Australia Pacific LNG Project
Supplemental information to the EIS
Marine Ecology - Pipeline

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1. Introduction

This marine ecology report has been provided as supplementary information for the Upstream component of the Australian Pacific LNG Project (the Project). This report also assess the potential impacts of the revised construction works associated with the gas pipeline crossing of the intertidal mudflats and The Narrows in Port Curtis (see Figure 1-1).

Dredging has been proposed for the pipeline across The Narrows and construction of the proposed Australia Pacific LNG marine infrastructure on Curtis Island. Mitigation measures associated with managing dredging works are discussed within the Port of Gladstone Western Basin Dredging and Disposal Project EIS and accompanying Addenda (GHD 2010).

Considering the prior EIS work (Vol 5 Attachments Attachments 19 and 20), and to ensure consistency, this report addresses the upstream section of the Project and considers the potential impacts from the proposed pipeline to the creeks and adjacent saltmarsh and mangrove communities on the mainland; the pipeline crossing across The Narrows in Port Curtis; and the pipeline installation across the mangrove communities on the western side of Curtis Island.

Figure 1-1 Proposed Pipeline Crossing

2. Project Description

2.1 Pipeline

The Narrows crossing has three distinct sections: the creeks (Mosquito and Targinie Creeks), the mudflats (1,300m) and The Narrows channel (2,400m). These sections will be crossed by different, but interrelated methods tailored for the respective environments.

2.1.1 Crossing of the Intertidal Mudflats

For assessment purposes the following methodology has been evaluated. This methodology is consistent with the open cut construction across the mudflats and dredging across the Narrows as described in the EIS as the alternative. An open cut trench will be constructed with sheet piling proposed along the whole section of the mudflats. To allow water to flow through the creeks, sheet piles will be constructed under the typical water level, maintaining inundation patterns.

Proposed access across the mudflats will be by a stabilised elevated access road though the mangroves. Pipe string for The Narrows shall be from this constructed access road. Where needed, the ground will be stabilised to hold the pipe string. Construction material shall be removed after construction.

The footprint is 40 m wide across the intertidal mudflats

Potential and Actual Acid Sulphate Soils (ASS) will need to be excavated separately and treated with lime on an adjacent treatment area. The area required is calculated to be approximately 20 ha to treat approximately 27,250 m^3.

Once the installation of the pipeline is complete, sheet piling and any other construction materials will be removed from the mudflats, including access road fill. It is anticipated that construction will require between nine and 12 months to complete (EIS Vol 5 Attachments 19 and 27).

2.1.2 Crossing of The Narrows

The base case is an open trench using a cutter suction dredge (CSD) across The Narrows. The footprint at the seabed surface is estimated to be 40 m wide, with the depth of the trench up to 7m, dependent on bathymetry. The total in-situ spoil is estimated at 363,500m^3.

3. Existing Conditions

Port Curtis estuary has a natural water depth to 12 m and is protected from the open ocean by Curtis and Facing Islands. Port Curtis has areas largely unaffected by human activity, as well as areas highly modified by port developments and various industries.

The proposed location for the LNG plant is near Laird Point on the western side of Curtis Island. It is situated within the Gladstone Port Limits, however all of the Port waters below the mean low water mark lie within the Great Barrier Reef World Heritage Area. The gas pipeline will cross from the mainland to Curtis Island between Friend and Laird Point. This is at the southern end of The Narrows, a 20,903 ha passage separating Curtis Island from the mainland and one of only five tidal passages within Australia.

The proposed location of the pipeline crossing is within Gladstone Port limits, but also within the Great Barrier Reef World Heritage Area. Habitat types within the wetland include saline coastal flats, mangrove forest, intertidal sand and mud flats, seagrass beds and open marine and estuarine waters. The Narrows is zoned as a habitat protection zone and the southern boundary of this zone is a straight line from Laird Point to Friend Point.

Ramsar wetlands are not located within, or adjacent to the proposed development site. The closest Ramsar wetlands are Corio Bay and Shoalwater Bay, which are approximately 150km north of the site. Laird Point is within the Curtis Island Nationally Important Wetland (QLD021). The nearest declared fish habitat areas are the Fitzroy River, which includes large parts of the northern and north-western parts of Curtis Island (FHA-072), Colosseum Inlet (FHA-037) and Rodds Harbour (FHA-036). These are approximately 23km, 35km and 50km respectively, from the proposed LNG plant. The Rodds Bay Dugong Protection Area encompasses the proposed Port Curtis development site and crossing of the Narrows.

3.1 Water Quality

Water quality in the study area was addressed in the EIS (Vol 5 Attachment 27) by investigating the environmental values in and around Port Curtis, the applicable water quality guidelines and the existing water quality conditions as described in the literature.

3.1.1 Water Quality Guidelines/Objectives

Under the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) 2000), Port Curtis estuary can be considered as a ‘slightly to moderately’ disturbed ecosystem. ANZECC/ARMCANZ (2000) guidelines for toxicants in aquatic ecosystems apply a 95% protection level to ecosystems which are classed as moderately disturbed. Table 3.1 provides the relevant ANZECC/ARMCANZ (2000) default trigger values for slightly disturbed estuarine ecosystems in waters of tropical Australia. In addition to the national guidelines, the Queensland Department of Environment and Resource Management (DERM) (formerly the Environmental Protection Agency (EPA)) provide state wide Queensland Water Quality Guidelines (QWQG) (DERM 2009). The QWQG objectives for mid-estuarine waters in the Central Coast region of Queensland are also provided in Table 3-1.

Table 3-1 Water Quality Guidelines/Objectives

	QWQG (DERM 2009)	ANZECC/ARMCANZ (2000)
Ammonia N (µg/L)	10	15
Oxidised N (µg/L)	10	30
Organic N (µg/L)	280	N/A
Total N (µg/L)	300	250
Filterable P (µg/L)	6	5
Total P (µg/L)	25	20
Chlorophyll-a (µg/L)	4.0	2.0
DO (% saturation) Upper	105	120
DO (% saturation) Lower	85	80
Turbidity (NTU)	8	1 - 20
Secchi (m)	1.0	N/A
Suspended solids (mg/L)	20	N/A
pH Upper	8.4	8.5
pH Lower	7.0	7.0
Conductivity	N/A	N/A

3.1.2 Additional Water Quality Sampling

To complement the work undertaken and develop a better understanding regarding the existing water quality conditions in and around Port Curtis, water quality sampling was undertaken in Targinie Creek, upstream from The Narrows, on 15 May 2010 (see Figure 3-1). Five sites were sampled (TC1 – TC5). Median water quality values for Targinie Creek were determined and are compared to the relevant ANZECC/ARMCANZ (2000) and QWQG (DERM 2009) estuarine water quality guidelines.

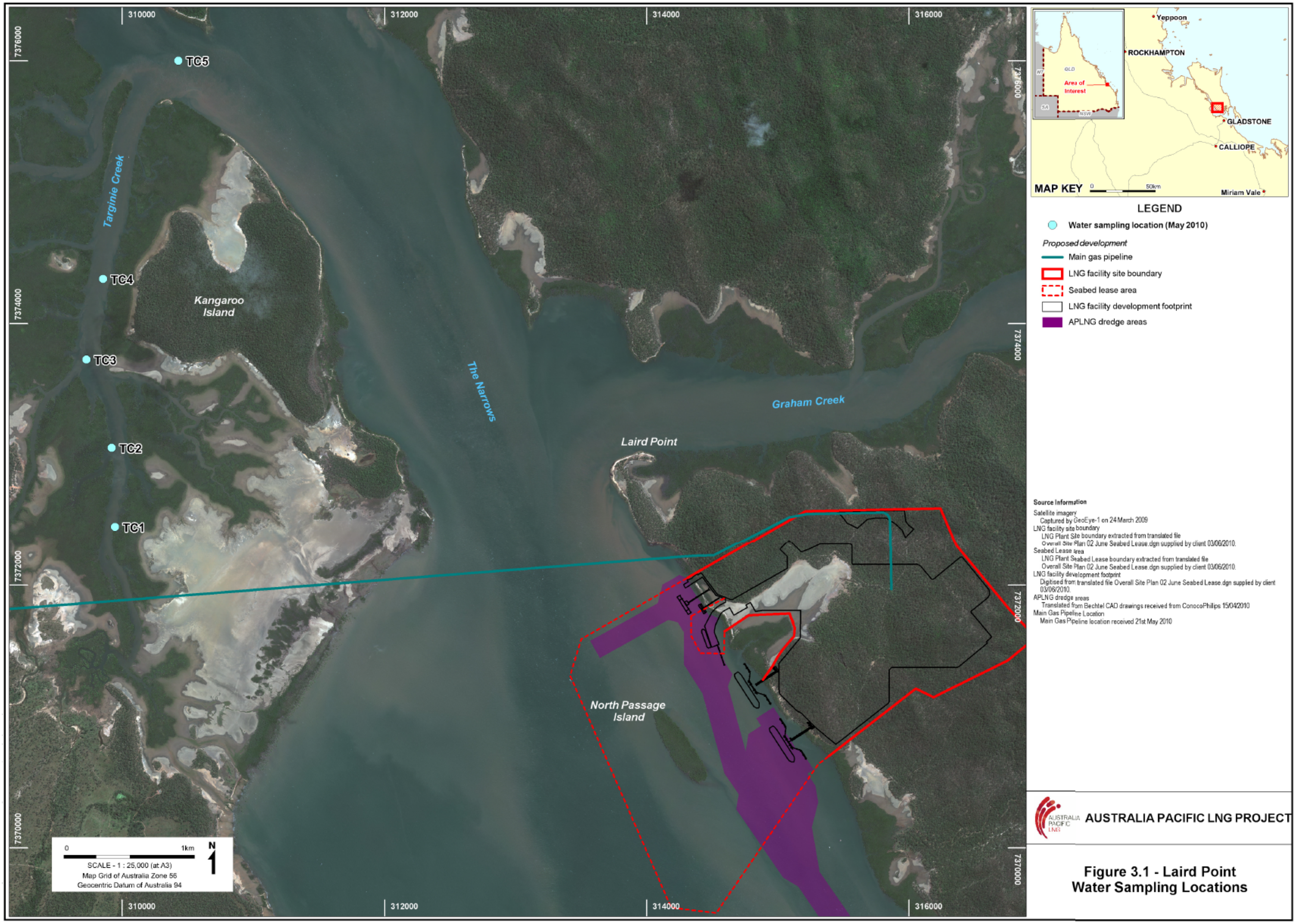

Figure 3-1 Additional Water Quality Sampling Sites in Targinie Creek

The water quality parameters tested for at the five sites within Targinie Creek were as follows:

- **Physical Parameters** – salinity (conductivity), total suspended solids (TSS), total dissolved solids (TDS)
- **Nutrients** – total nitrogen (TN), total Kjeldahl nitrogen (TKN), total phosphorus (TP), nitrate, nitrite, reactive phosphorus, ammonia
- **Metals** (total and dissolved metals) – lead (Pb), zinc (Zn), nickel (Ni), mercury (Hg), copper (Cu), chromium (Cr), cadmium (Cd), arsenic (As), iron (Fe), cobalt (Co), manganese (Mn), molybdenum (Mo), silver (Ag), vanadium (V) and galium. Laboratory analysis failed to obtain the reporting limits required under the ANZECC/ARMCANZ criteria, making comparison to guidelines difficult
- **Hydrocarbons** –total petroleum hydrocarbons (TPH) (C6-C36), benzene, toluene, ethylbenzene and xylenes (BTEX), and total polycyclic aromatic hydrocarbons (PAHs)

3.1.3 Results of Additional Sampling

Physical Parameters

Electrical conductivity, and TDS measures were generally consistent over all five sites (Table 3-2). TDS were noticeably lower at WQ2 than the other sites. Owing to an absence of recent rainfall, discharge to the estuary via local groundwater systems may be a possible source of this variation. TSS were found to vary slightly between sites, with the highest level of 8 mg/L found at the most upstream and downstream sites (TC1 and TC5) and lowest level of 4 mg/L at TC3, which is located at the confluence of Targinie Creek with two smaller creeks. At all sites TSS levels were well below the QWQG limit of 20 mg/L for mid-estuarine ecosystems (DERM 2009).

Table 3-2 Water quality physical parameters

	TC1	TC2	TC3	TC4	TC5	Median	QWQG (DERM 2009)
Electrical Conductivity (µS/cm)	51900	51400	52000	52600	53600	52000	N/A
Total Dissolved Solids (TDS) (mg/L)	35200	26600	34100	36200	34000	34100	N/A
Total Dissolved Solids (TDS) (est.) (mg/L)	33700	33400	33800	34200	34800	33800	N/A
Total Suspended Solids (SS) (mg/L)	8	6	4	6	8	6	20

Nutrients

Nutrient results from water quality sampling in Targinie Creek were compared to the ANZECC/ARMCANZ (2000) default trigger values for 'slightly to moderately' disturbed estuarine ecosystems in tropical Australia' and the QWQG (DERM 2009) for mid-estuarine ecosystems (Table 3.3). Levels of ammonia were above the ANZECC/ARMCANZ (2000) and QWQG (DERM 2009) guidelines for estuarine ecosystems (15 µg/L and 10 µg/L respectively) at all five sites, with a median value of 80 µg/L. Nitrite levels were below the level of reporting (LOR) (10 µg/L) at all sites sampled and had a median value of 5 µg/L. Nitrate was below the LOR at TC2 and TC3, with values only slightly above the LOR for the other two sites. A median value of 10 µg/L was found for nitrate. Neither the ANZECC/ARMCANZ (2000) or DERM (2009) guidelines specify limits for nitrite or nitrate. Levels of total nitrogen (TN) were well above the ANZECC/ARMCANZ (2000) and DERM (2009) guidelines (250 µg/L and 300µg/L respectively) at all sites with a median value of 700 µg/L. Most significantly, levels of total phosphorus (TP) at all sites were between approximately ten (TC5) and almost 160 (TC3) times the ANZECC/ARMCANZ (2000) guideline concentration of 20 µg/L, with a median concentration of 1660 µg/L. Total reactive phosphorus was below the LOR (10 µg/L) at all sites. However as the QWQG for Total Reactive Phosphorus (6 µg/L) is actually below the LOR, no discussion on this could be made.

Table 3-3 Nutrients in Water Quality Samples

	TC1	TC2	TC3	TC4	TC5	Median *	ANZECC/ARMCANZ (2000) / QWQG (DERM 2009)
Ammonia (µg/L)	80	90	80	80	100	80	15 µg/L / 10 µg/L
Nitrite (µg/L)	< 10	< 10	< 10	< 10	< 10	5	N/A
Nitrate (µg/L)	10	< 10	< 10	10	20	10	N/A
Nitrite + Nitrate (µg/L)	10	< 10	< 10	10	20	10	N/A
Total Kjeldahl Nitrogen (µg/L)	60	60	80	70	70	70	N/A
Total Nitrogen (µg/L)	600	600	800	700	700	700	250 µg/L / 300µg/L
Total Phosphorous (µg/L)	1540	1750	3160	1640	230	1640	20 µg/L / 25 µg/L
Reactive Phosphorous (µg/L)	< 10	< 10	< 10	< 10	< 10	5	6 µg/L (QWQG)

* Where the individual result was less than the detection limit the median was calculated using ½ the level of detection.

Total Metals

Metal results from water quality sampling undertaken in Targinie Creek were compared to the ANZECC/ARMCANZ (2000) default trigger values for toxicants applying to 'slightly to moderately' disturbed marine waters. Although the upstream environment is classified as estuarine, ANZECC/ARMCANZ (2000) trigger values for toxicants are only provided for freshwater or marine waters.

Table 3-4 shows the concentrations of total metals at upstream water quality sampling sites. Levels of arsenic, cadmium, cobalt, copper, gallium, lead, nickel, silver, iron, vanadium and mercury were all below the LOR. However, the LOR was well above the ANZECC/ARMCANZ (2000) guideline values in most cases (with the exception of vanadium). As such, no conclusive comments can be made as to the level of these metals compared to the national guidelines. Chromium was the only metal for which concentrations were obtained above the LOR and a guideline value was available. Chromium levels were below the ANZECC/ARMCANZ (2000) guidelines of 27.4 µg/L at all sites. For other metal toxicants including manganese, molybdenum and iron, there is no ANZECC/ARMCANZ (2000) guideline.

Table 3-4 Total Metals in Water Quality Samples

	TC1	TC2	TC3	TC4	TC5	Median *	ANZECC/ ARMCANZ (2000)
Arsenic (µg/L)	< 50	< 50	< 50	< 50	< 50	25	N/A
Cadmium (µg/L)	< 5	< 5	< 5	< 5	< 5	2.5	0.7 µg/L
Chromium (µg/L)	11	12	11	12	< 10	11	27.4 µg/L
Cobalt (µg/L)	< 10	< 10	< 10	< 10	< 10	5	1 µg/L
Copper (µg/L)	< 50	< 50	< 50	< 50	< 50	25	1.3 µg/L
Gallium (µg/L)	< 10	< 10	< 10	< 10	< 10	5	N/A
Lead (µg/L)	< 10	< 10	< 10	< 10	< 10	5	4.4 µg/L
Manganese (µg/L)	21	18	17	< 10	13	17	N/A
Molybdenum (µg/L)	12	12	12	13	12	12	N/A
Nickel (µg/L)	< 50	< 50	< 50	< 50	< 50	25	7 µg/L
Silver (µg/L)	< 10	< 10	< 10	< 10	< 10	5	1.4 µg/L
Zinc (µg/L)	< 50	< 50	< 50	< 50	< 50	25	15 µg/L
Iron (µg/L)	980	800	960	820	1020	960	N/A
Vanadium (µg/L)	< 50	< 50	< 50	< 50	< 50	25	100 µg/L
Mercury (µg/L)	< 1	< 1	< 1	< 1	< 1	0.5	0.1 µg/L

* Where the individual result was less than the detection limit the median was calculated using ½ the level of detection.

Dissolved Metals

Table 3-5 shows the concentrations of dissolved metals in water quality samples from the five upstream sites. Similar to total metals, levels of the dissolved metals arsenic, cadmium, cobalt, copper, gallium, lead, nickel, silver, iron, vanadium and mercury at all upstream sites were below the LOR, despite the LOR values being higher than the ANZECC/ARMCANZ (2000) guideline values in most cases (with the exception of vanadium). For the metals which were in concentrations above the LOR, and for which ANZECC/ARMCANZ (2000) guidelines are available, the median concentration of chromium was found to be below the guideline value of 27.4 µg/L, while the median concentration of zinc was greater than the guideline value of 15 µg/L. However, it must be noted that both of these median values were calculated using a majority of values which were below the LOR.

Table 3-5 Dissolved Metals in Water Quality Samples

	TC1	TC2	TC3	TC4	TC5	Median *	ANZECC/ ARMCANZ (2000)
Arsenic (µg/L)	< 50	< 50	< 50	< 50	< 50	25	N/A
Cadmium (µg/L)	< 5	< 5	< 5	< 5	< 5	2.5	0.7 µg/L
Chromium (µg/L)	< 10	< 10	< 10	23	< 10	5	27.4 µg/L
Cobalt (µg/L)	< 10	< 10	< 10	< 10	< 10	5	1 µg/L
Copper (µg/L)	< 50	< 50	< 50	< 50	< 50	25	1.3 µg/L
Gallium (µg/L)	< 10	< 10	< 10	< 10	< 10	5	N/A
Lead (µg/L)	< 10	< 10	< 10	< 10	< 10	5	4.4 µg/L
Manganese (µg/L)	12	10	< 10	< 10	< 10	5	N/A
Molybdenum (µg/L)	12	12	12	10	12	12	N/A
Nickel (µg/L)	< 50	< 50	< 50	< 50	< 50	25	7 µg/L
Silver (µg/L)	< 10	< 10	< 10	< 10	< 10	5	1.4 µg/L
Zinc (µg/L)	< 50	< 50	< 50	69	< 50	25	15 µg/L
Iron (µg/L)	< 500	< 500	< 500	< 500	< 500	250	N/A
Vanadium (µg/L)	< 50	< 50	< 50	< 50	< 50	25	100
Mercury (µg/L)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.05	0.1 µg/L

* Where the individual result was less than the detection limit the median was calculated using ½ the level of detection.

Hydrocarbons

Total petroleum hydrocarbons (TPH) were below the LOR for the C6 - C9 Fraction and C10 - C14 Fraction at all sites. Values of the C15 - C28 Fraction, C29 - C36 Fraction and C10 - C36 Fraction (sum) were also below the LOR at three of the four sites with the exception of site TC3 (Table 3-6). It is possible that the elevated TPH results found at TC3 could be due to anthropogenic inputs from recreational boating activities (several vessels were present within the creek system at the time of sampling).

BTEX compounds were below the LOR at all sites (Table 3-7). No ANZECC/ARMCANZ (2000) guidelines are available for any BTEX compounds reported except for benzene. All total polynuclear aromatic hydrocarbon (PAH) concentrations were below the LOR and no ANZECC/ARMCANZ (2000) guidelines are available except for naphthalene (Table 3-8).

Table 3-6 Total Petroleum Hydrocarbons (TPH) (C6-C36)

	TC1	TC2	TC3	TC4	TC5	Median *	ANZECC/ ARMCANZ (2000)
Total Petroleum Hydrocarbons (µg/L)							
C6 - C9 Fraction	<20	<20	<20	<20	<20	10	N/A
C10 - C14 Fraction	<50	<50	<50	<50	<50	25	N/A
C15 - C28 Fraction	<100	<100	450	<100	<100	50	N/A
C29 - C36 Fraction	<50	<50	170	<50	<50	25	N/A
C10 - C36 Fraction (sum)	<50	<50	620	<50	<50	25	N/A

* Where the individual result was less than the detection limit the median was calculated using ½ the level of detection.

Table 3-7 BTEX Compounds - Benzene, toluene, ethylbenzene and xylenes

	TC1	TC2	TC3	TC4	TC5	Median *	ANZECC/ ARMCANZ (2000)
BTEX (µg/L)							
Benzene	<1	<1	<1	<1	<1	0.5	500 µg/L
Toluene	<2	<2	<2	<2	<2	0.5	N/A
Ethylbenzene	<2	<2	<2	<2	<2	0.5	N/A
meta- & para-Xylene	<2	<2	<2	<2	<2	0.5	N/A
ortho-Xylene	<2	<2	<2	<2	<2	0.5	N/A

* Where the individual result was less than the detection limit the median was calculated using ½ the level of detection.

Table 3-8 Total Polynuclear Aromatic Hydrocarbons (PAHs)

	TC1	TC2	TC3	TC4	TC5	Median *	ANZECC/ ARMCANZ (2000)
Polynuclear Aromatic Hydrocarbons (µg/L)							
Naphthalene	<1.0	<1.0	<1.0	<1.0	<1.0	0.5	50 µg/L
Acenaphthylene	<1.0	<1.0	<1.0	<1.0	<1.0	0.5	N/A
Acenaphthene	<1.0	<1.0	<1.0	<1.0	<1.0	0.5	N/A
Fluorene	<1.0	<1.0	<1.0	<1.0	<1.0	0.5	N/A
Phenanthrene	<1.0	<1.0	<1.0	<1.0	<1.0	0.5	N/A
Anthracene	<1.0	<1.0	<1.0	<1.0	<1.0	0.5	N/A
Fluoranthene	<1.0	<1.0	<1.0	<1.0	<1.0	0.5	N/A
Pyrene	<1.0	<1.0	<1.0	<1.0	<1.0	0.5	N/A
Benz(a)anthracene	<1.0	<1.0	<1.0	<1.0	<1.0	0.5	N/A
Chrysene	<1.0	<1.0	<1.0	<1.0	<1.0	0.5	N/A
Benzo(b)fluoranthene	<1.0	<1.0	<1.0	<1.0	<1.0	0.5	N/A
Benzo(k)fluoranthene	<1.0	<1.0	<1.0	<1.0	<1.0	0.5	N/A

* Where the individual result was less than the detection limit the median was calculated using ½ the level of detection.

3.2 Port Curtis Integrated Monitoring Program

The Port Curtis Integrated Monitoring Program (PCIMP) is a collaborative monitoring program undertaken for the whole of Port Curtis. The program was established in 2001 as a consortium of members from 16 bodies representing industry, government (both local and state), research institutions and other stakeholders to develop a cooperative monitoring program for assessing the ecosystem health of the estuary. The water quality monitoring program within PCIMP commenced in 2005 (Storey et al. 2007). The PCIMP has generally found that water conditions in the estuary, including metal concentrations, have met the ANZECC/ARMCANZ (2000) Australian Water Quality Guidelines for 99% species protection.

METHODS

The PCIMP divides the Harbour into nine zones which include a full cross section of inner Harbour regions of high activity, as well as reference zones of lesser impact in the outer Harbour and oceanic areas. Oysters and passive sampling devices (diffuse gradients in thin films (DGT)) are used to measure the level of contaminants in Harbour while collection of physiochemical parameters and measurement of nutrient and metal concentrations in the water at each site is also undertaken to assess the water quality of the Harbour. Results of the monitoring program are collated to give an overall Ecosystem Health (EH) rating/standardised score which is displayed in a Report Card format (Storey et al. 2007).

The nine zones that are monitored in Port Curtis are as follows:

- The Narrows
- Inner Harbour – Fisherman's
- Inner Harbour – Calliope
- Auckland Creek
- Mid Harbour
- Inner Harbour – South Trees
- Boyne Tannum
- Reference - Estuarine
- Reference – Oceanic

Of these zones, The Narrows and Inner Harbour – Fisherman's are in the vicinity of the proposed APLNG Upstream works.

Water Quality Parameters Measured

The physical water quality parameters measured in the PCIMP include pH, dissolved oxygen (DO), temperature, oxidation reduction potential (ORP), specific conductivity, turbidity, light attenuation, fluoride and nutrients (total phosphorous (TP), orthophosphate, ammonia, nitrate, nitrite, total nitrogen (TN) and total Kjeldahl nitrogen (TKN)). Metals are tested as totals within water and as labile/dissolved fractions using passive samplers named Diffusive Gradient Thin-films (DGT). 10 metals are tested for using this method; aluminum, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel and zinc. Bioaccumulation in oysters tests for 17 metals; aluminum, arsenic, cadmium, chromium, cobalt, copper, gallium, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, vanadium and zinc, and fluoride.

Of the parameters measured those applied as predictable indicators of disturbance are as follows:

- Physical parameters - pH, DO, turbidity, total nitrogen, total phosphorous
- DGT – aluminium, cadmium, chromium, cobalt, copper, lead, manganese, nickel
- Oyster bioaccumulation – aluminium, cobalt, copper, manganese, nickel, selenium, zinc

Ecosystem Health Guidelines

Ecosystem Health (EH) is the ability of an environment/ecosystem to cope with stress from both human and non-human impacts. Data for each indicator is measured against appropriate Australian Water (or sediment) Quality Guidelines or background reference zone data, and a standardised score from 0 to 1 produced. The closer the result is to a score of 1, the healthier the ecosystem. The indicators are grouped into performance categories (such as water chemistry, DGT metals, sediment metals etc.) and these are averaged to develop a final health rating grade from A+ to F for that zone. A rating below a D+ would be highlighted for action, while attaining a rating close to reference zone ratings (A+) indicates a relatively un-impacted ecosystem.

For the EH rating for water chemistry and DGT, the majority of indicators were assigned EH guidelines using ANZECC/ARMCANZ (2000) water quality trigger values for estuarine ecosystems of tropical Australia for the protection of 99% of species. The 99% guideline for cobalt is regarded as exceedingly conservative, so in the case of this metal the 95th percentile value of all local reference data (oceanic and estuarine) was the value assigned as the EH. This method was also used for parameters where no trigger value was available. For metals in oysters, the 95th percentile value of rate of uptake of each metal based on historic reference data (oceanic and estuarine) was used. The EH guidelines for Port Curtis are shown in Table 3-9 and determination of ratings are shown in Table 3-10.

Table 3-9 Ecosystem Health Guidelines (EH) and Worst Case Scenario (WCS) trigger values for Port Curtis

Indicator	EH	WCS
Water Chemistry		
* pH	7.0 – 8.5	< 6 & > 9.5
* DO (%)	80	60
* Turbidity (NTU)	20	200
* Total nitrogen (TN) (µg/L)	250	2500
* Total phosphorous (TP) (µg/L)	20	200
Contaminants in Oysters		
Aluminium (mg/kg)	1.9	19
Cobalt (mg/kg)	0.006	0.06
Copper (mg/kg)	0.2	2.1

Indicator	EH	WCS
Manganese (mg/kg)	0.16	1.6
Nickel (mg/kg)	0.005	0.05
Selenium (mg/kg)	0.03	0.3
Zinc (mg/kg)	2.8	28
Contaminants in DGTs		
Aluminium (µg/L)	1.5	15
* Cadmium (µg/L)	0.7	14
* Chromium III (µg/L)	7.7	49
Cobalt (µg/L)	0.07	0.71
* Copper (µg/L)	0.3	3
* Lead (µg/L)	2.2	6.6
Manganese (µg/L)	2.9	29
* Nickel (µg/L)	7.0	200

* represents parameters for which ANZECC/ARMCANZ (2000) guidelines were applied

Table 3-10 Overall EH Ratings

Standardised Score	Zone Rating	Condition
> 0.95 – 1.00	A+	Equals Reference
> 0.90 – 0.95	A	Mild departure from reference
> 0.85 – 0.90	A-	
> 0.80 – 0.85	B+	
> 0.75 – 0.80	B	Moderately impacted
> 0.70 – 0.75	B-	
> 0.65 – 0.70	C+	
> 0.60 – 0.65	C	
> 0.55 – 0.60	C-	
> 0.50 – 0.55	D+	Severely impacted
> 0.45 – 0.50	D	
> 0.40 – 0.45	D-	
> 0.35 – 0.40	E+	
> 0.30 – 0.35	E	
> 0.25 – 0.30	E-	
> 0.20 – 0.25	F+	

Standardised Score	Zone Rating	Condition
> 0.15 – 0.20	F	
0.10 – 0.15	F-	
< 0.00 - < 0.11	Fail	Degraded

PCIMP Water Quality Results - Summary

Physicochemical data

Physicochemical water quality characteristics of the inner harbour zones were similar to characteristics of reference zones, though the more estuarine sites tended to have lower pH and greater levels of turbidity, especially the upper estuarine sites. In shallow, mangrove-lined estuaries, episodic elevations in turbidity are expected. Most water quality parameters were above the ANZECC/ARMCANZ (2000) water quality guidelines for protection of 95% of species and no parameters were found to overly exceed guidelines in any of the zones (Storey *et al.* 2007).

The average and lowest values of total phosphorous (TP) in all zones were less than the highest accepted EH value indicating that some concentrations had exceeded the ANZECC/ARMCANZ (2000) guidelines. Values of TP were up to 2.7 times the guidelines. However, only a small proportion of the TP was biologically available with concentrations of filterable reactive phosphorous at all zones approximating the lab limit of detection. TP values recorded during water quality sampling undertaken in Targinie Creek during this study were well above the adopted criteria, though reactive phosphorous was also approximating the limit of detection. The PCIMP found that concentrations of total nitrogen were all within guidelines in all zones (Storey *et al.* 2007). However, sampling undertaken in Targinie Creek found that levels of total nitrogen (TN) were well above the ANZECC/ARMCANZ (2000) and QWQG (DERM 2009) guidelines.

DGT-labile Metals

While conclusive comments on metal concentrations resulting from sampling undertaken in Targinie Creek could not be made (due to most concentrations being below the LOR and the LOR being above the ANZECC/ARMCANZ (2000) guideline levels,), PCIMP found that mean concentrations of DGT-labile metals in all zones were at acceptable limits, below the ANZECC/ARMCANZ 2000 water quality guidelines for the protection of 95% of species in a slightly to moderately disturbed ecosystem (Storey *et al.* 2007). Inner Harbour zones tended to have greater concentrations of DGT-labile metals while outer zones and reference sites had the lowest, especially copper, aluminium, iron, lead and zinc. Manganese, cobalt and nickel appeared to show an estuarine influence within the estuarine reference zone and The Narrows zone. This influence showed the same trend as the inner Harbour estuaries suggesting that some elevation may be due to natural influences. However, elevated levels of metals in the inner Harbour and South Trees zones reflect the increase in anthropogenic activity in these areas (Storey *et al.* 2007).

Metals in Oysters

Inner Harbour zones were found to have greater elevations of metals in oysters than outer Harbour zones. The spatial distribution of metals in oysters was related to the location of anthropogenic influence, with more metals available for uptake in those areas. Accumulation of metals in oysters in The Narrows was low (Storey *et al.* 2007).

PCIMP Water Quality Results – By Location

Overall, all Harbour zones were given an overall rating / grade of B+ or above. This indicates that all zones within Port Curtis either equal the reference locations in terms of water quality, or show only a mild departure from the reference locations. A summary of ratings for each zone is given in Table 3-11.

Table 3-11 Overall average ratings

Zone	Water Chemistry	DGT-Labile Metals	Oyster-Labile Metals	Average Ecosystem Health Grade *
The Narrows	0.96	0.99	0.97	A
Inner Harbour – Fisherman’s	0.96	0.90	0.87	B+
Inner Harbour – Calliope	0.96	0.96	0.87	A
Auckland Creek	0.97	1.00	0.79	A
Mid Harbour	0.96	0.99	0.94	A-
Inner Harbour – South Trees	0.95	0.95	0.93	B+
Boyne Tannum	0.95	0.98	0.99	A+
Reference - Estuarine	0.98	1.00	1.00	A+
Reference - Oceanic	0.98	1.00	1.00	A+

* grade incorporates sediment ratings not shown

The Narrows - A

The Narrows is a narrow estuarine passage separating Curtis Island from the mainland. It is one of only five narrow tidal passages separating large continental islands from mainland Australia. This PCIMP estuarine zone encompasses Grahams Creek on the southern end of Curtis Island. The Narrows is located within the Great Barrier Reef World Heritage Area and marine parks. The Narrows is in a near pristine state and is listed on the Australian Heritage Commission Register of National Estate (QEPA 2003). Due to its estuarine influence, The Narrows has lower pH and higher turbidity than other areas in Port Curtis. Total phosphorous is elevated as it is within all other zones in the Harbour. Cobalt and manganese in DGT is also elevated in this area, however this is common to upper estuaries in Port Curtis. Elevated aluminium in DGT is attributed to a couple of high anomalous readings. Bioaccumulation of copper and zinc in oysters is higher in The Narrows than in reference zones, but lower than Inner Harbour zones (Storey *et al.* 2007).

2. Inner Harbour - Fisherman’s - B+

This area extends from the base of The Narrows to just north of Wiggins Island seagrass beds and includes the small estuary of Boat Creek. A number of industries are located in the adjacent catchment area and there are two licenced discharge points associated with the Fisherman’s Landing wharf. The upper estuarine areas of Boat Creek tend to have a lower pH, higher turbidity and lower DO than in the lower estuary. Total phosphorous is moderately elevated in this zone, as for other zones in Port Curtis. Elevations of aluminium, copper, cobalt and manganese in this zone are attributed to the conditions in Boat Creek. Uptake of copper, nickel and zinc in oysters is noted across the whole zone (Storey *et al.* 2007).

3. Inner Harbour - Calliope – A

This zone is located just north of Gladstone city, encompasses the Calliope River and Anabranch, and the coastal wetlands at the river mouth. This zone also incorporates the CQPA's largest wharf centre (RG Tanna Coal Loading Facility). The Gladstone Power Station is located further upstream and discharges heated saltwater from the cooling process into the Calliope River. Water chemistry in this zone is of a high standard. Areas of elevated turbidity in this zone are associated with more silty areas of the Wiggins Island seagrass beds. Total phosphorous is elevated as with other Port Curtis zones. Copper and aluminium are elevated in DGT in the Calliope Rover and wharf area. Bioaccumulation of copper and zinc is elevated in oysters across the zone compared to background reference areas (Storey *et al.* 2007).

4. Auckland Creek – A

This zone encompasses Auckland Creek and the Gladstone Marina and adjacent wharf areas. A number of maritime businesses and a fisherman's co-op are located along the foreshore. Water quality is of a generally high standard in this zone with transient elevated turbidity. Total phosphorous is slightly elevated here as within the entire Harbour. Metal accumulation in DGT is very low, however, accumulation of copper, zinc, and aluminium in oysters is above background levels across the zone (Storey *et al.* 2007).

5. Mid Harbour – A-

The Mid Harbour Zone incorporates the southern end of Curtis Island and the outer Harbour area including the western side of Facing Island and Gatcombe Head. This area is immediately adjacent to, or within, the Great Barrier Reef World Heritage Areas and marine parks and incorporates a major seagrass meadow. Water chemistry in this zone is generally of a high standard. Transient elevated turbidity is seen here. As with all other sites, total phosphorous is elevated in this zone. Accumulation of metals in DGT is very low in this zone, with the exception of aluminium which shows elevated levels at some sites. Bioaccumulation of copper in oysters is elevated compared to background reference levels across the entire zone (Storey *et al.* 2007).

6. Inner Harbour - South Trees – B+

This zone incorporates the mouth of the South Trees Inlet. It is adjacent to wharf facilities, the estuary and its tributaries (including Spillway Creek). South Trees Inlet supports the largest mangrove and salt flat ecosystem in the Curtis Coast outside of The Narrows (QEPA 2003). Queensland Alumina Ltd and Boyne Smelters Aluminium discharge into the South Trees Inlet and Spillway Creek respectively. The upper estuaries of this zone show elevated levels of turbidity and low levels of DO, which is common for shallow mangrove lined estuaries. Total phosphorous is elevated as expected. Aluminium, cobalt and manganese accumulation in DGT is mainly associated with the upper estuarine and wharf areas. Oysters show elevated levels of copper, nickel, selenium and zinc compared to background reference areas (Storey *et al.* 2007).

7. Boyne Tannum – A+

This zone incorporates the Boyne River and river mouth, and the entrance to Wild Cattle Creek. The Boyne Tannum zone is predominately urban. The Awoonga Dam, located on the upper Boyne River, has significantly altered freshwater flows. Water quality in this zone is generally high except for elevated levels of total phosphorous and lower levels of DO. Low levels of all metals with the exception of aluminium are found in DGT. Elevated levels of aluminium are found at a Harbour site which is not located within the river. Elevated DGT manganese is also found in the upper estuary, which is typical of Port Curtis estuaries (Storey *et al.* 2007).

8. Reference Estuarine – A+

The reference estuarine zone is located to the south of Port Curtis, incorporating the Colosseum Inlet. This zone includes a Great Barrier Reef World Heritage site, a marine park, fish habitats and the Rodds Bay Dugong Protection Area (QEPA 2003). Water chemistry in this zone is of a high standard. Some lower DO readings are found in the upper estuary. Slightly elevated readings of total phosphorous are found. Low accumulation of metals in oysters and DGT occurs (Storey *et al.* 2007).

9. Reference Oceanic – A+

This reference zone includes sites to the north and south of Port Curtis, outside of the Port's anthropogenic influence. The oceanic reference zone has very low accumulation of metals in DGT and oysters. Water quality is very high except for slightly elevated total phosphorous, as found for all other zones in the Port Curtis estuary (Storey *et al.* 2007).

3.3 Marine Flora and Fauna

A general description of the marine flora and fauna attributes has been provided in the following sections, in line with the existing marine environment descriptions provided in the EIS (Vol 5 Attachments Attachments 19 and 20), for the purposes of examining the potential impacts on the key marine and coastal habitat areas from the proposed gas pipeline options, offshore infrastructure off Curtis Island and the ocean outfall wastewater discharge.

Seagrass meadows, mangrove and saltmarsh areas are the primary environmental features of interest in the vicinity of the proposed pipeline crossing. These vegetated habitats significantly contribute to the high primary productivity of estuarine areas. These structurally complex habitats maximise food availability and minimise predation for fish, prawns and crabs (Halliday and Young 1996; Thomas and Connolly 2001; Heck *et al.* 2003).

Rocky intertidal and shallow subtidal environments in the study area are important foraging areas for various fish species, while man-made structures such as jetties and seawalls provide additional hard substrata within the Port Curtis region. Extensive un-vegetated intertidal banks around Laird Point and Friend Point also provide foraging opportunities for fish at high tide and shorebirds at low tide.

3.3.1 Seagrass

The seagrass beds of the Port Curtis region have been extensively investigated and mapped by Rasheed *et al.* (2003), Taylor *et al.* (2007) and more recently by Chartrand *et al.* (2009). Around 20% of the intertidal (7,246 ha) and subtidal (6,332 ha) seabed of Port Curtis is covered by seagrass, although this is considered an overestimate due to the high seasonal variation observed at this location (Connolly *et al.* 2006). The areal extent of seagrass and its biomass peaks in later spring and summer and is lowest over winter (McKenzie 1994; Lanyon and Marsh 1995). Subtidal seagrass beds in Port Curtis show more temporal variability in seagrass cover, in comparison to intertidal seagrass beds (Chartrand *et al.* 2009). This temporal and spatial variability in seagrass cover has been largely attributed to local and regional climate conditions (Rasheed *et.al* 2008).

Seagrass around Laird Point and the Western Basin, which are closest to the proposed alignment, generally consist of aggregated and isolated patches of *Zostera capricorni* with a light cover of *Halophila ovalis*, *H. decipiens* and *H. spinulosa*. Overall biomass is generally low and varies between 2 – 3 g (dw)/m^2.

3.3.2 Mangrove and Saltmarsh

Extensive mangroves occur along the coastline from the Gladstone city precinct and into The Narrows (Danaher *et al.* 2005). Within the Gladstone region, it is estimated there are 3,875 patches of mangroves with an area of 203km^2 and a perimeter of 4,855km (Manson *et al.* 2005). However, Duke *et al.* (2003) reported a regional loss of almost 40% of mangrove area in Port Curtis between 1941 and 1999.

The proposed pipeline crossing will result in disturbance of intertidal areas in the vicinity of Friend Point and an area on Curtis Island just south of Graham Creek. Friend Point has intertidal flats and an extensive mangrove forest dominated by red mangrove. The intertidal flats are principally mudflats although areas of rubble field are also present.

The seaward edge of the proposed development site (Port Curtis) consists of an upper area of sandy beach extending into a predominantly rocky shore which transitions to mud flat in the lower part of the shore. This area also contains a number of small isolated mangrove trees. Taylor *et al.* (2007) identified that a small area of seagrass (principally *Zostera capricorni*) occurs on these mudflats.

3.3.3 Rocky Intertidal

Intertidal rocky shores occur at a number of locations in the Port Curtis region including in the vicinity of the proposed LNG plant and associated marine infrastructure. These rocky shores are best described as a “rubble field” with significant oyster cover, and other macro-invertebrates that associate with oyster cover, in particular the oyster borer (*Morula marginalba*).

In relation to the proposed pipeline crossing, the main intertidal rocky habitat present is ~0.5 km south of Laird Point. A moderate sloping rocky shoreline with oyster encrusted rocks between the mid to low tide levels occurs at this location (URS 2009). Species diversity was considered low due to the high silt content on the rocks.

Rasheed *et al.* (2003) also identified rubble reef areas in the deep channel area from the vicinity of Graham Creek to Fishermen’s Landing which contained medium density cover (>15% of the area surveyed) of bivalves, ascidians, bryozoans and hard corals. Other such areas of reef habitat are located in the vicinity of Hamilton Point.

3.3.4 Benthic epifauna and infauna

The subtidal area in the vicinity of the proposed LNG plant and pipeline crossing is principally bare substrate. A high amount of unconsolidated shell and rubble material was present at many of the sites surveyed. Some macroalgae was present attached to shell and rubble at a number of locations. Evidence of bioturbation was largely absent. No hard coral was present and there was no reef structure that afforded any vertical relief, although isolated epifauna individuals (e.g. gorgonians) were present.

Additional survey work at the pipeline crossing between Friend Point and Laird Point undertaken as part of the GLNG proposal (URS 2009) also confirm the presence of coarse sand with a high proportion of shell. It was also noted that the proportion of silt on the seabed increased towards Laird Point. Soft corals and zooanthids were the most common species encountered while sea whips, sea fans and sponges were less common, although the overall percentage cover of marine species was low and much lower compared to equivalent habitat at Hamilton Point.

Much of the existing knowledge of the macrobenthic infaunal assemblage of Port Curtis are based on the work of Currie and Small (2005 and 2006) and Alquezar (2008) who also undertook some additional work, in the area of interest for the proposed project. These surveys show that assemblages are dominated by filter feeders, the most abundant species being the bivalve mollusc *Carditella torresi.* Other common species were the ascidian *Ascidia sydneiensis* and additional bivalve species (*Corbula tunicata*, *Mimachlamys gloriosa*, *Leionuculana superba*, *Mactra abbreviata* and *Placamen tiara*), the ascidian (*Ascidiacea* sp.), the polychaete worm (*Eunice vittata*) and the caridean shrimp (*Alpheus* sp.)

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

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

3.3.5 Plankton

Phytoplankton concentrations are measured by assessing the concentration of chlorophyll *a* in the water column. Chlorophyll *a* is the phytoplankton's principal photosynthetic pigment. Prediction of chlorophyll *a* winter levels in the Port of Gladstone range from 0.6 to 3.2µg/L and are between 2.0µg/L and 2.3µg/L in waters adjacent to Curtis Island.

3.3.6 Fish and Invertebrate Communities

All sub-tropical inshore fish assemblages are temporally and spatially variable. Components of this fish assemblage in the Port Curtis region support regionally important commercial and recreational fisheries.

Currie and Connolly (2006) identified the fish assemblages from intertidal and shallow, nearshore sedimentary parts of Port Curtis area. They found a diverse assemblage consisting of 88 species of which two small schooling species, common ponyfish (*Leiognathus equulus*) and southern herring (*Herklotsichthys castelnaui*), in combination comprising about half of the total fish abundance. The structure of the sub-tidal fish assemblage in the vicinity of Laird Point is similar to most other inshore sites surveyed in Port Curtis. The most abundant species present were common ponyfish (*L. equulus*), finny scad (*Megalapsis cordyla*), southern herring (*H. castelnaui*), estuary perchlet (*Ambassis marianus*), happy moments (*Siganus rivulatus*), large-scaled grinner (*Saurida undosquamis*), striped cardinalfish (*Apogon fasciatus*), yellow-fin tripod fish (*Tripodichthys angustifrons*), large-toothed flounder (*Pseudorhombus arsius*) and winter whiting (*Sillago maculata maculata*). All of these species are common and widely distributed and typical of inshore habitats in sub-tropical Australia.

Saltmarsh and saltpan habitats tend to have lower species richness than other inshore habitats such as mangroves and seagrass (Sheaves *et al*. 2007), but nonetheless provide important habitat for fish species, including some of recreational and commercial significance. Although fish utilisation of saltmarsh habitats in the Gladstone region is not well studied, Sheaves *et al*. (2007) presented information on the saltmarsh fish assemblages of Munduran Creek which drains into The Narrows approximately 15km from the proposed development location. The numerically dominant species recorded were mullet (unspecified), ponyfish (*L. equulus*) and silverbiddies (*Gerres subfasciatus*). It is likely these species are also numerically dominant at the proposed development location.

Fish utilisation of mangrove habitats in the Port Curtis area has not been studied, however Halliday and Young (1996) examined density, biomass and species composition of fish inhabiting mangrove forests further south at Tin Can Bay. Similar to the mangroves in Port Curtis, the mangroves examined by Halliday and Young (1996) were dominated by the red mangrove *Rhizophora stylosa*. They recorded 42 fish species from the mangrove forests with economically important fish species representing approximately 76% by number and 74% by weight of the total catch. The numerically dominant species were yellowfin whiting, common toadfish, common silverbiddy and the flat-tail mullet.

Although specific information is lacking, the rock and reef habitat within Port Curtis is likely to be utilised by a range of adult and juvenile fish species including yellowfin bream, sweetlip, estuary cod and blubber-lip bream.

In terms of fish species of conservation significance, the whale shark (*Rhincodon typus*), listed as Vulnerable and Migratory under the EPBC Act, occurs in oceanic waters east of Facing and Curtis islands and as such is unlikely to occur in an estuarine environment such as Port Curtis. The grey nurse shark (*Carcharius taurius*) is listed as Endangered under the Queensland *Nature Conservation Act* 1992, is associated with offshore rocky reefs in southern to central Queensland and is unlikely to inhabit nearshore estuarine waters of Port Curtis. The green sawfish (*Pristis zijsron*) has been recorded from shallow inshore coastal environments including estuaries, although detailed records of the occurrence of the species from 1912 to 2004 identify no individuals of the species in the Gladstone region during that period (Stevens *et al.* 2005). The estuary stingray (*Dasyatis fluviorum*) is ranked as a high priority species by the DERM Back on Track species prioritisation framework, which prioritises Queensland's native species to guide conservation, management and species recovery. The estuary stingray utilises a range of shallow inshore habitats and is likely to occur frequently within the area of the proposed development.

Nektobenthic invertebrates are larger, more mobile benthic invertebrates such as crabs, prawns and lobsters which are typically absent or significantly underestimated in standard benthic sampling gear such as grabs or sleds. Nektobenthic invertebrates are often important fisheries components. Although a comprehensive analysis of locally-occurring nektobenthic invertebrate fauna is lacking, the Port Curtis area provides habitat for various portunid crabs (including the blue swimmer crab), juvenile prawns (including tiger prawns, eastern king prawns and banana prawns) and mud crabs (Walker 1997).

Commercial and Recreational Fishing

3.3.6.1.1. Commercial fisheries

Net and mud crab fisheries are the principal commercial fisheries in the Port Curtis area, although beam trawling also permitted for relevant endorsement holders. Net and crab fishers operating in Port Curtis are also permitted to operate anywhere on Queensland's east coast in areas where these fishing activities are permitted. Commercial fishers with endorsements to beam trawl in the Port Curtis area are only permitted use of such equipment in Port Curtis, The Narrows, mouth of the Fitzroy River and Keppel Bay.

Commercial fisheries in Queensland are monitored through a compulsory logbook program administered by the Queensland Primary Industries and Fisheries (QPI&F). Data collated from the logbook program is available via the coastal habitat and resource inventory system (CHRISweb) database[1] which is also administered by the QPI&F. A key consideration when interpreting information from the database is the spatial resolution is very coarse. Commercial net and crab fishers record spatial information on catch and effort in 30 minute (i.e. nautical mile) grid squares. In the current area of interest this scale includes all of the Gladstone Port Area and The Narrows area as well as significant areas in offshore waters east of Curtis Island (Figure 3-2).

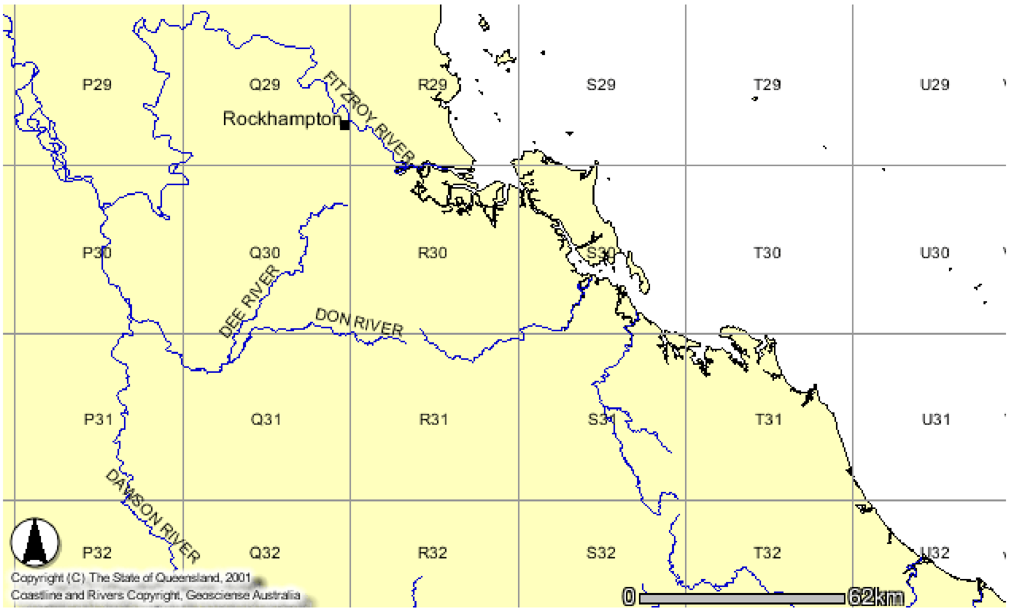

Figure 3-2 Map of the 30 minute grids for recording commercial fishing catch and effort in the Port Curtis region. Grid S30 contains the proposed development location

The annual catch weight and value of the catch for the commercial net and crab fishery in the Gladstone Port area (grid S30) between 1988 and 2005 is shown in Figure 3-3.

1 http://chrisweb.dpi.qld.gov.au/chris/

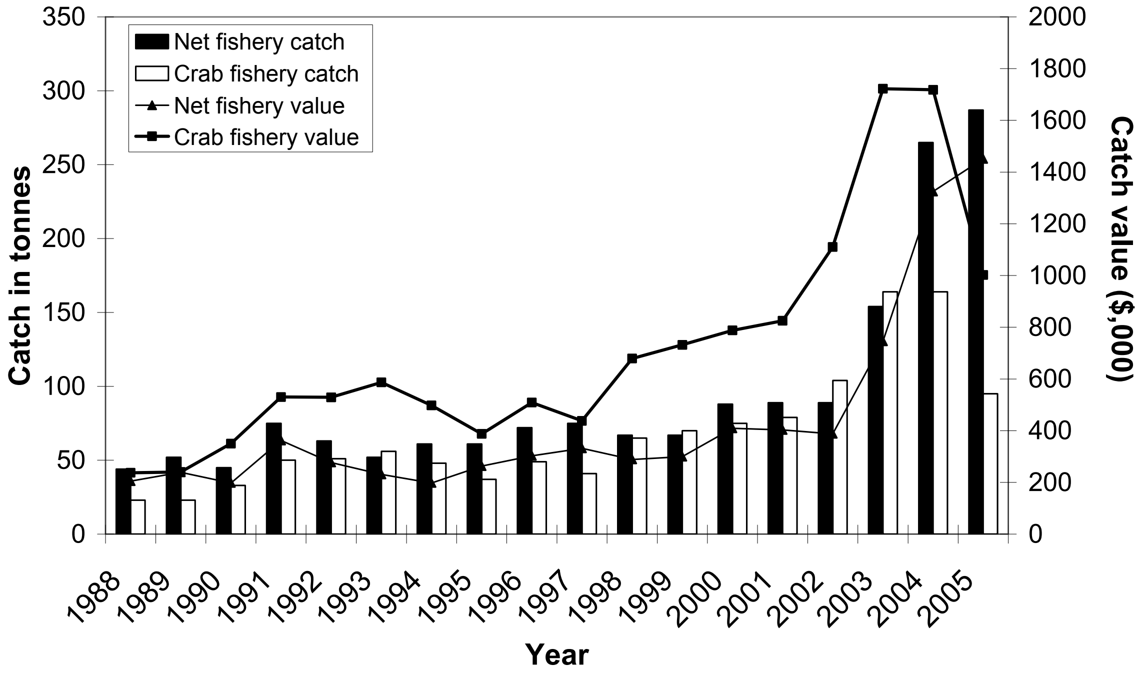

Figure 3-3 The annual catch weight and value of the commercial net and crab fishing catch between 1988 and 2005 in grid S30

Both the catch weight and value of the local net and crab fishery has tended to increase over time with a more rapid increase since 2003, particularly for the net fishery. No data is currently publicly available for years after 2005. The crab fishery in the region is almost solely focused on the mud crab (*Scylla serrata*). Most of the commercial mud crab fishery is concentrated in The Narrows and the associated tributary creeks (for example Graham Creek, D.McPhee pers. obs). By catch weight and value, the key target species in the net fishery include various species of shark, blue threadfin salmon, mullet, barramundi and grey mackerel. Additionally a small net fishery for bait fish targets garfish and mullet using ring nets.

The beam trawl fishery targets various species of prawns with banana prawns, school prawns and greasyback prawns comprising most of the catch. The beam trawl fishery within the Port Curtis/Fitzroy River/Keppel Bay area contributes around 15% of the total Queensland beam trawl catch. However, while the Port Curtis region is within the area, and can be accessed by the fishery, available logbook information demonstrates the area is rarely fished in practice.

Recreational fisheries

Statewide recreational fishing surveys have been undertaken in 1997, 1999, 2002 and 2005. These surveys report catch and effort information at a broad spatial scale – specifically the statistical division a fisher resides in. Like information on commercial fishing, information on recreational fishing can be accessed through CHRISweb. In the current instance, the relevant statistical division is the Fitzroy region and the available information indicates that whiting, mullet and yellowfin bream are the three types of fish most often taken by anglers.

Platten *et al.* (2007) provided information on the levels of boat-based fishing effort through Central Queensland including Gladstone. From 1985 to 2005, boat registrations in the Gladstone region increased 110% from 2,171 to 4,581 with most of these boats used for recreational fishing. It was estimated between the period June 2005 and May 2007, around 16,395 boating trips commenced from the Gladstone boat ramp (adjacent to Gladstone Volunteer Marine Rescue) which is the main public boat ramp in the region. While the number of vessels utilising the Laird Point and Graham Creek area was unknown, the Graham Creek area was recognised as a very important anchorage area for recreational vessels and an important area for recreational fishing, particularly mud crabbing. Graham Creek is also utilised as a safe anchorage for yachts.

3.3.7 Invasive Marine Pest Species

The Port of Gladstone is one of 18 ports in Australia that is targeted for ongoing monitoring for marine pests as it is recognised that there is an ongoing high risk of introductions and translocations to the area. Baseline investigations have been completed by Gladstone Ports with assistance from Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management and Tasmania's CSIRO Centre for Research on Marine Pests.

Lewis *et al.* (2001) undertook a study of the distribution and abundance and risk of exotic marine species in Port Curtis and identified the presence of nine exotic marine species but none of these are classified as marine pest species. Marine pest species are those introduced species that can have a significant impact on marine industries, the marine environment, coastal communities and the economy. The nine exotic marine species present in Port Curtis consists of four bryozoans (*Amathia distans*, *Bugula neritina*, *Cryptosula pallasiana*, and *Watersiporia subtoraquata*), two ascidians (*Botrylloides leachi* and *Styela plicata*), one isopod crustacean (*Paracerceis sculpta*), one hydrozoan (*Obelia longissima*) and one dinoflagellate (*Alexandrium* sp.). These species have successfully colonised ports within Australia and worldwide and are unlikely to have significant impact on native marine assemblages.

3.3.8 EPBC Listed Fauna

Cetaceans

The EPBC database has identified ten cetacean species in the Port Curtis region, and of these, the Indo-Pacific Humpback dolphin, the Australian snubfin dolphin and the bottlenose dolphin are known to occur within the Project area (GHD, 2009). Snubfin dolphins and Indo-Pacific humpback dolphins are considered to be periodic visitors in the Gladstone region rather than permanent residents (GHD, 2009).

The following species of whale are unlikely to occur within the project area as they are principally oceanic species – minke whale, humpback whale, Bryde's whale, Risso's dolphin, spotted dolphin, common dolphin and the killer whale (GHD, 2009).

Dugong

Dugongs are a listed migratory and marine EPBC species and are also present within the project area, and are managed within Port Curtis and Gladstone Harbour under The Port of Gladstone - Rodds Bay Dugong Protection Area. Dugong's present within Port Curtis are associated with the seagrass meadows, namely within areas around the Rodds Bay and near Wiggins Island. However, field investigations have observed Dugong over scattered seagrass meadows at Friend Point, with their presence possible throughout the Narrows.

Marine Turtles

Of the six species of marine turtle present in Queensland Waters, green, loggerhead, hawksbill and flatback have internationally significant populations in Queensland. The Port Curtis/Gladstone region represents a medium density nesting site for flatback turtles and an occasional, low density nesting habitat for green turtles (and loggerheads) and within this region south east Curtis Island, the seaward coastline of Facing Island and the coastal beaches of Tannum Sands are considered important nesting habitat (GHD, 2009).

Sea Snakes

The EPBC protected matters database identified 12 species of sea snake that may occur in the Project area and three species, namely the elegant seasnake, spine bellied seasnake and the small headed seasnake, are most likely to occur within the Project area based on habitat preference (GHD, 2009).

Pipefish and Seahorses

The EPBC protected matters database identified 33 species of sygnathids that may occur in the study area (GHD, 2009).

4. Assessment of Impacts

4.1 Direct Impacts

Constructing the gas pipeline through the intertidal mudflats present within the coastal environment and subtidal habitats across The Narrows, at the northern extent of Port Curtis, may have a direct impact where the construction method results in direct and permanent loss of existing habitat. The construction method chosen will have a significant influence over the nature and magnitude of any potential impacts.

Three habitat types have been identified as being affected by the proposed gas pipeline construction, namely the seagrass meadows present within the subtidal habitat in The Narrows (see Figure 4-1) and the intertidal areas including saltmarsh and mangroves communities present within the intertidal mudlflats (see Figure 4-2). Direct loss of seagrass, mangroves and saltmarsh has been quantified in the tables provided in Figure 4-1 and Figure 4-2).

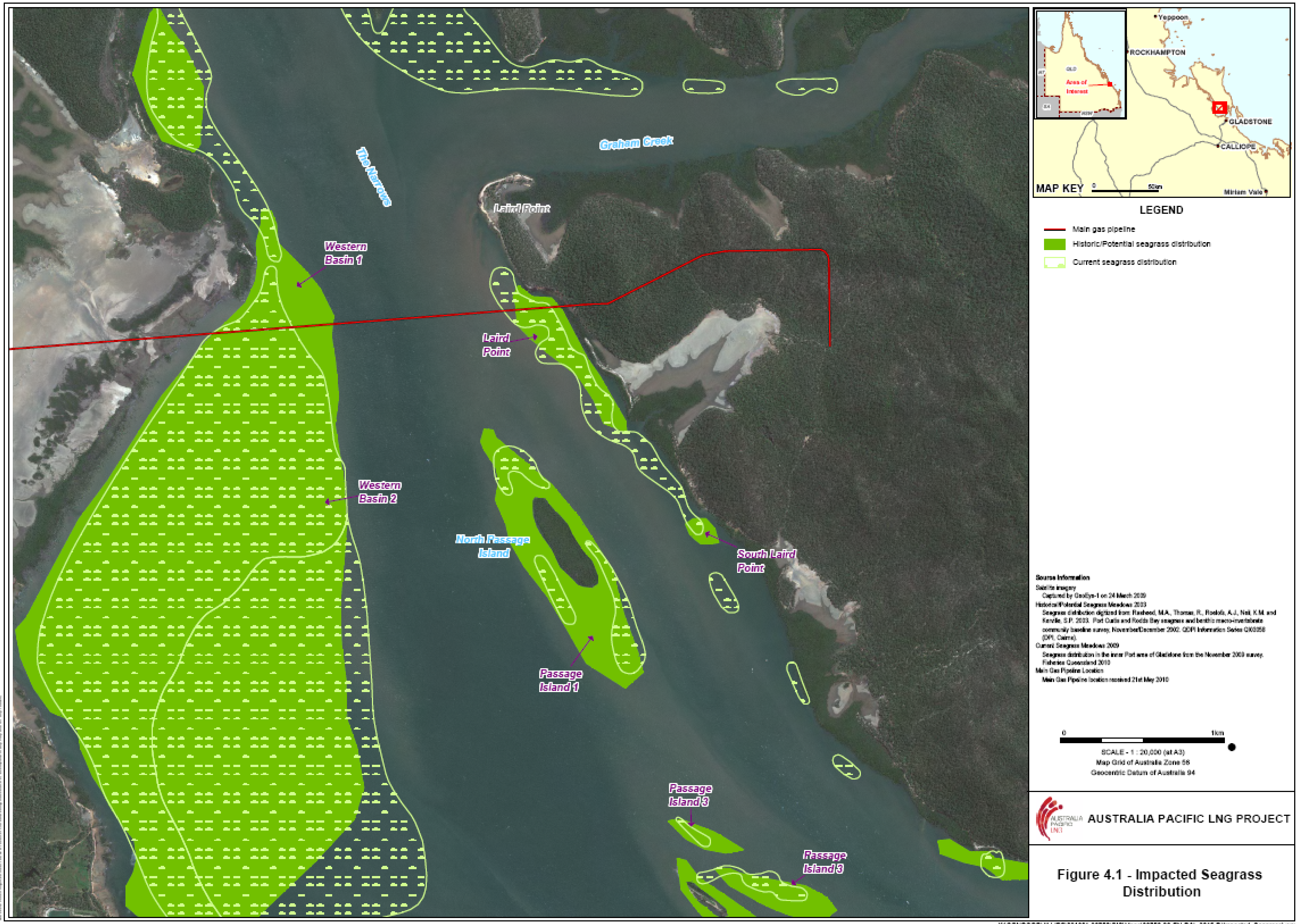

Figure 4-1 Seagrass distribution and areas impacted by the proposed gas pipeline

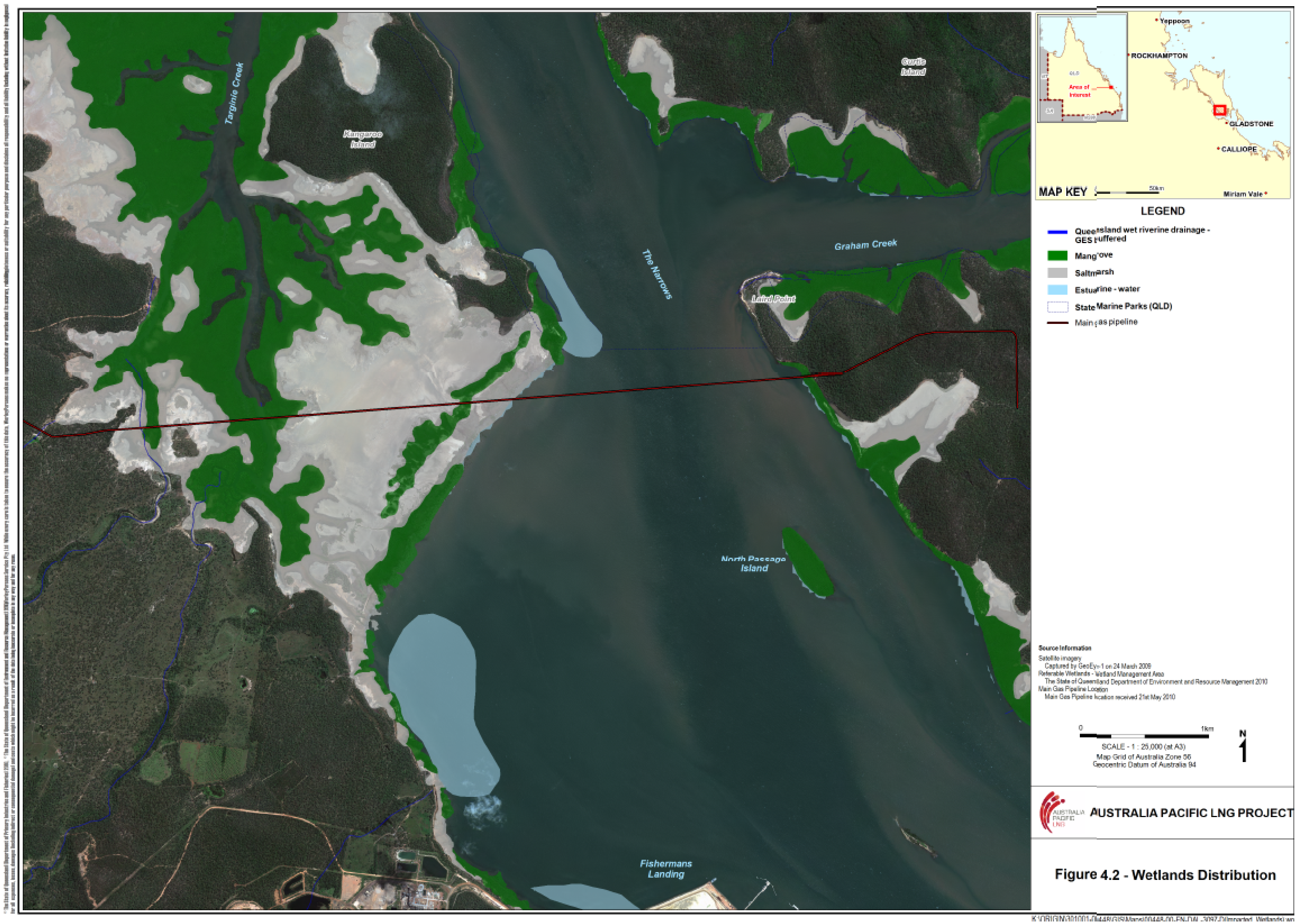

Figure 4-2 Mangrove and Saltmarsh distribution within the intertidal mudflats and areas impacted by the proposed gas pipeline

4.1.1 Assessment

Estimates of seagrass loss are provided in Figure 4-1 and proportional percentage loss, compared to total seagrass extent, is provided in Table 4-1. Estimates are based on the most recent habitat estimates provided by Rasheed *et al.* (2010).

Table 4-1 Proportional loss of seagrass coverage within Port Curtis associated with each pipeline option, relative to total seagrass cover within Port Curtis

Pipeline Option	Seagrass Distribution Impacted	
	Historic/Potential	Current
Single pipeline route	0.31%	0.09%

The principal subtidal habitat in the vicinity of the pipeline crossing is bare sandy substrate, with a high proportion of unconsolidated shell and rubble. Excavation of this type of material will result in the loss of soft sediment habitat that supports infaunal species that reside in the sediment. Once the construction works are completed, recovery of the soft sediment fauna would occur over a number of years. Ultimate recovery/change would depend on the end construction method.

If rock armour is installed over the pipelines for mechanical protection and remains or becomes exposed, some colonisation by epibenthic species such as sponges and soft corals is possible. Where, the trench is backfilled by sand, the benthic habitat is likely to revert to its original condition with a very low cover of epibenthic species and higher numbers of infaunal species. The loss of soft sediment habitat due to excavation is not considered significant, as the relative area affected is very small and the potential for recovery is high (Table 4-2).

Table 4-2 Direct Loss of Soft Sediment Habitat due to Pipeline Construction

Pipeline Option	Nominal Width (m)	Area of Soft Sediment Impacted (ha)
Single Pipeline Route	40	10

Estimates of mangrove and saltmarsh loss are shown in Figure 4-2 and summarised in Table 4-3. Estimates are based on the most recent habitat estimates provided by Rasheed *et al.* (2010).

Table 4-3 Proportional extent of intertidal wetland habitat affected, relative to the areal extent of each habitat type within 10km radius of Laird Point

Pipeline Option	Intertidal wetlands (mainland)		Intertidal wetlands (western side of Curtis Island)		Combined	
	Mangroves	Saltmarsh	Mangroves	Saltmarsh	Mangroves	Saltmarsh
Single pipeline route	0.04%	0.17%	0.003%	0	0.04%	0.17%

4.2 Indirect Impacts

Indirect impacts may occur from the presence of the pipeline construction causing temporary changes in coastal processes, altered hydrology causing changes in surface water movement into mangrove communities and turbidity and water quality related issues to subtidal communities (i.e. seagrass).

4.2.1 Assessment

Seagrass Meadows

Under natural conditions, seagrass within Port Curtis are exposed to elevated turbidity levels and high rates of sediment deposition for extended periods of time. Turbidity levels of 55 NTU (184 mg/L TSS) have been reported within the Western Basin seagrass bed, 91 NTU (317 TSS) in the vicinity of Wiggins Island and South Fishermans Landing and 20 NTU (56 mg/L) in the deep water channels (see Chapter 7 of the Western Basin Dredging and Disposal Project EIS, GHD, 2009). These turbidity levels and TSS concentrations have been shown to persist for up to 7 days at a time.

Considering the maximum TSS concentrations of between 20 mg/L and 80 mg/L (plus background) likely within areas surrounding the pipeline route (between 250 m and 500 m from the pipeline), it is likely that there will be short durations of zero light on the seabed within the seagrass meadows near Friend Point in the northern Western Basin, and those seagrass meadows adjacent to Laird Point and North Passage Island.

Further afield, TSS concentrations are predicted to be less than 20 mg/L. At the Graham Creek, location peak TSS concentrations coincide with high tides and occur over a two week period. The range of TSS concentrations in Graham Creek is predicted to vary up to a peak value of 15mg/L and is less than 8.2mg/L for 99% of the time. This peak value is less than the Queensland Water Quality Guidelines TSS trigger value (DERM, 2009) of 20 mg/L and so, is unlikely to have a measurable impact to the marine environment, given the TSS concentrations proposed and short duration of high turbidity.

The light tolerances of the seagrass species which occur within the Project area are fundamental to understanding impacts from increased TSS concentrations. The seagrass species present within the project area include *Zostera capricorni, Halodule uninervis, Halophila spinulosa* and *Halophila ovalis*. A large percentage (70% of the biomass) of the seagrass beds in the project area are intertidal. Therefore, the resultant affect of any increase in light attenuation and reduction in incident light levels on the seabed, vary between tidal states.

Field investigations have identified that *Zostera capricorni* may tolerate 5% surface irradiance for periods up to one month and *Halophila ovalis* 0% surface irradiance for similar periods (Erftemeijer and Lewis, 2006). Considering the baseline data and threshold tolerances described above, if turbidity remains elevated for greater than three weeks, such that light remains excluded, then this may impact on seagrass meadows within the vicinity of the dredge plumes. However, due to prevailing current directions, persistent elevations over seagrass meadows from the crossing of The Narrows is considered unlikely. Rather modeling undertaken suggests that turbid plumes of up to 400 mg/L (and greater, up to 2,300 mg/L) are only likely to persist for a few days at Friend Point, 20 mg/L for up to 1 week within the tidal flats of the Western Basin and 5–7 mg/L above background for up to 1 week in The Narrows (see Figure 4-3 to Figure 4-5).

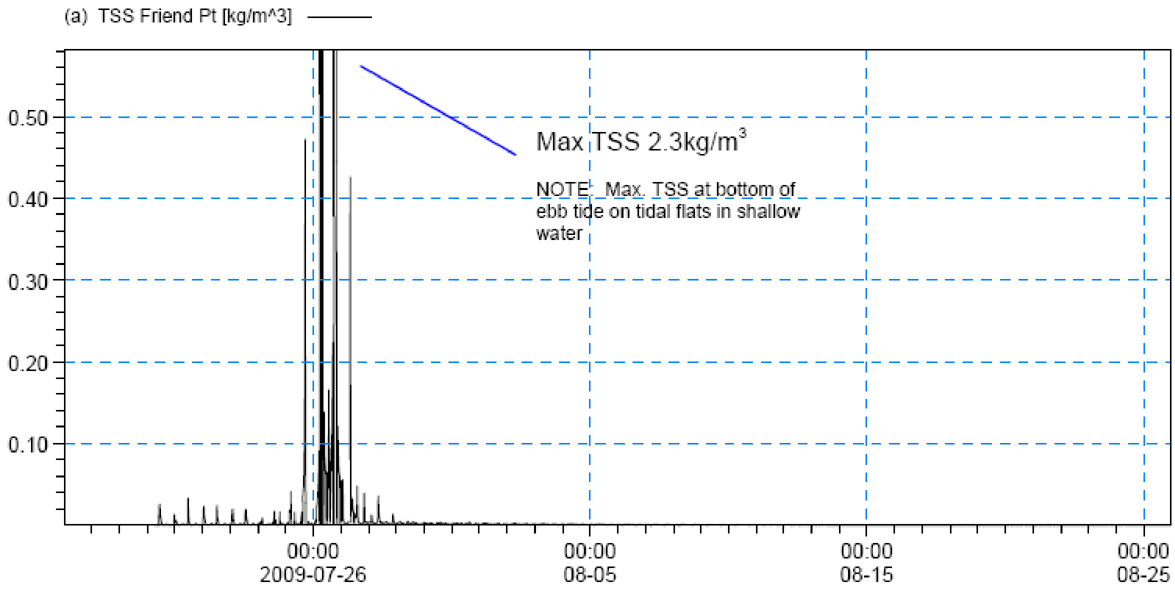

Figure 4-3 TSS time series at Friend Point

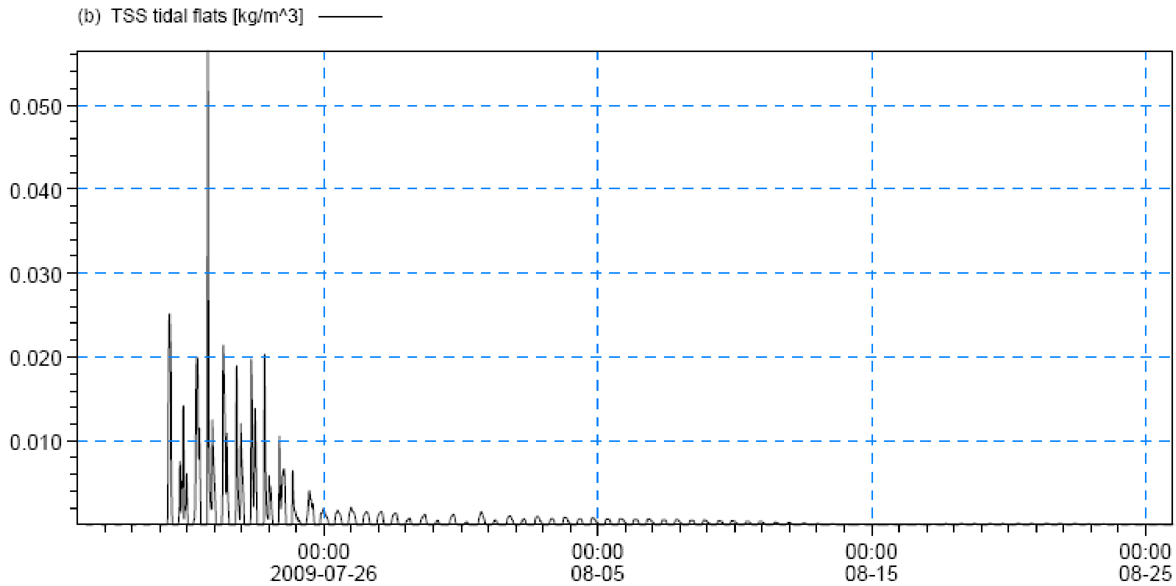

Figure 4-4 TSS time series within the tidal flats of the Western Basin

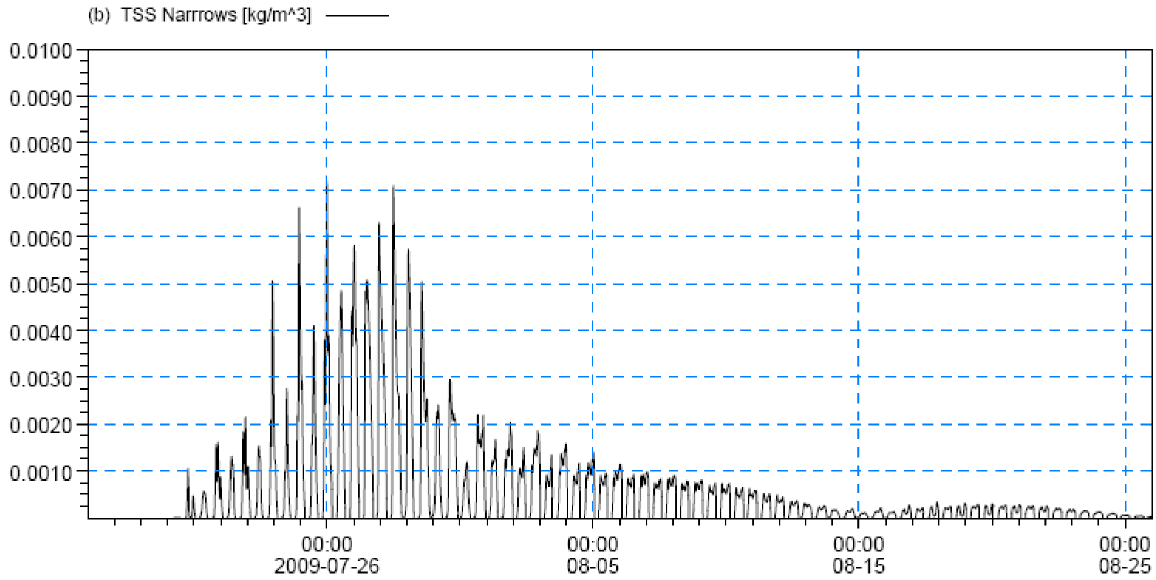

Figure 4-5 TSS time series in The Narrows

Sedimentation rates during dredging have also been considered. Maximum sedimentation rates predicted during dredging for the proposed Western Basin Dredging and Disposal Project vary from 0.022 to 0.4 mm/day in calm and low velocity conditions (GHD, 2009). *Zostera spp*. and *Halophia ovalis* were reported to tolerate approximately 2 cm of sedimentation per year (Erftemeijer and Lewis, 2006). These rates of deposition fall between sedimentation rates observed during baseline studies, where accumulation was reported at 0.43 to 15cm per year (see Western Basin Dredging and Disposal Project EIS, GHD, 2009). Given the range observed during baseline conditions, maximum sedimentation rates would need to occur for greater than 50 days, to generate impacts from smothering.

It is noteworthy that the duration of dredging, volume of dredge material, TSS concentrations and dredge plume durations associated with the APLNG pipeline is considerably smaller than the proposed 12-18 month dredging of 36 Million m^3 of material proposed for the Western Basin Dredging and Disposal Project (GHD, 2009) and therefore any contribution from the APLNG pipeline dredging activities will therefore be insignificant (see Figure 4-6 and Figure 4-7).

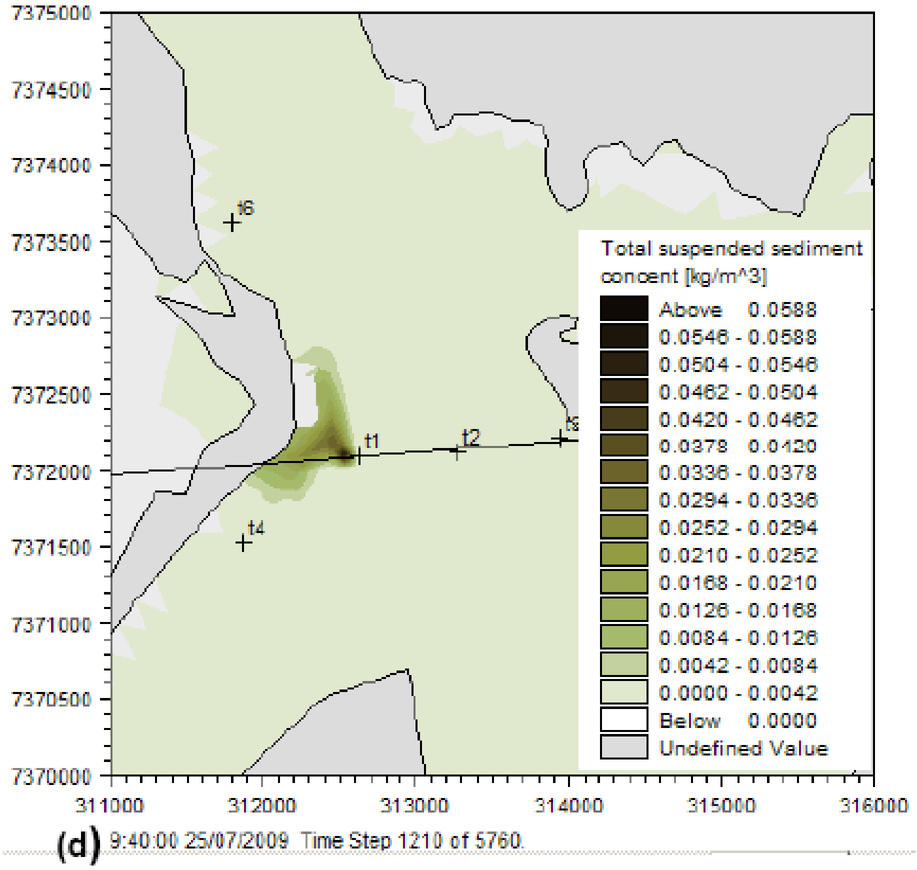

Figure 4-6 Pipeline dredge plume snapshot near Friend Point (not including Western Basin dredging)

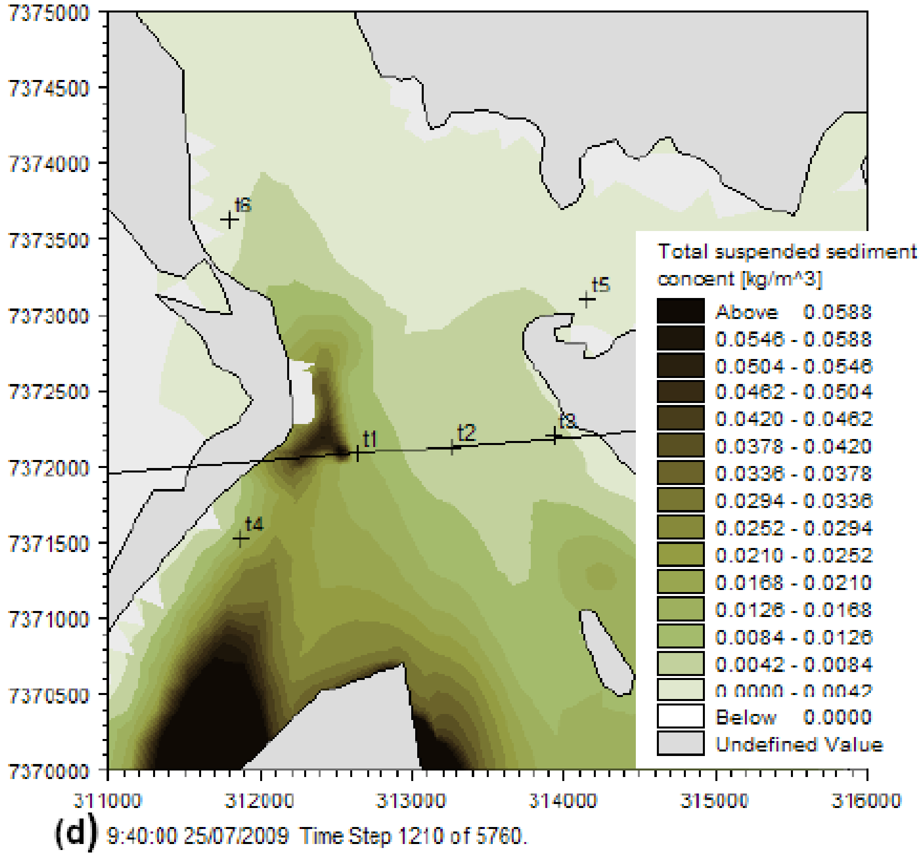

Figure 4-7 Pipeline and WBDDP dredge plume snapshot near Friend Point

Due to the substantially increased duration and extent of the WBDDP dredge plume, should the proposed dredging of The Narrows be undertaken at the same time as the WBDDPdredging program, the cumulative affect as a result of the Narrows crossing is considered of minor affect. Although predicted maximum concentrations demonstrate a clear interaction between the two programs, the consideration of mean TSS demonstrates a minor cumulative increase of approximately 20 mg/L adjacent to Friend Point and no discernable interaction at Laid Point. TSS maximum and mean concentrations modelled for the dredge plumes generated from both programs undertaken at the same time are illustrated in Figure 4-8 and Figure 4-9.

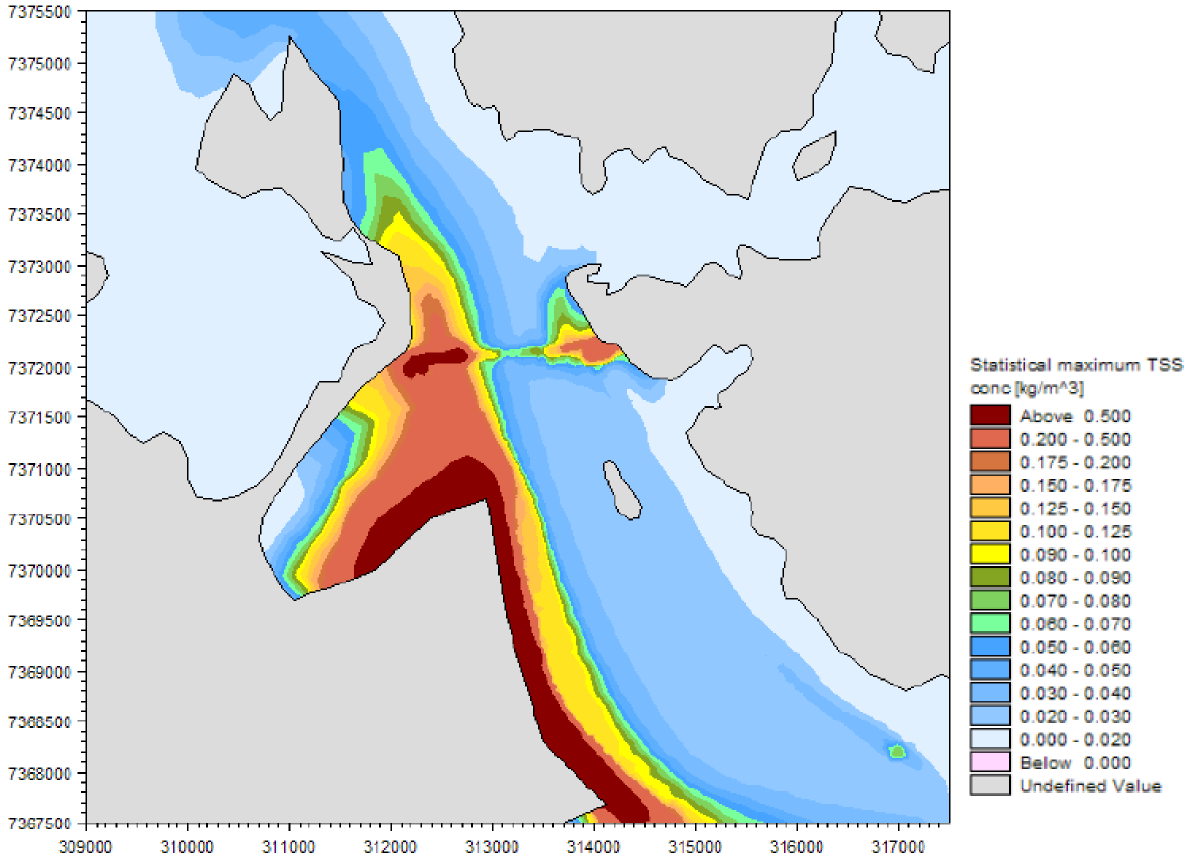

Figure 4-8 Pipeline trench and WBDDP dredging – statistical maximum TSS concentrations above background

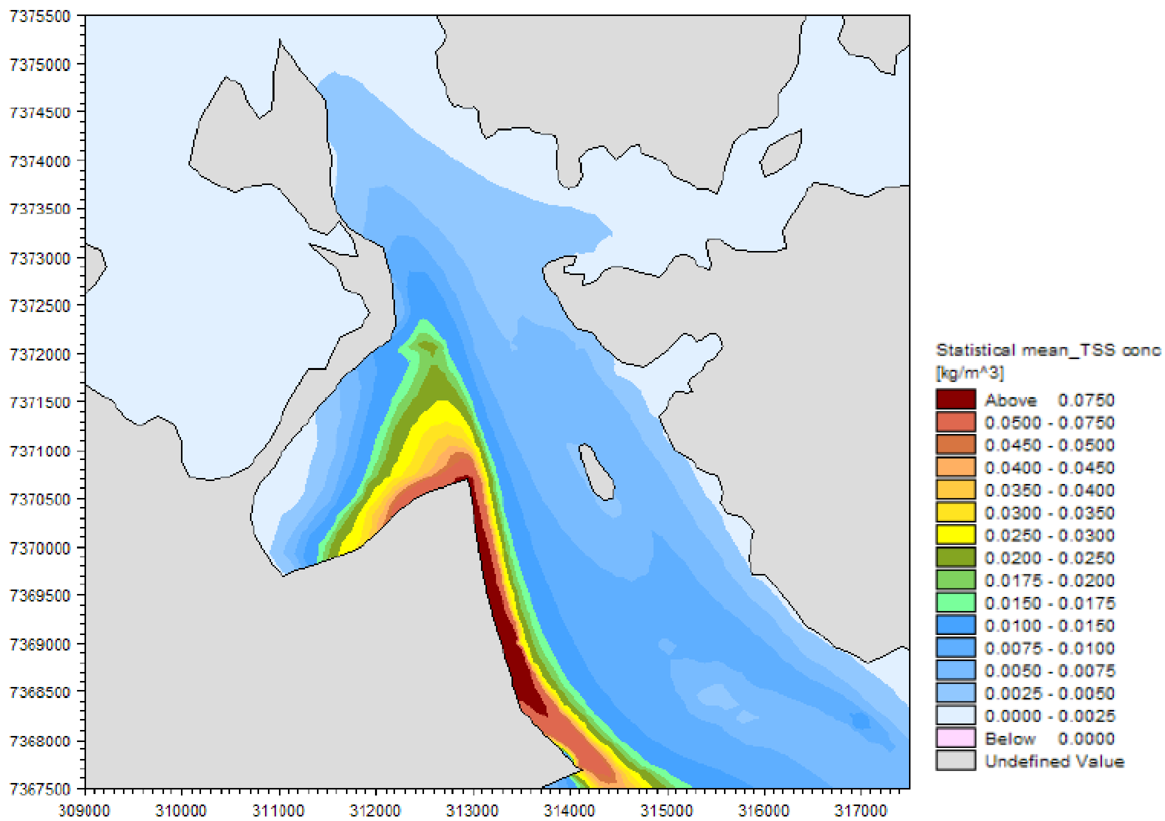

Figure 4-9 Pipeline trench and WBDDP dredging – statistical mean TSS concentrations above background

Considering the threshold light tolerances previously mentioned for the seagrass species present within Port Curtis and the concentrations and durations of the plumes (see Figure 4-10), there is a high likelihood of seagrass meadows within the Western Basin and off Friend Point being significantly impacted by high TSS concentrations for extended durations during the WBDDP dredging program. These high TSS concentrations will also lead to smothering of benthic communities nearer the reclamation area to the south. These impacts are related to the WBDDPdredging activities, with only minor contribution to the changed light regimes originating from the Narrows crossing, as demonstrated above.

The seagrass meadows within Graham Creek, at Laird Point and at North Passage Island are unlikely to be impacted given the short duration of elevated turbidity, based on the modelling results presented (Figure 4-11). Monitoring of turbidity at each of these locations should be undertaken, to ensure that the turbid plumes do not persist in these areas for greater than three weeks, and that deposition levels remain at sustainable levels. However, given the small particle sizes, prevailing tidal and current velocities, remobilisation is thought to be substantial.

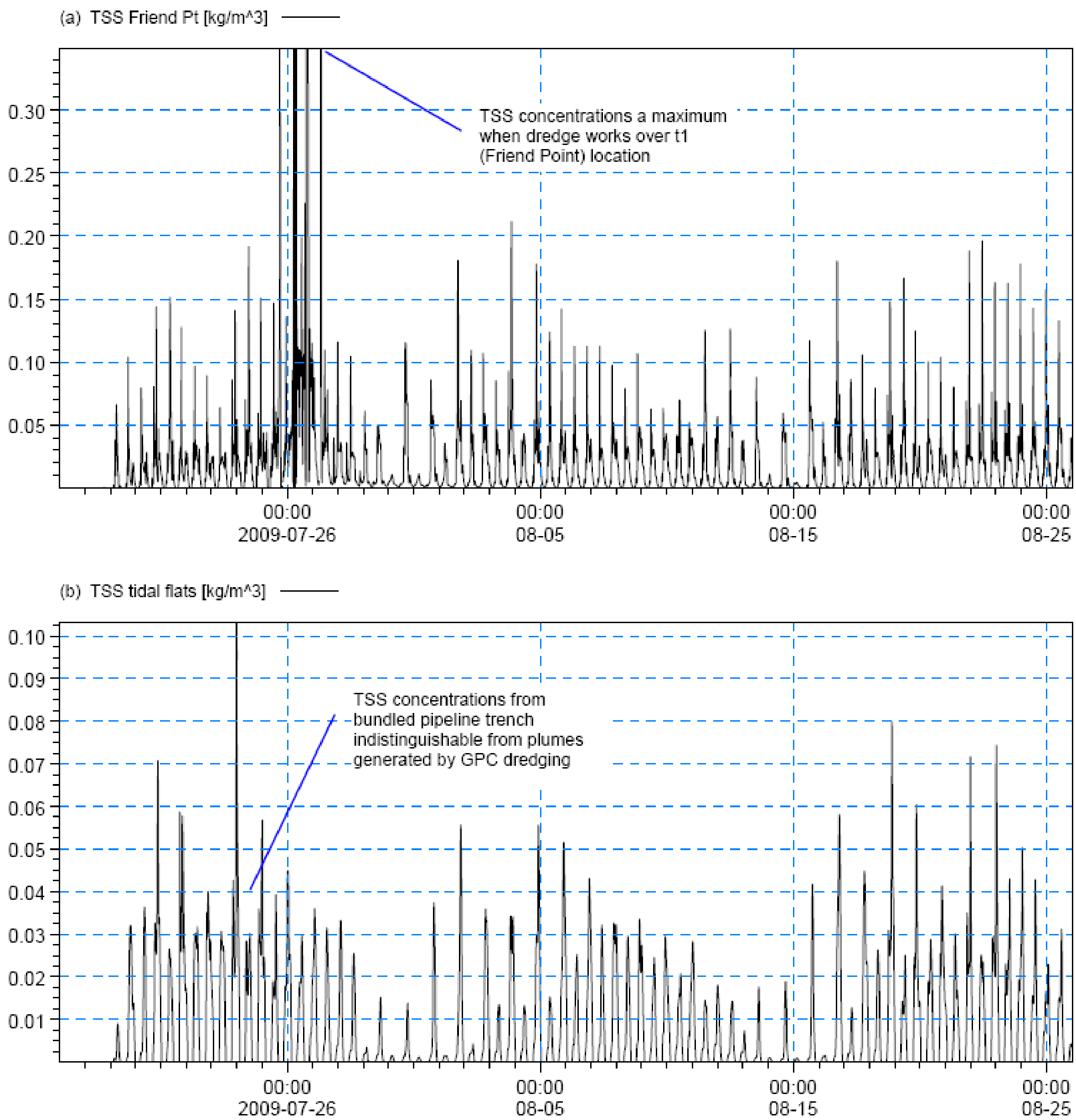

Figure 4-10 Pipeline trench and WBDDPdredging TSS concentration time series for Friend Point and the tidal flats in the Western Basin

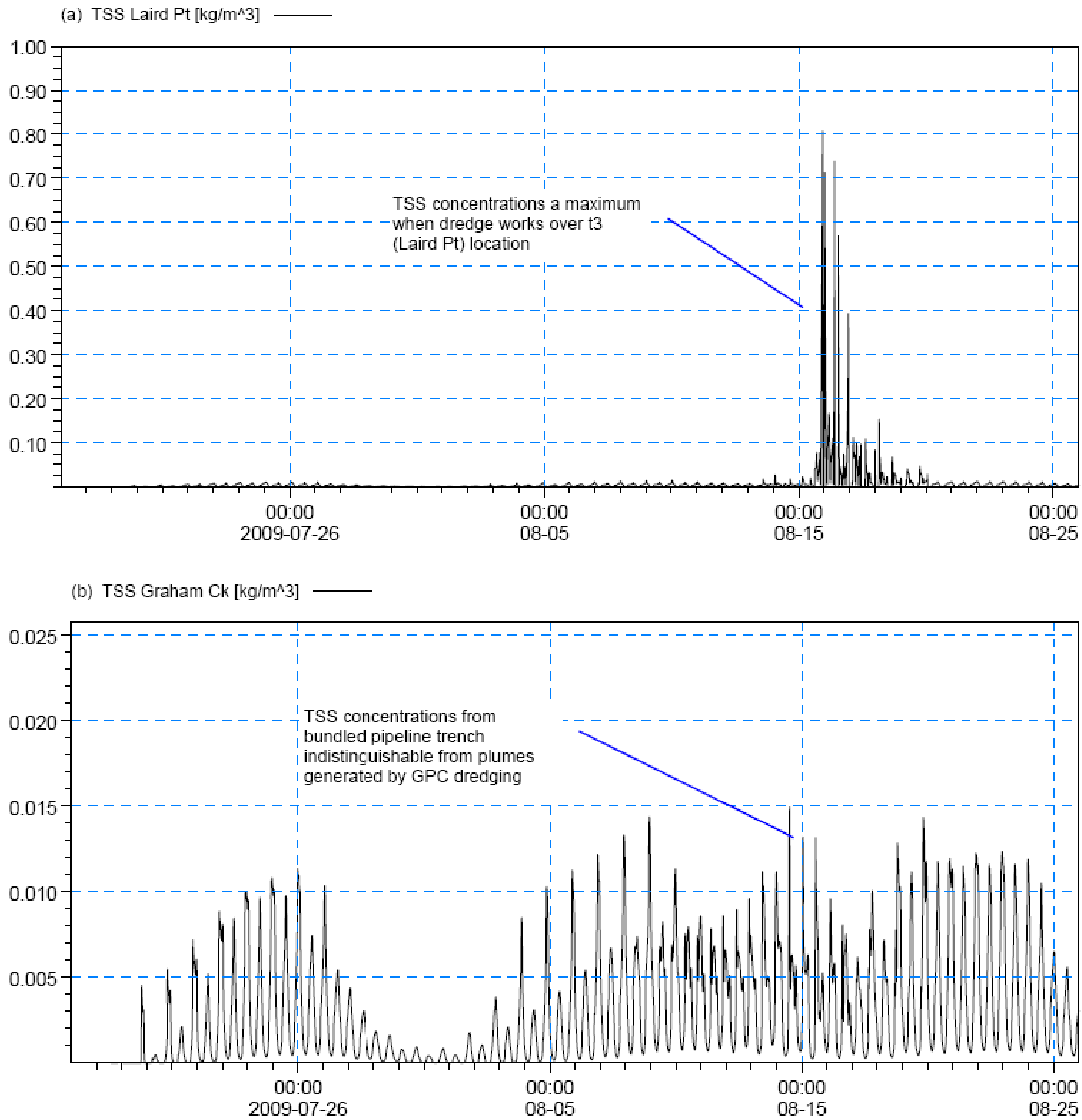

Figure 4-11 Pipeline trench and WBDDPdredging TSS concentration time series at Laird Point and Graham Creek

Mangroves

Limiting the direct impact on mangrove and saltmarsh communities will in turn, limit the potential indirect impacts on alterations in hydrology, turbidity and overall primary productivity.

Large construction footprints, should these areas become inundated at high tide, have the potential to cause turbid plumes in the surrounding marine environment, once these areas are drained on the ebb tide. Therefore, limiting the size of the construction footprint would limit the potential indirect impacts on the surrounding marine and estuarine environments.

Clearance of mangrove and saltmarsh within the intertidal wetland area has the potential to alter primary productivity and the lower trophic levels of the food chain, by reducing nutrient cycling and in turn, food availability in the intertidal areas. The benthic communities within the intertidal and subtidal estuarine areas, which rely on the mangrove and saltmarsh communities, would also be influenced by loss of key habitat. The intertidal wetlands host a variety of marine molluscs and invertebrate crustaceans, which utilise these habitats for refuge and predator avoidance.

Larval and juvenile fish species would also rely on these key habitats for food and to avoid predators and so, any direct loss of habitat would indirectly affect estuarine fish species. Effects on the local fishery, has been further discussed in the following paragraphs.

Impacts to the Local Fishery

In spite of the limitations of available QPI&F data, the assessment of likely APLNG impacts to commercial fishing (Volume 4, Chapter 10) concluded that most of the local crab catch is taken from The Narrows which will likely be largely unaffected by the proposed laying of pipeline across seagrass beds to Laird Point. Loss of commercial access to areas adjacent to proposed APLNG infrastructure along the western shoreline of Curtis Island (and also to the Fisherman's Landing extension) is considered small relative to the much larger areas of productive seagrass habitat throughout the Western Basin and the Port Curtis estuarine environments generally. Accordingly it is considered that the productivity of local commercial net fisheries should be largely unaffected by pipeline installation across the Western Basin. Additionally, beam trawling is rarely practiced within the Port Curtis region and hence is also unlikely to be appreciably affected by the proposed APLNG pipeline installation.

Available recreational fishing data relates to the statistical division in which the fisher resides rather than the specific areas fished. Available local knowledge, outlined in EIS Vol. 4, s10.2.12, suggests bream, mullet and whiting are the most often caught finfish, and that Graham Creek is recognised as an important anchorage and local recreational fishing area, particularly for those targeting mud crabs. The area of seagrass potentially lost to pipeline(s) installation is small relative to the historic and current distribution of seagrasses within the Western Basin of Port Curtis and also within Graham Creek and The Narrows, and it is therefore assumed that any seagrass loss resulting from pipeline installation will exert limited, if any, affects on the availability of finfish and mud crab resources for local recreational fishers.

Physical disturbance during construction, from dredging and construction vessels is thought to result in a larger impact on short term fish behavior and habitat utilization than the significance of habitat loss.

Loss of potentially productive fisheries habitat, such as seagrass meadows, has been minimised during the planning and design phases of the APLNG project. Saltmarsh and mangrove habitats are generally recognised as important contributors to production of fisheries resources. The importance of these habitat types as nursery areas may be attributed to their provision of refuge areas from predators, to their relatively high level of nutrients and to the shelter they provide from physical disturbance.

Various studies have endeavoured to correlate the areal and linear extent of mangrove/saltmarsh/ seagrass areas and local fisheries catches, with seaward fringes of Australian mangroves contributing 20 to 290 kg of fish per mangrove hectare and 450 to 1000 kg of prawns per mangrove hectare per year (Blaber, 2002; Robertson and Blaber, 1993). Mazumder *et al*. (2005) estimated saltmarsh contributed around 6 kg of fish per hectare. Whilst the actual contributions of mangroves and saltmarsh areas to fish production are likely to be positive, they are also likely to vary with space and time. Also, in addition to natural and fishing-related fish mortalities, the relative abundance of fish resources are also influenced by a large suite of habitat and environment variables of which, in this circumstance, intertidal wetlands are but one component.

4.3 Potential Water Quality Impacts

4.3.1 Dredging/Excavation Impacts

Dredging has been proposed as part of the trenching works for the pipeline across The Narrows, while construction of the material offloading facility (MOF) on Curtis Island will involve dredging and reclamation of intertidal and subtidal environments. During construction of the pipeline across the intertidal mudflats at Friend Point sediments will also be excavated.

Remobilisation of sediments associated with dredging, excavation and reclamation has the potential to impact on water quality through increases in turbidity, remobilisation and spread of potentially contaminated sediments (organics and heavy metals) and through the remobilisation, oxidation and generation of acidic leachate from potential acid sulfate soils (PASS) or actual acid sulfate soils (AASS). Incident light regimes are reduced during the passage of turbid water plumes and the introduction of increased metals and nutrients concentrations can occur over the longer term. The release of nutrients can increase the risk of algal blooms, which in-turn may affect dissolved oxygen regimes. Long-term elements of the associated projects such as the WBDDP dredging may be considered of greater risk in generating water quality affects due to the duration of their proposed activities.

4.3.2 Narrows Dredge Trench

For the pipeline trench across The Narrows, dredging is assumed to commence from the Friend Point side and move across to Laird Point. It is proposed that once the pipeline has been towed into place at the bottom of the trench it would backfilled with a 2 m deep layer of rock armour. A model derived by WorleyParsons (2010c) for construction of the pipeline across The Narrows assumes that a floating pipeline is connected to a cutter suction dredge which transfers the dredged material directly to the northern Fisherman's Landing reclamation area. It is assumed the reclamation bund or a temporary containment area will be available by the time the pipeline trench is constructed.

Geotechnical and sediment sampling studies completed in the Western Basin by Coffey (2009) and WorleyParsons (2010c) indicate that the composition of the material to be dredged will vary over the distance of the route from gravelly sands to silty and clayey sands. Higher percentages of fine material resuspension during dredging are expected nearer the shorelines on both sides of The Narrows unless some form of containment is implemented. In shallower areas adjacent to Targinnie Channel the spring tide currents are strong enough to suspend fine sediments into the water column. Under-water video camera work has confirmed that even sandy bed sediments are highly mobile in these areas and flocculated particles lift off into suspension and then settle out at slack tide conditions as a readily mobile, unconsolidated layer (WorleyParsons 2010c). Gravel and coarse sand bed material will settle out of suspension relatively quickly during dredging but fine material will remain in suspension for some time due to ambient turbulence and prevailing currents.

Contaminants in marine sediments from The Narrows were all reported below the NAGD (DEWHA 2009) sediment screening levels (WorleyParsons 2010 c). As such, these sediments are not considered to be contaminated and are unlikely to pose any water quality impacts associated with suspension of contaminants.

APASA (2010) analysed background TSS concentrations in Port Curtis (based on a satellite-derived 250 m grided dataset) and determined the average TSS concentration to be approximately 20 mg/L. Higher average turbidity between 25 mg/L and 50 mg/L occurred in the main navigation channels where stronger currents are present. These values are at or above the QWQG for TSS in mid-estuarine waters in the Central Coast region of Queensland of 20 mg/L. Modelling undertaken by WorleyParsons (2010c) has indicated that dredging of The Narrows will increase TSS concentrations above these natural background levels for short periods, especially on the eastern and western sides of The Narrows, nearer to the shorelines, where high percentages of fine materials are found.

4.3.3 Excavation of Intertidal Mudflats

It is proposed that excavated material from construction across the mudflats at Friend Point would be transferred to an ASS treatment area. Insufficient containment around excavation locations in the mudflats may allow for the movement of dredge plumes into creeks causing water quality issues such as increased turbidity, smothering of aquatic flora and benthos. Leaching of ASS from the excavated trench may also result in lower pH waters around the trench and possibily extending into the creeks. At creek crossings the free movement of tidal flows would potentially be accompanied by the spread of a sediment plume along the waterway.

4.3.4 Marine Pest Species

Australia maintains existing protocols to minimise the risk of marine pest incursions and the early detection of an incursion if one occurs. There is a National System for the Prevention and Management of Marine Pest Incursions which includes three major components:

- prevention
- emergency response
- ongoing control and management of existing pests

Since 2001, requirements have been in place for the management of internationally sourced ballast water that apply to all ships arriving from overseas. These requirements are implemented through the *Quarantine Act 1908* and are administered by the Seaports Program within the Australian Quarantine Inspection Service (AQIS). No ballast water may be discharged from internationally trading vessels in Australian waters without express written permission from AQIS.

Baseline surveys have identified the presence of up to 9 introduced marine species. However, to-date, no problematic invasive species have been identified from Port Curtis. However, introduction of marine pests could still potentially occur via:

- Translocation of species introduced to other ports within Australia (i.e. translocations from ports, such as Cairns, Weipa, Brisbane etc
- Direct introduction via ballast water discharge or hull fouling from international trading vessels contracted for the dredging and construction process

International ships servicing the marine operations will be required to manage ballast waters inline with the existing management strategy. Australian Quarantine and Inspection Service (AQIS) is the lead agency for the management of ballast water taken up overseas with the intention of discharge within an Australian port. Part of AQIS's charter is to ensure that foreign ballast water has been managed in accordance with the Australian Ballast Water Management Requirements before permitting its discharge inside Australia's territorial sea (12 nautical mile limit generally applies).

The risk of introducing marine pest species as part of the proposed operations is considered small, owing to the existing management controls regarding ballast water. Dredges and plant servicing the project would also need clearance certificates before being allowed to operate within Australian waters. This is a risk mitigation measure for the possible incidence of hull fouling. The impact from invasive marine species introduction is considered minor, and on-going monitoring would ensure possible outbreaks are identified and options for management developed.

5. Conclusions and Recommendations

The proposed pipeline crossing of the intertidal wetlands will result in the clearance of saltmarsh and mangrove communities. The intertidal wetlands, as previously discussed, provide habitats which significantly contribute to the high primary productivity of the estuaries around the Gladstone region, including maximising food availability and minimising predation on the lower trophic levels, such as predation of juvenile fish and crustaceans. The direct loss of mangrove and saltmarsh communities results in less intertidal habitat for these coastal species.

For trenching and sheet piling activities used in the creeks and areas which are routinely inundated with seawater at high tide, effort should be made to limit the interactions between tidal waters and exposed excavations. Any alterations to local hydrology will require mitigation, and consideration of applicable drainage diversions may be considered appropriate.

Once final design is defined, assessment of the proposal using surface water inundation modelling techniques would assist in defining locations and sizing of appropriate diversion or drainage linkage structures. Following installation, all works should be reinstated back to the same Australian Height Datum (AHD) levels, and the easement rehabilitated.

Options for physically handling, treating and replacing ASS materials have not been sufficiently defined to allow full consideration of impact at this stage. However, the management of ASS and acid drainage is considered of great importance where crossing the wetlands is undertaken via open excavation and sheet piling. Treatment of ASS and PASS within the proposed construction corridor will need to be supported by a fully documented construction management plan.

Water quality monitoring undertaken by WorleyParsons (2010) found the concentrations of TSS in Targinie Creek to be well within the QWQG value for mid-estuarine environments of 20 mg/L (DERM 2009), reporting an average value of 6.4 mg/L. During construction, water quality monitoring should be undertaken in Targinie Creek, to manage and maintain water quality conditions. A water quality monitoring program should be implemented which includes measures to avoid prolonged increased turbidity in Mosquito Creek and the surrounding marine environment, adjacent to construction activities. Monitoring for pH and chemical parameters, including metals and nutrients, would also be required.

Turbid plumes are likely to increase light attenuation over adjacent seagrass beds in the northern Western Basin, around North Passage Island and on the eastern side of The Narrows at Laird Point for short intermittent periods and cause localised smothering. Given however, the short duration of dredging (23 days for the pipeline); the spatial cover and temporal duration of the plumes (i.e. 400 mg/L for a few days at Friend Point; 20 mg/L for up to 1 week within the tidal flats of the Western Basin; and 5–7 mg/L above background for up to 1 week in The Narrows), and the threshold tolerances of the seagrass species from published literature, there are unlikely to be any acute of chronic long term impacts on seagrass communities resulting from dredge affects outside the direct foot print of the construction activity.

Adverse water quality impacts from the proposed dredging and excavation works can be minimised through the employment of appropriate management mitigation measures including:

- The area of any visible dredge plume should be recorded/photographed so that the impact area can be determined, satellite imagery is an effective tool for identifying plume boundaries

- Water quality monitoring (turbidity and sedimentation rates) around the dredge area should be undertaken and more specifically, over seagrass communities in the Western Basin, at North Passage Island and on the eastern side of The Narrows at Laird Point, to make sure that elevated turbidity does not persist for greater than three weeks (to manage reduced incident light levels) and maximum sedimentation rates of 0.4 mm/day do not occur for greater than 50 days (for managing the effects of smothering)
- Where possible direct pumping of the sediment slurry from the dredge in The Narrows to the reclamation area, which would limit the production of sediment plumes that may be generated by an overflowing barge and rehandling activities
- If possible, dredging should be undertaken during peak senescence, to reduce the impact on seagrasses from light deprivation (e.g. Bulthuis 1983)
- Potential acid sulfate soils (PASS) must be transported, treated and disposed of in accordance with an approved Acid Sulfate Soils Management Plan. Treatment areas should be fully bunded to avoid impacts on adjacent saltmarsh and mangrove communities

6. References

Alquezar, R., (2008). Macroinvertebrate and sediment assessment for the Curtis Island gas pipeline EIS. A report to URS by the Centre for Environmental Management, CQUniversity Australia, Gladstone, Queensland.

Andersen, L. E., (2004). Imposex: A biological effect of TBT contamination in Port Curtis, Queensland. *Australasian Journal of Ecotoxicology*, **10**(2): 105-113.

ANZECC/ARMCANZ (Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand), (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Volume 1. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand. Canberra, ACT, Australia.

APASA (2010)

Apte, S., L. Duivenvoorden, R. Johnson, M.A. Jones, A. Revill, S. Simpson, J. Stauber and V. Vicente-Beckett, (2005). Contaminants in Port Curtis: Screening level risk assessment. Technical Report No. 25, CRC for Coastal Zone, Estuary and Waterway Management, Brisbane, 146 pages.

Blaber, S.J.M., (2002). "Fish in hot water": the challenges facing fish and fisheries research in tropical estuaries. *J. Fish Biol*, 61: 1-20.

Bulthuis, D. A. (1983). Effects of light reduction on density and growth of the seagrass *Heterozostera tasmanica* (Martens ex Aschers) den Hartog in Western Port, Victoria, Australia. *Journal of Experimental Marine Biology and Ecology* **67**, 91-103.

Chartrand K.M., Rasheed, M. A., and Unsworth R. K. F. (2009). Long term seagrass monitoring in Port Curtis and Rodds Bay, November 2008. DEEDI Publication PR09-4407.

Coffey 2009

Connolly et al (2006)

Currie, DR and Connolly, RM 2006, 'Distribution and assemblage composition of demersal fish in shallow, nearshore waters of Port Curtis', in RM Connolly, DR Currie, KF Danaher, M Dunning, A Melzer, JR Platten, D Shearer, PJ Stratford, PR Teasdale and M Vandergragt (eds), *Intertidal Wetlands of Port Curtis: Ecological Patterns and Processes, and their Implications,* Coastal CRC Technical Report No.43.

Currie D. R., and Small K. J. (2005). Macrobenthic community responses to long-term environmental change in an east Australian sub-tropical estuary. *Hydrobiologia* **560**, 345-361.

Currie D. R., and Small K. J. (2006). The influence of dry season conditions on bottom dwelling fauna of an east Australian subtropical estuary. *Hydrobiologia* **560**, 345-361.

Danaher, K, Rasheed, MA and Thomas, R 2005, *The Intertidal Wetlands of Port Curtis,* Department of Primary Industries and Fisheries Information Series QI05031.

DERM (2009). Queensland Water Quality Guidelines. Version 3. Department of Environment and Resource Management. Queensland Government. Queensland.

DEWHA (2009). Commonwealth of Australia (2009). National Assessment Guidelines for Dredging, Commonwealth of Australia, Canberra, 2009.

Duke, N.C., P.T. Lawn, C.M. Roelfsema, K.N. Zahmel, D.K. Pederson, C. Harris, N. Steggles and C. Tack, (2003). *Assessing historical change in coastal environments*. *Port Curtis, Fitzroy River Estuary and Moreton Bay Regions*. Report to the CRC for Coastal Zone Estuary and Waterway Management. July 2003. Marine Botany Group, Centre for Marine Studies, University of Queensland, Brisbane.

Erftemeijer P. L. A., and Lewis III R. R. R. (2006). Environmental impacts of dredging on seagrasses: A review. *Marine Pollution Bulletin* **52**, 1553-1572.

GHD 2009. Western Basin Dredging and Disposal Project EIS

GHD (2010). GLNG Pipeline Feed. Mechanised Marine Crossing Installation Concept. GHD. Brisbane. Qld.

Western Basin (2009). Western Basin Dredging and Disposal Project. Environmental Impact Statement, Gladstone Ports Corporation. Gladstone. Queensland.

Halliday, IA and Young, WR 1996, 'Density, biomass and species composition of fish in a subtropical *Rhizophora stylosa* mangrove forest', *Marine and Freshwater Research,* vol. 47, pp. 609-615.

Heck K. L., Hays G., and Orth R. J. (2003). Critical evaluation of the nursery role hypothesis for seagrass meadows. *Marine Ecology Progress Series* **253**, 123-136.

Henry, GW and Lyle, JMC 2003, *The National Recreational and Indigenous Fishing Survey,* Fisheries Research and Development Corporation Project 99/158.

Jones, M., Staubner, J., Apte, S., Simpson, S., Vicente-Beckett, V., Johnson, R., and Duivenvoorden, L. (2005). A risk assessment approach to contaminants in Port Curtis, Queensland, Australia. *Marine Pollution Bulletin* **51**, 448-458.

Lanyon J. M., and Marsh H. (1995). Temporal changes in abundance of some tropical intertidal seagrasses in North Queensland. *Aquatic Biology* **84**, 110-120.

Lewis, R.R., (2005). Ecological engineering for successful management and restoration of mangrove forests. *Ecological Engineering*, **24:** 403-418.

Lewis, J., Hewitt, C. and Melzer, A. (2001) *Port Survey for Introduced Marine Species – Port Curtis.* A report to the Gladstone Port Authority.

Manson, FJ, Loneragen, NR, Harch, BD, Skilleter, GA and Williams, L 2005, 'A broad-scale analysis of links between coastal fisheries production and mangrove extent: A case study for northeastern Australia', *Fisheries Research*, vol. 74, no.1-3, pp. 69-85.

Mazumder, D., N. Saintilan and R.J. Williams, (2005). Temporal variations in fish catch using pop nets in mangrove and saltmarsh flats at Towra Point, NSW, Australia. *Wetlands Ecology and Management*, 13: 457-467.

McKenzie L. J. (1994). Seasonal changes in biomass and shoot characteristics of a *Zostera capricorni* Aschers. dominant meadow in Cairns Harbour, northern Queensland. *Australian Journal of Marine and Freshwater Research* **45**, 1337-1352.

Platten, J., B. Sawynok, and W. Parsons, (2007). How Much Fishing Effort Is There? Patterns of Fishing Effort of Recreational Fishers Offshore from Central Queensland. Infofish Services, Brisbane.

QEPA (2003). The Curtis Coast regional coastal management plan. Queensland Environmental Protection Agency, Rockhampton, 152pp.

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. Department of Primary Industries and Fisheries Information Series Q103058. Marine Ecology Group. Northern Fisheries Centre. Queensland Government. Queensland.

Rasheed M. A., McKenna, S., Taylor, H., Sankey, T. (2008). Long term seagrass monitoring in Port Curtis and Rodds Bay, Gladstone - November 2007. Department of Primary Industries and Fisheries. Marine Ecology Group. Northern Fisheries Centre. Publication PR07- 3271. Queensland Government. Queensland.

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Robertson, A.I. and S.J.M. Blaber, (1993). Plankton, epibenthos and fish communities. In. A.I. Robertson and D.M. Alongi (eds), *Tropical Mangrove Ecosystems*. Coastal and Estuarine Studies, Volume 41, American Geophysical Union, Washington DC, pp. 173-224.

Sheaves, M, Johnston, R and Abrantes, K 2007, 'Fish fauna of dry tropical and subtropical estuarine floodplain wetlands', *Marine and Freshwater Research,* vol. 58, pp. 931-943.

Stevens, JD, Pillans, RD and Salini, J 2005, *Conservation assessment of* Glyphis sp. *A (speartooth shark*), Glyphis sp. C *(northern river shark),* Pristis microdon *(freshwater sawfish) and* Pristis zijsron *(green sawfish),* CSIRO Marine Research Final Report to the Department of the Environment and Heritage.

Storey, A., Andersen, L., Lynas, J. and Melville, F. (2007). *Port Curtis Ecosystem Health Report Card*. Port Curtis Integrated Monitoring Program.

Taylor H., Rasheed M. Dew K. and Sankey T. (2007). Long term seagrass monitoring in Port Curtis and Rodds Bay, Gladstone, November 2006. Queensland Department of Primary Industries and Fisheries Publication PR07-2774.

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. *Marine Ecology Progress Series* **209**, 275-288.

URS (2009). GLNG Marine Ecology Technical Report. Prepared for Santos Ltd. Brisbane. Qld.

Walker, MH 1997, Fisheries Resources of the Port Curtis and Capricorn Regions, report prepared for the Fisheries Management Authority, Queensland.

WorleyParsons 2010a. Terrestrial Ecology Report

WorleyParsons 2010b. Coastal Environment EIS - Supplementary

WorleyParsons 2010c. Marine Modelling Report

WorleyParsons 2010? Water Quality Monitoring