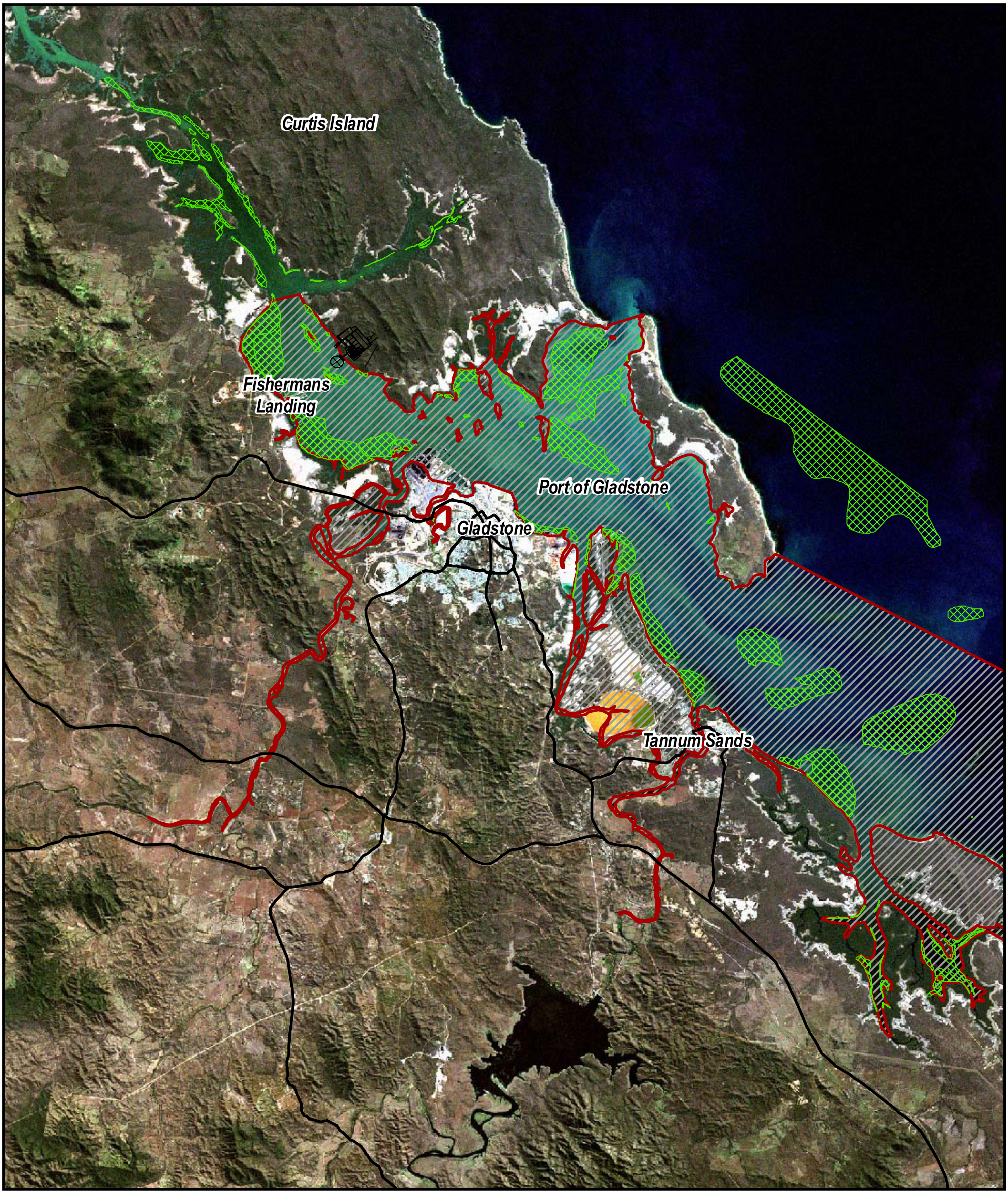
101 Marsh H and Lawler I R (2006) ***Dugong distribution and abundance on the urban coast of Queensland: a basis for management***. Marine and Tropical Science Research Facility Interim Projects 2005-06 FINAL Report Project 2:

102 Marsh H and Lawler I R (2006) ***Dugong distribution and abundance on the urban coast of Queensland: a basis for management***. Marine and Tropical Science Research Facility Interim Projects 2005-06 FINAL Report Project 2:

103 Taylor H, Rasheed M, Dew K. and Sankey T. (2007) ***Long Term Seagrass Monitoring in Port Curtis and Rodds Bay, Gladstone, November 2006***. Queensland: Queensland Department of Primary Industries and Fisheries Publication PR07-2774.

104 Rasheed M A, McKenna S A, Taylor H A and Sankey T L (2008) ***Long term seagrass monitoring in Port Curtis and Rodds Bay, Gladstone – October 2007***. DPI&F Publication PR07- 3271 (DPI&F, Cairns), 32 pp.

105 Rasheed M A, McKenna S A, Taylor H A and Sankey T L (2008) ***Long term seagrass monitoring in Port Curtis and Rodds Bay, Gladstone – October 2007***. DPI&F Publication PR07- 3271 (DPI&F, Cairns), 32 pp.



Legend

- QCLNG Footprint Plant Layout
- Seagrass
- Dugong Protection Areas

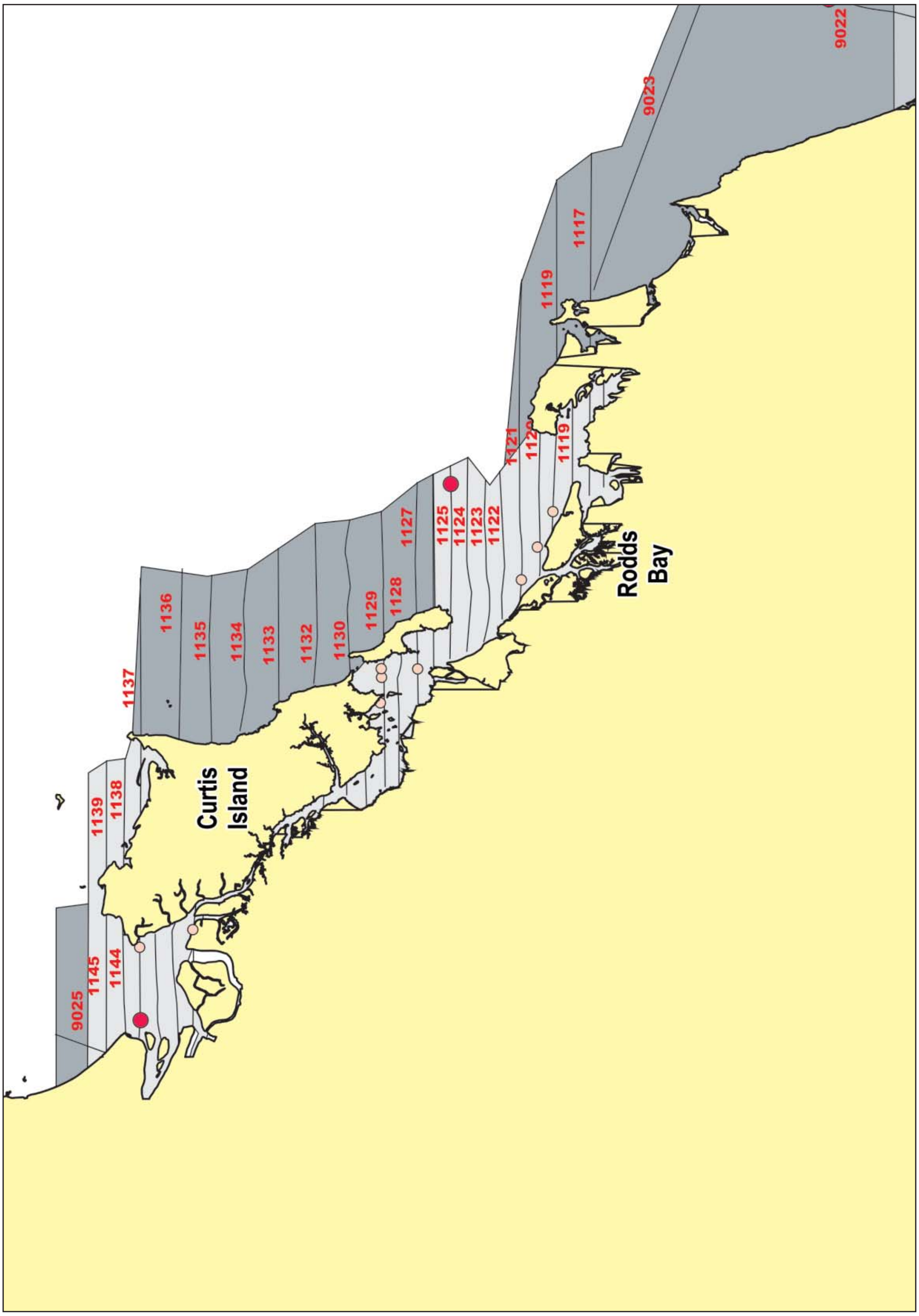
Source Note:
Dugong Protection Areas and Gladstone November 2002
Seagrass distribution produced by Queensland Department of Primary Industries and Fisheries.
Landsat ETM+ Image source: USGS 2009. Aquired May 2000.

Projection: UTM MGA Zone 56 Datum: GDA 94

0 2 4 8 km

N

QUEENSLAND CURTIS LNG A BG Group business	Project: Queensland Curtis LNG Project Client: QGC - A BG Group business	Title: **Dugong Protection Area and Areas of Seagrass in the Port of Gladstone Region**
ERM Environmental Resources Management Australia Pty Ltd	Drawn: JF/JB — Volume 5 — Figure 5.8.9 Approved: JT — File No: 0086165b_EIS_ME_GIS011_F5.8.9 Date: 20.07.09 — Revision 1	Disclaimer: Maps and Figures contained in this Report may be based on Third Party Data, may not to be to scale and are intended as Guides only. ERM does not warrant the accuracy of any such Maps and Figures.



N

Source Note:
GPS tracks of transect flown in Blocks S1-3 in the Southern Section of the Great Barrier Reef Marine Park during the aerial survey in November 2005 showing the positions and sizes of the dugong groups sighted and the transect numbers (extracted from Marsh and Lawler, 2006).
Figure not to scale.

Legend

Dugongs

- 1
- 2
- 2 - 5
- 5 - 10
- 10 or greater
- Survey Block Outline

QUEENSLAND CURTIS LNG A BG Group business	Project: Queensland Curtis LNG Project Client: QGC - A BG Group business	Title: **GPS Tracks of Transects Flown in Blocks S1-3**
ERM Environmental Resources Management Australia Pty Ltd	Drawn: JF/JB — Volume 5 — Figure 5.8.10 Approved: GB — File No: 0086165b_EIS_ME_CDR005_F5.8.10 Date: 13/05/09 — Revision 1	Disclaimer: Maps and Figures contained in this Report may be based on Third Party Data, may not to be to scale and are intended as Guides only. ERM does not warrant the accuracy of any such Maps and Figures.

Table 5.8.7 **EPBC Act** ***and*** **Nature Conservation Act** ***(Qld) Listed threatened and migratory marine reptiles***[106]

Species name	Status	Type of Presence (EPBC definition)	Likelihood of presence in the Port of Gladstone
Green turtle *(Chelonia mydas)*	*EPBC Act*: Vulnerable/ Migratory *NC Act*: Vulnerable *IUCN Category*: Endangered	Species or species habitat may occur within the area	Likely (occasionally breed in the area)
Loggerhead turtle *(Caretta caretta)*	*EPBC Act*: Endangered/ Migratory *NC Act*: Endangered *IUCN Category*: Endangered	Breeding known to occur within the area	Likely (occasionally breed in the area)
Leatherback turtle *(Dermochelys coriacea)*	*EPBC Act*: Vulnerable/ Migratory *NC Act*: Endangered *IUCN Category*: Critically Endangered	Species or species habitat may occur within the area	Highly unlikely (oceanic species - may migrate occasionally through the area)
Pacific Ridley turtle (*Lepidochelys olivacea)*	*EPBC Act*: Endangered/ Migratory *NC Act*: Endangered *IUCN Category*: Vulnerable	Species or species habitat may occur within area	Unlikely (may migrate occasionally through the area)
Hawksbill turtle *(Eretmochelys imbricata)*	*EPBC Act*: Vulnerable/ Migratory *NC Act*: Vulnerable *IUCN Category*: Critically Endangered	Species or species habitat may occur within area	Unlikely (may migrate occasionally through the area)
Flatback turtle *(Natator depressus)*	*EPBC Act*: Vulnerable/ Migratory *NC Act*: Vulnerable *IUCN Category*: Data Deficient	Breeding known to occur within area	Highly likely (breed in the area)
Estuarine/Salt-water Crocodile *(Crocodylus porosus)*	*EPBC Act*: Migratory *NC Act*: Vulnerable *IUCN Category*: Least Concern	Species or species habitat likely to occur within area	Unlikely (may migrate occasionally through the area)

106 Area search of the EPBC Act Protected Matters database on 19th February 2008

Turtles

Figure 5.8.11 illustrates major turtle-nesting sites in the Curtis Island region. Important turtle-nesting beaches for Flatback turtles *(Natator depressus)* have been identified on the east coast of Curtis Island and Facing Island and further south at Tannum Sands (approximately 15 km south of Gladstone)[107,108]. The majority of turtle nesting for Curtis Island occurs on South End Beach[109].

There are no known turtle-nesting beaches close (within 5 km) to the proposed LNG Marine Facilities. Green turtles have been regularly observed within the seagrass meadows particularly on Pelican Banks (eastern side of Curtis Island)[110].

Table 5.8.8 illustrates the key periods of annual turtle-nesting activity in the Port of Gladstone. Flatback turtle nesting in Eastern Queensland commences in mid-October, reaching a peak in late November/early December and ceases around late January. Hatchlings emerge from nests during early December until around late March, with a peak of hatching in February[111]. Nesting adults display a high degree of fidelity to chosen nesting beaches, with most females returning to the same beach for their successive clutches within a nesting season, and over successive nesting seasons[112,113].

Curtis Island has been used as an index beach for monitoring population dynamics of Flatback turtles within the eastern Australian stock. Mid-season nightly census studies at Curtis Island since 1970 have shown no obvious trend in the size of the annual nesting population, with a range from approximately 35 to 80 individuals per season recorded[114]. The Curtis Island Flatback turtle nesting population has maintained an approximately constant size over the 35 years since monitoring began[115].

In South Queensland, Green turtle nesting commences in mid to late October, reaches a peak in late December to early January and ends around late March to early April[116]. Hatchlings emerge from nests from late December until

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107 Limpus C J, McLaren M, McLaren G and Knuckey B. (2006) ***Queensland Turtle Conservation Project: Curtis Island and Woongarra Coast Flatback Turtle Studies, 2005-****2006*.

108 Queensland Environmental Protection Agency (QEPA) (2003) ***Curtis Coast Regional Coastal Management Plan***.

109 Limpus C J, McLaren M, McLaren G and Knuckey B. (2006) ***Queensland Turtle Conservation Project: Curtis Island and Woongarra Coast Flatback Turtle Studies, 2005-****2006*.

110 Taylor H, Rasheed M, Dew K. and Sankey T. (2007) **L*ong Term Seagrass Monitoring in Port Curtis and Rodds Bay, Gladstone, November 2006.*** *Queensland*:

111 Limpus C J (2007a) ***A biological review of Australian Marine Turtles. 5: Flatback Turtle Natator depressus*** *(Garman*).

112 Limpus C J, Fleay A and Baker V. (1984*)* ***The flatback turtle, Chelonia depressa, in Queensland: reproductive periodicity, philopatry and recruitment***.

113 Limpus C J, Miller J D, Parmenter C J, Reimer D, McLachlan N and Webb, R (1992) ***Migration of green (Chelonia mydas) and loggerhead (Caretta caretta) turtles to and from eastern Australian rookeries***.

114 Limpus C J, Parmenter J and Limpus D J (2002). ***The status of the flatback turtle,*** **Natator depressus*****, in Eastern Australia*.**

115 Limpus C J, McLaren M, McLaren G and Knuckey B. (2006) ***Queensland Turtle Conservation Project: Curtis Island and Woongarra Coast Flatback Turtle Studies, 2005-****2006*.

116 Limpus C J (2007b) ***A biological review of Australian Marine Turtles. 2: Green Turtle*** **Chelonia Mydas *(Linnaeus***).

around May with a peak of hatching in February and March. Loggerhead turtle nesting commences in late October, peaks in December and ends in early March. Hatchlings emerge from nests from late December through to April[117].

Green turtles *(Chelonia mydas)* and Loggerhead turtles (*Caretta caretta*) nest occasionally on the beaches of Curtis Island and Facing Island. The Capricorn Group of islands (60 km offshore from Gladstone) provide internationally significant rookeries for Loggerhead and Green turtles[118]. For example, Tryon Island and Reef are of international importance for Loggerhead turtles, with the reef flat an important feeding area for young turtles.

Tryon Island and Reef are also of regional significance for Green turtle nesting. North West Island and Reef constitute a regionally important rookery for Loggerhead turtles and internationally significant rookery for Green turtles.

Wreck Island and Reef have a Green turtle rookery of international importance and the most important offshore rookery for Loggerhead turtles in eastern Australia.

Leatherback turtles (*Dermochelys coriacea*), Hawksbill turtles (*Eretmochelys imbricata*) and Olive Ridley turtles (*Lepidochelys olivacea*) are not known to nest in the Port of Gladstone area. Individuals may migrate through the area, but significant numbers of them are unlikely in the Project area.

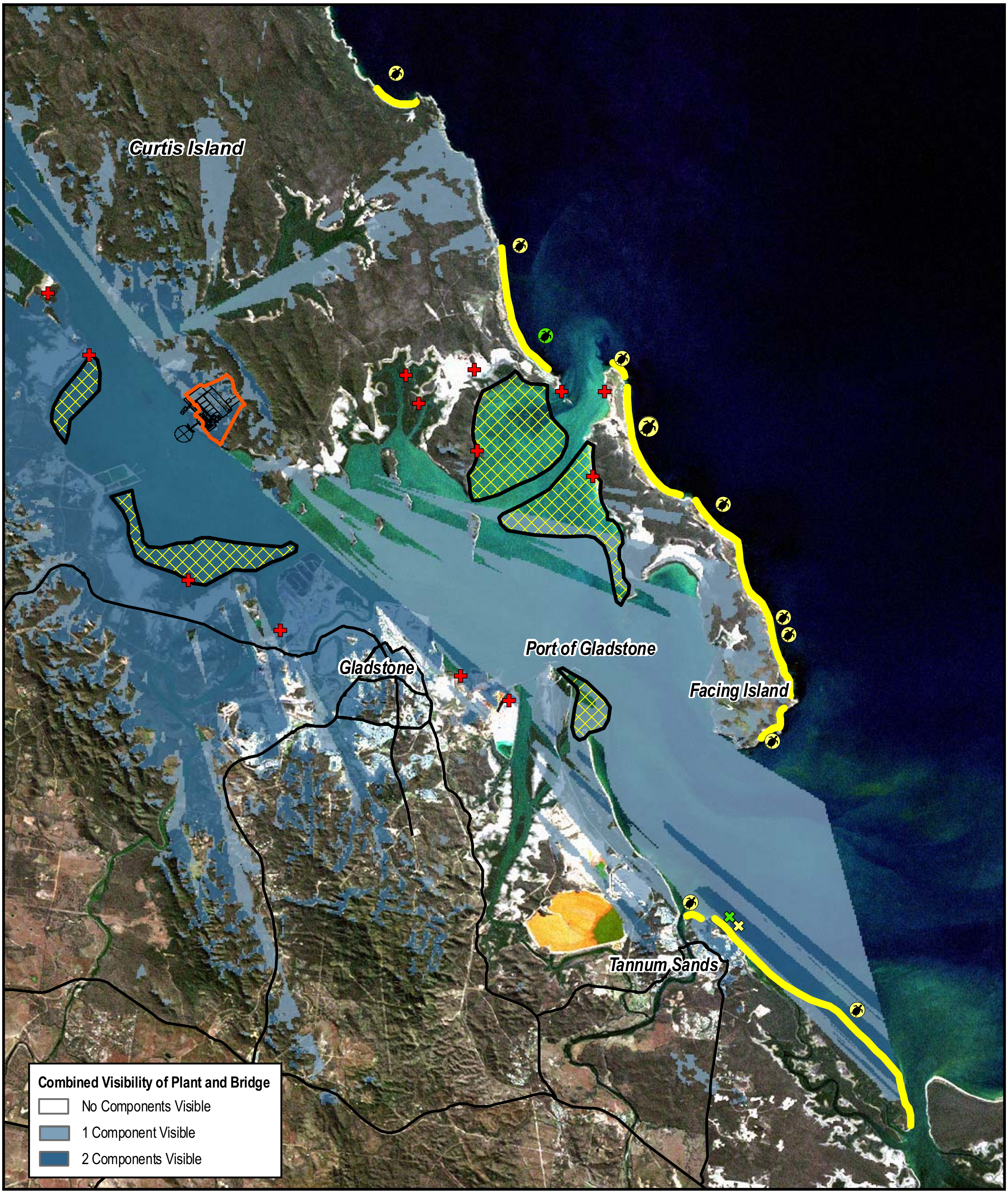
Sea Snakes and Kraits

An area search of the EPBC Protected Matters database on 19 February 2009 (refer to *Annex 5.3*) identified 11 species of sea snakes and two species of sea kraits that may occur in the vicinity of the Project area (refer to *Table 5.8.9*).

None of the sea snake species found in the GBR are listed in the 2008 Red List of Threatened Species of the World Conservation Union (IUCN). However, sea snakes are a listed marine species under the *EPBC Act*.

117 Department of Environment and Heritage (2005) ***Draft Turtle Recovery Plan, Issues Paper: For six species of marine turtles found in Australian waters that are listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999***. 39pp.

118 Queensland Environmental Protection Agency (QEPA) (2003) ***Curtis Coast Regional Coastal Management Plan***.



Legend

- QCLNG Footprint Plant Layout
- Major Shorebird Roost Sites
- Major Shorebird Feed Sites
- Turtle Nesting Beaches
- Flatback Turtle
- Green Turtle

Turtle Nest Rates

- Not Quantified
- 1-10 females/year
- 10-100 females/year

Source Note:
Turtle and shorebird data adapted from QEPA 2003.
Landsat ETM+ Image source: USGS 2009. Aquired May 2000.

Projection: UTM MGA Zone 56 Datum: GDA 94

0 1.25 2.5 5 km

N

QUEENSLAND CURTIS LNG A BG Group business	Project: Queensland Curtis LNG Project		Title: Key Areas for Turtle Nesting and Shorebird Feeding/Roosting in Port of Gladstone Region
	Client: QGC - A BG Group business		
ERM Environmental Resources Management Australia Pty Ltd	Drawn: JF/JB	Volume 5 Figure 5.8.11	Disclaimer: Maps and Figures contained in this Report may be based on Third Party Data, may not to be to scale and are intended as Guides only. ERM does not warrant the accuracy of any such Maps and Figures.
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	Date: 11.05.09	Revision 1	

Table 5.8.8 Key periods of annual turtle nesting activity in the Port of Gladstone

Species/Activity		June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Flatback turtles	Nesting												
	Hatching												
Green turtles	Nesting												
	Hatching												
Loggerhead turtles	Nesting												
	Hatching												

	Total period of activity
	Period of peak activity

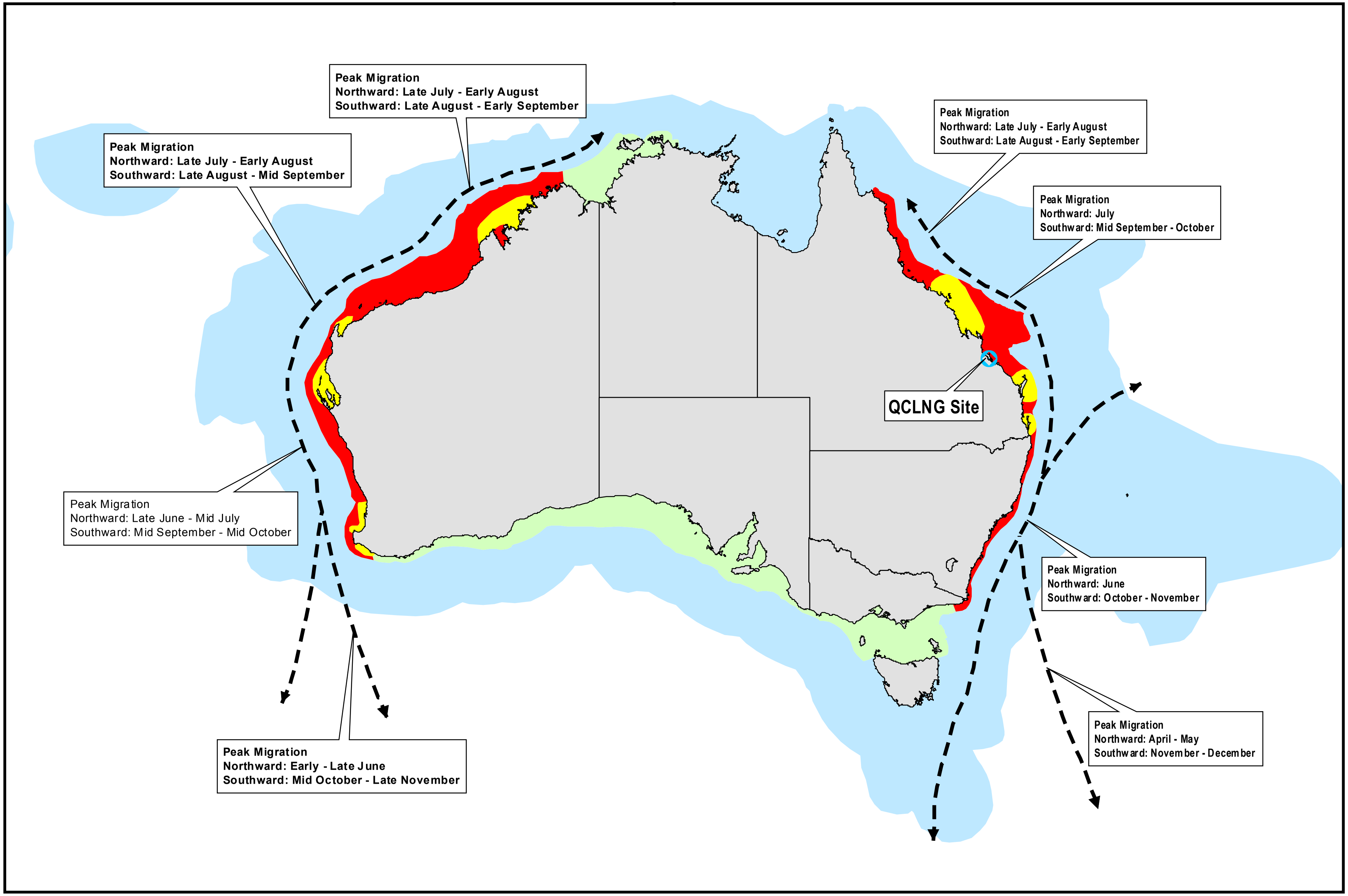
Table 5.8.9 EPBC Act _and_ Nature Conservation Act _(Qld) listed sea snakes and kraits_[119]

Species name	Status	Type of Presence (EPBC definition)
Horned sea snake *(Acalyptophis peronii)*	*EPBC Act*: Listed	Species or species habitat may occur within the area
Dubois sea snake *(Aipysurus duboisii)*	*EPBC Act*: Listed	Species or species habitat may occur within area
Spine-tailed sea snake *(Aipysurus eydouxii)*	*EPBC Act*: Listed	Species or species habitat may occur within the area
Olive sea snake *(Aipysurus laevis)*	*EPBC Act*: Listed	Species or species habitat may occur within area
Stokes' sea snake *(Astrotia stokesii)*	*EPBC Act*: Listed	Species or species habitat may occur within area
Spectacled sea snake *(Disteira kingii);)*	*EPBC Act*: Listed	Species or species habitat may occur within area
Olive-headed sea snake *(Disteira major)*	*EPBC Act*: Listed	Species or species habitat may occur within area
Turtle-headed sea snake *(Emydocephalus annulatus)*	*EPBC Act*: Listed	Species or species habitat may occur within area
Elegant sea snake *(Hydrophis elegans)*	*EPBC Act*: Listed	Species or species habitat may occur within area
Spine-bellied sea snake *(Lapemis hardwickii)*	*EPBC Act*: Listed	Species or species habitat may occur within area
Yellow-bellied sea snake *(Pelamis platurus)*	*EPBC Act*: Listed	Species or species habitat may occur within area
Sea kraits (*Laticauda colubrine* and *Laticauda laticaudata*)	*EPBC Act*: Listed	Species or species habitat may occur within area

Sea snakes and kraits are highly mobile and can cover large distances. Sea snakes occur in a wide variety of habitats with some species found mostly on coral reefs, whereas others are found over sandy and muddy areas of seabed. Many species are specialist feeders that are restricted to the specific habitats used by their prey. The distribution of sea snake and krait species is highly variable and thought to be influenced by seasonal factors[120]. Little is known of the distribution of individual species. There is also very little known of sea snake and krait ecology, population sizes and dynamics.

119 Area search of the EPBC Act Protected Matters database on 19 February 2009

120 Great Barrier Reef Marine Park Authority (GBRMPA) (2005) **The State of the Great Barrier Reef: Reptiles**. Available



Legend

- Indicative Migratory Pathways
- Commonwealth Marine Areas
- Aggregation areas
- Species known to be present
- Species may be present

Source Note:
Humpback whale aggregation areas and migratory pathways reproduced from data sourced from Department of the Environment, Water, Heritage and the Arts, 2006.

Projection: UTM MGA Zone 56 Datum: GDA 94

0 250 500 1,000 km

N

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Project	Queensland Curtis LNG Project		
Client	QGC - A BG Group business		
Drawn	JF/JB	Volume 5	Figure 5.8.12
Approved	GB	File No: 0086165b_EIS_ME_GIS013_F5.8.12	
Date	12.05.09	Revision 1	

Title **Distribution, Migration and Recognised Aggregation Areas of the Humpback Whale in Australia**

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Crocodiles

The Estuarine crocodile (*Crocodylus porosus)* is listed as vulnerable under the *NC Act* (Qld) and as a migratory species under the *EPBC Act*. Crocodiles occur in mangrove wetlands, estuaries and associated wetlands (fresh and saline). In Australia, estuarine crocodiles are distributed throughout the Northern Territory, northern Western Australia and in Queensland from the Queensland–Northern Territory border to Gladstone in the south[121].

The key area for Estuarine crocodile populations in Queensland is the north-western Cape York peninsula, particularly the Wenlock River and Lakefield National Park[122]. Gladstone lies at the southernmost boundary of the breeding distribution of the Estuarine crocodile in eastern Australia[123] and accordingly, the occurrence of crocodiles in this region is rare[124].

8.3.2.9 Seabirds and Shorebirds

A search of the *EPBC Act* Protected Matters database on 19 February 2009 (refer to *Annex 5.3*), Queensland Environmental Protection Agency Wildlife Online database and surveys conducted for *Section 7.3.8.3*, found that one bird species listed as critically endangered, one species as endangered and five species listed as vulnerable under the *EPBC Act* may potentially occur in or around the Project area (refer to *Table 5.8.10*). A further 41 migratory bird species are listed under the *EPBC Act* and potentially occur within the area.

Table 5.8.10 **EPBC Act** ***and*** **Nature Conservation Act** ***(Qld) listed threatened and migratory marine and wetland bird species***[125]

Species name	Status	Type of Presence (EPBC definition)
Yellow chat (*Epthianura croceri macgregori)*	*EPBC Act:* Critically Endangered *NC Act:* Endangered	Species or species habitat known to occur within area
Southern giant petrel (*Macronectes giganteus*)	*EPBC Act:* Endangered/ Migratory *NC Act:* Migratory	Species or species habitat likely to occur within area

121 Read M A, Miller J D, Bell I P, and Felton A. (2004) **The distribution and abundance of the estuarine crocodile, *Crocodylus porosus*.**

122 Read M A, Miller J D, Bell I P, and Felton A. (2004) **The distribution and abundance of the estuarine crocodile, *Crocodylus porosus*.**.

123 Taplin L E (1987) **The management of crocodiles in Queensland, Australia**, pp. 129–140 in Wildlife Management: Crocodiles and Alligators, G.J.W. Webb, S.C. Manolis and P.J. Whitehead (eds).

124 Read M A, Miller J D, Bell I P, and Felton A. (2004) **The distribution and abundance of the estuarine crocodile, Crocodylus porosus.**

125 Area search of the EPBC Act protected Matters database on 19 February 2009, a search of the Queensland EPA Wildlife Online database and surveys conducted for Section 7.3.8.3, Volume 5

Species name	Status	Type of Presence (EPBC definition)
Kermadec petrel (western) (*Pterodroma neglecta*)	*EPBC Act:* Vulnerable	Species or species habitat may occur within the area
Australian Painted snipe (*Rostratula australis*)	*EPBC Act:* Vulnerable/ Migratory *NC Act:* Vulnerable *CAMBA*[126] (as *Rostratula benghalensis*)	Species or species habitat may occur within the area
Red goshawk (*Erythrotriorchis radiatus*)	*EPBC Act*: Vulnerable/Migratory	Species or species habitat likely to occur within area
Squatter pigeon – southern (*Geophaps scripta scripta*)	*EPBC Act:* Vulnerable *NC Act:* Vulnerable	Species or species habitat likely to occur within area
Black-breasted Button-quail (*Turnix melanogaster*)	*EPBC Act:* Vulnerable	Species or species habitat likely to occur within area
Fork-tailed swift *(Apus pacificus)*	*EPBC Act:* Migratory *CAMBA/JAMBA*[127]*/ROKAMBA*[128]	Species or species habitat may occur within area
Great egret/White egret (*Ardea alba*)	*EPBC Act:* Migratory *CAMBA/JAMBA*	Species or species habitat may occur within the area
Cattle egret (*Ardea ibis*)	*EPBC Act:* Migratory *CAMBA/JAMBA*	Species or species habitat may occur within the area
Latham's snipe/Japanese snipe (*Gallinago hardwickii*)	*EPBC Act:* Migratory *CAMBA/JAMBA/ROKAMBA*	Species or species habitat may occur within the area
Cotton Pygmy-goose (*Nettapus coromandelianus albipennis*)	*EPBC Act:* Migratory *NC Act:* Vulnerable	Species or species habitat may occur within area
Little curlew/Little whimbrel (*Numenius minutus*)	*EPBC Act:* Migratory *CAMBA/JAMBA/ROKAMBA*	Species or species habitat may occur within the area
White-bellied sea eagle (*Haliaeetus leucogaster*)	*EPBC Act:* Migratory *CAMBA*	Species or species habitat likely to occur within area
Little tern (*Sterna albifrons*)	*EPBC Act*: Migratory *NC Act*: Endangered *CAMBA/JAMBA/ROKAMBA*	Species or species habitat may occur within the area
Eastern curlew (*Numenius*	*EPBC Act*: Migratory *NC Act*: Rare	Species or species habitat likely to occur within area

126 CAMBA - China Australia Migratory Bird Agreement

127 JAMBA - Japan Australia Migratory Bird Agreement

128 ROKAMBA - Republic of Korea Australia Migratory Bird Agreement

Species name	Status	Type of Presence (EPBC definition)
madagascariensis)		
Beach Stone-curlew (*Esacus magnirostris/neglectus*)	*EPBC Act*: Marine *NC Act*: Vulnerable	Species or species habitat may occur within area
Radjah shelduck (*Tadoma radjah*)	*EPBC Act*: Migratory *NC Act*: Rare	Species or species habitat likely to occur within area
Square-tailed kite (*Lophoictinia isura*)	*EPBC Act*: Migratory *NC Act*: Rare	Species or species habitat likely to occur within area
Grey goshawk (*Accipiter novaehollandiae*)	*EPBC Act*: Migratory *NC Act*: Rare	Species or species habitat likely to occur within area
Black-necked stork (*Ephippiorhynchus asiaticus*)	*NC Act*: Rare	Species or species habitat likely to occur within area
Sooty oystercatcher (*Haematopus fuliginosus*)	*NC Act*: Rare	Species or species habitat likely to occur within area
Lewin's rail (*Lewinia pectoralis*)	*NC Act*: Rare	Species or species habitat likely to occur within area
Black-chinned honeyeater) *(Melithreptus gularis)*	*NC Act*: Rare	Species or species habitat likely to occur within area
Powerful owl *(Ninox strenua)*	*NC Act*: Vulnerable	Species or species habitat likely to occur within area
Wandering Whistling duck (*Dendrocygna arcutata*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Magpie goose (*Anseranas semipalmata*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Black swan (*Cygnus atratus*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Pacific black duck (*Anus superciliosa*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Pacific baza (*Aviceda subcristata*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Whistling kite (*Haliastur sphenura*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Brown goshawk (*Acciptera fasciatus*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Brahminy kite (*Haliastur indus*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Eastern osprey (*Pandion cristatus*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Australian hobby (*Falco longipennis*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area

Species name	Status	Type of Presence (EPBC definition)
Whimbrel (*Numenius phaeopus*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Common greenshank (*Tringa nebularia*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Great knot (*Calidris tenuirostris*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Grey-tailed tattler (*Tringa brevipes*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Terek sandpiper (*Xenus cinereus*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Red-necked stint (*Calidris ruficollis*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Sharp-tailed sandpiper (*Calidris acuminata*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Pacific golden plover (*Pluvialis fulva*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Lesser sand plover (*Charadrius mongolus*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Masked lapwing (*Vanellus miles*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Caspian tern (*Hydroprogne caspia*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
White-throated needletail (*Hirundapus caudacutus*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area
Rainbow bee-eater (*Merops ornatus*)	*EPBC Act*: Migratory	Species or species habitat likely to occur within area

A large proportion of shorebird species that inhabit the Port of Gladstone region are internationally significant and listed under the Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA) and Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA) (refer to *Section 8.3.3.2).* Shorebirds in the region include plovers, stilts, curlews, sandpipers, stone-curlews, godwits, and oystercatchers.

Approximately 70 per cent of these birds undertake an annual migration every southern hemisphere spring when they fly to Australia from northern breeding grounds, returning the following autumn[129]. The Port of Gladstone region is recognised as an important staging area for a number of migratory bird species during their annual migration. Two habitats are especially important to shorebirds:

129 Queensland Environmental Protection Agency (QEPA) (2003) ***Curtis Coast Regional Coastal Management Plan***.

- low-tide feeding areas comprising exposed tidal flats
- high-tide roosting areas comprising coastal salt flats, sand spits and the mangrove fringe.

As described in *Section 8.3.2.4* the intertidal mudflats within the Port of Gladstone support a high biodiversity and biomass of benthic invertebrates and provide important feeding grounds for migratory shorebirds.

When they are not feeding, shorebirds roost generally at or above the high tide mark. Shorebirds select roost sites that are likely to be free from disturbance. They also select roost sites that are close to feeding areas, usually within 2 km, for energy conservation[130].

Figure 5.8.11 provides an indication of important feeding and roosting sites for shorebirds in the Port of Gladstone region[131]. The Narrows, extending from Kangaroo Island in the south to the mouth of Raglan Creek in the north, provide habitat for a range of shorebirds including the Beach Stone-curlew (*Esacus neglectus*) and Great-billed heron (*Ardea Sumatrans*). Boyne Island and South Trees inlet provide habitat for a number of species (including the Sooty oystercatcher (*Haematopus fuliginosus*) and Cotton Pygmy-goose (*Nettapus coromandelianus*) and feeding habitat for a variety of wading birds. Rundle Island provides feeding and roosting site for ospreys (*Pandion haliaetus*) and White-bellied sea eagles (*Haliaeetus leucogaster*).

The Painted snipe (*Rostratula australis*), listed as vulnerable under the *EPBC Act* and *NC Act,* has a scattered distribution throughout many parts of Australia and may occur in small numbers in the Port of Gladstone region. The species is found in coastal regions and generally inhabits coastal grass-sedge wetlands in both freshwater and saline environments, as well as lakes and saltmarshes. Recent surveys of waterbirds on marine plains in central Queensland have revealed small numbers of Painted snipe. There is no robust estimate of the population size of this species but a decline in numbers across Australia has been documented[132].

The Southern giant petrel (*Macronectes giganteus*) and Kermadec petrel (*Pterodroma neglecta*) are listed as endangered and vulnerable respectively under the *EPBC Act*, and may occur in the Port of Gladstone Region (refer to *Table 5.8.10*). The petrels are pelagic species, feeding in the open ocean and generally nesting on remote islands. The waters off south-east Australia are potentially important wintering grounds for the Southern giant petrel[133]. However, due to its near-shore location, there are no significant petrel breeding or feeding habitats in the Port of Gladstone area and these species are therefore unlikely to occur in any substantial numbers.

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130 Queensland Environmental Protection Agency (QEPA) (2003) ***Curtis Coast Regional Coastal Management Plan***.

131 Queensland Environmental Protection Agency (QEPA) (2003) ***Curtis Coast Regional Coastal Management Plan***.

132 Jaensch and Joyce (2006). ***Wetland Management Profile: Coastal Grass-Sedge Wetland.***

133 Environment Australia (2001*)* ***A directory of important wetlands in Australia,*** *Third Edition*.

Offshore islands located in the Capricorn Group, approximately 60 km offshore from Gladstone City, provide support for up to 75 per cent of the total seabird biomass of the GBR[134]. The islands provide key roosting and feeding sites for a range of seabirds and shorebirds including the Little tern (*Stern albifrons*) and Sooty oystercatcher.

North Reef provides habitat for colonies of Crested terns (*Sterna bergii*), Roseate terns (*Sterna dougallii*), Black-naped terns (*Sterna sumatrana*) and shearwaters. Masthead Island is a nationally important seabird-nesting site due to high species diversity and numbers (including shearwaters, noddies, Bridled terns (*Sterna anaethetus*), Roseate terns, Black-naped terns and Silver gulls (*Larus novaehollandiae*)[135].

8.3.3 Matters of National Environmental Significance

8.3.3.1 EPBC Act Listed Marine Species

An area search of the *EPBC Act* Protected Matters database on 19 February 2009 (refer to *Annex 5.3*) for species of national environmental significance identified a total of 12 threatened marine species, 25 migratory marine species and 72 listed marine species. Threatened and migratory species are described in the relevant sections above.

8.3.3.2 JAMBA, CAMBA and ROKAMBA Species

The JAMBA, CAMBA and ROKAMBA are treaties between Australia, Japan, China and Republic of Korea to minimise harm to the major areas used by birds which migrate between Australia and the respective countries.

Fifty-four species of migratory shorebirds are known to utilise the East Asian-Australasian (EAA) Flyway[136]. A recent review of migratory shorebirds has drawn together population estimates and identified internationally important sites of the EAA Flyway[137]. One hundred and nineteen internationally important sites were recognised in Australia, with Moreton Bay/Great Sandy Strait (around 250 km south of the Port of Gladstone) recognised as a major site with importance for over 10 species of migratory shorebirds.

Intertidal mudflats in the Project area provide important feeding habitat for

134 Queensland Environmental Protection Agency (QEPA) (2003) ***Curtis Coast Regional Coastal Management Plan***.

135 Queensland Environmental Protection Agency (QEPA) (2003) ***Curtis Coast Regional Coastal Management Plan***.

136 Bamford M, Watkins D, Bancroft W, Tischler G and Wahl J (2008) ***Migratory Shorebirds of the East Asian - Australasian Flyway; Population Estimates and Internationally Important Sites*** *Wetlands International - Oceania*.

137 Bamford M, Watkins D, Bancroft W, Tischler G and Wahl J (2008) ***Migratory Shorebirds of the East Asian - Australasian Flyway; Population Estimates and Internationally Important Sites*** *Wetlands International - Oceania*. Canberra, Australia.

listed migratory waders, protected under JAMBA, CAMBA and ROKAMBA migratory bird agreements (refer to mangrove areas highlighted on *Figure 5.8.6*).

8.3.3.3 Zoning/Marine Protected Areas

World Heritage Areas

The Port of Gladstone lies primarily within the GBRWHA, but is situated outside state and commonwealth marine parks. The GBRWHA encompasses an area of approximately 34,800,000 ha, extending from the low watermark of the mainland and includes all islands, internal Queensland waters and *Sea and Submerged Lands Act 1973* (Cth) exclusions. The Queensland Government controls parts of the Port of Gladstone, which are defined as internal Queensland waters.

The GBRMP was declared in 1975 and is legislated primarily by the *Great Barrier Reef Marine Park (GBRMP) Act 1975* (Cth). The Great Barrier Reef Marine Park Authority (GBRMPA) is responsible for the management of the GBRMP. The Port of Gladstone area is situated at the southern end of the GBRMP and is designated as a General Use Zone under the GBRMP Zoning Plan 2003, MPZ17 (refer to *Figure 5.8.13*).

General Use Zones allow activities such as line fishing, boating, diving, trawling, netting and limited spearfishing. Other activities such as aquaculture, tourism and research may require permits to operate in this zone. For management and administrative purposes the Amalgamated Great Barrier Reef (AGBR) Section covers more than 99 per cent of the GBR Region and is divided into four management areas. The Port of Gladstone region is covered by the Mackay/Capricorn Management Area.

The Great Barrier Reef Coast Marine Park (GBRCMP) is a state marine park that runs the full length of the GBRMP from just north of Baffle Creek (north of Bundaberg) to Cape York and is legislated by the Queensland Government under the *Marine Parks Act 2004*, *Marine Parks Regulation 2006* and Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004 (refer to *Figure 5.8.2*).

Within the vicinity of Gladstone, the GBRCMP includes The Narrows (north of Friend and Laird Points), 3 nautical miles (nm) from the highest astronomical tide (HAT) of Curtis and Facing Islands and the mainland south of Canoe Point. The GBRMP extends from the low watermark of Curtis and Facing Islands and includes Seal Rocks and the mainland south of Wild Cattle Island (refer to *Figure 5.8.13*).

Commonwealth Marine Area

Commonwealth marine areas begin at 3 nm from the coast out to 200 nm. The proposed LNG Facility is therefore not located within a Commonwealth marine area.

Ramsar Wetlands

Ramsar wetlands are sites that are recognised under the Convention on Wetlands of International Importance (Ramsar Convention) as being of international significance in terms of ecology, botany, zoology, limnology or hydrology. There are no Ramsar wetlands in the vicinity of the proposed LNG Facility. The closest Ramsar wetland sites are the Shoalwater and Corio Bay areas approximately 140 km north-west of the proposed site.

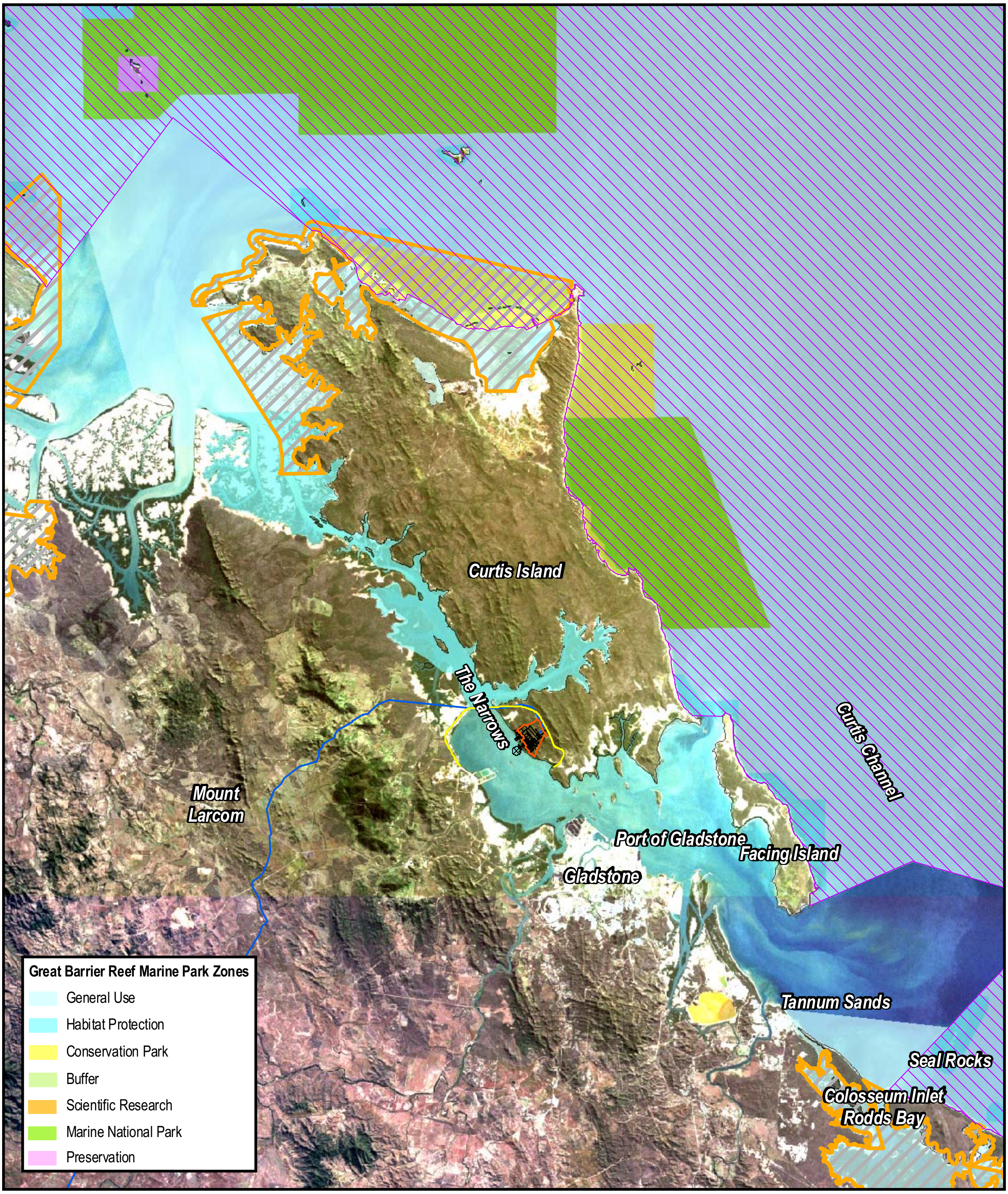
Significant Wetlands

Based on the Ramsar Convention description of Wetlands of International Importance, the Directory of Important Wetlands in Australia (DIWA) developed a number of criteria to determine a Nationally Important Wetland, as described below.

A wetland may be considered nationally important if it meets at least one of the following criteria:

- It is a good example of a wetland type occurring within a biogeographic region in Australia.
- It is a wetland that plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex.
- It is a wetland that is important as the habitat for animal taxa at a vulnerable stage in their lifecycles, or provides a refuge when adverse conditions such as a drought prevail.
- The wetland supports 1 per cent or more of the national populations of any native plant or animal taxa.
- The wetland supports native plant or animal taxa or communities, which are considered endangered or vulnerable at the national level.
- The wetland is of outstanding historical or cultural significance.

Based on the above criteria, three nationally listed wetlands occur in the Port of Gladstone area, The Narrows (approximately 7.5 km north-west), the Port of Gladstone and the Colosseum Inlet-Rodds Bay area (approximately 30 km south-east). The Narrows is a declared habitat protection zone of the GBRCMP (refer to *Figure 5.8.13)*.



Legend

- Proposed QCLNG Site Boundary
- QCLNG Footprint Plant Layout
- Possible Curtis Island Road/ Bridge Corridor
- Proposed Export Pipeline
- Fish Habitat Area, Management 'A'
- Great Barrier Reef Marine Park

Source Note:
Landsat ETM Image: USGS 2009, Aquired 2002.
Marine Park Boundaries: Great Barrier Reef Marine Parks Authority
Data extracted from MPZ17 - Gladstone

Projection: UTM MGA Zone 56
Datum: GDA 94

0 2.5 5 10 km

N

QUEENSLAND CURTIS LNG A BG Group business	Project: Queensland Curtis LNG Project		Title: **Great Barrier Reef Marine Park Zoning Plan**
	Client: QGC - A BG Group business		
ERM Environmental Resources Management Australia Pty Ltd	Drawn: JF/JB	Volume 5 Figure 5.8.13	Disclaimer: Maps and Figures contained in this Report may be based on Third Party Data, may not to be to scale and are intended as Guides only. ERM does not warrant the accuracy of any such Maps and Figures.
	Approved: JC	File No: 0086165b_EIS_ME_GIS023_F5.8.13	
	Date: 12/05/09	Revision 1	

The Port of Gladstone wetland includes all tidal areas from a line between Laird Point and Friend Point, to a line between Gatcombe Head and Canoe Point, including the seaward side of Facing Island and Sable Chief Rocks, and southern Curtis Island, west of a line between North Point and Connor Bluff[138].

The wetland area supports a diverse range of flora and fauna and is the preferred feeding ground of several listed migratory birds protected under CAMBA, JAMBA, ROKAMBA and the Convention on Migratory Species (Bonn Agreement).

The management and/or planning authorities responsible for the Port of Gladstone wetland are GPC, DERM, GBRMPA and Gladstone Regional Council.

Fish Habitat Areas

Declared Fish Habitat Areas (FHAs) are protected by the *Fisheries Act 1994* (Qld) and are designed to protect inshore and estuarine fish habitats important for local and regional fisheries. The closest FHA is surrounding the northern end of Curtis Island, in the Curtis Channel (refer to *Figure 5.8.13*).

Habitat Protection Zones

Habitat Protection Zones (HPZ) are administered and managed by the GBRMPA under the *GBRMP Act 1975* and GBRMP Zoning Plan 2003. According to Section 2.3.4 (l) of the GBRMP Zoning Plan, written permission from the GBRMPA is required to conduct various activities within a HPZ involving operating a facility for a purpose that is consistent with the objective mentioned in Section 2.3.2 for the zone, including:

- discharging waste from the facility
- building, assembling, fixing in position, maintaining or demolishing the facility
- constructing or operating mooring facilities for vessels or aircraft
- operating a landing area or facility for aircraft.

There are a number of HPZ located in the Port of Gladstone area (refer to *Figure 5.8.13*);

- Seal Rocks on the southern boundary of the Port of Gladstone shipping channel
- eastern side of Facing Island
- The Narrows, an area between Curtis Island and the mainland.

138 Environment Australia (2001) **A directory of important wetlands in Australia,** Third Edition. Environment Australia, Commonwealth Government, Canberra.

Dugong Protection Areas (DPAs)

DPAs were declared in legislation under the Queensland *NC Act* and as Special Management Areas under the *GBRMP Regulations 1983* and the GBRMP Zoning Plan 2003. The Rodds Bay/Port of Gladstone area including the area adjacent to the Project area is designated a DPA "B" (refer to *Figure* 5.8.9). DPAs are a two-tiered management scheme where DPA "A" represents the most significant dugong habitat in the southern GBR while DPA "B" represents habitat that is less significant but still important. The main difference in management arrangements between DPAs "A" and "B" relates to commercial mesh-netting fishing.

Dugongs are associated with seagrass beds in the Port of Gladstone area, which is not identified as supporting large populations of these animals. The dugongs that do occur in the Port of Gladstone region are centred around the Rodds Bay area, which is approximately 40 km south of the Project area. As described in *Section 8.3.2.7*, in 2005 it was estimated that there were 183 (± 66) in this area[139]. Dugongs are however, recorded as frequently using the seagrass beds in the vicinity of Wiggins Island, approximately 6 km south-east of the Project area[140].

8.3.4 Introduced Marine Species

Introduced marine species are those that have been introduced to an area outside their natural range of occurrence, generally by human activities. Species can be introduced by a variety of vectors, including ballast water discharged by shipping and bio-fouling on hulls.

The National Introduced Marine Pest Information System (NIMPIS) identifies the presence of 26 marine pests in the waters of Queensland (refer to *Table* 5.8.11). The Port of Gladstone receives vessels from all over the world. Therefore, the potential exists for the introduction of exotic marine species through ballast water and/or hull fouling.

The Central Queensland Ports Authority (CQPA) commissioned a baseline study and survey of the Port of Gladstone in 2000 for introduced marine species/pests. The survey area targeted habitats which were likely to be colonised by introduced species, including wharves, marinas and channel markers. Samples were collected from over 20 sites within the Port, including scrapings of marine organisms, sediment cores for macrobenthos and dinoflagellates, and plankton and dinoflagellate net samples. Nine introduced species were identified: five bryozoans, two ascidians, one hydrozoan and one isopod crustacean[141] (refer to *Table 5.8.11*).

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139 Marsh H and Lawler I R (2006) ***Dugong distribution and abundance on the urban coast of Queensland: a basis for management*** *Marine and Tropical Science Research Facility Interim Projects 2005-06 FINAL Report Project 2*.

140 Taylor H, Rasheed M, Dew K and Sankey T (2007) ***Long Term Seagrass Monitoring in Port Curtis and Rodds Bay, Gladstone, November 2006*** *Queensland:*

141 Lewis S, Hewitt C L and Melzer A (2001) ***Port survey for introduced marine species Port Curtis. Final Report to the Gladstone Port Authority.***

None of the species found are classified as a pest species (i.e. they do not threaten endemic species, the natural ecology of the harbour, fisheries or human health) and none of them are among the target species identified by the Australian Ballast Water Management Advisory Committee.

Table 5.8.11 Numbers of Introduced Marine Species in Australian, Queensland and the Port of Gladstone waters.

Source	Location	Type of Species	Number of Species
Hayes et al (2005)	Australia-wide	Introduced pests	129
Hayes et al (2005)	Australia-wide	Cryptogenic pests (unknown origin)	209
NIMPIS	Queensland	Introduced pests	26
CQPA	Port of Gladstone	Introduced (none classified as pests)	9

8.3.5 Management of Shipping on the Great Barrier Reef

The GBRMP was declared under the *GBRMP Act 1975* (refer to *Section 8.3.3.3*). It is a nationally and globally significant area and designated as a World Heritage Area (refer to *Section 8.3.3.3*). It is further declared internationally for shipping by the International Maritime Organisation (IMO) in 1990 as a Particularly Sensitive Sea Area (PSSA)[142].

It is recognised that shipping within the GBRMP presents particular and significant hazards to its wellbeing and continued survival. Controls to mitigate impacts from the shipping industry are complicated by the international nature of the shipping industry. However the GBR receives the highest protection afforded of any marine protected area through a number of international conventions, domestic legislation and special measures coordinated by national and state agencies.

8.3.5.1 Main Legislation regulating shipping on the GBR

International

- International Convention on Oil Pollution Preparedness (OPRC 90)
- International Convention for Prevention of Pollution by Ships 73/78 (MARPOL)
- United Nations Law of the Sea (UNCLOS 82)
- International Convention for Safety of Life at Sea (SOLAS 74)

142 International Marine Organisation (IMO) Assembly Resolution A 982 (24)

- Convention on International Regulations for Prevention of Collision at Sea (COLREGS 72)

Domestic

- *Transport Operations (Marine Pollution) Act (TOMPA)1990*
- *GBRMP Act 1975*
- *Protection of the Sea (Prevention of Pollution by Ships) Act 1983* (Cth)
- *Navigation Act 1912* (Cth)
- *Environmental Protection and Biodiversity Conservation Act 1999.*

A report of shipping management in 2003–2005[143] considered that the greatest threats from shipping for the GBR are major oil or chemical spills and the introduction of marine pests. Pollution from operational discharges and direct damage from collisions or groundings can also impact the marine environment.

Although there have been a number of shipping incidents on the GBR and Torres Strait (refer *Table 5.15.3* in *Volume 5, Chapter 15*), there has, to date, been no significant pollution event affecting the GBR since the *Oceanic Grandeur* in 1970.[144]. A 2002 review of shipping safety on the GBR and Torres Strait[145] found that between 1985 and 2000 there were 40 major shipping incidents in the GBR and Torres Strait region, consisting of 26 groundings and 14 collisions, fewer than 2.5 per annum.

There has been no known introduction of marine pests into the GBR[146]. The Asian green mussel incursion in 2001 at Cairns, though successfully contained, highlights the very real threat that is present from shipping in the region.

The 2002 review gave rise to two important documents; the shipping impact study[147] and the shipping management study[148], both highlighting the potential serious risk of shipping-related incidents on the marine environment of the GBR. The economic implications of closing the GBR and Torres Strait to shipping were also analysed. Analysis of the costs of using alternative shipping routes and land transport if the inner route through the GBR and the Torres Strait were closed to shipping showed that it was economically unviable.

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143 GBRMPA (2003) ***Great Barrier Reef and Torres Strait shipping impacts study***.

144 Australian Marine Safety Authority (www.amsa.gov.au)

145 Review of Great Barrier Reef Ship Safety and Pollution Prevention Measures,2001

146 www.gbrmpa.gov.au

147 GBRMPA (2003) ***Great Barrier Reef and Torres Strait shipping impacts study***.

148 Great Barrier reef and Torres Strait Shipping management plan 2002-2005, GBRMPA

8.3.5.2 *Responsibility for management of shipping*

The Commonwealth Department of Infrastructure, Transport, Regional Development and Local Government is responsible for the national regulation of interstate and, in some circumstances, intrastate coastal shipping services, including shipping along the Queensland coast. The Australian Transport Safety Bureau (ATSB) is an agency within the Department that undertakes safety investigations to establish the causes of maritime incidents.

Shipping operations in the GBR and Torres Strait region are jointly managed by the Commonwealth Australian Maritime Safety Authority (AMSA), the GBRMPA and the Maritime Safety Queensland (MSQ).

AMSA is responsible for the regulation of safety and environmental performance of trading ships engaged on international and interstate voyages, and for prevention of pollution by shipping. They are further responsible for the licensing of coastal pilots and regulating the safe operation of ships under coastal pilotage in the region.

The IMO declared the GBR a PSSA in 1990 allowing implementation of specific measures relating to shipping. GBRMPA legislation implements the associated protective measures arising from the designation including IMO-endorsed compulsory pilotage measures. It also includes measures relating to protection of the environment from shipping activities through a zoning system, places restrictions on certain activities, and imposes offences and penalties for environmental damage.[149]

MSQ is responsible for regulating intrastate shipping and recreational boat users for safety and environmental outcomes. MSQ administers legislation that provides for the protection of Queensland coastal waters from ship sourced pollution and gives effect to IMO pollution prevention standards[150]. MSQ is also responsible for the licensing and provision of pilots in Queensland ports, managing and monitoring vessel movements, providing navigation aids, and delivering cartographic and hydrographic services.

Responses to environmental issues from shipping involve all agencies with each taking respective leads and operating under a number of plans. The response to oil or chemical pollution, for example, is covered by Australia's National Plan, including response arrangements for the GBR region under the Reef Water Quality Protection Plan (REEFPLAN) and for Torres Strait under TORRESPLAN.

The compulsory reporting system, REEFREP Ship Reporting System, based at Hay Point, provides enhanced safety for shipping through monitoring of ship movements and provision of marine safety information and is jointly operated by AMSA and MSQ. GBRMPA and Queensland Parks and Wildlife Service (QPWS) cooperate in the day to day management of the marine parks. In

149 Great Barrier Reef Marine Park Authority (www.gbrmpa.gov.au)

150 The Reef Water Quality Protection Plan (REEFPLAN) (www.reefplan.qld.gov.uk)

addition a range of powers and enforcement or prosecution functions are delegated to police officers. *Table 5.8.12,* below, highlights broad areas of agency involvement.

Table 5.8.12 Agency involvement with shipping responsibility

Area of responsibility	Agency role
Marine Incident Response and Oil Spill Response	MSQ and AMSA take the lead
Ship Monitoring	AMSA and MSQ operate ReefRep from Hay Point to monitor all ships in GBR
Investigations	All three agencies involved according to agreements in place
Coastal Pilotage	Legislation through GBRMPA and administered by AMSA
1. Source Pers comm Jim Huggett (MSQ)	

The ultimate responsibility for safety of navigation and prevention of marine pollution from ships rests with the ship's operator, master and crew. Liability for damage resulting from shipping incidents rests with the ship owner and operator. Under international law, Australia is unable to ban certain types of ships or cargoes from the region. It is further considered impractical from an operational, economic, and international relations standpoint.

The more specific measures to manage shipping-related impacts in the GBR and Torres Strait are[151]:

- compulsory and recommended pilotage areas
- quality of pilot services
- compulsory Ship Reporting System
- MARPOL no-discharge zone for GBR and Torres Strait
- 11 ports equipped with resources to assist ships
- specific oil and chemical spill plans
- extensive navigation aids network
- *Places of Refuge Guidelines*
- weather forecasting and warning systems
- emergency towing tug stationed in Gladstone
- emergency towing vessel stationed near Torres Strait
- specified designated pilotage area (refer to *Figure 5.8.14*).

151 Great Barrier reef and Torres Strait hipping management plan 2002-2005, GBRMPA

8.4 EVALUATION OF IMPACTS, MITIGATION AND MANAGEMENT MEASURES

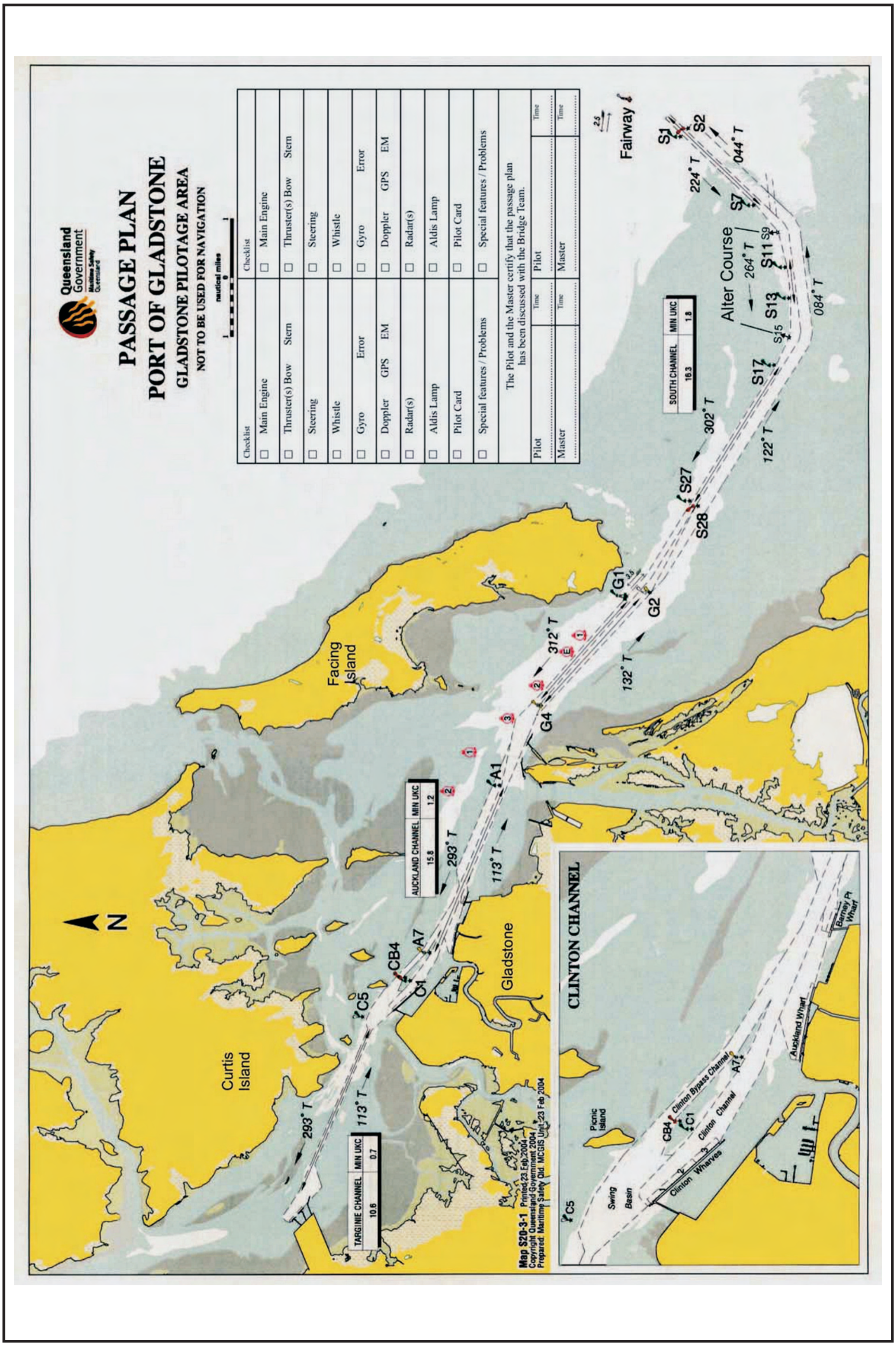
The impact assessment process resulted in a systematic evaluation of impacts, mitigation and management measures for all aspects of the Project. Consistent with this systematic process, the discussion of impacts has also been divided into a number of sections and sub-sections, as outlined in *Table 5.8.13*.

Table 5.8.13 Outline of Impact Evaluation Chapter

Impact Type	Category	Section
Physical Impacts	Physical presence – permanent	8.4.1.1
	Physical presence – temporary	8.4.1.2
	Underwater noise	8.4.1.3
	Light	8.4.1.4
Solid Waste	Food scraps and putrescibles	8.4.2.2
	General non-hazardous waste	8.4.2.3
	General hazardous solid waste	8.4.2.4
Marine Discharges	Sewage and sullage	8.4.3.2
	Saline discharges	8.4.3.3
	Stormwater runoff	8.4.3.4
	Deck drainage	8.4.3.5
	Anti-fouling leachate	8.4.3.6
Unplanned Events	Hydrocarbon spills	8.4.4.1
	Chemical spills	8.4.4.2
Introduced Marine Species		8.4.5
Impact on Matters of National Environmental Significance		8.4.6

8.4.1 *Physical Impacts*

As described in *Table 5.8.13*, the physical impacts associated with the Project have been divided into four categories. A short overview of these categories is summarised in *Table 5.8.14*



Source Note:
Extracted from Limpus and Miller, 2008.

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QUEENSLAND CURTIS LNG A BG Group business	Project	Queensland Curtis LNG Project	Title: Port of Gladstone Shipping Channel and Berthing Facilities
	Client	QGC - A BG Group business	
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	Approved GB	File No: 0086165b_EIS_ME_CDR007_F5.8.14	
	Date 13/05/09	Revision 1	

Table 5.8.14 Overview of Physical Impact Categories

Type of Physical Impact	Description
Physical presence – permanent	Impacts to receptors that arise as a result of the installation and presence of "permanent" infrastructure, such as the Bridge (if built), Pipeline or Jetty.
Physical presence – temporary	Temporary or short duration impacts that arise from the physical presence of vessels during the construction, installation and operation phases
Underwater noise	Impacts associated with the generation of noise, and the subsequent propagation of that noise through the air and marine environment, during each of the phases of the Project.
Light	Impacts to receptors that arise as a result of the introduction of artificial light sources.

8.4.1.1 Physical Presence – Permanent

Sources and Characteristics

The major components of the marine infrastructure for the Project include:

- Possible bridge and road access at The Narrows (Bridge) which is no longer recommended by this EIS or by QGC. Commentary with regard impact of the Bridge (and associated roads) is provided, but construction of the Bridge is not part of the Project and management and mitigation measures associated with the Bridge and roads are recommendations only made for these items of infrastructure.
- Pipeline crossing at The Narrows (Pipeline)
- Materials Offloading Facility (MOF)
- Loading Jetty.

In this section, the development and potential impacts of these sources will be discussed and are outlined in *Table 5.8.15*. The life expectancy for the permanent infrastructure is approximately 20 years and the following section details the potential impacts during construction, operation and decommissioning phases.

Table 5.8.15 Summary of Sources and Characteristics of Physical Presence – Permanent Impacts During Different Phases of the Project

Project Component	Impact	Receptor	Construction	Operation	Decommissioning
Possible Bridge Crossing Pipeline Crossing MOF Loading Jetty	Suspended sediment and sedimentation	Bathymetry and seabed Water quality	✓	✓	✓
	Subsidence and compaction	Bathymetry and seabed	✓	✓	
	Infrastructure water obstruction	Water quality Bathymetry and seabed Change to hydrodynamic regime		✓	✓
	Reduced shoreline habitat	Water quality Mangroves Seabird and Shorebirds	✓	✓	✓
	Physical disturbance to benthic habitat	Seagrass Invertebrates Other benthic habitat	✓	✓	✓
	Land reclamation	Water quality Bathymetry and seabed Change to hydrodynamic regime Seagrass Invertebrates Marine mammals Fish Other benthic habitat	✓	✓	
	Altered fauna interaction	Marine mammals Marine reptiles Fish Seabird and Shorebirds	✓	✓	✓
	Artificial habitat	Marine mammals Marine reptiles Fish Seabird and Shorebirds		✓	✓

Possible Bridge crossing

The Queensland Government is investigating the possibility of building a bridge and road access to Curtis Island that could transport equipment, labour and materials to the LNG Facility. However, the Curtis Island Bridge and Roads infrastructure are currently not part of the base case for the Project and it is intended that materials for Project construction and operation will be delivered by barge, and personnel ferried to and from the LNG Facility. The proposed location of the Bridge crossing is shown in *Figure 5.8.15*. This figure also shows the preferred Pipeline route (option 1 in *Figure 5.8.15*) across The Narrows which has been subject to detailed assessment as part of this EIS.

The proposed Bridge and Pipeline area is located adjacent to and overlapping the southernmost boundary of the GBRMP. Under the provisions of the *Marine Parks Act 2004* (Qld) and the *GBRMP Act 1975* (Cth), Marine Parks Permits will be required for any activities which may affect the Marine Parks. The preferred Pipeline option (option 1 as shown in *Figure 5.8.15*) is located in The Narrows which is recognised as a key coastal site in the Curtis Coast Regional Coastal Management Plan[152] The current proposed Pipeline alignment lies outside the boundary of the GBRCMP.

Pipeline

The Pipeline will require a marine crossing from the mainland to Curtis Island (refer to *Figure 5.8.15*), in an area between Friend Point on the mainland and Laird Point on Curtis Island, commonly referred to as The Narrows. The proposed Pipeline crossing between the mainland and Curtis Island is located within the limits of the Port of Gladstone. The area has been identified in the Curtis Coast Regional Coastal Management Plan.

Materials Offloading Facility (MOF)

The MOF is a permanent wharf structure required to dispatch and receive heavy equipment, including pre-assembled process modules from ships directly or on barge vessels travelling between the mainland and Curtis Island, as described in *Volume 2, Chapter 9*.

Loading Jetty

A dedicated Jetty containing specialised LNG loading facilities and LNG tanker berth(s) would be constructed to transfer LNG produced by the LNG Facility to tankers for shipment to markets. Details of proposed Jetty layout and design are provided in *Volume 2, Chapter 9* and *Chapter 13*.

Dredging is required to deepen and widen the shipping access channels and create an appropriate turning basin to access the LNG loading facilities and berth(s) (refer to *Volume 6).*

Extent of Impact

The impacts from the presence of the permanent marine infrastructure are expected to persist throughout all phases of the development, but will be most intense during the construction phase.

152 Queensland Environmental Protection Authority (EPA) 2003. **Curtis Coast Regional Coastal Management Plan**.

Legend

- Proposed QCLNG Site Boundary
- Wet Lease Area
- Proposed LNG Facility Plant Layout
- Great Barrier Reef Coast Marine Park
- Possible Curtis Island Road/ Bridge Corridor
- 1 - 9 Indicative Potential Pipeline Crossing Options

Source Note:
Aerial Photo - SPOT 10m 2008 08 30
Curtis Island Road/Bridge Corridor - Connell Wagner
Indicative Pipeline Options - Xodus Group

Projection: UTM MGA Zone 56
Datum: GDA 94

0 0.5 1 2 km

N

QUEENSLAND CURTIS LNG A BG Group business	Project: Queensland Curtis LNG Project		Title: **Bridge and pipeline crossing options for The Narrows**
	Client: QGC - A BG Group business		
ERM Environmental Resources Management Australia Pty Ltd	Drawn: KP	Volume 5 — Figure 5.8.15	Disclaimer: Maps and Figures contained in this Report may be based on Third Party Data, may not to be to scale and are intended as Guides only. ERM does not warrant the accuracy of any such Maps and Figures.
	Approved: KR	File No: 0086165b_EIS_ME_GIS028_F5.8.15	
	Date: 02.06.09	Revision: 1	

At this stage of the assessment the spatial extent of the area to be dredged or reclaimed has not been determined, and as such all possible reclamation options are discussed and general impacts assessed. The extent of impacts from dredging required for the LNG Facility only are assessed in *Volume 6*.

The construction method for the Pipeline crossing is yet to be determined but options include either seabed trenching or horizontal directional drilling (HDD) under the seabed. Based on a five-day work week, open-cut trenching to install the Pipeline crossing of The Narrows in the following areas, is estimated to take approximately 200 days. If HDD is used the duration and impacts to the seabed are minimal, although costs are higher.

Details of construction methodology and timeframe for the Bridge, MOF and Loading Jetty are provided in *Volume 2*.

Description of Impact

The marine infrastructure components will involve a variety of activities that may cause potential impacts to the receiving marine environment. The three main activity sources that have the potential for impacts to the receiving environment are:

- construction and installation, which includes activities such as pile driving, HDD, land clearing and levelling, trenching, backfilling, and dredging
- physical presence of permanent infrastructure
- dredge spoil disposal for land reclamation in the area of Fisherman's Landing. It is noted that GPC proposes to undertake the Western Basin Strategic Dredging and Disposal Project which involves the dredging of shipping channels and swing basins, and construction and management of a proposed Fisherman's Landing dredge material management area. While assessment of impacts is outlined for these activities below, based on information currently available more comprehensive impact assessment associated with the WBSDD Project will also be undertaken separately by GPC in the WBSDD Project EIS.

A description of the impacts are outlined in *Table 5.8.16* below.

Table 5.8.16 List and Description of Impacts for Permanent Physical Marine Structures

Impact	Description
Suspended solids and sedimentation	Disturbance to seabed due to construction activities Erosion from cleared shoreline vegetation and levelling
Subsidence and compaction	Backfilling of trench for Pipeline, or if HDD method, compaction at shoreline Load on seabed from marine infrastructure
Infrastructure water obstruction	Water movement and velocities may be altered by physical structure Altered water movement may affect water quality, in particular suspended solids and turbidity, and seabed features and bathymetry
Reduced shoreline habitat	Shoreline clearing of vegetation and levelling Erosion from cleared shoreline vegetation and levelling
Physical disturbance to benthic habitat	Disturbance to seabed and other benthic habitats due to earthwork activities and physical presence
Land reclamation	Modification to bathymetry and seabed profile Permanent modification to benthic and aquatic fauna/flora habitat
Altered fauna interaction	Disturbance to seabed attributed to construction activities Physical presence of marine infrastructure may alter marine fauna behaviour and movement
Artificial habitat	Physical presence of marine infrastructure provide artificial substrate for marine flora and fauna

Receptors Affected

The following section presents the impact of the physical marine infrastructure to the identified marine receptors. As summarised in *Table 5.8.15* the receptors discussed are:

- bathymetry and seabed features
- hydrodynamic regime
- water quality
- seagrass and algae
- mangroves

- other benthic habitats
- invertebrates
- fish
- marine mammals
- marine reptiles
- seabirds and shorebirds.

Bathymetry and seabed features

The bathymetry and seabed features will primarily be impacted during the construction phase of the Pipeline, MOF and Jetty, especially in relation to suspended solids and sedimentation.

To accommodate vessels in 14 m to 15 m LAT of water, the dredging for the Jetty will alter the bathymetry and seabed floor in the Project area. As part of the Project recent bathymetry data was collected in the beginning of 2009 and provides a reference dataset to track bathymetry changes.

The bathymetry and seabed profile will be highly modified with the land reclamation of the Fisherman's Landing area. The dredged material will be used for land reclamation options, and will alter the bathymetry from an estuarine environment to a terrestrial environment (see below section on Hydrodynamic Regime).

Construction for the Pipeline crossing at The Narrows is likely to be either by HDD or trenching, with geotechnical investigations ongoing to determine the preferred methodology. The seabed profile is likely to be altered slightly at the approach through the intertidal areas (see below section on Other Benthic Habitats).

Hydrodynamic Regime

The physical presence of the marine infrastructure has the potential to act as a water obstruction and is expected to cause minor alteration to the hydrodynamic regime around the Project area and Port of Gladstone. The dredging required for the LNG Facility and associated dredge disposal for land reclamation is also expected to alter the hydrodynamic regime.

Modelling suggests impacts to the hydrodynamic regime from the proposed works are generally minimal, with the exception of the immediate vicinity of the proposed dredged swing basin where the large amount of dredging would change velocities quite considerably. Modelling indicates practically indiscernible differences in flushing behaviour with and without the Project[153].

Hydrodynamic changes may be expected to tidal water levels, tidal velocities, tidal flow rates and tidal flow distribution.

153 BMT WBM Pty Ltd (2009) **Proposed BG LNG Facility EIS Marine Water Quality Assessment**.

The maximum predicted reduction in tidal range associated with the Project is 11 mm, or 0.24 per cent[154]. Minimum (i.e. spring low tide) water levels at sites upstream and downstream of the proposed LNG Facility swing basin are predicted to be reduced by no more than 9 mm, with the maximum change immediately downstream (south) of the Bridge. Maximum (i.e. spring high tide) water levels at sites upstream and downstream of the Bridge are also expected to reduce, in this case by no more than 4 mm, with the maximum change predicted in the channel upstream (north) of the Bridge and in Graham Creek.

Tidal velocities that have been modelled predict no change in minimum velocities, which were all zero at slack water. Maximum (i.e. spring tide) velocities at sites upstream and downstream of the proposed LNG Facility swing basin reduced by 0.034 m/s (or 3.5 per cent of the peak base velocity), with the maximum change predicted in the main channel immediately upstream (north) of the proposed swing basin.

Some minor local changes in current velocity and direction are predicted as a result of the MOF. However, other than the local impacts associated with the MOF[155] there was no significant change in tidal flow distribution upstream and downstream of the proposed LNG Facility site.

Predicted changes in tidal flow rates mirrored the above changes in tidal velocities, with a predicted reduction by up to 15 per cent through a section of the Port at the proposed LNG Facility swing basin latitude.

As described in *Section 8.3.1,* a modelling study in 2004 confirms that this region is tidally dominated[156]. The Port of Gladstone estuary region appears well-connected throughout, however the estuary is poorly connected with the offshore region seaward of Facing Island. This is evident in flushing, passive tracer and particle analyses. Tracers are transported efficiently throughout the estuary but inefficiently transported out of the estuary to offshore regions. Release at the dredging spoil site, in the outer harbour, results in tracer distributions forming a plume originating from the source and directed north-westwards along the seaward coast of Facing Island. The prevailing wind conditions are likely to influence distributions offshore, thus seasonal variability is expected.

Fisherman's Landing Land Reclamation

A number of alternative modelling scenarios have been simulated[157] for reclamation of the Fisherman's Landing area in order to determine potential impacts on the hydrodynamic regime in the western harbour. The options discussed include (*Figure 5.8.16*):

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154 BMT WBM Pty Ltd (2009) **Proposed BG LNG Facility EIS Marine Water Quality Assessment**.

155 BMT WBM Pty Ltd (2009) **Proposed BG LNG Facility EIS Marine Water Quality Assessment**.

156 Herzfeld J, Parslow J, Andrewartha P, Sakov and Webster I T (2004) ***Hydrodynamic Modelling of the Port Curtis Region***.

157 BMT WBM Pty Ltd (2009) ***Preliminary Hydrodynamic Assessment of Fisherman's Landing Reclamations***.

1. QGC LNG scenario – the proposed swing basins (both QGC and Santos) dredged, MOF, and Bridge
2. FL153 – QGC scenario plus Fisherman's Landing reclamation FL153
3. FL1b – QGC scenario plus Fisherman's Landing reclamation FL1b
4. FL2 – QGC scenario plus Fisherman's Landing reclamation FL2

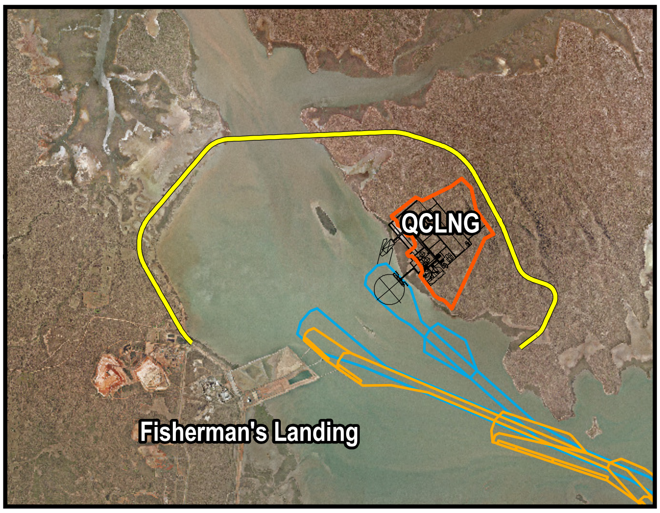
It is important to note that the modelling for the listed reclamation scenarios was based solely on changes to the shoreline and intertidal areas and did not take into consideration the compensatory effects of seabed deepening which will take place as a result of the proposed capital dredging program. As most if not all of the reclamation infill material will come from the proposed dredging within the western harbour the net change to the tidal volume within this section of harbour is likely to be considerably smaller than was modelled in the above scenarios. The following synthesis should therefore be considered as a worst-case assessment. It is reasonable to assume that many of the potential impacts identified below will be mitigated by both the intrinsic compensatory actions of dredging as well as purpose designed mitigation measures.

An analysis of low- and high-tide water level behaviours was undertaken for each scenario. Maximum change in low- and high-water levels at the reclamation options are predicted to be in the order of 5 cm or less, with low-water level changes being the greatest. The maximum change observed at The Narrows is for reclamation option FL2, with low-water surface elevations being increased by 4.5 cm compared to the QGC LNG scenario reference case[158]. For this specific low tide, other reclamation options impacts are as follows:

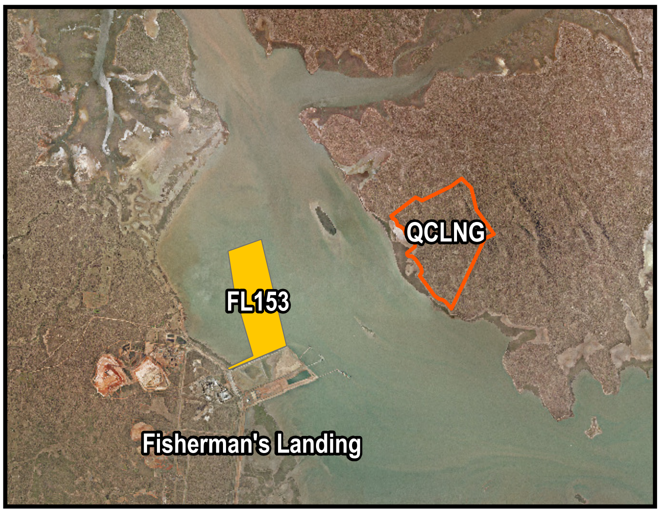
- FL2 – low tide increased by 4.5 cm (i.e. from -1.733 m AHD to -1.688 m AHD)
- FL1b – low tide increased by 2.8 cm (i.e. from -1.733 m AHD to -1.705 m AHD).

Overall changes in water surface elevations between the various reclamation options and the QGC LNG scenario reference option are maximal during mid-ebb tides (rather than at low or high water). Differences of up to 11 cm are predicted within the main channel north-west of the QGC LNG swing basin.

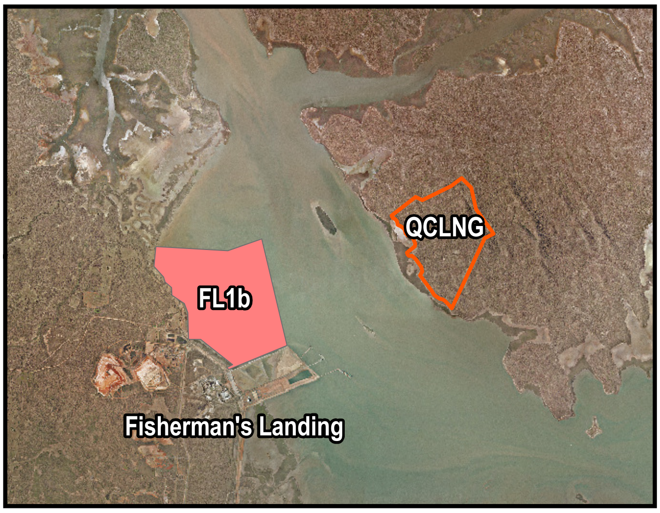
158 BMT WBM Pty Ltd (2009) ***Preliminary Hydrodynamic Assessment of Fisherman's Landing Reclamations***.



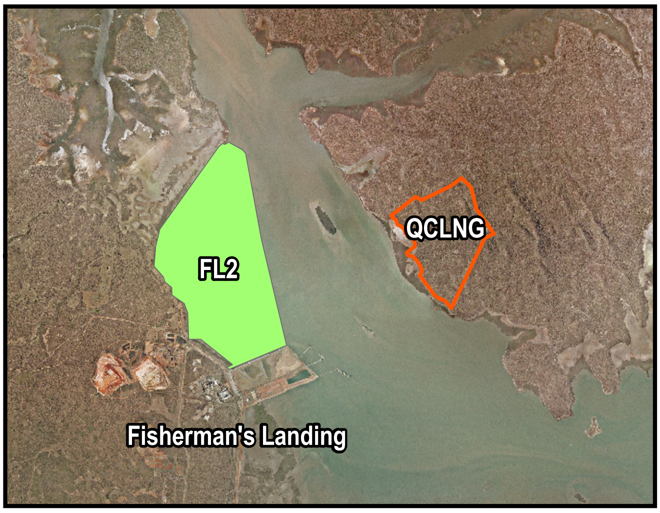
1. QCLNG LNG Scenario - Proposed Swing Basin, MOF and Bridge



2. QCLNG Scenario and Fisherman's Landing reclamation FL153



3. QCLNG Scenario and Fisherman's Landing reclamation FL1b



4. QCLNG Scenario and Fisherman's Landing reclamation FL2

Legend

- Proposed QCLNG Site Boundary
- QCLNG Footprint Plant Layout
- Possible Curtis Island Road/ Bridge Corridor

Shipping Channel and Swing Basin

- Proposed Channel
- Existing Channel

Source Note:
Aerial Photo - Department of Infrastructure and Planning for QCLNG Project
Curtis Island Road/Bridge - Connell Wagner
BMT WBM Pty Ltd (2009)
Preliminary Hydrodynamic Assessment of Fisherman's Landing Reclamations

0 1 2 4 km

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Project	Queensland Curtis LNG Project		
Client	QGC - A BG Group business		
Drawn	JB	Volume 5	Figure 5.8.16
Approved	KC	File No: 0086165b_EIS_ME_GIS029_F5.8.16	
Date	10.06.09	Revision 1	

Title **Fisherman's Landing Reclamation Options**

All tidal ranges are reduced by the various reclamation options, with low waters being higher and high waters being lower than the QGC LNG scenario case. The spring tide range is reduced by up to 1 per cent within the main channel to the north-west of the proposed QGC swing basin for the FL2 reclamation option. The neap tide range is reduced by up to 1.3 per cent up in The Narrows for the FL2 reclamation option. Option FL153 is predicted to have the least impact on tidal water levels[159].

Predicted velocity magnitude impacts were created for spring ebb and spring flood tide conditions. The impacts vary in space and intensity with time. In particular, the greatest impacts around Fisherman's Landing and the main channel areas are not co-temporal. To illustrate this, two different plots are presented, which correspond to two different times in the tidal cycle. The times have been chosen to illustrate the greatest impacts near the reclamations and channels. General patterns show decreases in velocity magnitudes downstream (south-east) of the Fisherman's Landing reclamation site(s), within the main channel.

The impact of the various reclamation options relative to the Project scenario is negligible upstream (north) of the proposed Bridge. Within the QGC and Santos swing basins, the occurrence of velocity magnitudes greater than 0.20 m/s is predicted to increase between approximately 4 per cent and 6 per cent, the maximum change being predicted for reclamation option FL2[160].

Velocity flows through Port of Gladstone were assessed for each reclamation option compared to the QGC LNG scenario. Increases of up to 25 per cent are predicted along the Fisherman's Landing profile for reclamation option FL153. These changes in maximum flow propagate upstream into The Narrows, but with a reduced influence. Decreases of up to 20 per cent are predicted along the QGC swing basin profile for scenario FL2[161].

The preferred reclamation option is yet to be decided.

Changes in the hydrodynamic regime may cause erosion of the shoreline in some areas and subsequent deposition of sediments on sensitive habitats such as seagrass. Transport of sediment due to erosion may also affect water quality (i.e. turbidity) and reduce light attenuation, which may in turn affect seagrass health.

Water Quality

Suspended sediment elevations and increased sedimentation during the construction of the marine infrastructure is likely to be the main stressor to water quality, particular in relation to total suspended solids and turbidity.

159 BMT WBM Pty Ltd (2009) ***Preliminary Hydrodynamic Assessment of Fisherman's Landing Reclamations***.

160 BMT WBM Pty Ltd (2009) **Preliminary Hydrodynamic Assessment of Fisherman's Landing Reclamations**. Unpublished

161 BMT WBM Pty Ltd (2009) **Preliminary Hydrodynamic Assessment of Fisherman's Landing Reclamations**. Unpublished

The main activity source for an increase in suspended sediments will be from earthworks and installation during the construction phase, which includes dredging, bridge pile driving, pipeline landfall and trenching, clearing of shoreline vegetation for access for the Bridge, Pipeline, MOF and Jetty. Water quality can also potentially be impacted by the disposal of dredge spoil for the reclamation options for Fisherman's Landing.

Disturbance of sediment is also likely to affect water quality in relation to contaminants entering the water column, and although the vicinity of the Project area is not covered by published acid sulfate maps, there is a potential for acid sulfate soils which may generate acid water drainage if allowed to be oxidised. A separate dredging assessment is currently ongoing to determine contaminants for disposal to ocean or land reclamation, and is therefore not discussed in detail here.

As the dredging and bridge construction works associated with the Project will have minimal impact on tidal flushing times, and the fact that there are minimal additional pollutant loads associated with the Project, it can be inferred that there is minimal potential for changes in the existing water quality regime of the Port of Gladstone associated with the Project[162]. However, this statement does not include impacts to water quality from the Fisherman's Landing reclamation options, which are discussed below.

Detailed construction methodology for Pipeline crossing of The Narrows is yet to be determined. For the purposes of this assessment, it has been assumed that the Pipeline will be installed within a trench as the worst-case scenario in regard to potential water quality impacts. Modelling has indicated the likely worst-case rate of sediment immobilisation due to the combined influence of Pipeline trenching and backfilling is 1.5 kg/s, this being the same as the rate derived for the effect of the dredging for the swing basin and MOF.

Modelling results show that for the Pipeline construction there are elevated total suspended solids (TSS) levels in and around the area of proposed dredging work, with this region occupying an area of approximately 150 m by 200 m during neap tides and approximately 100 m by 100 m during spring tides (refer to *Figure 5.8.17* and *Figure 5.8.18*). Outside these areas, maximum levels of increase of the order of 15 mg/L to 17 mg/L are predicted. Again, when compared with typical background levels in the Port of Gladstone it is apparent that these TSS levels, while high, are comparable to the existing levels of variability in TSS present in the region.

Depending on the method employed, there is potential for the generation of sediment plumes during bridge construction. However, it is highly likely that with appropriate management, such plumes should be far smaller than those which will be developed by the other sources of potential construction impact such as the Pipeline and swing basin and MOF development. Piling does not typically give rise to sediment plumes in the same way that dredging/trenching

162 BMT WBM Pty Ltd (2009) **Proposed BG LNG Facility EIS Marine Water Quality Assessment**.

does and therefore the impacts can be expected to be less.

Water Flushing

As outlined above, modelling of the six dredge material reclamation options for Fisherman's Landing has been undertaken. Modelling of time-series tracer concentration scenarios has also been simulated for the different reclamation options. Although definitive flushing times cannot be reported, the time-series data suggests differences of less than 0.06 mg/L in flushing behaviour between the Project scenario reference case and the various Fisherman's Landing reclamation options upstream (north) of the Bridge, and particularly small differences (less than 0.03 mg/L) within Graham Creek.

Downstream of the Bridge (to the south), increases in tracer concentration of up to 0.1 mg/L can be anticipated within the main channel immediately downstream of the Bridge and further south opposite the proposed reclamation, and out towards Gatcombe Head. Very slight changes in flushing behaviour at the Project swing basin location can be inferred from the time-series modelling[163].

The simulations predict that the water within the estuary is 100 per cent flushed due simply to tidal action, although potential implications for receptors outside the estuary have not been assessed. Results show differences in the spatial distribution and state of the tracer at a specific time between the various reclamation options, with the residual tracer concentrations generally increasing with increasing reclamation. Reclamation option FL153 (refer to *Figure 5.8.16*) shows some net accumulation of tracer right behind the proposed reclamation area, due to the restriction of flushing at this location, compared to the Project scenario case. This may highlight the potential for water quality and/or sedimentation issues for seagrass in this area[164].

Seagrass and Algae

Seagrass meadows can be highly susceptible to changes in hydrodynamic regimes particularly in relation to turbidity (light penetration and sedimentation rates), water temperatures, and biological oxygen demand (BOD) as outlined in *Section 8.3.2.2*. Seagrass meadows in the Project area are important feeding grounds for dugongs (*Dugong dugon*), a species listed as vulnerable under Queensland legislation and "marine and migratory" under Commonwealth legislation. Areas that support dugongs and seagrass are identified as a DPA.

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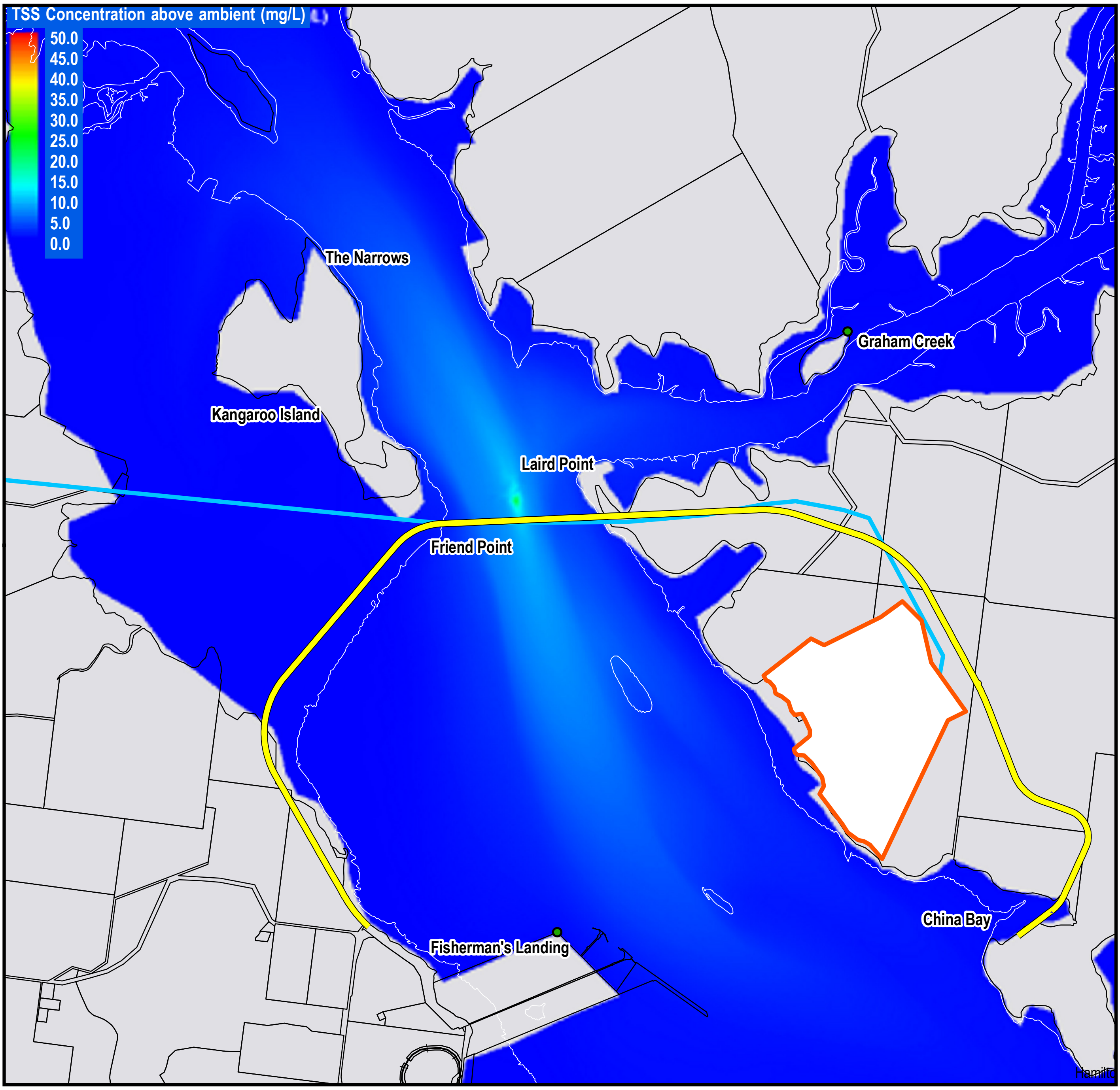
163 BMT WBM Pty Ltd (2009) ***Preliminary Advection-Dispersion Assessment of Fisherman's Landing Reclamations***.

164 **BMT WBM Pty Ltd 2009** ***Preliminary Advection-Dispersion Assessment of Fisherman's Landing Reclamations*.**



Legend

- Proposed QCLNG Site Boundary
- Proposed Export Pipeline
- Possible Curtis Island Road/ Bridge Corridor
- Swing Basin & Shipping Channel

Source Note:

BMT WBM Ltd 2009 Proposed BG LNG Facility EIS
Marine Water Quality Assessment Unpublished
R.B 17261.002.00.doc
Cadastral/Tenure Currency: August 2008,
Department of Natural Resource and Water
Curtis Island Road/Bridge - Connell Wagner

Projection: UTM MGA Zone 56 Datum: GDA 94

0 0.5 1 2 km

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Project	Queensland Curtis LNG Project	
Client	QGC - A BG Group business	
Drawn JB	Volume 5	Figure 5.8.17
Approved RS	File No: 0086165b_EIS_ME_GIS024_F5.8.17	
Date 09.06.09	Revision 1	

Title **Average Total Suspended Solids Increases, Due to Pipeline Construction - Neap Tide**

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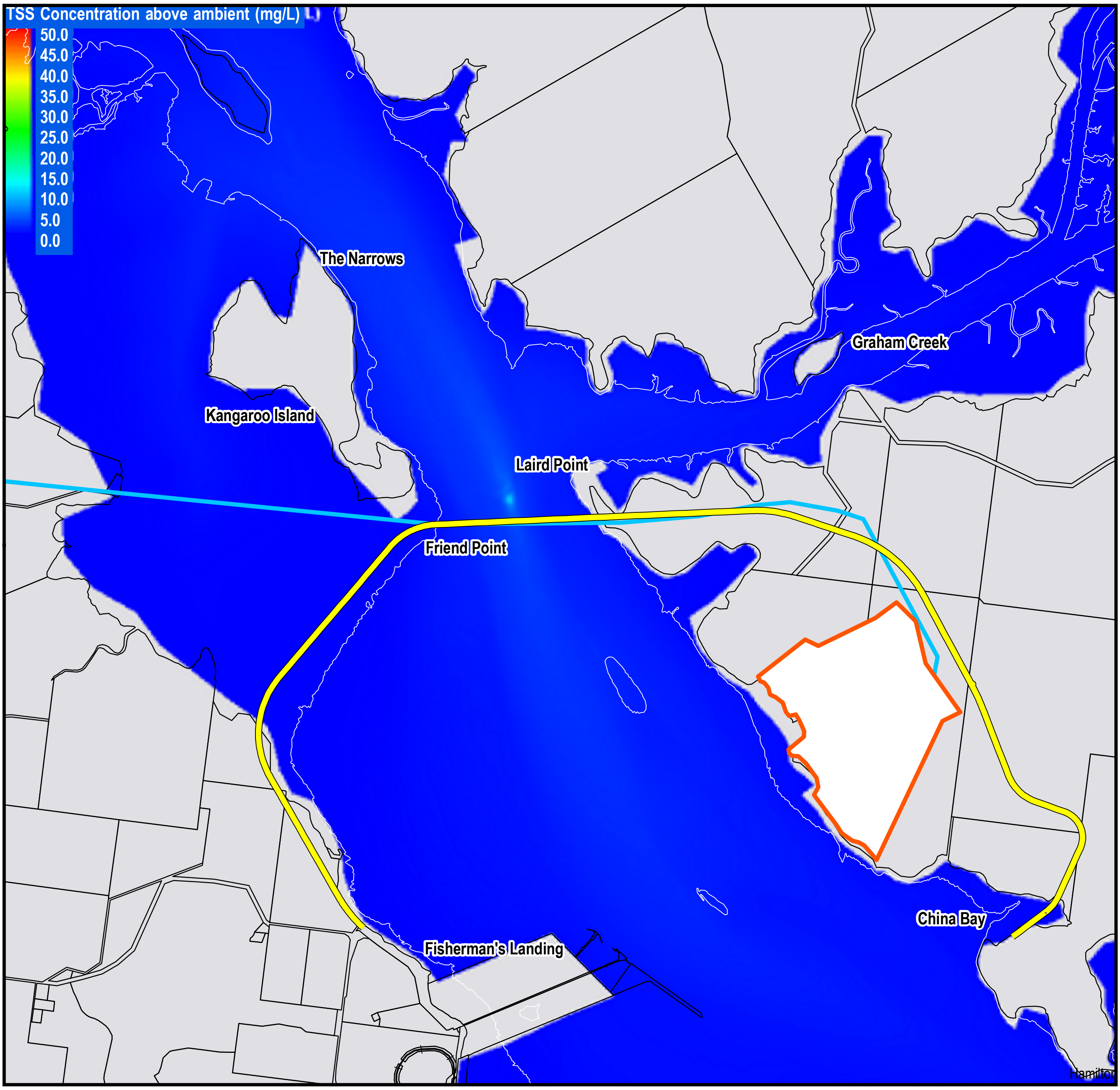

Legend

- Proposed QCLNG Site Boundary
- Proposed Export Pipeline
- Possible Curtis Island Road/ Bridge Corridor
- Swing Basin & Shipping Channel

Source Note:
BMT WBM Ltd 2009 Proposed BG LNG Facility EIS Marine Water Quality Assessment Unpublished R.B 17261.002.00.doc
Cadastral/Tenure Currency: August 2008, Department of Natural Resource and Water
Curtis Island Road/Bridge - Connell Wagner

Projection: UTM MGA Zone 56
Datum: GDA 94

0 0.5 1 2 km

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Project	Queensland Curtis LNG Project		
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Date	09.06.09	Revision 1	

Title **Average Total Suspended Solids Increases, Due to Pipeline Construction - Spring Tide**

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The impacts to seagrass will primarily occur during the construction phase due to seabed disturbance from earthworks to install infrastructure. The seabed disturbances will not only directly alter the seagrass density but suspended sediment may smother the seagrass or reduce light availability in the water column. At this stage of the assessment the spatial extent of seagrass to be disturbed from either clearing or sedimentation is unknown.

As outlined in *Section 8.3.2.2* the assemblages of seagrass species are important resources for a number of species, including fish, mammals and shorebirds. In the Port of Gladstone there has been long-term monitoring of seagrasses from 2002 to 2007, and in 2007 they became an annual inclusion in the PCIMP monitoring program. However, there is limited seagrass monitoring data in the direct vicinity of the LNG Facility. Seagrass assemblages are known to the south of Friend Point and the proposed Bridge and Pipeline crossing at The Narrows (refer to *Figure 5.8.9*)

As depicted by *Figure 5.8.9*, there is a substantial seagrass meadow in the area north of Fisherman's Landing, consisting of *Halophila sp* and *Zostera sp* assemblages[165]. This is the proposed area for land reclamation, using the dredge spoil, which will impact the seagrass in this immediate area. This is likely to have secondary impacts to the receiving marine environment, such as reduction of food source for grazing dugongs, and as a nursery area for juvenile fish. The spatial extent of the area to be reclaimed has not yet been fully determined. An assessment on the relative proportion of seagrass affected compared to the known seagrass areas in the Port of Gladstone has been discussed in *Volume 6, Chapters 2, 3* and *4*.

Mangroves

Estuarine environments of the Port of Gladstone include mangroves, saltmarsh and mudflat communities that are recognised for their value to fisheries production[166] and these environments receive a limited supply of fresh water. As outlined in *Section 8.3.2.2* mangroves are marine plants (trees and shrubs) that grow in the marine tidal zone.

Mangroves have the potential to be impacted during the construction and operation phases, attributed to vegetation clearing for the marine infrastructure. The degree of mangrove removal will be dependent upon the marine infrastructure, including approach pathways for the Bridge and Pipeline crossing, and construction method. The area of mangroves to be cleared will be minimised by micro-siting infrastructure so as to avoid the densest areas of mangroves[167]. Studies in 2005[168] recorded closed *Rhizophora sp* in the areas which will require approach pathways for the Bridge, Pipeline, MOF and Jetty. Given the extensive nature of mangroves in the area, the predicted impact

165 Danaher K F, Rasheed M A, and Thomas R (2005). ***The intertidal wetlands of Port Curtis***.

166 Danaher K F, Rasheed M A, and Thomas R (2005). ***The intertidal wetlands of Port Curtis***.

167 British Gas and Queensland Gas Company (2008). ***Queensland Curtis LNG Project Initial Advice Statement***.

168 Danaher K F, Rasheed M A, and Thomas R (2005). ***The intertidal wetlands of Port Curtis***.

from the Project is expected to be minimal and is characterised more fully in *Volume 6, Chapter 7*.

Other Benthic Habitats

A number of benthic habitats exist within the harbour and provide important habitat for a wide range of species. As outlined in *Section 8.3.2.4* predominant subtidal benthic habitats exist in the Port of Gladstone, and comprise of mudflats, saltmarshes, sandbanks and rocky substrate. Approximatelyone-third of the estuary is intertidal, next third shallow sub-tidal sandbanks (less than 5 m depth) and the remainder of the estuary consists of channels of a wide depth range (5 m to 21 m)[169].

During the construction of the Bridge, Pipeline, MOF and Jetty the earthworks and installation are likely to impact on the mudflats, sandbanks and rocky substrates. Once in the operation phase, the physical presence of the marine infrastructure is unlikely to cause impacts as the intertidal area will be re-established with tidal movement and inundation.

These habitats will be impacted upon during the land reclamation of the Fisherman's Landing area. The Fisherman's Landing area is dominated by exposed mud and sandbanks, which provide habitat substrate for other benthic habitats such as seagrass, invertebrates and juvenile fish and prawns[170].

Invertebrates

Invertebrates will be impacted during construction of the Bridge, Pipeline, MOF and Jetty due to seabed and intertidal disturbance from earthworks, resulting in reduced benthic habitat and suspended sediment entering the water column.

The physical presence of the marine infrastructure will provide artificial habitat for macroinvertebrates, which may result in a positive impact as it provides more substrate for macroinvertebrates to occupy, however it may have a follow-on impact if it alters where other organisms higher in the food chain obtain their food. Upon completion of the Project and during the decommissioning and rehabilitation phase the removal of artificial habitat may have reverse impact, by removing a well-established habitat for the invertebrate organisms. At the time of decommissioning further assessment will be completed to determine whether the marine infrastructure should be left in place or removed.

Invertebrates will also be impacted by the disposal of dredge spoil for the land reclamation in the Fisherman's Landing area. As this area is known to be a mudflat, sandbank and seagrass habitat, it is likely that the macroinvertebrates

169 Currie D R and Small K J (2006) ***The influence of dry-season conditions on the bottom dwelling fauna of an east Australian sub-tropical estuary***.

170 Danaher K F, Rasheed M A, and Thomas R (2005). ***The intertidal wetlands of Port Curtis***.

and invertebrate species will be affected. Due to the large extent of other mudflat and sandbank habitats it is likely that invertebrates will be re-established in these other areas.

Fish

Fish are highly mobile and inhabit a variety of habitats including, mangroves, seagrass and open water environments. Estuarine environments provide substantial refuge for fish, especially juvenile and nursery fish stocks. The impact from the marine infrastructure would initially relocate fish species during the construction phase, due to noise and possibly suspended solids. Primarily during the operation phase it would provide an artificial habitat for the fish species present in the Port of Gladstone. It is therefore possible that fish behaviour and interaction may alter due to the physical presence of the marine infrastructure, however it is expected that once this physical structure is inhabited by sessile organisms it will create an appealing artificial habitat for fish species to occupy.

Fish species, including two *EPBC Act* protected species (Whale shark and Green sawfish), have the potential to occur within or migrate through the area and are described in *Section 8.3.2.6*. However, these species are not expected to utilise the Port of Gladstone or areas immediately adjacent to the Project area.

A total of 33 Syngnathids (seahorse and pipefish) identified in the *EPBC Act* Protected Matters Report (refer to *Annex 5.3*) are occasionally associated with marine structures and potentially inhabit the seagrass communities within the Port of Gladstone. It is possible then the marine infrastructure is likely to provide artificial habitat for seagrass and therefore the potential to provide habitat for Syngnathids species.

The land reclamation of the Fisherman's Landing area is likely to impact the fish communities of Port of Gladstone. However, as these organisms are mobile it is likely that the preparation work will distract and direct the fish inhabiting the water column away from the area before bunding and spoil disposal commences.

Marine Mammals

The construction of the marine infrastructure will involve disturbance to the seabed, which will alter the immediate vicinity benthic habitat, seagrass and invertebrate communities. Given the extensive areas of seagrass, it is unlikely the marine infrastructure will result in such a loss of seagrass that would adversely impact dugong populations[171]. Proposed land reclamation of Fisherman's Landing and potential loss to a dense seagrass community is discussed in *Volume 6, Chapters 2, 3*, and *4*. The physical presence of the marine infrastructure may alter the movement of the dugongs, but primarily they will be influenced by feeding areas rather than avoidance of

171 British Gas and Queensland Gas Company (2008). **Queensland Curtis LNG Project Initial Advice Statement**.

infrastructure.

Marine mammals listed in the *EPBC Act 1999* and *NC Act 1992* are unlikely to occur in the Project area (refer to *Section 8.3.2.7*) as they are predominantly ocean migratory species. Two dolphin species may occur in the Port of Gladstone region, the Snubfin dolphin (*Orcaella heinsohni)* (previously listed as Irrawaddy dolphin, *Orcaella brevirostris)* and the Indo–Pacific Humpback dolphin *(Sousa chinensis).* Currently there is no published information available for either species in the Port of Gladstone region, and therefore likely impacts from the Project are unknown.

Marine Reptiles

Marine reptiles in the Port of Gladstone are turtles, sea snakes and crocodiles (refer to *Section 8.3.2.8*). It is unlikely that marine reptiles will be impacted during the construction or operation of the marine infrastructure.

There are no known turtle-nesting beaches close to the Project area. Although nesting areas are not near the Project area, turtles may be in transit and their behaviour or movement may be altered during the construction or operation of the marine infrastructure. In particular the physical presence of Project marine infrastructure may alter the course turtles take through the Port of Gladstone.

Fourteen species of sea snakes inhabit Queensland waters and it is likely that they may inhabit the Port of Gladstone area. Given the mobile nature of sea snakes and the fact the Project area has not been identified as important sea snake habitat, it is likely there is no impact to these species.

Seabirds and Shorebirds

The impacts to seabirds and shorebirds will occur during the construction of the marine infrastructure as the noise and activities will disturb and move the birds from the area. Impacts will also occur during operation when the marine infrastructure will be a physical structure. The physical presence of the marine infrastructure may alter the seabird and shorebird movement throughout the Project area. It is likely that the seabird and shorebirds will use the physical structures as artificial habitat for roosting, and they may also be affected by artificial light, as discussed in *Section 8.4.1.4*

The proposed crossing for the Bridge and Pipeline at The Narrows is adjacent to areas on the mainland known to be feed sites for shorebirds. Several threatened and significant species covered by the *NC Act* 1993 and *EPBC Act 1999* have been identified as potentially occurring in the Gladstone region. The Port of Gladstone region is recognised as an important staging area for a number of migratory bird species during their annual migration.

As noted previously, the area for the proposed land reclamation at Fisherman’s Landing is dominated by mudflats and sandbanks which are primary habitat and feeding grounds for shorebirds. GPC will undertake its own detailed assessment of impacts arising from placement of dredged material at Fisherman's Landing. Refer *Volume 6* for more detailed discussion.

Management and Mitigation Measures

There is an array of impacts on marine receptors and therefore implementation of a range of management strategies is under consideration to provide sufficient management of the potential impacts.

Management and mitigation measures specifically associated with dredging works are discussed in Volume 6.

Similarly, construction of the Bridge and associated access roads do not form part of the Project and management and mitigation measures associated with these items of infrastructure are recommendations only provided for information by QGC.

Management principles and practices being proposed include:

- conducting dredging, pipeline installation and other construction activities in a manner to minimise the extent and duration of sediment plumes which may otherwise be generated during the construction phase of the Project
- implementing procedures and policies in the areas of Environmental Management and Social Performance and Health and Safety, Security and Environment Management Systems (EMS) including the operation of Project-specific Health, Safety, Security and Environment (HSSE) construction and operations plans which form part of Quality Management Systems
- developing Environmental Management Plans (EMPs) prior to construction
- complying with or exceeding all applicable laws, regulations, advisory and industry standards, obtaining relevant permits and applying standards and codes of practice.

The following provides a selection of management options that further mitigates the effects of developing the permanent marine infrastructure:

- development of a Dredging Management Plan that includes the timing, duration and location of dredging activities to minimise the overall impact from dredging on marine receptors
- the Pipeline, Bridge, MOF and Jetty have been designed where possible to minimise impacts to intertidal habitats, by micro-siting and burying infrastructure using construction methods such as HDD
- land reclamation activities have been designed and will be managed to reduce the impact to benthic habitats and marine flora and fauna
- in conjunction with the GPC and other port users, QGC will support the broader monitoring programs established for the Port to monitor environmental changes in the marine environment
- during decommissioning of the physical structures, an assessment will be made at the time and best practices adopted.

Level of Risk

The probability of impact from the physical permanent infrastructure during all phases of the Project is predicted to be "high" or "medium". The potential significance of the predicted environmental impacts is also considered to be "high" or "medium". By adopting best practices and minimising impacts to the receiving environment during the phases of the Project the residual risk associated with physical infrastructure on marine receptors is considered to be "medium" to "low" (refer to *Table 5.8.17*).

Table 5.8.17 Risk Assessment Summary for Physical Permanent Structures

Aspect	Phase	Probability	Significance/Severity	Residual Level of Risk
Physical Presence – Permanent (Pipeline)	Construction	High	High	Medium
	Operation	Medium	Medium	Low
	Decommissioning	Low	Low	Low
Physical Presence – Permanent (MOF)	Construction	High	High	Medium
	Operations	Medium	Medium	Low
	Decommissioning	Low	Low	Low
Physical Presence – Permanent (Jetty)	Construction	High	High	Medium
	Operations	Medium	Medium	Low
	Decommissioning	Low	Low	Low

Although not proposed as part of this project, using the above methodology determines that the residual risk to the marine environment from construction of the bridge is 'medium'. Operation and decommissioning of the bridge have been gauged to be of low risk to the marine environment.

8.4.1.2 Physical Presence – Temporary

Sources and Characteristics

This section describes the environmental risk and impacts from temporary physical presence in the Project area, which is primarily associated with vessel activity. The construction, installation and operation phases of the LNG Facility and associated infrastructure will generate additional shipping movements for the transport of goods, services and employees within the Port area, as outlined in *Volume 2, Chapters 9* and *13*.

Table 5.8.18 Summary of Sources and Characteristics of Physical Presence – Temporary Impacts During Different Phases of the Project.

Project Component	Impact	Receptor	Construction	Operation	Decommissioning
Vessel Activity	Physical injury	Marine mammals	✓	?	?
		Marine Reptiles	✓	✓	✓
		Seagrass	✓	✓	✓
		Other benthic habitats	✓	?	✓
	Seabed damage	Seabed features	✓	✓	✓
	Re-suspension of sediments in vessel turning area		✓	✓	✓

Vessel Activity

Although considerable shipping already exists in Gladstone harbour, there is limited vessel movement in the immediate vicinity of the Project area. Increases in shipping traffic during construction and operation are likely to increase the risk of impact on the marine environment.

Vessels operating in the area during construction include supply vessels and barges, a pipe-lay barge (if pipeline is not installed by HDD), dredger and support vessels. During operations, supply vessels, LNG off-take tankers and passenger ferries will be utilising the Port facilities.

Vessels movements can be summarised as the following:

- barge/ferry to and from the construction docks/ferry terminals on the mainland and Curtis Island associated with the transportation of construction and operations equipment and personnel between the mainland and Curtis Island
- tug and pilot boat operation to support safe passage of LNG and LPG shipping; ship refuelling operations
- LNG ship operation, including disposal of ballast water
- butane ship operation, including disposal of ballast water
- any other associated shipping and navigational aids and activities.

The physical presence of vessels gives rise to a number of potential impacts:

- damage to seabed habitat through anchors and chains scouring and the increased risk of grounding or collision

- injury and fatality of marine fauna through vessel strikes
- re-suspension of sediments through vessel turning.

Extensive and long-term seabed damage can occur through the risk of grounding and collision. The current estimated risk associated with grounding/collision in the GBR and Torres Strait is 2 x 10-5 which is considered extremely low on a world scale. There are excellent shipping controls and navigation systems in place for the Port of Gladstone and therefore a low risk of collisions or grounding events[172].

The use of anchors and chains scouring is likely to cause physical disturbance to the seabed. This would be particularly damaging in areas of seagrass beds and soft sediments. However, LNG vessels will anchor within a dedicated LNG anchorage area in an extension to the bounds of the existing anchorage and pilot boarding area for the Port of Gladstone. This area is outside the GBRMP.

Vessel movements can disturb animals such as dugongs, marine turtles and cetaceans from their habitat, interfere with behaviouror result in injury or death as a result of boat strikes. [173] [174] Boat strike generally results when there is a large number of fast, small pleasure craft (e.g. less than six metres long) operating in shallow water. The depth of water may prevent the animals from avoiding the vessel. In comparison, LNG vessels are large and slow moving and will be under pilotage within the Port of Gladstone Pilotage Area. There are several species in the development area where there is potential for collisions between vessels and marine fauna particularly during construction and the initial increase in traffic. Marine mammals (whales, dolphins and dugongs) and marine turtles are particularly susceptible to vessel strikes.

Although there is high vessel traffic within the Port of Gladstone, there is limited vessel movement in the direct Project area. Marine animals in these areas are likely to be relatively undisturbed by vessel movements at present. The present risk of whale strikes for the GBR region is calculated at 3.16 x 10-4 per year, which is considered negligible given the amount of traffic. There are no figures for strikes of dolphins, which are likely to be more readily able to avoid vessels. Dugongs who are slow moving are more vulnerable to strikes in shallow areas with increases in vessel traffic [175] Likewise, marine turtles use shallow seagrass areas and although there are no nesting sites near the main Project activity area, turtles are known to forage and use the extensive seagrass beds close by and are likely to suffer disturbance or strikes.

Dredging activities also pose risks to marine turtles with fatalities caused by

172 Lloyds shipping QRA Gladstone Port, 2008

173 Hodgson A J, Marsh H (2007) **Response of dugongs to boat traffic: the risk of disturbance and displacement**.

174 Knowlton A R, Kraus S D (2001) Mor**tality and serious injury of northern right whales (*Eubalaena glacialis*) in the western North Atlantic Ocean**. J Cetacean Res Manage Spec Iss 2: 193–208

175 http://www.unep.org/dewa/reports/dugongreport.asp

hopper dredges using suction drag heads[176] [177] and incidental takes of sea turtles from cutter suction or other types of dredges. Other species that may be at risk from dredging include dugongs and sea snakes. Potential impacts on marine fauna from dredging are discussed in more detail in *Volume 6, Chapter 3*.

Receptors Affected

The following section presents the impact of the physical marine infrastructure to the identified marine receptors. As summarised in Table 5.8.15 the receptors discussed are:

- water quality
- seagrass and other benthic habitats
- marine mammals
- marine reptiles.

Water Quality

Disturbance of sediment from vessel activity (e.g. propwash) is also likely to affect water quality in relation to contaminants entering the water column. Although the vicinity of the Project area is not covered by published acid sulfate maps, there is a potential for acid sulfate soils which may generate acid water drainage if allowed to be oxidised.

Seagrass and Other Benthic Habitats

Damage to benthic habitats can occur due to vessel strikes or anchor and chain damage. A number of benthic habitats in the harbour may be at risk from anchor and chain use and vessel strikes. They vary in their sensitivity to damage; from soft silt sediments, rock substrates, sandy gravel and macro algae dominated seabeds. The most significant and sensitive are the extensive seagrass beds especially the Rodds Bay Dugong Sanctuary. At present monitoring shows that seagrass beds in the Project area are healthy.[178]

Marine Mammals

Physical interaction with vessels and marine mammals may cause localised and short-term behavioural changes as they attempt to avoid vessels.

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176 Plotkin PT (2003) Adult migrations and habitat use. In: Lutz PL, Musick JA, Wyneken J (eds) The biology of sea turtles, Vol II. CRC Press, Boca Raton, FL, p 225–241

177 http://www.unep.org/dewh/reports/dugongreport.asp

178 Wilson S P, Andersen L E and Melville F (2008). Port Curtis Seagrass Water Quality Data Report: December 2007 – April 2008. Centre for Environmental Management Faculty of Sciences, Engineering & Health Central Queensland University Gladstone QLD.

This can result in injury or fatality for whale species[179] . However, as described in *Section 8.3.2.7* no whale aggregation areas are in the Project area. It is highly unlikely that there are whales at the development site. The bulk of construction occurs on the west side of Curtis Island limiting contact with whales and risk of interaction with vessels. There is then a low risk of whale collisions.

Two dolphin species, the Snubfin and Indo-Pacific are thought to occur in Port waters, however there are no published studies on their populations. Dolphins are more likely to be able to avoid vessels due to their highly mobile nature.

During construction interaction between vessels and dugongs is likely. Behavioural changes are possible and collisions and boat strikes are recorded in other areas[180]. Any fatalities are likely to impact the population locally[181]. Reduced vessel speeds and marine mammal watches will reduce and avoid impacts of vessel presence on dugongs. During operations the probability of vessel strike is reduced due to fewer vessels than in construction phase.

Turtles

Six species of turtle use the Project area with three known to breed in the area; the Flatback, Loggerhead and Green turtles. No known nesting beaches exist close (within 5 km) to the Facility. However, green turtles are regularly sighted in seagrass meadows on the eastern side of Curtis Island. Flatback turtles especially use soft-bottom habitat[182] and may be found in the shipping channel of the Port of Gladstone. The most likely impact on marine turtles is expected to occur during construction with dredging and increased vessel movements. Dredging can also pose risks to marine turtles with fatalities caused by hopper dredges using suction drag heads[183]. No incidental takes of sea turtles from cutter suction or other types of dredges have been recorded. However, dredging is likely to result in a localised risk. The dredge program for the LNG Facility may occur for two to three years and therefore may affect the following for nesting species:

- resident foraging juvenile adults, Green and Flatback, year round
- migratory male and female and breeding Loggerhead, Green and Flatback during operations
- post hatchlings

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179 Knowlton A R, Kraus S D (2001) Mortality and serious injury of northern right whales (Eubalaena glacialis) in the western North Atlantic Ocean. J Cetacean Res Manage Spec Iss 2: 193–208

180 Hodgson A J, Marsh H (2007) Response of dugongs to boat traffic: the risk of disturbance and displacement. Journal of Experimental Marine Biology and Ecology 340:50–61.

181 www.unep.org

182 Plotkin PT (2003) Adult migrations and habitat use. In: Lutz PL, Musick JA, Wyneken J (eds) The biology of sea turtles, Vol II. CRC Press, Boca Raton, FL, p 225–241

183 Dickerson D, Wolters M, Theriot C, and Slay C (2004). Dredging impacts on sea turtles in the Southeastern USA: A historical review of protection .In Csiti, A. ed. Proceedings of the World Dredging Congress XVII: Dredging in a Sensitive Environment, Hamburg, Germany, 27 September 1 October 2004. World Dredging Conference, October 2004, Germany.

- Females may be sensitive to disturbance from vessels and especially dredging with impacts recorded as mortality, increased stress and reduced fecundity. The consequences would be loss of females from breeding populations and reduction in nesting success[184].

Management and Mitigation Measures

Management and mitigation measures to minimise the impacts of vessel movements, especially during construction activities (e.g. dredging) may include the following:

- Vessels will abide by Port of Gladstone vessel speed restrictions and exclusion zones, in particular within DPAs.
- Navigation permitting, vessels will take the most direct route.
- Vessels will minimise unnecessary movements, such as use of thrusters, to avoid sediment disturbance.

Further detailed discussion of risk mitigation measures for dredging activities are discussed in *Volume 6, Chapter 4*.

Level of Risk

Impacts are likely to be higher during construction with the dredging program and subsequent increase in vessel traffic and are considered to be of "medium" risk to marine receptors. Population-level impacts through vessel strikes to marine fauna are unclear. Seabed damage is unlikely with plans and controls in place in the Project area. Impacts from vessel turning are likely to be low in sensitive areas such as seagrass beds (refer to *Table 5.8.19*).

Table 5.8.19 Risk Assessment Summary for Physical Temporary Structures

Aspect	Phase	Probability	Significance/Severity	Residual Level of Risk
Vessel Activity	Construction	Medium	Medium	Medium
	Operations	Medium	Medium	Medium
	Rehabilitation and Decommissioning	Low	Low	Low

8.4.1.3 Underwater Noise

The definition of sound level depends on a number of factors, including the intensity of the sound wave, the frequency and the length of the sound exposure, and whether the sound is propagating in air or in water. Sound is

184 Heppell S S, Snover M L and Crowder L B 2003. Sea turtle population ecology. pp 275–306, In P L Lutz , J A Musick, and J Wyneken (Eds.). The Biology of Sea Turtles Vol. II. CRC Press, Boca Raton, FL. 496 pp.

transmitted more efficiently through water, compared to air, and can therefore be detected at much greater distances from the source. The standard scientific approach is to describe underwater noise levels in terms of sound pressure. While a decibel (dB) is a relative measure of sound level, in order to make this measure meaningful for underwater noise, it is referenced to a standard 'reference pressure' of 1 µPa (dB re 1 µPa). Underwater noise is also measured over a specified frequency, usually either a 1 Hz bandwidth (expressed in dB re 1 $\mu Pa^2/Hz$), or over a broadband that has not been filtered. Where the frequency has not been expressed, it may be assumed that the measurement is a broadband measurement.

Underwater noise impacts associated specifically with dredging are addressed further in Volume 6.

Sources and Characteristics

Noise will be produced from various sources during all phases of the Project. *Table 5.8.20* outlines sources of noise from Project components during the different phases of the Project.

Table 5.8.20 Summary of Sources and Characteristics of Noise Impacts During Different Phases of the Project.

Project Component	Impact	Receptor	Construction	Operation	Decomm.
Bridge and Pipeline Crossing of The Narrows (Trenching or HDD for Pipeline) (Pile Driving for Bridge Supports)	Disturbance, causing behavioural changes or displacement Masking of biologically important sound Injury to hearing or other organs Indirect behavioural or physical changes in predator or prey species	Marine mammals Fish Marine Reptiles (Turtles)	✓		
MOF (Dredging and Pile Driving)	As above	As above	✓		
Loading Jetty (Dredging and Pile Driving)	As above	As above	✓		
Vessel Activity	As above	As above	✓	✓	✓

Construction and installation of the MOF and Loading Jetty may require dredging and pile driving depending on the location and the structures chosen for the facilities. Both of these activities will provide a source of underwater noise. In addition, dredging may be required for trenching of the Pipeline crossing between the mainland and Curtis Island (although trenchless techniques such as HDD are being considered).

Dredging

The sound produced from dredging activities may be detectable above background levels for a considerable distance from the source. The frequency and level of sound produced during dredging activities will depend on the type of dredge used. As with ship noise, most of the sound energy is at low frequencies below 500 Hz, but mid-frequency (1,000 Hz) tones may be generated by the operating machinery and sound emissions may extend up to 10 kHz[185] [186]. Operating dredges will emit sound at their maximum source levels, which are in the 180 dB to 190 dB range at 1 m from source[187] [188]. *Table 5.8.21* provides some examples of sound levels and frequencies produced by various dredge types. Refer also Volume 6 Chapter 3.

Table 5.8.21 Typical Sound Levels Produced by Dredges[189] [190]

Dredge Type	Frequency Range (Hz)	Distance from source (m)	Peak Sound Level (dB)	Approximate Frequency of Peak (Hz)	Comment
Cutter Suction	Broadband	1	180	100	
	Broadband	1	177	80–200	
	20–1,000	190	133		
	20–1,000	200	140		
Cutterhead	70–1,000		100–110		Inaudible at 500 m
Hopper	Broadband	1	188	10	
	20–1000	430	138		Loading
	20–1000	930	142–177		
	20–1000	1,500	131		Dumping
	10–2000	2,000	127		
	10–2000	5,000	120		
	10–2000	9,000	110		

185 Richardson W J, Würsig B and Greene, C R (1990) Reactions of Bowhead Whales, Balaena mysticetus, to drilling and dredging noise in the Canadian Beaufort Sea.

186 Richardson W J, Greene, C R, Malme, C I and Thomson, D H. (1995) Marine Mammals and Noise.

187 Richardson W J, Greene, C R, Malme, C I and Thomson, D H. (1995) Marine Mammals and Noise.

188 Simmonds, M.P., Dolman, S. and Weilgart, L. (eds). 2004. Oceans of Noise: A WDCS Science Report.

189 Richardson W J, Greene, C R, Malme, C I and Thomson, D H. (1995) Marine Mammals and Noise

190 Simmonds, M.P., Dolman, S. and Weilgart, L. (eds). 2004. Oceans of Noise: A WDCS Science Report.

HDD

If HDD is the chosen method for installation of the Pipeline crossing between the mainland and Curtis Island, then noise and vibrations will be emitted to the marine environment from the rotating drill head in the substrate below sea level. The level of noise produced will depend on the substrate type, amount of drilling lubricant used, depth of drill bit, and coupling of the substrate to the seawater. Where soft sediment overlies the substrate being drilled, the coupling of the sub-surface drill noise into the seawater can be expected to be reduced and to attenuate high frequencies rapidly.

HDD equipment will be located onshore and will therefore provide a source of airborne noise to the surrounding area. Noise from the onshore equipment may be audible underwater depending on distance of the equipment from the waterline.

The contribution of HDD to underwater noise from Project activities will be short term during construction and is expected to be less than the noise contributed by vessels.

Pile Driving

A Loading Jetty will be constructed to provide berthing for LNG tankers and propane ships, with facilities for loading LNG and unloading propane. The Jetty is expected to consist of a driven-pile trestle structure. A MOF will be installed for transfer of supplies from the mainland to Curtis Island during the construction phase. The MOF may also require pile driving (sheet piles) for installation. In addition, pile driving may be required for installation of supports for the Bridge crossing.

Where pile driving is used to install Jetty/MOF facilities, the hammering sounds produced will generate underwater sound pulses. Sound pulses from pile driving have been reported with received levels to 135 dB re 1 μPa at a distance of 1 km from the source, with peak frequencies in the 50 Hz to 200 Hz band and an audible range extending to 10 km to 15 km[191]. A 2002 study of pile driving operations (to construct a new Australian Defence Force wharfing area in Twofold Bay, Eden, NSW) recorded an average mean-squared pressure of 167 dB re 1 μPa (at 300 m from the operation), falling to 145 dB and 136 dB re 1 μPa at 1.8 km and 4.6 km respectively[192]. Curve-fitting of nine sets of measurements indicated that average signal strength fell from 150 dB to 140 dB re 1 μPa between 1 km and 3.1 km from the operation.

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191 Richardson W J, Greene, C R, Malme, C I and Thomson, D H.(1995) Marine Mammals and Noise

192 McCauley R, Maggi A, Perry M & Siwabessy J 2002, *Analysis of Underwater Noise*

Vessel Activity

Vessels associated with construction and operation of the Project will include installation, supply and support vessels, LNG tankers, propane ships and passenger ferries. Supply barges/ferries will operate between the mainland and Curtis Island for the transportation of construction and operations equipment and personnel. Tugs and pilot boats will be required to support safe passage of LNG and propane shipping in the Port.

Individual shipping routes outside the Port of Gladstone through the GBRMP will vary, with movement of LNG ships through the GBRMP undertaken within approved shipping zones. In general, ships will follow the most direct route between Capricorn Channel and Gladstone Sea Buoy, considering depth of water, obstructions, and zone use restrictions.

Vessel noise varies with the size, speed, and engine type of the vessel and its activities (refer to *Table 5.8.3*). Smaller, faster vessels typically produce higher-frequency sound at lower source levels than large, relatively slow-moving ships. The sound level from a given vessel is also highly dependant upon its speed, declining rapidly as a vessel slows from its normal cruising speed. The particular activity being conducted by the vessel also greatly influences the noise characteristics, for example, if it is idle, holding position using bow thrusters, or accelerating.

Under normal operating conditions when a vessel is idling or moving between sites, vessel noise would be detectable only over a short distance. In contrast, the noise from a vessel holding its position using bow thrusters and strong thrust from its main engines may be detectable above background noise levels for significant distances. Other sources of noise will be onboard cranes, compressors and generators. Shipboard sound will be transmitted as continuous broadband sounds through the hulls of the vessels[193].

Small shipping vessels (such as support vessels) generally have sound emissions dominated by low-frequencies below 1 kHz[194]. Broadband source levels for most small ships underway are approximately 170 to 180 dB re 1µPa, and drop with reduced speed[195][196]. Noise from the LNG tankers is likely to be dominated by lower frequencies (less than 100 Hz) with source levels of 180 to 190 dB re 1µPa (refer to *Table 5.8.3*).

193 Sakhalin Energy. 2003. Western Gray Whale Environmental Impact Assessment.

194 Simmonds, M.P., Dolman, S. and Weilgart, L. (eds). 2004. Oceans of Noise: A WDCS Science Report.

195 Richardson, W.J., Greene, C.R., Malme, C.I. and Thomson, D.H.(1995). Marine Mammals and Noise.

196 Simmonds, M.P., Dolman, S. and Weilgart, L. (eds) (2004) Oceans of Noise: A WDCS Science Report.

Extent of Impact

Construction Phase

A large proportion of the underwater noise generated by Project activities will occur during the construction phase, from the increased volume of vessel traffic and installation of the Jetty and MOF.

The impulsive nature and high level of noise produced by pile driving during construction may result in significant disturbance and potential injury to marine animals close to the activity if it is required in the installation of the Jetty and MOF. This activity is expected to be temporary and of limited duration.

Specific information on the levels of noise that will be emitted from dredging activity is unavailable. However, given the number of shipping movements within the Port of Gladstone and the usual program of maintenance dredging to maintain navigable channels, it is unlikely that the addition of noise from Project-related dredging will result in a substantial change to marine animal behaviour within the vicinity of the Port. Similarly, the incremental increase in noise from vessel activities above normal shipping levels in the Port of Gladstone during construction is not expected to result in a detectable impact.

Operations Phase

The LNG Facility at full production is expected to increase vessel movements into the Port of Gladstone by approximately 2.5 per cent. However, vessels will not be expanding shipping into new areas outside of those already designated for shipping and thus an additional noise source disturbance will not be introduced into any new areas. The greatest source of noise is likely to come from the simultaneous use of thrusters by support tugs and tankers to position on the Jetty. Generation of this level of noise, however, will only occur for short periods.

Description of Impact

The use of underwater sound is important for marine animals, particularly cetaceans, to navigate, communicate and forage effectively.

Underwater noise produced from Project activities may therefore impact on marine animals in the following ways:

- disturbance, leading to behavioural changes or displacement
- masking or interference with other biologically important sounds such as vocal communication or echolocation pulses (used by certain marine mammals for location of prey and other objects)
- physical injury to hearing or other organs (for extreme levels of noise)
- indirectly by inducing behavioural and physiological changes in predator or prey species.

The extent of the impacts of underwater noise from Project activities on marine animals will depend upon the frequency range and intensity of the noise produced, and upon the hearing, vocalisation and other biological characteristics of the animals affected. The effects of sound have mostly been studied in cetaceans, with much less known about the effects of sound on other groups of animals.

Direct studies of hearing in marine animals are limited to a few species. Where direct measurements of hearing are inadequate, vocalisation frequencies can provide an idea of hearing sensitivities, i.e. it is likely that marine animals have particularly sensitive hearing for sound frequencies that are the same as their social calls and echolocation clicks[197]. Vocalisation frequencies also indicate the range of noise frequencies from Project activities with the potential to mask or interfere with communication or echolocation.

The level of behavioural response and stress caused by development noise may decrease with habituation. Consequently, marine animals will often approach or remain near to a noise source even if the level of noise exceeds that at which behavioural changes have been observed to occur.

Receptors Affected

Marine Mammals

Marine mammals that are likely to be present in the vicinity of the Project development area in the Port of Gladstone are discussed in *Section 8.3.2.7.* Other than dolphins and dugongs, the remaining marine mammal species (baleen and large-toothed whales) are not expected to occur close to the Project and construction sites as they primarily occur in coastal waters. Noise impacts on these species are therefore not discussed further in this section.

Underwater sound is used by cetaceans for effective navigation, communication and foraging. Research has indicated that toothed whales, including dolphins, are most sensitive to sounds above approximately 10 kHz[198]. Bottlenose dolphins may detect sounds at frequencies as low as 40 Hz to 125 Hz. However, below ~10 kHz sensitivity deteriorates with decreasing frequency and below 1 kHz, sensitivity appears to be poor. Studies have indicated that because of the efficient transfer of sound in water, dolphins can detect vessels, for example, at distances up to approximately 5 km[199].

197 Simmonds, M.P., Dolman, S. and Weilgart, L. (eds). 2004. Oceans of Noise: A WDCS Science Report.

198 NRC (2003) Ocean Noise and Marine Mammals

199 Richardson, W.J., Greene, C.R., Malme, C.I. and Thomson, D.H. (1995) Marine Mammals and Noise.

Very little research has been undertaken to investigate the sensitivity of dugongs to noise. Dugongs are reported to have relatively low-level underwater vocalisations[200]. Dugongs produce sounds (described as whistles, chirps and chirp-squeaks) in the middle frequencies (1 kHz to 8 kHz)[201].

Table 5.8.22 and *Table 5.8.21* provides a comparison of sound frequencies expected from noise produced by Project activities and the frequencies utilised by marine mammals.

Table 5.8.22 Sound Frequencies and Source Levels Expected from Project Noise Compared with Frequencies Utilised by Marine Mammals[202 203 204]

Source	Frequency Range (Hz)	Peak Sound Pressure at 1 m from source (unless otherwise stated) (dB re 1μPa)
Toothed whales (vocalisation)	500–25,000	–
Toothed whales (echolocation)	12,000–130,000	–
Dugongs	1,000–8,000	–
LNG tanker	<100	180–190
Support vessels	<1,000	170–180
Cutter suction dredge	20–500 (with tones to 1,000)	180
Hopper dredge	20–1,000	188
Pile driving	50–200	170–220 (10 m)

200 NRC (2003) Ocean Noise and Marine Mammals.

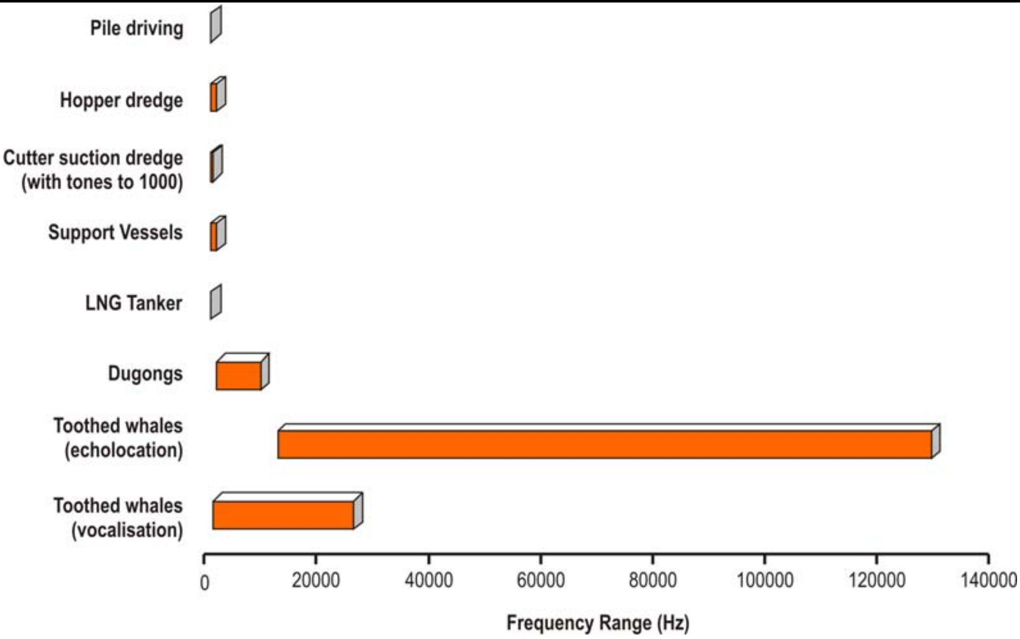
201 Richardson, W.J., Greene, C.R., Malme, C.I. and Thomson, D.H. (1995) Marine Mammals and Noise.

202 Richardson, W.J., Greene, C.R., Malme, C.I. and Thomson, D.H. (1995). Marine Mammals and Noise.

203 Simmonds, M.P., Dolman, S. and Weilgart, L. (eds). (2004) Oceans of Noise: A WDCS Science Report.

204 Hastings, M.C. and Popper, A. (2005). Effects of Sound on Fish. Final Report # CA05-0537. Project P476 Noise Thresholds for Endangered Fish. .

Figure 5.8.19 Sound Frequencies Expected from Project Noise Compared with Frequencies Utilised by Marine Mammals



Observed disturbance responses to anthropogenic sound in marine mammals include altered swimming direction; increased swimming speed including pronounced startle reactions; changes to surfacing, breathing and diving patterns; avoidance of the sound source area, and other behavioural changes[205]. The occurrence and intensity of such responses are highly variable and depend on a range of factors relating to the organism and situation[206].

Auditory masking of natural noise from noise produced by Project activities has the potential to interfere with communication and socialisation, the detection of predators and prey, navigation and orientation.

The amount by which the intensity of a sound must exceed the background noise to be audible to an organism is called the critical ratio. Critical ratio varies with frequency and tends to increase with increasing frequency. Man-made noise will only mask a natural acoustic signal if its frequency is in a critical bandwidth around the frequency of the signal; noise outside this range has little effect[207]. Impacts from masking of biologically important noise are likely to result mostly from sustained noise sources from the development, and not from impulsive sources such as pile driving.

As shown in *Table 5.8.22,* toothed whales generally hear and communicate at frequencies above those of the noise sources that will result from Project activities. They are therefore unlikely to be affected by auditory masking.

205 NRC (2003) Ocean Noise and Marine Mammals.

206 NRC (2003) Ocean Noise and Marine Mammals.

207 Richardson, W.J., Greene, C.R., Malme, C.I. and Thomson, D.H. (1995) **Marine Mammals and Noise**.

Physiological damage from noise, such as hearing loss, is only likely to result from proximity to intense sound from high-energy sources, and may be temporary or permanent. Animals are generally most vulnerable to temporary hearing loss at frequencies near those of their peak hearing sensitivity. The threshold peak impulse sound pressure that may result in direct physical trauma in marine mammals is generally considered to be greater than 200 dB re 1μPa[208]. Possible implications of hearing loss include a reduced ability to communicate with other members of the species, to detect predators and prey, and in the case of cetaceans and other marine mammals that echolocate, to detect objects in the environment.

The highest intensity sound produced by Project activities is likely to occur from pile driving during construction of the Jetty/MOF. If percussive pile driving is used then sound levels could exceed thresholds that may result in physical injury to marine mammals close to the activity. However, marine mammals are highly mobile and are likely to avoid areas of loud noise.

Fish

Fish species, including two *EPBC Act* protected species (Whale shark and Green sawfish), found in the Port of Gladstone area are described in *Section 8.3.2.6*. Given that Whale sharks are generally found in offshore waters, this species is not expected to occur close to the Project. However, Green sawfish may inhabit the waters adjacent to the Project.

Fish hearing sensitivity is a function of the inner ear, specialised auditory structures and swim bladder (a gas-filled internal organ used to control buoyancy). Cartilaginous fish (sharks and rays) lack a swim bladder and are considered less sensitive to sound than bony fishes. Fish may use sound to communicate, locate prey, detect predators, and as a cue for orientation[209]. Fish vary widely in their vocalisations and hearing abilities even within families, but hear best at low frequencies (below 1 kHz)[210].

Fish have been shown to respond to high levels of man-made noise by changing schooling behaviour, moving away from the source of noise or by becoming stunned and disoriented. Intense sound wave vibrations (blasting or piling) can cause fish swim bladders and auditory structures to be damaged or destroyed. In a review of the impact of sound impulses on fish species, it was recommended that pile driving should not exceed peak sound pressure level of 208 dB re 1 μPa and a sound exposure level of 187 dB re 1 μPa^2-sec in any one strike in order to avoid injury to fish[211].

208 Richardson, W.J., Greene, C.R., Malme, C.I. and Thomson, D.H.(1995) Marine Mammals and Noise.

209 McCauley, R.D., and Cato, D.H. (2000). Patterns of Fish Calling in a Nearshore Environment in the Great Barrier Reef.

210 Ladich, F. (2000). Acoustic Communication and the Evolution of Hearing in Fishes.

211 Popper, A.N., Carlson, T.J., Hawkins, A.D., Southall, B.L. and Gentry, R.L. (2006). Interim Criteria for Injury of Fish Exposed to Pile Driving Operations***: A White Paper***.

Turtles

Six species of marine turtles may occur in or around the Project area, with three of these species (Flatback, Green and Loggerhead turtle) known to nest on beaches in the Port of Gladstone region.

There is little information available in relation to noise impacts on turtles. Turtles have been shown to respond to low-frequency sound, with indications that they have the highest hearing sensitivity in the frequency range 100 to 700 Hz[212]. Reported responses of turtles to high levels of man-made noise include increased swimming activity and erratic swimming patterns. Thegreatest potential for disturbance to turtles is likely to occur if high levels of Project-related noise are generated in the vicinity of mating and nesting grounds. As nesting beaches are located on the eastern side of Curtis Island and Facing Island, greater than 5 km from the Project, noise impacts are expected to be negligible.

Shorebirds

Shorebirds may be affected by atmospheric noise and vibrations produced during HDD activities (if this is the chosen method for installation of the Pipeline crossing between the mainland and Curtis Island), pile driving and vessel activities. There are recognised shorebird feeding and roosting sites on the mainland in the vicinity of The Narrows crossing route (refer to *Figure* 5.8.11). Disturbance of shorebirds by noise from Project activities may lead to temporary behavioural changes and displacement from feeding and roosting habitat.

Management and Mitigation Measures

Management and mitigation measures to minimise the impacts of underwater noise from Project activities may include the following:

- Construction activities (for example, dredging, HDD, pile driving) will be undertaken in as short a timeframe as practicable to minimise disturbance.
- The requirement for an exclusion zone for percussive piling activities may be evaluated when more information on construction methods are available.
- Vessels will abide by Port of Gladstone speed restrictions.

Level of Risk

The levels of underwater noise that are expected to occur from Project activities during all phases of the development are not expected to cause significant impacts to marine animals. The sensitive receptors are generally highly mobile (enabling them to avoid the immediate vicinity in which noise levels are high). Some temporary behavioural effects such as displacement

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212 Bartol SM, Musick JA. **Sensory biology of sea turtles**. In: Lutz PL, Musick JA,Wyneken J, editors. The biology of sea turtles, volume II. Boca Raton, FL: CRC Press; 2003. p. 79–102.

may occur. However, given the current number of shipping movements and other noise-generating activities in the Port of Gladstone, the incremental increase in impacts from Project-generated noise is expected to be "low" (refer to *Table 5.8.23*).

Table 5.8.23 Risk Assessment Summary of Noise

Aspect	Phase	Probability	Significance/Severity	Level of Risk
Noise	Construction	Low (2)	Medium (3)	Low
	Operations	Low (2)	Low (2)	Low
	Rehabilitation and Decommissioning			

8.4.1.4 Light

This section provides an assessment of the impacts of artificial light on receptors in the marine environment emanating from the LNG Marine Facility and associated infrastructure. A general light impact assessment is provided in *Volume 5, Chapter 16*.

Given the preliminary stages of LNG Facility lighting design this assessment is based on the assumption that industry standard lighting design is implemented for the Project.

Sources and Characteristics

Artificial light sources and their particular characteristics will be present throughout the phases of the Project (construction, operation and decommissioning) The effects on marine receptors in the Project area will differ according to the particular receptor considered and in reference to the location of light source as well as intensity and wavelength of the light.

LNG Marine Facility

The LNG Marine Facility will normally be in operation on a continuous basis (24-hour operation) and lighting will create light spill.

Flaring of gas, a potential source of light, could also disturb marine fauna and will occur during commissioning; periods of process shutdown and start-up and in emergency conditions.

Bridge and Pipeline Crossing of The Narrows

Lighting will be required on the Bridge during construction and operations for vessel navigation and traffic movement. The indicative height of the proposed Bridge of The Narrows is 20.5 m, and overall length 1,500 m. Some lighting may be required during the construction of the Pipeline crossing.

Materials Offloading Facility

The MOF will require lighting during all phases of the Project.

Loading Jetty

The loading Jetty will have requirements while LNG loading/LPG loading is ongoing. These are as follows: approximately 150 Lux for loading arms during loading operations; approximately 20 Lux along the Jetty while operating, plus navigation lights at all times; approximately 10 Lux along the approach to the dock while operating.

At other times lighting on the Jetty will be appropriate to mitigate navigation hazard.

Vessels

Vessels associated with construction and operation of the Project will include installation, supply and support vessels, LNG tankers, propane ships and passenger ferries. Vessel activity will vary depending on the particular phase of the Project. Vessels transiting at night will require navigation lights and additional lighting when loading/offloading materials and during LNG loading operations at night. This source of lighting is expected to be intermittent and generally in motion.

Extent of Impact

The impacts of artificial light are expected to occur throughout all phases of the development, but will vary according to the level of activity.

Construction Phase

Construction areas for the LNG Marine Facility will be lit for safety and security and vessels involved in construction activities (barges etc.) will be lit for navigation. The extent, intensity and location of light spill are likely to vary with different stages of construction.

Any increase in light spill from vessel activities above normal shipping levels in the Port of Gladstone during construction is expected to be incremental and not result in a detectable impact.

Operations Phase

The primary source of light during the operations phase is expected to emanate from the LNG Facility, Loading Jetty and MOF. Some light will also occur from transiting vessels. However, light spill from vessels is expected to be incremental to current levels in the Port of Gladstone and will be intermittent in nature.

Description of Impact

Marine fauna that use visual cues for orientation, navigation, or other purposes may be disoriented by, attracted to, or repelled by artificial light sources. Impacts from artificial lighting associated with the Project may include the following:

- disorientation, attraction or repulsion
- disruption to natural behavioural patterns and cycles
- physical damage to eyes.

Behavioural responses to light can alter foraging and breeding activity in turtles, seabirds, fish and dolphins, conferring competitive advantage to some species and reducing reproductive success and/or survival in others. The effects on marine fauna of increased artificial lighting are dependent on the intensity and wavelength of the light. It also depends on the extent to which light spills into areas that are significant for breeding and foraging, the timing of overspill relative to breeding and foraging activity and the resilience of the fauna populations that are affected.

Receptors Affected

The identification of light-sensitive receptors is based on documented knowledge of light impacts in conjunction with the knowledge of the species expected to inhabit or migrate through the proposed Project area.

With the exception of birds and marine turtles, the general study of light pollution and its effects on fauna is a relatively new discipline[213]. As such most published studies do not specifically address artificial lighting impacts, making it difficult to conduct comprehensive literature reviews on the subject. This paucity of literature is noted within the description of each receptor below.

A detailed impact assessment on light-sensitive receptors is described in *Volume 5, Chapter 16* which includes visibility mapping methodology used in the impact assessment process. Visibility mapping or viewshed analysis works on the premises of line of sight and is best used to determine the potential impacts of light spill. The viewshed analysis describes the total area of visibility of an object based on the object height, observer height, and the surrounding topography. Combined with the habitat mapping, the viewshed analysis also defines a map of where light spill is likely to occur, and the potential visibility for sensitive marine fauna.

This following section presents the extent of the impact of light to the identified marine receptors with consideration of the viewshed analysis as described in *Volume 5, Chapter 16.* The receptors discussed are:

- marine reptiles

213 Rich and Longcore (2006) Ecological Consequences of Artificial Night Lighting.

- seabirds and shorebirds
- fish
- marine mammals.

Marine Reptiles

Artificial lighting has been linked to disorientation primarily in marine turtles, particularly during periods of nesting and hatching[214] as they have a tendency to orientate towards brightness[215]. Artificial lighting may affect other reptiles (sea snakes and crocodiles) in the Project area, but it is largely unknown as to the level and extent of the impact. It is assumed that for reptiles, other than marine turtles, impacts will be minimal and largely related to changes in behaviour. Sea snakes may be attracted to well-lit areas around infrastructure (e.g. jetties) due to the associated attraction of prey species (e.g. fish).

Six species of marine turtles may occur in or around the Project area, with three of these species (Flatback, Green and Loggerhead turtle) known to nest on beaches in the Port of Gladstone region. Of the nesting beaches identified to exist nearby the Project, based on the visibility mapping, none are expected to be subjected to light spill (refer to *Volume 5, Chapter 16*). Therefore lighting impacts on turtle-nesting behaviour and hatchlings is not discussed further.

Adult and juvenile marine turtles use shallow seagrass areas and are known to forage and use the extensive seagrass beds close to the Project area and are likely to be disrupted by artificial lighting. Examples of the most disruptive light sources include fluorescent, metal halide and mercury vapour, flares (no moonlight). Least disruptive light sources include low-pressure sodium vapour lights and flares (with moonlight) (refer to *Table 5.8.24*).

Table 5.8.24 Disruptive Light Sources to Marine Turtles

Parameter	Most Disruptive	Least Disruptive
Light	White lights	Yellow light (less atmospheric scatter than white lights)
Wavelength	Short wavelength light	Long wavelengths (moonlight, orange and red lights)
Colour emissions	Blue/green emissions	Yellow emissions (less glow and scatter)

214 Salmon M (2003). Artificial Night Lighting and Sea Turtles.

215 Witherington B E and Martin R E 1996. ***Understanding, Assessing, and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches.*** *Florida Marine Research Institute (FMRI) Technical Report*

With each nesting beach expected to remain in darkness, nesting adult marine turtles are not expected to be impacted by artificial illumination from the proposed infrastructure. However, the ambient glow, combined with the existing surrounding light sources, has the potential to affect marine turtle hatchlings. Any increased glow on the horizon inland of a nesting area has the potential to result in both misorientation and disorientation of hatchlings. It should be noted that glow is currently generated by the Port of Gladstone. Light emissions (and any cumulative glow) generated by the Project, and any other proposed development nearby, installed inland of turtle-nesting beaches should be considered as part of the future plans for the entire development area of the Port.

Seabirds and Shorebirds

There is evidence that seabirds and migrating birds are subject to disorientation from artificial light[216]. Birds may either be attracted by the light source itself or indirectly as lighted structures in coastal and marine environments tend to attract marine life at all trophic levels, creating food sources and shelter for seabirds. The light from the LNG Marine Facilities, including flares, and associated infrastructure (MOF, Loading Jetty, Bridge/Pipeline crossing) may also provide enhanced capability for seabirds to forage at night. Potential adverse impacts to seabirds attracted by artificial lighting include collisions with infrastructure and flares, and disorientation.

Light from marine structures has also been shown to attract migrating birds, and birds that migrate during the night are especially affected[217]. This may result in direct mortality from collisions, or may have indirect adverse effects from disorientation and/or delays leading to exhaustion and depletion of energy reserves.

EPBC Act migratory and listed shorebirds occur throughout the Port of Gladstone and the region is recognised as an important staging area for a number of migratory bird species during their annual migration. A description of *EPBC Act* listed species and important habitat areas for feeding or roosting is found in *Section 8.3.2.9*.

Of the roosting and foraging areas identified to exist in and surrounding the Project, those located to the south and west are expected to be subjected to light spill (refer to *Figure 5.8.11*). It is at these locations that any potential impacts are expected to occur.

216 Wiese F K, Montevecci W A, Davoren G K, Huettmann F, Diamond A W and Linke J (2001) Seabirds at risk around offshore oil platforms in the northwest Atlantic.

217 Verheijen F J (1985) Photopollution: Artificial light optic special control systems fail to cope with. Incidents, causations, remedies. .

For the roosting sites, the impacts are expected to be negative, and include detrimental change to growth, metabolism, skeletal development, sexual development, courtship and mating, reproductive cycle, and moulting. Anypotential impacts on these locations are expected to be difficult to differentiate from natural fluctuations or trends. The impacts are also expected to be cumulative, given the existing light sources, and potential industrial growth on neighbouring sites. Without quantitative data on bird numbers, and relativity to a greater population, the extents of such impacts are unknown. It is possible that displacement of birds to alternative roosting sites may occur.

Within the foraging site, however, an increase in food source is expected with the introduction of artificial illumination. This could also result in adverse effects caused by increased foraging competition, and ultimately predation. Similar to the roosting sites, the impacts are also expected to be cumulative, given the existing light sources, and potential industrial growth on neighbouring sites. Without quantitative data on bird numbers, and relativity to a greater population, the extents of such impacts are unknown.

Fish

The attraction of fish and fish larvae to artificial lighting has the potential to alter natural patterns of larval recruitment in proximity to the Project facilities. Light-attraction devices enhanced larval fish recruitment to patch reefs on the GBR[218], and light traps are a commonly used sampling method for fish larvae. Artificial lighting might alter not only the total number but also the species composition of settling larvae because larval attraction to light is selective. The impact on adult community structure, however, is likely to be less important due to the additional effects of post-recruitment factors such as predation, competition and resource availability[219]. The significance of any disruption to larval recruitment patterns as a result of Project-related artificial lighting is likely to be small as effects would be highly localised. An estimate on the effective range of light traps in attracting fish larvae and juveniles is about 90 m[220]. Artificial lighting above the water will propagate further than underwater lights, but will strike the sea surface at progressively greater angles, and therefore reflect more, with greater distance from the source. The range of attraction from such sources is unknown but likely to be at most a few hundred metres and probably less.

218 Munday P L, Jones G P, Ohman M C & Kaly U L (1998) Enhancement of recruitment to coral reefs using light-attractors.

219 Carr M H & Hixon M A (1995*) Predation effects on early post-settlement survivorship of coral-reef fishes,*

220 Milicich M J, Meekan M G & Doherty P J (1992) ***Larval supply: a good predictor of recruitment in three species of reef fish.***

Artificial lighting could alter competitive and predator-prey relationships. Some fish have diel cycles of feeding activity, with individual species being predominantly diurnal, nocturnal, or crepuscular (feeding at dawn and dusk), and artificial light could alter these activity patterns in favour of species who are active in bright light. Dim light tends to favour predation on fishes, whereas zooplankton predation tends to occur in bright light. The concentration of organisms attracted to light could make them more vulnerable to predation, and marine predators are known to aggregate at the edges of artificial light halos.

Although potentially occurring in the area, Whale sharks are not expected to occur in Port waters and therefore not exposed to light sources from the LNG Facility. Whilst it is recognised that fish activity is expected to increase with the introduction of artificial illumination, this is expected to be localised. The existing illumination of nearby coastline suggests that impacts caused by artificial illumination currently exist, and any increase caused by the proposed development could contribute to cumulative impacts. Such impacts however, are generally difficult to discern from natural fluctuations in population.

Marine Mammals

There is no direct evidence to suggest that artificial light sources impact on the migratory, feeding or breeding behaviours of marine mammals. Dolphins may indirectly be attracted to lighted structures in marine environments as these areas tend to attract marine fauna, creating food sources (i.e.aggregations of fish).

Management and Mitigation Measures

There is no singular solution to light impacts on sensitive receptors, so detailed lighting design for the LNG Facility will be done in the most conservative manner consistent with the safety of the plant operators and cognisant of the need to minimise spillover.

The lighting design will be undertaken using AGI32 lighting design software that permits the use of efficient (high lumens per watt) floodlights that are aimed within the software to establish Lux goals for each unique location. The software also permits rendering in three dimensions, and an iterative process will be undertaken to re-aim lighting fixtures within the model or model the installation of louvres to minimise light visible from outside the LNG Facility.

Floodlights on the Jetty will also be aimed so they are not a blinding hindrance to a captain landing a vessel. However, the lights will still provide adequate illumination at the dolphins and loading arms. Also, egress illumination energised from the LNG Facility emergency bus will be provided so persons can egress in safety.

Where possible, lighting will not be installed where it can be avoided. For example, almost no perimeter fence illumination will be installed, with use of infrared-sensing cameras and motion-detection software resident in the security system computer instead.

Level of Risk

Any increase in light spill from the Project is expected to be incremental. As such the probability of impact from artificial lighting during all phases of the Project is predicted to be “low”. The significance of the predicted environmental impacts is also considered to be “low”. Therefore, the level of environmental risk associated with artificial light on marine receptors is considered to be “low” for all phases of the Project (refer to *Table 5.8.25*).

Table 5.8.25 Risk Assessment Summary of Light

Aspect	Phase	Probability	Significance/Severity	Level of Risk
Light	Construction Operations Rehabilitation and Decommissioning	Low (2)	Low (2)	Low

8.4.2 Solid Waste

A summary of waste categories is provided in *Table 5.8.26*. Solid wastes will be generated during all phases of the Project. These wastes will be produced in relatively small quantities and will consist of both hazardous and non-hazardous materials.

Table 5.8.26 Overview of Impacts Associated with Solid Waste

Waste Categories	Description
Food scraps and putrescible wastes	Impacts arising from the generation of food scraps and other putrescibles during the construction, installation and operations phases that have a potential to enter the marine environment.
General non-hazardous wastes	Impacts associated with the generation of non-hazardous wastes such as scrap metal, timber, packaging material and empty containers.
General hazardous wastes	Hazardous waste impacts are those that have the potential to arise as a result of the generation of hazardous wastes such as batteries, oils, chemicals and otherwise contaminated materials that cannot be disposed of as non-hazardous waste.

Receptors Affected

The solid wastes discussed in the following section are not expected to have different impacts on the separate receptors and as such, the impacts of this aspect have been discussed collectively.

Solid waste, if introduced to the marine environment, may reduce water quality, which has subsequent impacts on marine flora and fauna. Benthic primary producers and other benthic habitats may be smothered by discarded solid waste. Marine fauna such as fish, reptiles or seabirds may become entangled or ingest discarded solid waste.

8.4.2.2 Food scraps and Putrescibles

Sources and Characteristics

Food scraps and other putrescible wastes, including cooking oils and grease, will be produced during all phases of the Project. Potential impacts include: localised reduction in water quality; and direct and indirect attraction (increased food availability and prey species) for receptors including marine reptiles, seabirds and shorebirds, and fish.

Extent and Description of Impact

The only food scraps and putrescibles that may be introduced to the marine environment will be from operating vessels, which according to MARPOL can only discharge 12 nm or more from the Great Barrier Reef. No measurable impact to surrounding water quality is expected, based on the low volumes of discharge within an open ocean environment (i.e. currents and wave action will result in rapid dispersion).

Management and Mitigation Measures

Management and mitigation measures to minimise the impacts to the marine environment from the disposal of food scraps and putrescible wastes will include the following:

- Food scraps and putrescible wastes from the LNG Facility will be disposed of onshore and will not therefore be discharged to the marine environment.
- Food scraps and other putrescible wastes from vessels will be disposed of in accordance with *MARPOL 73/78 Annex V*.
    - Food scraps will be macerated to a diameter of less than 25 mm prior to overboard disposal. Macerated food scraps will ensure rapid biodegradability.
    - Macerated food scraps will not be discharged within 12 nm (22 km) of the Great Barrier Reef .
    - Cooking oils and greases will be collected for onshore disposal.
- The low volumes of discharge within an open ocean environment

(beyond 12 nm from land) will facilitate rapid dispersion of food scraps and putrescible wastes.

Level of Risk

The environmental impact on the surrounding marine environment from the disposal of food scraps and putrescible waste is expected to be minimal. The residual environmental risk from food scraps and putrescibles to the Port of Gladstone is predicted to be insignificant.

8.4.2.3 General non-hazardous solid waste

Sources and Characteristics

General non-hazardous solid waste will be generated throughout the life of the Project during all phases (refer to *Volume 5, Chapter 17*).

Table 5.8.27 Summary of Sources and Characteristics of General Non-hazardous Solid Waste Impacts During Different Phases of the Project.

Project Component	Impact	Receptor	Construction	Operation	Rehabilitation & Decommissioning
LNG Facility	Localised reduction in water quality	Water Quality	✓	✓	✓
	Entanglement, ingestion	Marine Reptiles Marine Mammals Seabirds and Shorebirds Fish	✓	✓	✓
Bridge and Pipeline Crossing of The Narrows	As above	As above	✓	✓	✓
MOF	As above	As above	✓	✓	✓
Loading Jetty	As above	As above	✓	✓	✓
Vessel Activity	As above	As above	✓	✓	✓

Extent and Description of Impact

It is expected that the majority of general non-hazardous waste will be produced during the construction phase of the LNG Facility and associated infrastructure, primarily from excess building materials and from the construction workforce. Waste will continue to be produced during operations and as a result of decommissioning.

In line with the MARPOL regulations no discharge of general non-hazardous waste will occur from vessels. A potential impact to the marine environment may result in the unlikely event of an accidental disposal overboard of general solid waste material.

Potential impacts to the marine environment from general non-hazardous wastes, if accidentally discharged to the sea, include water pollution and death or injury to wildlife through ingestion or entanglement.

Management and Mitigation Measures

Management and mitigation measures to minimise the impacts to the marine environment from the disposal of general non-hazardous wastes will include the following:

- The primary mitigation measure will be to avoid or minimise wastes being generated. This will be achieved through the tendering and contracting process where waste minimisation will be included in the criteria.
- Waste Management Plans will be developed and implemented for the construction, operation and decommissioning phases of the Project. These plans will define the approved methods for the disposal of all waste.

Non-hazardous solid wastes will be segregated at the source into recyclable and non-recyclable wastes and stored in clearly marked, covered bins. Waste will then be transported to an onshore recycling or waste disposal facility by an appropriately licenced waste management contractor.

Level of Risk

The level of environmental risk from general non-hazardous solid waste to the Port of Gladstone is predicted to be insignificant (refer to *Table 5.8.28*).

Table 5.8.28 Risk Assessment Summary for General Non-hazardous Solid Waste

Aspect	Phase	Probability	Significance/Severity	Level of Risk
General non-hazardous solid waste	Construction	Medium (3)	Low (1)	Insignificant
	Operation	Low (2)	Low (1)	Insignificant
	Rehabilitation & Decommissioning	?	?	?

8.4.2.4 *General hazardous solid waste*

Sources and Characteristics

Hazardous wastes are defined as waste materials that are, or contain ingredients that are, harmful to health or the environment and include substances that are explosive, flammable, corrosive, oxidising or radioactive. The hazardous wastes expected to be generated by Project activities are detailed in *Volume 5, Chapter 17* and will occur throughout all phases of the Project (refer to *Table 5.8.29*).

Table 5.8.29 Summary of Sources and Characteristics of General Hazardous Solid Waste Impacts During Different Phases of the Project.

Project Component	Impact	Receptor	Construction	Operation	Decommissioning
LNG Facility	Localised reduction in water quality	Water Quality	✓	✓	✓
	Bioaccumulation and toxicity effects of all exposed biota	Marine Reptiles Marine Mammals Seabirds and Shorebirds Fish	✓	✓	✓
Bridge and Pipeline Crossing of The Narrows	As above	As above	✓	✓	✓
MOF	As above	As above	✓	✓	✓
Loading Jetty	As above	As above	✓	✓	✓
Vessel Activity	As above	As above	✓	✓	✓

Extent and Description of Impact

No general hazardous wastes will be disposed of to the marine environment from onshore activities or from vessels (in line with the MARPOL regulations). The main concern with the use of hazardous materials is their accidental loss to the sea and eventual method of disposal. General hazardous solid wastes will be stored for disposal to an appropriately licensed facility.

In the unlikely event of accidental loss to the marine environment, impacts would be localised.

Management and Mitigation Measures

Management and mitigation measures to minimise the impacts to the marine environment from the disposal of general hazardous wastes will include the following:

- The primary mitigation measure will be to limit the creation of hazardous solid wastes during construction via the tendering and contracting process wherever practicable. Non-hazardous solid materials that serve the same purpose and are as cost effective as hazardous materials will be given preference wherever practical.
- All hazardous waste material volumes generated during any phase of the development will be segregated from other waste streams, appropriately labelled and stored. Recyclable hazardous wastes, such as batteries, will be stored separately.
- Waste Management Plans will be developed and implemented for all phases of the Project. These plans will define the approved methods for the disposal of all hazardous waste.
- All hazardous waste materials will be disposed of or recycled at appropriately licensed facilities.

Level of Risk

The impact on the marine environment from disposal of general hazardous solid wastes during all phases of the Project is expected to be insignificant (refer to *Table 5.8.30*).

Table 5.8.30 Risk Assessment Summary for General Hazardous Solid Waste

Aspect	Phase	Probability	Significance/Severity	Level of Risk
General hazardous solid waste	Construction Operation Rehabilitation & Decommissioning	Low (2)	Low (1)	Insignificant

8.4.3 Marine Discharges

This section provides an assessment of the impacts of marine discharges from the LNG Facility and associated infrastructure on receptors in the marine environment.

Discharges from dredging activities have not been discussed as a “marine discharge” in this section as they are addressed previously as part of the discussion about the installation of permanent infrastructure..

Table 5.8.31 Overview of Impacts Associated with Marine Discharges

Source of Impact	Description
Sewage and sullage	Impacts arising as a result of the discharge of sewage and sullage from vessels and onshore sources such as construction camp and proposed LNG Facility (once operational).
Saline discharges	Impacts to the marine environment from the discharge of saline water produced by the desalination plant which forms part of the proposed LNG Facility and will produce the necessary potable water for the construction phase of the Project.
Stormwater runoff	Impacts arising from the potential entry of stormwater runoff (treated and untreated) from the proposed LNG Facility and associated infrastructure during all phases of the Project.
Deck Drainage	Impacts associated with deck drainage entering the marine environment from vessels during both the construction as well as installation and operations phases.
Antifouling leachate	Impacts to marine receptors as a result of leachate from antifouling paints entering the marine environment.

Receptors Affected

The marine discharges discussed in the following section are not expected to have different impacts on the separate receptors and as such the impacts of these discharges have been discussed here collectively. Receptors impacted are:

- water quality
- marine mammals
- marine reptiles
- fish
- invertebrates (including corals)
- benthic primary producers
- other benthic habitat
- mangroves.

Associated impacts in relation to marine discharges include increased sediment, nutrient and contaminant (e.g. hydrocarbons) loads. The potential impacts on the marine environment are primarily through decreased light penetration and the smothering of BPPH and other benthic habitat adjacent to the MOF jetties and the Pipeline crossing and potentially contribute to bioaccumulation of contaminants in marine biota. Hydrocarbon impacts are expected to be minor, however should be minimised with suitable mitigation. The impact on threatened/listed species, migratory marine species and cetaceans is likely to be minimal as these species are mobile and able to utilise other preferred habitat areas for foraging.

Discharges to the Port of Gladstone will occur during all stages of the Project, including sewage and sullage, desalination brine, stormwater, deck drainage, ballast water and anti-fouling leachate.

8.4.3.2 Sewage and Sullage

Sources and Characteristics

Sewage effluent from the LNG Facility will be treated on site and discharged from the MOF (using a diffuser) during construction and operational phases. Details of average water quality and volumes of treated sewage discharge are outlined in *Volume 2, Chapter 9*.

Table 5.8.32 Summary of Sources and Characteristics of Sewage and Sullage Impacts During Different Phases of the Project.

Project Component	Impact	Receptor	Construction	Operation	Decommissioning
LNG Facility (discharge from MOF)	Localised reduction in water quality	Water Quality	✓	✓	
	Toxic effects on marine fauna/flora	Marine mammals Marine reptiles Fish Invertebrates (inc corals) Benthic Primary Producers Other Benthic Habitat Mangroves	✓	✓	

Indicative sewage discharge rates for a three LNG train plant are provided in *Table 5.8.33*. As shown, the construction phase has the maximum flow rates and as such the maximum potential impacts.

Shore-based production of sewage and sullage will be treated before discharge to the marine environment. In accordance with the *TOMPA Act 1995,* vessels associated with the Project will not discharge sewage and sullage in a boat harbour, and therefore will not discharge in the Port of Gladstone.

Table 5.8.33 LNG Facility Sewage/Sullage Discharge Rate

Flow Rate (L/s)			
Construction Phase		Operational Phase	
Average	Maximum	Average	Maximum
1.7	3.4	0.7	0.97

Beyond 1 nm of land, sewage and sullage may be discharged in accordance with the *TOMPA Act 1995*, although in all instances the requirements of MARPOL will be complied with.

Extent of Impact

Construction Phase

The volume of sewage and sullage generated will be highest during the construction phase of the Project. Using worst-case scenarios, modelling of sewage discharge was undertaken[221] and showed that discharge received greater than 20:1 dilution within 4 m of the end of the outfall. By the time the discharge plume is dispersed 40 m from the outlet, dilution rates exceed 200:1.

Given the rapid dilution of discharges the risk of impact to local water quality conditions is considered low, with model results indicating that there will no detectable changes in local water quality patterns due to this discharge[222]. Details of modelling undertaken and full conclusions reached are provided in *Appendix 5.9.*

Operations Phase

The addition of readily degradable biological material contained within sewage discharged to a closed ecosystem (or one with limited exchange) can lead to the depletion of oxygen from the water and to anoxic effects as the material decays, referred to collectively as saprogenic effects. Given that the sewage wastes will be treated prior to discharge, the risk of this occurring will be insignificant.

Generally the effects of toxicity only occur where high volumes are discharged. The small volumes of treated sewage and sullage that will occur from the development combined with the rapid dilution and dispersal in the receiving waters mean that the potential for these impacts is low.

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221 BMT WBM Pty Ltd 2009 Proposed BG LNG Facility EIS Marine Water Quality Assessment.

222 ibid

Description of Impact

Due to the increased number of personnel present in the Project area there will be an increase in the volumes of treated sewage and sullage (consisting of laundry, shower and hand-basin waters) produced in the Project area, including on vessels associated with the Project.

Impacts associated with the discharge of sewage and sullage to the Port of Gladstone include:

- nutrient enrichment of the surrounding waters
- toxicity to marine biota.

Sewage has a high BOD resulting from organic and other nutrient matter in the detergents and human wastes, and can impair water quality in the immediate vicinity of discharge.

Management and Mitigation Measures

- A diffuser configuration will be selected to to give an approximate exit velocity from each outfall port of the order of 1 m/s, which will encourage maximum initial mixing and also minimise the likelihood of marine biofouling. The following measures will also be incorporated into the design:
- The diffuser discharge point will be designed and located to maximise mixing and dilution of the wastewater being discharged through the marine discharge outfall.

In addition, both the sewage and sullage and desalination brine effluent streams will be pre-mixed and discharged via a common outlet on the MOF.

Level of Risk

The level of environmental risk from the discharge of sewage and sullage to the Port of Gladstone is predicted to be low (refer to *Table 5.8.34*).

Table 5.8.34 Risk Assessment Summary for Sewage and Sullage

Aspect	Phase	Probability	Significance/Severity	Level of Risk
Sewage and Sullage (Treated)	Construction Operation	High (6)	Low (2)	Low

8.4.3.3 Saline Discharges

Sources and Characteristics

Desalination brine resulting from operation of the LNG Facility Reverse Osmosis (RO) plant (used for water supply for both construction and operations) will be discharged as a point source from the MOF during construction and operations (refer to *Table 5.8.35*). Based on the maximum expected salinity in intake waters of the order of 35 g/L, the brine will have an associated salinity level of the order of 63.5 g/L. This will be the main water quality constituent of concern with the brine discharge. Details of the desalination brine stream for the LNG Facility are provided in *Table 5.8.36*. Anticipated brine stream water quality and volume are described in *Volume 2, Chapter 9,* although it should be noted that volumes will be subject to numbers of personnel on site at any given point in time and will vary significantly throughout the construction phase.

Table 5.8.35 Summary of Sources and Characteristics of Saline Discharge Impacts During Different Phases of the Project.

Project Component	Impact	Receptor	Construction	Operation	Decomm.
LNG Facility	Localised reduction in water quality	Water Quality	✓	✓	
	Stress on flora/fauna associated with osmotic stress & hypersalinity, sensitivities	Marine mammals Marine reptiles Fish Invertebrates (inc corals) Benthic Primary Producers Other Benthic Habitat	✓	✓	

Details of the anticipated desalination brine stream for the LNG Facility (based on preliminary design) are provided in *Table 5.8.36*.

Table 5.8.36 Desalination Brine Discharge Rate

Flow Rate (L/s)			
Construction Phase		Operational Phase	
Average	Maximum	Average	Maximum
16.7	16.7	4.2	11.1

Extent of Impact

Construction Phase

The construction phase has the maximum flow rate and as such the maximum potential impacts. Using worst-case scenarios, modelling of the discharge was undertaken[223] and showed that discharge received greater than 20:1 dilution within 4 m of the end of the outfall. By the time the discharge plume is dispersed 40 m from the outlet, dilution rates exceed 200:1. Overall, model results indicate that there will no detectable changes in local water quality patterns due to this discharge[224]. Details of modelling undertaken and full conclusions reached are provided in *Appendix 5.9*.

Operations Phase

The volume of the discharge is dependent on the requirement for fresh (or potable) water, and for the LNG Facility would be expected to average about 360 m³/day during production, to 960 m³/day during additional maintenance activities.

Description of Impact

On discharge to the Port of Gladstone, the desalination brine, being of greater density than seawater, will sink and disperse in the currents. As discussed above, the discharge received greater than 20:1 dilution within 4 m of the end of the outlet. The largest increase of salinity experienced would be approximately 10 per cent at a range of 4 m from the discharge point. Osmotic stress and hypersaline sensitivities may cause undue stress to marine fauna/flora within this direct impact zone. However, most marine species are able to tolerate short-term fluctuations in the order of 20 per cent to 30 per cent[225], and it is expected that most pelagic species passing through the proposed development area would be able to tolerate short-term exposure to the slight increase in salinity caused by the discharged brine.

Management and Mitigation Measures

The main avoidance measure will be to limit the generation of potable water to only that which is necessary for operational requirements. Scale inhibitors normally used in these water treatment systems are suitable for human consumption and will not adversely impact on any marine organisms. Further mitigation of impacts will be achieved by the rapid dispersion of the brine when discharged to the ocean. The outfall will pass through a diffuser as for desalination brine and will aid the rapid dilution in the receiving waters.

Level of Risk

The residual environmental risk from the discharge of desalination brine to the Port of Gladstone from desalination processes is predicted to be low (refer to *Table 5.8.37*).

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223 BMT WBM Pty Ltd 2009 Proposed BG LNG Facility EIS Marine Water Quality Assessment.

224 ibid

225 Walker D I and McComb A. J (1990) Salinity response of the seagrass Amphibolus antartica: an experimental validation of field results .

Table 5.8.37 Risk Assessment Summary for Saline Discharges

Aspect	Phase	Probability	Significance/Severity	Level of Risk
Saline Discharge	Construction Operation	High (6)	Low (2)	Low

8.4.3.4 *Stormwater runoff*

Sources and Characteristics

Stormwater runoff will occur throughout all phases of the Project from the LNG Facility, MOF, Loading Jetty and Bridge and Pipeline crossing. Potential impacts include localised reduction in water quality; toxic effects on marine fauna/flora (marine mammals, marine reptiles, fish, invertebrates (including corals), benthic primary producers, other benthic habitat, and mangroves). Bridge and pipeline crossing construction may also result in turbidity created by erosion from land.

Extent of Impact

The volumes and quantities of stormwater and fire water runoff that will be generated cannot be accurately quantified until detailed design phases have been completed.

Description of Impact

Stormwater runoff may cause localised, short-term reductions in water quality. Bioaccumulation of chemicals and the physical effect of oils and chemicals may also impact upon susceptible marine flora and fauna.

Management and Mitigation Measures

Fuel and chemical storage areas, as well as refuelling areas, will be adequately bunded to ensure no oil or chemical contaminated water is discharged to the marine environment.

Lube oil may be captured in bunded areas around compressors. Compressor stations have an oily-water separator, from which oil will be removed off site to a licensed waste disposal facility.

Runoff high rainfall events will be managed through the detention basins and other sediment control structures. Cleared surfaces will be stabilised to further reduce erosion.

Level of Risk

Stormwater from process areas will be treated on site to ensure no adverse impact on water quality. The level of environmental risk from stormwater runoff to the Port of Gladstone is predicted to be “low” (refer to *Table 5.8.38*).

Table 5.8.38 Risk Assessment Summary for Stormwater Runoff

Aspect	Phase	Probability	Significance/Severity	Level of Risk
Stormwater runoff	Construction Operation Decommissioning	High (6)	Low (2)	Low

8.4.3.5 Deck drainage

Sources and Characteristics

Deck drainage from vessels associated with the relevant Project components and indirect vessel activity will operate throughout all phases of the Project. The effects on marine receptors will differ according to the receptor and the type of contaminant.

Deck drainage consists of washdown and occasional rainwater runoff. Small quantities of contaminant used on vessels may be inadvertently washed into the surrounding marine environment. While there is no routine discharge, deck drainage or washdown containing small quantities of oil, grease or detergents directed overboard. Potential impacts include: localised reduction in water quality; increases in localised turbidity resulting in light attenuation; and potential toxic effect on marine fauna / flora (marine mammals, marine reptiles, fish, invertebrates (including corals), benthic primary producers, other benthic habitat, and mangroves).

Extent of Impact

Vessels associated with construction and operation of the Project are outlined in *Volume 2, Chapter 9* and *Chapter 13*.

Individual shipping routes outside the Port of Gladstone through the GBRMP will vary, with movement of LNG ships through the GBRMP undertaken within approved shipping zones. In general ships will follow the most direct route between Capricorn Channel and Gladstone Sea Buoy, considering depth of water, obstructions, and zone use restrictions.

Construction and installation of the MOF and Loading Jetty may require dredging and pile driving depending on the location and the structures chosen for the facilities. Both of these activities will require the use of vessels. In addition, dredging may be required for trenching of the Pipeline crossing between the mainland and Curtis Island (although trenchless techniques are being considered).

Although there are increases in vessels in the Project area, it is considered that the amount of contaminants entering the marine environment through runoff associated with deck washdown or rainfall is insignificant. Deck drainage contamination, where there are no routine discharges, is generally considered to be very low, and any runoff is able to disperse into the marine environment with a negligible impact.

Description of Impact

Specific ecological impacts of deck drainage include:

- physical and chemical alteration of natural habitats, including water quality and turbidity
- lethal or sub-lethal toxic effects on flora and fauna
- changes in biological communities resulting from hydrocarbon effects on key organisms.

Management and Mitigation Measures

No contaminated waste will be intentionally discharged via deck washdown activities. All process areas and bulk chemical storage areas will be segregated and drain to a closed drain systems.

Level of Risk

There is likely to be an increased risk during operations with increases in vessel traffic within the Project area. However with controls and procedures regards deck drainage in place on vessels the probability of impact from deck drainage during all phases of the Project is predicted to be “low”. The significance of the predicted environmental impacts is also considered to be “low” and the level of environmental risk associated with deck drainage on marine receptors is considered to be “insignificant” for all phases of the Project (refer to *Table 5.8.39*).

Table 5.8.39 Risk Assessment Summary for Deck Drainage

Aspect	Phase	Probability	Significance/Severity	Residual Risk
Deck drainage	Construction Operations Rehabilitation and Decommissioning	Low (1)	Low (1)	Insignificant

8.4.3.6 Anti-fouling Leachate

Sources and Characteristics

This section discusses with the effects of anti-fouling paint on vessels and structures used in all phases of the Project (refer to *Table 5.8.40*). Anti-foulant will be applied to the Marine Facilities including vessels to prevent biofouling. The use of anti-fouling systems results in a significant reduction in the operating costs for vessels through savings in fuel (through less drag in the water), less dry-docking and reduced maintenance costs. The use of effective anti-fouling systems also reduces the risk of translocation of marine species, as they are less likely to be transported on vessel bottoms.

Table 5.8.40 Summary of Sources and Characteristics of Anti-fouling Leachate Impacts During Different Phases of the Project.

Project Component	Impact	Receptor	Construction	Operation	Decommissioning
Bridge and Pipeline Crossing	Localised reduction in water quality	Water Quality	✓	✓	✓
	Acute and chronic toxic effects on marine fauna	Marine mammals Marine reptiles Fish Invertebrates (including corals)	✓	✓	✓
	Localised pollution or contamination of marine sediments	Sediment Quality	✓	✓	✓
MOF	As above	As above	✓	✓	✓
Loading Jetty	As above	As above	✓	✓	✓

Extent of Impact

Current additives to anti-fouling paint contain copper[226] and "booster biocides", such as Irgarol 1051 diuron, and zinc pyrithione. The concentrations of these additives likely to occur in surrounding waters as a consequence of leaching from anti-fouling paints are far less than the concentrations at which toxicity effects would occur. There is potential for these chemicals to be deposited on the seabed where they would remain in the sediments for a period of months before degradation through chemical and biological mechanisms. However, the quantity of diuron or Irgarol 1051 from anti-fouling leachate being sedimented would be extremely low, and the rate of degradation, although slow, would exceed the rate of new sedimentation, thereby preventing concentrations reaching levels sufficient to cause detectable environmental effects (refer to *Table 5.8.41*). Pyrithiones are used widely and degrade rapidly in the water column with a reported half life in seawater of four minutes[227].

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226 ANZECC (2000) ***Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*** *Agriculture and Resource Management*

227 DEFRA (2003) ***Evaluation on zinc pyrithione: Use as a booster biocide in antifouling products.***

Table 5.8.41 Concentration of Active Anti-fouling Components in Paints and their Rate of Leaching

Additive	Minimum concentration (w/w)	Rate of leaching Mg/cm²/day	Toxicity to algae	Toxicity to fish
Copper oxide	10-50	1-101	1-8,000 (Cu^{++})	10-10,200
Copper Thiocyanate	5-25	1-101	1-8,000 (Cu^{++})	10-10,200
Diuron	1-10	0.1-2.5	5-120	8,500-25,000
Irgarol 1051	0.1-5.0	2-16	1.4-2.4	400-2900
Zinc Pyrithone	2	2.3-18	28	5-9,0.3-400

Overall impact is likely to be slight during all phases and any concentration of leachates in the surrounding water column or sediments is likely to be less than the concentrations required to elicit a detectable biological impact. There is also considered to be a low risk of leachate accumulation in sediments. Biocide use on vessels is unlikely to cause harm to the marine environment during all phases of development.

Description of Impact

The main concern associated with the application of anti-fouling paints on vessel hulls was that the main chemical component, tributyltin (TBT), an organotin compound, had toxic effects on non-target marine species. TBT anti-fouling works by providing an unstable surface so that organisms are both unable to attach for prolonged periods and are poisoned by the organotin content ([228],[229]). While TBT breaks down to less harmful products within days in the water column, its accumulation in bottom sediments in such areas as ports and marinas can take much longer (i.e., decades) to break down[230].

However, in 1989 Australia prohibited the use of TBT-based paints on vessels less than 25 m in length, with a maximum leaching rate of 5 µg per cm² per day specified for vessels greater than 25 m in length. All dry docks and all anti-foulants are registered with the state environmental protection agencies. In November 1999, the IMO directed the Marine Environment Protection Committee to develop an instrument, legally binding throughout the world, to address the harmful effects of anti-fouling coatings used on ships and impose a global ban on the application of TBT paints on ships by 1 January 2003 and a complete prohibition on the presence of TBT paints on ships by 1 January 2008. Australia has adopted the convention and has prohibited the application

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228 ANZECC (1997) Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance.

229 Bray S (2006) Tributyltin pollution on a global scale. An overview of relevant and recent research: impacts and issues.

230 Fremantle Ports (2002) The Management of Tributyltin (TBT) Anti-Foulants in Western Australia.

of TBT-based anti-fouling paints since 1 June 2003. There is, however, a very small possibility that vessels may still have TBT-based anti-fouling paint that was applied prior to 2003.

In summary, the specific ecological impacts of anti-fouling leachate include:

- localised reduction in water quality
- acute and chronic toxic effects on marine fauna
- localised pollution or contamination of marine sediments.

Management and Mitigation Measures

TBT-based paints will not be used on new vessels. The selection of alternative non-TBT paints will be with a preference for those with least environmental impact.

Level of Risk

The probability of impact from anti-foulant leaching during all phases of the Project is predicted to be "low". The significance of the predicted environmental impacts is also considered to be "low". Therefore, the level of environmental risk associated with anti-foulants on marine receptors is considered to be "low" for all phases of the Project. (refer to *Table 5.8.42)*

Table 5.8.42 Risk Assessment Summary for Anti-foulant Leachate

Aspect	Phase	Probability	Significance/Severity	Level of Risk
Anti-foulant leachate	Construction Operations Rehabilitation and Decommissioning	Low (2)	Low (2)	Low

8.4.4 Unplanned Events

As described in *Figure 5.8.15* impacts associated with unplanned events have been divided into two categories, with a short overview of these categories summarised in *Table 5.8.43*.

Unplanned events are incidents or unplanned upsets that have the potential to trigger impacts that would otherwise not be anticipated during the normal course of construction, installation or operations. The severity of impact from unplanned events can often be greater than those associated with expected impacts. However, the probability of an unplanned event actually occurring is typically much lower. Given the high-potential severity, but low probability of occurrence, when unplanned events occur, they typically trigger plans specifically designed to respond to the event as quickly and effectively as possible. In addition to mobilising BG Group resources, additional resources from external parties such government agencies are often an inherent part of the incident response.

Table 5.8.43 Overview of Impacts Associated with Unplanned Events

Source of Impact	Description
Hydrocarbon spills	Impacts as a result of either small- or large-scale hydrocarbon releases to the marine environment. The risk profile for unplanned hydrocarbon spills changes over the lifetime of the Project and is related to factors such as number of vessels mobilised, size of hydrocarbon inventories at risk and the prevailing environmental conditions at the time of the unplanned event.
Chemical spills	Similar to the risk profile of hydrocarbon spills, the potential impacts on the marine environment from chemical spills is related to the type and volume of chemical, the sensitivity of the receiving environment and the level of response initiated in the event of an unplanned event.

8.4.4.1 Hydrocarbon Spills

Sources and Characteristics

This section considers the risk of contamination through spills of hydrocarbons: either large such as a vessel grounding or collision; smaller such as leaks from fuel storage tanks; or from leak and spills from construction and operational equipment (e.g. HDD). Hydrocarbon spills may occur throughout all phases of the Project from various Project components (refer to *Table 5.8.44*).

All vessels will carry a consignment of fuel oil on board. Unless ballast tanks are segregated from fuel tanks, oil contamination is possible. If a spill or leak occurs during vessel grounding/collision, contaminated ballast water can impact the marine environment. However, fully segregated tanks are a legal requirement under MARPOL 73/78 and are monitored by statutory inspection.

Extent of Impact

Although considerable shipping already exists in Gladstone harbour, there is limited vessel movement in the immediate vicinity of the Project area. Increases in shipping traffic during construction and operation are likely to increase the risk of impact on the marine environment. Vessels operating in the area during construction include supply vessels and barges, a pipe-lay barge (if pipeline is not installed by HDD), dredger and support vessels.

Table 5.8.44 Summary of Sources and Characteristics of Hydrocarbon Spill Impacts During Different Phases of the Project.

Project Component	Impact	Receptor	Construction	Operation	Decommissioning
Bridge and Pipeline Crossing	Localised reduction in water quality	Water Quality	✓	✓	✓
	Acute and chronic toxic effects on marine flora and fauna	Marine mammals Marine reptiles Fish Invertebrates (inc. corals) Benthic Primary Producers Other Benthic Habitat Mangroves	✓	✓	✓
	Localised pollution or contamination of marine sediments	Sediment Quality	✓	✓	✓
MOF	As above	As above	✓	✓	✓
Loading Jetty	As above	As above	✓	✓	✓
Vessel Activity	As above	As above	✓	✓	✓

During operations, supply vessels, LNG off-take tankers and passenger ferries will be using the Port facilities.

Machinery and equipment primarily required during construction, but also during operations, will increase the risk of leaks and spills of hydrocarbons. However, impacts from these sources are expected to be localised and of small volumes compared to hydrocarbon spills from vessels.

Description of Impact

The 2006 Global Peace oil spill of 25 tonnes of heavy fuel into Gladstone harbour dispersed across the harbour due to weather conditions at the time of the spill is an example of the potential impact that could occur from a hydrocarbon spill in the Port of Gladstone. Eighteen tonnes of oil was recovered after mitigation and oil was found deposited in intertidal areas. Studies of intertidal, mangrove, sediments and intertidal macro invertebrates were conducted immediately following the spill and then six and 12 months later[231]. PAH concentrations in oil-impacted areas were lower at six and 12 month-surveys than the baseline. The greatest decrease was at Wiggins Island over 12 months at 98 per cent. Sediment metal concentrations remained similar and there appeared little impact from the spill. However, mangroves showed significant impacts with higher seedling and tree mortality following 12-month surveys. Defoliation was much higher in impacted sites. Crab populations were reduced in oil-impacted sites and recovered after 12 months. Mangroves continued to display long-term impacts consistent with other studies.

Apart from localised reduction in water quality from a minor spill (less than 10 m^3) and more widespread pollution from a large spill (greater than 1,000 m^3), hydrocarbon leaks and spills would impact marine receptors of the Project site as described below.

Receptors Affected

Mangroves

Mangroves are highly susceptible to oil exposure; oiling may kill them within a few weeks to several months. Lighter oils such as diesel are more acutely toxic to mangroves than heavier oils. Although weathering generally lowers oil toxicity, mangroves can suffer long-term impacts at the cellular and the population level.

Fringing mangroves dominate the intertidal zones around Curtis Island and the mainland. Potential impacts from a spill are considered high around this area because of the sensitivity of mangroves to oiling and the difficulties with clean-up attempts.

Other Benthic Habitats

Mudflats/sandflats, saltmarsh and rocky shores are also significant habitats within the Port of Gladstone that are susceptible to acute and chronic oil pollution. Saltmarsh and mudflats harbour a large number of invertebrate species and are important feeding areas for shorebirds. They are particularly difficult areas to clean during oil spills and are likely to have long recovery times.

231 Storey A W, Andersen L E, Lynas J, and Melville F (2007). ***Port Curtis Ecosystem Health Report Card. Port Curtis Integrated Monitoring Program (PCIMP),***

Fish

A wide variety of fish species occur in the waters of the Port of Gladstone, with varying physiology, feeding behaviours and habitats. The eggs, larvae and young fish are comparatively sensitive to oil (particularly dispersed oil), as demonstrated in laboratory toxicity tests. There are increased risks to some species and life stages of fish in shallow near-shore waters such as estuaries, coral reefs, and seagrass and mangrove habitats. These foreshores are believed to function as essential feeding and "nursery" breeding grounds for many fish.

Marine Mammals

Marine mammals that may be present in the vicinity of the development area include dugongs, dolphins and whales (refer to *Section 8.3.2.7*). Marine mammals surface to breathe air and are therefore vulnerable to exposure to oil spill impacts caused by surfacing through an oil slick on the sea surface. These marine mammals are smooth-skinned and hairless so contact with oil may cause only minor oil adherence.

Marine Reptiles

Animals such as marine reptiles that nest on land are also affected by the disruption, alteration or destruction of their breeding and nesting sites. Particularly during nesting season while eggs are incubating. If oiling is heavy and penetrates sediments, nests may be contaminated resulting in oil permeating through shell membranes and contaminating emergent hatchlings. If turtles surface in an oil slick to breathe, oil will affect their eyes and damage airways or lungs. Marine turtles will also be affected by oil through contamination of the food supply or by absorption through the skin. Turtle species using nesting beaches on Curtis Island may be affected only if potential spills reach these nesting beaches. Turtles foraging in shallow areas of the Port of Gladstone and areas adjacent to LNG Marine Facilities are at risk of being impacted by oil spills.

Seabirds and shorebirds

Many oil spills have resulted in the death of a large number of shorebirds and seabirds. This is a group very sensitive to both internal and external affects of crude oil and its refined products. Seabirds and shorebirds have a high risk of contact to spilled oil due to the amount of time they spend on or near the surface of the sea and on oil-affected foreshores. Seabirds may also come in contact with spilled oil while searching for food, since several species of fish are able to survive beneath floating oil. Shorebirds are prevalent on the intertidal flats of the Port of Gladstone and the area is recognised as a significant shorebird site.

Invertebrates

The bioavailability and bioaccumulation of oil by marine organisms will depend upon species, lipid content of the organisms, surface area of the organisms, metabolic capacity and grazing rates[232] Observations of invertebrates such as crustaceans and molluscs treated with crude oil, dispersed oil and dispersant alone found that dispersed oil was more toxic to the species tested than oil alone (crab and clam spp.).

The specific ecological impacts of hydrocarbon spills and leaks to marine receptors include:

- physical and chemical alteration of natural habitats, including water quality
- physical smothering effects on flora and fauna
- lethal or sub-lethal toxic effects on flora and fauna
- changes in biological communities resulting from hydrocarbon effects on key organisms.

Management and Mitigation Measures

The following potential management and mitigation measures to reduce the level of risk from hydrocarbon spills are normal industry practice:

- Store all oily water for onshore disposal and pass through oily water separators on all vessels.
- Oil and chemical usage areas shall be contained with appropriate bunding and sumps.
- Fuel and other hydrocarbon storage, handling, operational and distribution areas subject to regular inspections to identify and respond to leaks.
- Regular inspections for general leaks and spills conducted on ships, plant and equipment and corrective action taken.
- Each ship will carry an oil pollution response kit.
- Clear procedures for reporting spills will be implemented.
- Regular maintenance of all ships and barges implemented to reduce risks of equipment failure resulting in hydrocarbon leakage.
- Applicable pollution prevention plans for the Port of Gladstone and other relevant regulations will be adhered to by all vessels and barges.
- Procedures for safe refuelling and fuel transfer will be implemented.
- Dry break couplings and floating hoses used where appropriate.
- Machinery/tanks will be fitted with overflow protection valves and

232 Burns K A, Garrity S D and Levings S C (1993) ***How many years until mangrove ecosystems recover from catastrophic oil spills?***

emergency shut-offs).

- Each ship will have its own Ship Board Oil Pollution Emergency Plan (SOPEP) and an activity-specific Oil Pollution Contingency Plan..
- Oil spill clean-up equipment and resources aligned with risk will be available to respond in a timely manner.

Level of Risk

The potential level of risk to the marine environment of the Port of Gladstone from hydrocarbon spills is “medium” (refer to *Table 5.8.45*). The potential for accidents resulting in small-volume spills during construction is likely to increase due to the increased number of small vessels. Modelling of reasonable scenarios will assist in identifying most at-risk receptors. Although risk increases, potential for spill remains relatively low because of the controlled manner of shipping and oil spill contingency plans in place.

Table 5.8.45 Risk Assessment Summary for Hydrocarbon Spills

Aspect	Phase	Probability	Significance/Severity	Level of Risk
Hydrocarbon spill	Construction Operations Rehabilitation and Decommissioning	Medium (3)	Medium (4)	Medium

8.4.4.2 Chemical spills

Sources and Characteristics

This section considers the risk of contamination through chemical spills to the marine environment (refer to *Table 5.8.46*).

Extent and Description of Impact

Chemical spills from Project activities may result from accidental leakage or release of chemicals from inadequate storage and handling. Chemicals to be used in the development of the LNG Facility and associated infrastructure are to be determined.

Table 5.8.46 Summary of Sources and Characteristics of Chemical Spill Impacts During Different Phases of the Project.

Project Component	Impact	Receptor	Construction	Operation	Decommissioning
Bridge and Pipeline Crossing	Localised reduction in water quality	Water Quality	✓	✓	✓
	Acute and chronic toxic effects on marine flora and fauna	Marine mammals Marine reptiles Fish Invertebrates (inc. corals) Benthic Primary Producers Other Benthic Habitat Mangroves	✓	✓	✓
	Localised pollution or contamination of marine sediments	Sediment Quality	✓	✓	✓
MOF	As above	As above	✓	✓	✓
Loading Jetty	As above	As above	✓	✓	✓
Vessel Activity	As above	As above	✓	✓	✓

Accidental discharge of chemicals to the marine environment would result in a local impact on water quality and could impact on the health of marine fauna and flora. Potential ecological impacts of chemical spills and leaks include:

- physical and chemical alteration of natural habitats, including water quality
- lethal or sub-lethal toxic effects on flora and fauna
- changes in biological communities resulting from chemical effects on key organisms.

Spill volumes, however, are likely to be small and impacts would therefore be localised and short term.

Receptors Affected

Chemical spills may result in localised impacts on water quality and toxicity effects on marine fauna and flora. Specific effects on individual receptors would depend upon the type and volume of chemical released.

Management and Mitigation Measures

Management and mitigation measures to minimise the impacts to the marine environment from the risk of chemical spills will include the following:

- The use of chemicals will be minimised through appropriate design where practicable.
- Chemicals will be stored safely in approved and clearly labelled containers.

Level of Risk

The level of risk from chemical spills during all phases of the Project is predicted to be "insignificant" (refer to *Table 5.8.47*).

Table 5.8.47 Risk Assessment Summary for Chemical Spills

Aspect	Phase	Probability	Significance/Severity	Level of Risk
Chemical spill	Construction Operations Rehabilitation and Decommissioning	Low (2)	Low (1)	Insignificant

8.4.5 Introduced Marine Species

Impacts from introduced marine species have the potential to be ecologically devastating and very expensive to manage once they have successfully colonised. This section discusses the potential impacts to the marine environment associated with the construction, installation and operations of the proposed LNG Facility and associated infrastructure.

Sources and Characteristics

Introduced marine species or marine pests are species which have been transported from their natural habitat to the receiving environment and have survived. The most common pathways leading to the introduction of non-indigenous marine species into Australian waters are via vessel fouling and ballast water discharge. Ballast water from vessels associated with the relevant Project components and indirect vessel activity will operate throughout all phases of the Project (construction, operation and decommissioning (refer to *Table 5.8.48*)

In the case of ballast water, marine organisms may be taken onboard in one location and transported to the development area via the uptake and discharge of ballast water. The survival of marine species via this pathway is dependent on:

- the marine organism being present at the location of ballast water uptake
- the survival of the marine organism during transportation to the development location
- the discharge of the marine organism in into the receiving marine environment.

The second vector, fouling on vessel hulls and other submerged parts of the vessel's structure may contain complex communities with many species present. The hulls of commercial tankers are regularly cleaned and treated with anti-fouling paint to prevent the establishment and growth of fouling communities. Smaller and non-commercial vessels are commonly not treated as regularly as commercial vessels and thus fouling is most common on these vessel types.

Table 5.8.48 Summary of Sources and Characteristics of Introduced Marine Species Impacts During Different Phases of the Project.

Project Component	Impact	Receptor	Construction	Operation	Decommissioning
Vessel Activity	Loss of native biodiversity	Marine mammals Marine reptiles Fish Invertebrates (inc corals) Benthic Primary Producers Other Benthic Habitat Mangroves	✓	✓	✓

Extent of Impact

The likelihood of survival of an introduced species is unpredictable however due to low risk of introduction via ballast and/or fouling, the extent of the impact shall be minimal. The increased number of vessels in the area, especially during construction phase, may heighten the risk of introduced marine species however the risk of these species becoming fully established and becoming pests is low. As described in *Section 8.3.4* nine introduced species have been identified in the Port of Gladstone. However, none of the species found are classified as a pest species and none of them are among the target species identified by the Australian Ballast Water Management Advisory Committee.

Description of Impact

The survival of introduced marine species in the introduced environment is dependent on a number of factors including temperature, salinity, sources of food and predators. The survival of these introduced species may pose a threat to the existing marine environment via altering the balance of the ecosystem. The introduced marine species may act as a new predator or alternatively compete with existing species for food, both of which may alter the dominance of the ecological community. Once established, introduced marine species potentially could have substantial ecological and economic impacts from loss of local biodiversity.

Management and Mitigation Measures

In July 2001, the Australian Quarantine Inspection Service (AQIS)[233] implemented mandatory ballast water management requirements for vessels engaged in international shipping. Where the potential risk is deemed to be high the three approved options for the management of ballast water are:

- Full ballast water exchange at sea
- tank-to-tank transfers
- no discharge of high-risk ballast water in Australian waters.

A Ballast Water Management plan will require for sequential exchange of ballast water in deep ocean areas. Therefore in the event of grounding whilst transiting the GBRMP in ballast condition only clean, deep ballast water would be discharged to the marine environment. In the event of grounding in loaded condition, no ballast would be onboard.

Ballast water will be managed in accordance with AQIS requirements.

Level of Risk

The full implementation of the AQIS requirements via the Ballast Water Management Plan, coupled with the regular maintenance and the application of anti-fouling paint to the marine vessels minimises the potential introduction of marine pests. The potential risk to the marine environment of the Port of Gladstone via the introduction of introduced species is “low” (refer to *Table 5.8.49*).

233 Department of Agriculture, Fisheries and Forestry (2008) ***Australian Ballast Water Management Requirements***.

Table 5.8.49 Risk Assessment Summary for Introduced Marine Species

Aspect	Phase	Probability	Significance/Severity	Level of Risk
Ballast water	Construction Operations Rehabilitation and Decommissioning	Low (1)	Medium (3)	Low

8.4.6 *Impact on Matters of National Environmental Significance*

The preceding sections have focused on the sources and predicted outcome of the potential impacts that are expected to occur as a result of the Project. In accordance with the requirements of the *EPBC Act* the impacts of the proposal on Matters of National Environmental Significance were assessed. This section provides a summary of the likely impacts on *EPBC Act* listed species and subsequent biodiversity as a result of Project aspects (refer to *Table 5.8.50*). There are 12 threatened marine species, 24 migratory marine species and 72 listed marine species that may be present in the Port of Gladstone area. Refer to *Annex 5.3* for a full list of *EPBC Act* listed species.

The assessment concluded that the Project would not have a significant impact on *EPBC Act* listed species, due to:

- the small number of individuals that utilise the subject site
- the likelihood that small numbers of marine fauna would continue to utilise parts of the site during the construction and operational phases of the Project.

8.5 SUMMARY OF MANAGEMENT AND MITIGATION MEASURES

Impacts on marine ecology were considered for the construction and operation of the MOF, Loading Jetty, the Curtis Island Bridge and Pipeline crossing of The Narrows. Impacts of shipping activities, dredging for the Swing Basin and Shipping Channel for the LNG Facility, disposal of dredge spoil to the north of Fisherman's Landing and discharges from the LNG Facility were also considered.

The most important impacts anticipated to occur during the construction phase arise as a result of the dredging and reclamation required to prepare and install infrastructure and dispose of the dredged material. Impacts include direct impacts on habitats such as seagrasses and mangroves, as well as secondary impacts on water quality and behavioural changes by mobile marine species that are likely to be temporarily disturbed by increased turbidity or noise.

Table 5.8.50 Summary of Predicted Environmental Risk to EPBC Act Protected Species for Project Aspects.

Protected Species	Physical Presence - Permanent	Physical Presence - Temporary	Underwater Noise	Light	Food Scraps & Putrescible	General non-hazardous solid waste	General hazardous solid waste	Sewage & Sullage	Saline Discharge	Stormwater runoff	Deck Drainage	Anti-fouling leachate	Introduced Marine Species	Hydrocarbon spills	Chemical Spills
Birds (Wetland and Marine)															
Southern Giant petrel	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Yellow chat	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
White-bellied sea eagle	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Fork-tailed swift	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Great egret, White egret	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Cattle egret	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Latham's snipe, Japanese snipe	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Australian Cotton Pygmy-goose	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Little curlew, Little whimbrel	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Kermadec petrel	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Little tern	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Australian Painted snipe	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Eastern curlew	M	L	I	L	I	L	I	L	L	L	I	I	I	L	L
Red goshawk	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Squatter pigeon	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Great knot	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L

Protected Species	Physical Presence - Permanent	Physical Presence - Temporary	Underwater Noise	Light	Food Scraps & Putrescible	General non-hazardous solid waste	General hazardous solid waste	Sewage & Sullage	Saline Discharge	Stormwater runoff	Deck Drainage	Anti-fouling leachate	Introduced Marine Species	Hydrocarbon spills	Chemical Spills
Grey-tailed tattler	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Terek sandpiper	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Red-necked stint	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Sharp-tailed sandpiper	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Pacific Golden plover	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Lesser Sand plover	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Masked lapwing	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Caspian tern	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
White-throated needletail	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Rainbow bee-eater	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Whistling kite	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Brown goshawk	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Brahminy kite	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Eastern osprey	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Australian hobby	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Whimbrel	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Common greenshank	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Beach Stone-curlew	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Radjah shelduck	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L

Protected Species	Physical Presence - Permanent	Physical Presence - Temporary	Underwater Noise	Light	Food Scraps & Putrescible	General non-hazardous solid waste	General hazardous solid waste	Sewage & Sullage	Saline Discharge	Stormwater runoff	Deck Drainage	Anti-fouling leachate	Introduced Marine Species	Hydrocarbon spills	Chemical Spills
Square-tailed kite	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Grey goshawk	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Black-necked stork	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Sooty oystercatcher	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Lewin’s rail	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Black-chinned honeyeater	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Wandering Whistling duck	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Magpie goose	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Black swan	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Pacific Black duck	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Pacific baza	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Whistling kite	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Brown goshawk	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Brahminy kite	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Eastern osprey	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Australian hobby	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Whimbrel	L	I	I	L	I	L	I	L	L	L	I	I	I	L	L
Marine Mammals															
Bryde’s whale	I	L	L	L	I	I	I	L	L	I	I	I	I	I	I

Protected Species	Physical Presence - Permanent	Physical Presence - Temporary	Underwater Noise	Light	Food Scraps & Putrescible	General non-hazardous solid waste	General hazardous solid waste	Sewage & Sullage	Saline Discharge	Stormwater runoff	Deck Drainage	Anti-fouling leachate	Introduced Marine Species	Hydrocarbon spills	Chemical Spills
Dugong	L	M	L	L	I	I	I	L	L	I	L	I	I	L	I
Humpback whale	I	L	L	L	I	I	I	L	L	I	I	I	I	I	I
Snubfin dolphin	I	L	L	L	I	I	I	L	L	I	L	I	I	L	I
Killer whale, orca	I	L	L	L	I	I	I	L	L	I	I	I	I	I	I
Indo-Pacific Humpback dolphin	I	L	L	L	I	I	I	L	L	I	L	I	I	L	I
Reptiles															
Loggerhead turtle	I	L	L	L	I	I	I	L	L	I	L	I	I	L	I
Green turtle	I	L	L	L	I	I	I	L	L	I	L	I	I	L	I
Estuarine crocodile, Salt-water crocodile	I	I	L	L	I	I	I	L	L	I	L	I	I	L	I
Leathery turtle, Leatherback turtle	I	L	L	L	I	I	I	L	L	I	L	I	I	L	I
Hawksbill turtle	I	L	L	L	I	I	I	L	L	I	L	I	I	L	I
Pacific Ridley turtle, Olive Ridley turtle	I	L	L	L	I	I	I	L	L	I	L	I	I	L	I
Flatback turtle	I	L	L	L	I	I	I	L	L	I	L	I	I	L	I
Fish															
Whale shark	I	L	I	I	I	I	I	I	I	I	I	I	I	I	I
Green sawfish	I	L	L	L	I	L	I	L	L	I	L	I	I	I	I

Risk Level: I – Insignificant L – Low M - Medium H - High

Impacts specifically associated with dredging of shipping channels or swing basins, or construction and management of the Fisherman's Landing dredge reclamation area are discussed in *Volume 6*.

No significant impacts to *EPBC Act* listed threatened and migratory fish, marine mammal or marine reptile species are predicted to result from construction or operation or the proposed infrastructure and activities due to the small number of individuals from these species that utilise the area and the likelihood that individuals would continue to utilise parts of the affected marine environment despite construction and operations-related activities. A summary of the impacts outlined in this chapter is provided in *Table 5.8.51* below.

Table 5.8.51 Summary of impacts for Marine Ecology

Impact assessment criteria	Assessment outcome
Impact assessment	Negative
Impact type	Direct and secondary
Impact duration	Permanent loss of habitat as a result of infrastructure that is constructed in the marine environment. Short-term changes to water quality and impacts on marine receptors in the event of a spill. Long-term impacts associated with vessel movements, lighting and discharges to the marine environment during the life of the Project.
Impact extent	Local
Impact likelihood	High for loss of habitat resulting from infrastructure construction, land reclamation and dredging. Unlikely for spills. High for impacts associated with vessel movements, lighting and discharges to the marine environment during the life of the Project.

Overall assessment of impact significance: Minor. This is provided that proposed management measures are implemented that will maintain structure and function of marine ecosystems, protect biodiversity and the integrity of populations of listed species within the study area. Summaries of project management measures and residual levels of risk for the construction and operation phases are provided below in *Table 5.8.52* and *Table 5.8.53* respectively.

The potential environmental consequences of the Project are unlikely to have long-term implications for the marine environment surrounding the Port of Gladstone. The overall level of risk to marine conservation values is therefore considered to be acceptable and environmental management objectives for the Project achievable.

The potential management measures indicated to manage impacts to marine environmental receptors will maintain ecological structure and function, and protect the biodiversity and the integrity of populations of listed species that naturally inhabit the marine environs of the Project area.

8.6 SUMMARY

This impact assessment has systematically evaluated the potential impacts associated with the construction and operation phases of QCLNG Project infrastructure with the potential to impact on the marine environment. Where possible, additional commentary has been made on the likely impacts associated with the decommissioning phase.

The main components of the Project with the potential to impact the marine environment are those associated with the construction and subsequent operation of the:

- Bridge and Pipeline crossing (no longer proposed by this EIS or QGC)
- MOF
- Loading Jetty
- LNG Facility itself, including the discharge source points.

The most significant impacts anticipated to occur during the construction phase arise from dredging and reclamation and disposal of dredge material. These activities may directly impact habitats such as seagrasses and mangroves (from the footprint of structures and the reclamation area) and cause secondary impacts on water quality and behavioural changes from mobile marine species that are likely to be temporarily disturbed by the increased turbidity or noise.

Impacts specifically associated with dredging are discussed in detail in Volume 6.

Table 5.8.52 Summary of Project Management Measures and Residual Level of Risk for the Construction Phase

Aspect	Management Action	Driver	Level of Risk
Physical presence (permanent)	Design infrastructure and apply construction methods to minimise direct footprint on sensitive habitats and reduce potential impacts on water quality.	Regulatory compliance Best practice	Medium
	Develop a Dredging Management Plan that includes the timing, duration and location of dredging activities to minimise the overall impact from dredging on marine receptors.	Regulatory compliance Best practice	
	Design and manage the land reclamation activities to reduce the impact to benthic habitats and marine flora and fauna.	Regulatory compliance Best practice	
Physical presence (temporary)	Vessels will abide by Port of Gladstone vessel speed restrictions and exclusion zones, in particular within Dugong Protected Areas (DPA).	Regulatory compliance	Medium
	Navigation permitting, vessels to take the most direct route.	Best practice Education	
Underwater noise	Construction activities (for example, dredging, HDD, pile driving) will be undertaken in as short a timeframe as practicable to minimise disturbance. The requirement for an exclusion zone for marine mammals during percussive piling activities may be evaluated when more information on construction methods is available.	Best practice	Low
	Vessels will abide by Port of Gladstone speed restrictions.	Regulatory compliance	
Light	Design lighting to meet relevant industry standards to reduce light spill onto receiving environment	Regulatory compliance Best practice	Low
Solid waste	Food scraps and putrescible wastes from the LNG Facility will be disposed of onshore and will not therefore be discharged to the marine environment.	Regulatory compliance Best practice	Insignificant
	Disposal of food waste from vessels will meet relevant standards to reduce impact to marine environment, including discharge to open ocean only (great than 22 km from land).	Regulatory compliance	

Aspect	Management Action	Driver	Level of Risk
	Collection of oils and greases will be collected for onshore disposal.	Regulatory compliance	
	Avoid or minimise waste to be generated by procuring services which provide alternative waste disposal methods.	Best practice	
	Develop and implement waste management plans for all solid wastes for the life of the Project.	Best practice Regulatory compliance	
	Non-hazardous waste will be segregated into recyclable and non-recyclable waste and disposed of onshore at approved recycling or waste disposal facilities.	Best practice Regulatory compliance	
	If hazardous wastes are required (and no alternative available) then these wastes will be appropriately labelled, stored and transported in accordance with appropriate standards, and disposed of onshore in an approved facility.	Best practice Regulatory compliance	
Marine discharges	Design and locate the diffuser discharge point to maximise mixing and dilution of the wastewater being discharged through the marine discharge outfall.	Regulatory compliance Best practice	Low to insignificant
	Design and manage the production of potable water to be minimised where possible, to reduce to requirement to discharge saline waste water.	Best practice	
	Surface water runoff during high rainfall events will be managed through the design of detention basins other sediment control structures, and cleared surfaces will be stabilised to further reduce erosion of fine sediments.	Best practice	
	Fuel and chemical storage areas, as well as refuelling areas will be adequately bunded to ensure no oil or chemical-contaminated water is discharged to the marine environment.	Regulatory compliance Best practice	
	No contaminated waste will be intentionally discharged via deck washdown activities.	Best practice	
	Anti-fouling products to be used on vessels will be procured to ensure least impact to receiving marine environment, this includes no use of TBT on new vessels.	Regulatory compliance Best practice	
Hydrocarbon spill	In accordance with the requirements of the Port of Gladstone, develop and	Regulatory compliance	Medium

Aspect	Management Action	Driver	Level of Risk
	implement emergency response plans to include spills, which will include the use of absorbent materials and disposing of these in an approved facility onshore.	Best practice	
	Oil and chemical usage area shall be contained with appropriate bunding and sumps.	Regulatory compliance Best practice	
	Adhere to industry standards for fuel and hydrocarbon storage, handling and operation, as well as vessel and equipment inspections to identify any potential leaks.	Regulatory compliance Best practice	
	Each vessel will have a SOPEP and carry an oil pollution kit.	Regulatory compliance Best practice	
Chemical spill	Chemicals will be stored safely in approved, labelled containers..	Regulatory compliance	Insignificant
Introduced marine species	Comply with all applicable AQIS requirements relating to management of ballast water.	Regulatory compliance	Low

Table 5.8.53 Summary of Project Management Measures and Residual Level of Risk for the Operation Phase

Aspect	Management Action	Driver	Level of Risk
Physical presence (permanent)	In conjunction with the Port of Gladstone, support the broader monitoring programs established for the Port to monitor environmental changes in the marine environment.	Best practice	Low
	Comply with all applicable laws, regulations, industry standards and obtain relevant licences or permits during operation of the Project.	Regulatory compliance Best practice	
Physical presence (temporary)	Vessels will abide by the Port of Gladstone vessel speed restrictions and exclusion zones, in particular within DPA.	Regulatory compliance	Medium
	Navigation permitting, vessels to take the most direct route..	Best practice	
Underwater noise	Navigation permitting, vessels will take the most direct route..	Best practice	Low

Aspect	Management Action	Driver	Level of Risk
	Vessels will abide by Port of Gladstone speed restrictions.	Regulatory compliance	
Light	Design lighting to meet relevant industry standards to reduce light spill onto receiving environment.	Best practice	Low.
Solid waste	Disposal of food scraps and putrescibles from vessels will meet relevant standards to reduce impact to marine environment, including discharge to open ocean only (greater than 22 km from land).	Regulatory compliance	Insignificant
	Collection of oils and greases will be collected for onshore disposal.	Regulatory compliance	
	Implement waste management plans for all solid wastes for the life of the Project.	Best practice Regulatory compliance	
	Non-hazardous waste will be segregated into recyclable and non-recyclable waste and disposed of onshore at government-approved recycling or waste disposal facilities.	Best practice Regulatory compliance	
	If hazardous wastes are required (and no alternative available) then these wastes will be appropriately labelled, stored and transported in accordance with appropriate standards, and disposed of onshore at an approved facility.	Best practice Regulatory compliance	
Marine discharges	Desalination brine produced will be discharged to the ocean using a rapid dispersion.	Best practice	Low
	Fuel and chemical storage areas, as well as refuelling areas will be adequately bunded to ensure no oil or chemical contaminated water is discharged to the marine environment.	Best practice Regulatory compliance	
	Operate and manage stormwater systems to accommodate erosion and sediment control structures, especially after heavy rainfall.	Best practice	
	No contaminated waste will be intentionally discharged via deck washdown activities.	Best practice	
	Anti-fouling products to be used on vessels will be procured to ensure least impact to receiving marine environment, this includes no use of TBT on new vessels.	Regulatory compliance Best practice	

Aspect	Management Action	Driver	Level of Risk
Hydrocarbon Spills	In accordance with the requirements of the Port of Gladstone, develop and implement emergency response plans to include spills, which will include the use of absorbent materials and disposing of these in an approved facility onshore.	Regulatory compliance Best practice	Medium
	Oil and chemical usage area shall be contained with appropriate bunding and sumps.	Regulatory compliance Best practice	
	Adhere to industry standards for fuel and hydrocarbon storage, handling and operation, as well as vessel and equipment inspections to identify any potential leaks.	Regulatory compliance Best practice	
	Each vessel will have a SOPEP and carry an oil pollution kit.	Regulatory compliance Best practice	
Chemical Spill	Chemicals will be stored safely in approved, labelled containers.	Regulatory compliance	Insignificant
Introduced species	Comply with all applicable AQIS requirements relating to management of ballast water.	Regulatory compliance	Low

Changes to local bathymetry and the currents/tidal flows through the Project area are inherently associated with dredging activities. These changes are not likely to have significant impacts on sensitive marine receptors. Dredging impacts are also discussed further in *Volume 6.*

The increased presence of vessels and frequency of vessel movements during both construction and operations phases pose a risk to marine fauna, and will have some localised impact on water quality from standard vessel discharges, the deployment and retrieval of anchors and chains, and the use of propellers and thrusters. Vessel movements themselves pose a risk to the marine receptors such as turtles and marine mammals. However, the Project is within the limits of the Port of Gladstone and as such, all vessel movements and activities will be undertaken in accordance with the requirements and procedures of the Port of Gladstone. Similarly, given that the Port of Gladstone is already a very active port, the existing marine receptors that use the Port's waters for feeding, breeding and transiting are already doing so within the disturbed conditions typical of a large port. The cumulative impact of vessel movements associated with this and other proposed developments in the vicinity of the Port of Gladstone will be subject to evaluation, with overall responsibility lying with the Port of Gladstone as the port operator.

Light impacts have been evaluated. Given the absence of the most sensitive receptors (nesting adults and turtle hatchlings) from within the identified impact zone, further evaluation of lighting impacts beyond the implementation of a lighting design philosophy that minimises light spill and glow, no further sensitive receptors have been identified to warrant further mitigation.

Solid wastes will be generated throughout the Project. However, the likelihood of solid wastes significantly impacting on the marine environment is minimised through the implementation of industry standard waste management practices.

The largest marine discharge associated with the Project occurs during the construction phase and is associated with the sewage and sullage discharges from the onshore construction and operations, as well as discharges from the desalination plant. These liquid discharges will be treated prior to discharge, with the final discharges occurring within any permit or discharge licence conditions. The design of the diffuser at the end of the discharge pipeline will further promote mixing. Given that the final treatment limits will be set and monitored for regulatory compliance, the overall impacts associated with these discharges will be kept within environmentally acceptable limits.

Other discharges that may have the potential to impact marine receptors include stormwater, deck drainage and anti-fouling leachate. The implementation of standard management plans and procedures will manage these discharges to ensure there is no unacceptable risk.

Unplanned events, specifically either hydrocarbon or chemical spills, have the potential to occur over the course of the Project. During the construction phase, there is an escalated risk of small spills from the increased number of vessels, and the number of activities, occurring at any particular time. Vessels and onshore construction activities in the vicinity of the marine environment will implement emergency response procedures in the event of an incident. The consequence of a spill is related to the nature of the material spilt, the prevailing conditions at the time, the sensitivity of the receiving environment and the response measures instigated at the time of the spill. All vessel activities, during both construction and operations will be under the jurisdiction and approved protocols of the Port of Gladstone, as well as international maritime law when transporting the LNG to market. In the event of an incident within the port limits, and the incident is beyond the capability of the vessel to adequately respond, the Port's response plans will be triggered and QGC will work with the Port or other appropriate authorities as required.

The Project has the potential to increase the risk of introduced marine species entering the port of Gladstone. This arises from the number of vessels that are likely to enter the Port from overseas destinations. However, there are national and international requirements that specifically target the management of risk from introduced marine species. These include protocols on the exchange of ballast water at sea and the inspection of vessel hulls and cavities that are likely to host potential species that may cause either environmental or economic harm if released to the local environment. There will be full collaboration with the procedures and protocols of the Port of Gladstone and AQIS on this issue.

As Project design progresses, additional mitigation measures may be identified and incorporated as required into the Project's EMPs and broader environmental management system.