Australia Pacific LNG Project

Volume 4: LNG Facility

Chapter 12: Coastal Environment

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12. Coastal environment

12.1 Introduction

12.1.1 Purpose

The Australia Pacific LNG's liquefied natural gas (LNG) plant will incorporate marine-based components such as a material offloading facility (MOF), ship berths and jetties. The ship swing basins and navigation channel are part of the Port of Gladstone's Western Basin Dredging and Disposal Project. During operations, utilities will include potable water production. This will be produced via a desalination plant to discharge relatively small volumes of concentrated brine into the marine environment.

Figure 12.1 presents the proposed location of the LNG plant in relation to the Curtis Coast Regional Coastal Plan boundary and the key coastal sites, as described in the Curtis Coast Regional Management Plan (Environmental Protection Agency and Queensland Parks and Wildlife Service (EPA / QPWS) 2003). Regional policies, resources and environmental values associated with key coastal sites are considered in relation to construction and operation activities around the LNG facility and the gas transmission pipeline route across The Narrows to Curtis Island.

This chapter identifies and assesses potential impacts to the existing coastal environment from the proposed LNG facility. Where possible, methods to avoid or mitigate adverse impacts are identified. Direct, indirect and cumulative impacts are fully examined and addressed.

Of Australia Pacific LNG's 12 sustainability principles, relevant principles for the coastal environment are as follows:

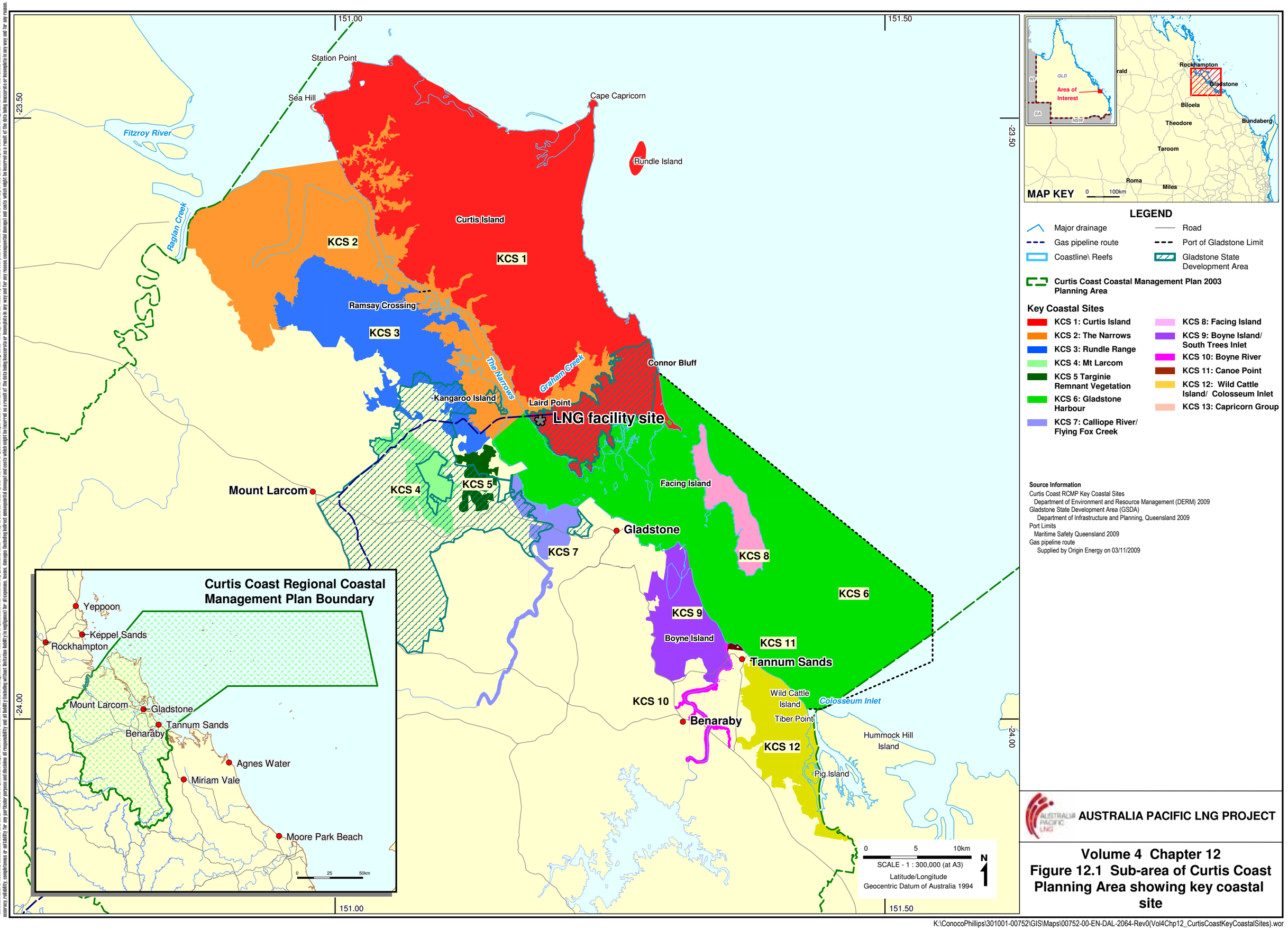
- Minimising adverse environmental impacts and enhancing environmental benefits associated with Australia Pacific LNG's activities, products or services; conserving, protecting, and enhancing where the opportunity exists, the biodiversity values and water resources in its operational areas
- Identifying, assessing, managing, monitoring and reviewing risks to Australia Pacific LNG's workforce, its property, the environment and the communities affected by its activities

The sustainability principles are to be upheld through the design methodology and construction techniques used in the establishment of the proposed marine and coastal works. After facilities are established, the monitoring and review of operational activities as outlined in Section 12.6, also provides a means to uphold the sustainability principles.

The proposed LNG facility near Laird Point on Curtis Island is 12km north by north-west from Gladstone. Laird Point is opposite Friend Point which is located on the mainland side at the southern end of The Narrows. The proposed LNG facility includes all process and waste management facilities, as well as associated marine infrastructure for a two-LNG train process by 2014, increasing to four-trains after 2015.

An overall land area of 2.7km^2 would be required for the LNG development, not including the MOF. The coastal wetland and foreshore of this land area is to be reclaimed and a causeway constructed with fill and rock by end dumping along the length of the site.

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AUSTRALIA PACIFIC LNG PROJECT

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Figure 12.1 Sub-area of Curtis Coast Planning Area showing key coastal site

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A MOF will be required to offload modules and general construction materials, provide shelter to support vessels and support load-out jetty construction. The construction will involve dredging and the subsequent management of the dredge material.

The marine facility includes a jetty and fender system equipped with product pipe work, manifold and fire-fighting systems to cater for large LNG vessels. The LNG ships will require a dredged swing basin with sufficient depth and clearance to allow safe turning while maintaining an adequate under-keel clearance.

Freshwater for the construction and operation of the LNG facility will be sourced from stormwater and the desalination of seawater. A reject brine waste stream from the desalination plant will discharge into the marine environment. Treated stormwater and treated sewage plant wastewater that exceeds on-site irrigation requirements will also be discharged to marine waters.

12.1.2 Scope of work

The scope of work, as specified in the terms of reference for the Australia Pacific LNG Project (the Project) (November 2009), relates to coastal processes. This includes descriptions of the physical processes within the study area and environmental values of the relevant coastal resources and how these could be affected by the proposed development.

The assessment is based upon hydrodynamic investigations and coastal processes interpretation that describe the influence of tides, waves, currents, turbidity, extreme events (cyclones) and how they influence the coastal environment.

The impacts from development of the MOF and causeway, and the desalination plant brine reject discharge into the marine environment, are assessed and described. Implications for marine flora and fauna are discussed within Volume 4 Chapter 10. Project components within the coastal study area are identified in Figure 12.2.

The impacts of dredging channels and swing basins within the Gladstone Harbour's Western Basin are being investigated through an environmental impact statement (EIS) being developed by Gladstone Ports Corporation (GPC). These impacts are outside the scope of works for the Project and where relevant, reference is made in this chapter to the Western Basin Dredging and Disposal Project EIS.

12.1.3 Legislative framework

The assessment of the coastal and marine activities in the study area has been undertaken in consideration of the following legislation:

- *Coastal Protection and Management Act 1995* (Queensland) and *Coastal Protection and Management Regulation 2003*
- State Coastal Management Plan – Queensland's Coastal Policy (2001) and includes the Curtis Coast Regional Coastal Management Plan
- *Marine Parks Act 2004* and Great Barrier Reef Marine Park (Mackay/Capricorn Section) Zoning Plan and Queensland Mackay/Capricorn Marine Park Zoning Plan
- *Environmental Protection Act 1994* and *Environmental Protection Regulation 2008*
- *Environmental Protection (Water) Policy 1997* (EPP Water)
- *Sustainable Planning Act 2009*

- *Transport Infrastructure Act 1994*
- *State Development and Public Works Organisation Act 1971*

An overview of the relevant Queensland legislation referred to above and its purpose is provided in Volume 1 Chapter 2. Statutory plans, state planning policies, and legislative regulations that are directly relevant to coastal activities undertaken by the Australia Pacific LNG Project are discussed below.

The LNG facility is located within a Great Barrier Reef World Heritage Area (GBRWHA) and borders the Great Barrier Reef Coast Marine Park. These are both significant coastal resources.

In July 2008 three new areas were included within the Gladstone State Development Area, one of which was the Curtis Island Industry Precinct.

Specific regional issues for the Australia Pacific LNG Project have been identified by reference to policies described within the Curtis Coast Regional Coastal Management Plan. The Curtis Coast Regional Coastal Management Plan is a statutory instrument under the *Coastal Protection and Management Act 1995* that has the effect of a state planning policy under the *Sustainable Planning Act 2009*.

Regional policies apply to the key coastal sites of:

- Curtis Island (South West)
- The Narrows
- Gladstone Harbour (in particular the Western Basin).

Regional policies considered relevant to the LNG facility are summarised in section 1.4.1 of Volume 5 Attachment 27.

151.15 | 151.20 | 151.25

-23.75

-23.80

OPTION 2a

OPTION 1b

Laird Point

Curtis Island

Fisherman's Landing

Fisherman's Landing Wharves

Targinie Channel

Swing Basin

Clinton Channel

Clinton Bypass Channel

Clinton Wharves

Auckland Channel

Auckland Wharf

Barney Pt Wharf

0 1 2km

SCALE - 1 : 50,000 (at A3)
Latitude / Longitude
Geocentric Datum of Australia 94

N

INSET MAP

Options for dredging of pipeline crossing

MOF and required dredging

Options for desalination brine reject outfall

Reclamation and causeway

0 1km

Yeppoon
ROCKHAMPTON
GLADSTONE
CALLIOPE
Miriam Vale
QLD
NT
SA
NSW
Area of Interest

MAP KEY 0 50km

LEGEND

- Gas pipeline route
- Property boundaries
- Cadastral boundaries
- Australia Pacific LNG dredge options
- Port of Gladstone passage channels
- Port of Gladstone Western Basin Master Plan dredge areas
- Port of Gladstone Western Basin Master Plan reclamation areas

Source Information

Cadastre and Easements
Department of Natural Resources and Water, Queensland 2009
Port of Gladstone Passage Channels
Digitised from MSQ Port of Gladstone Passage Plan - Gladstone Pilotage Area - March 2008
Development footprint
Conceptual Site Plan 25509-100-10005.dgn supplied by client 24/07/2009
Satellite Imagery
Captured by GeoEye-1 on 24 March 2009

AUSTRALIA PACIFIC LNG PROJECT

Volume 4 Chapter 12
Figure 12.2 Project components within the coastal environment study area

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12.2 Methodology

Assessment of the potential impacts to the coastal environment due to the construction and operation of the LNG facility has included the following tasks:

- A literature review and evaluation of existing coastal data sets relevant to the LNG facility site
- A review of the physical processes associated with the coastal and marine environment within the study area, including:
  - Wind
  - Waves
  - Tides
  - Currents
  - Storm tide
- A site inspection, acquisition of existing data and collection of new data for modelling purposes, including:
  - Hydrographic surveys
  - Wind speed and direction
  - Wave height and direction
  - Tide gauge predictions and measurements
  - Current speed and direction profiles
  - Water quality information
- Hydrodynamic modelling investigations, including:
  - Tides
  - Currents
  - Tidal flushing
  - Local sea states and storm waves
  - Storm tide
  - Dredge plume behaviour
  - Desalination brine discharge plume behaviour
  - Dredged area saltation.

Hydrodynamic modelling was used to simulate existing conditions as a base case from which the potential impacts of the proposed development could be assessed. Analysis of available existing data, fieldwork campaigns and modelling investigations supplemented the modelling results to provide a complete information set for the impact assessment.

The numerical tools, analysis and interpretation were applied to predict the potential impacts in relation to the Project's development options, including Option 1b and Option 2a berth facilities.

Furthermore, the predicted potential impacts to coastal environmental values were assessed and recommendations made, where possible, to mitigate the impact.

For details of the verification of the hydrodynamic model refer to section 4.3.2 of Volume 5 Attachment 27. The model domain is shown in Figure 12.3.

12.3 Existing environment

The Curtis Coast region includes areas of high conservation value as well as areas of state significance, which include strategic port land and state development areas. Areas of conservation include wetlands, seagrass beds, turtle nesting beaches, shore bird roosting areas, coral cays, and planar reefs.

The proposed development site and the Western Basin lie within the GBRWHA. Marine parks of state significance also border the Western Basin. The LNG facility site coincides with a scenic coastal landscape and significant coastal wetland that is listed as an area of state significance under the Regional Coastal Management Plan. Figure 12.4 contains samples of sites with high conservation value that are referenced from the Regional Coastal Management Plan. Figure 12.5 outlines the Great Barrier Reef Marine Park administrative boundaries.

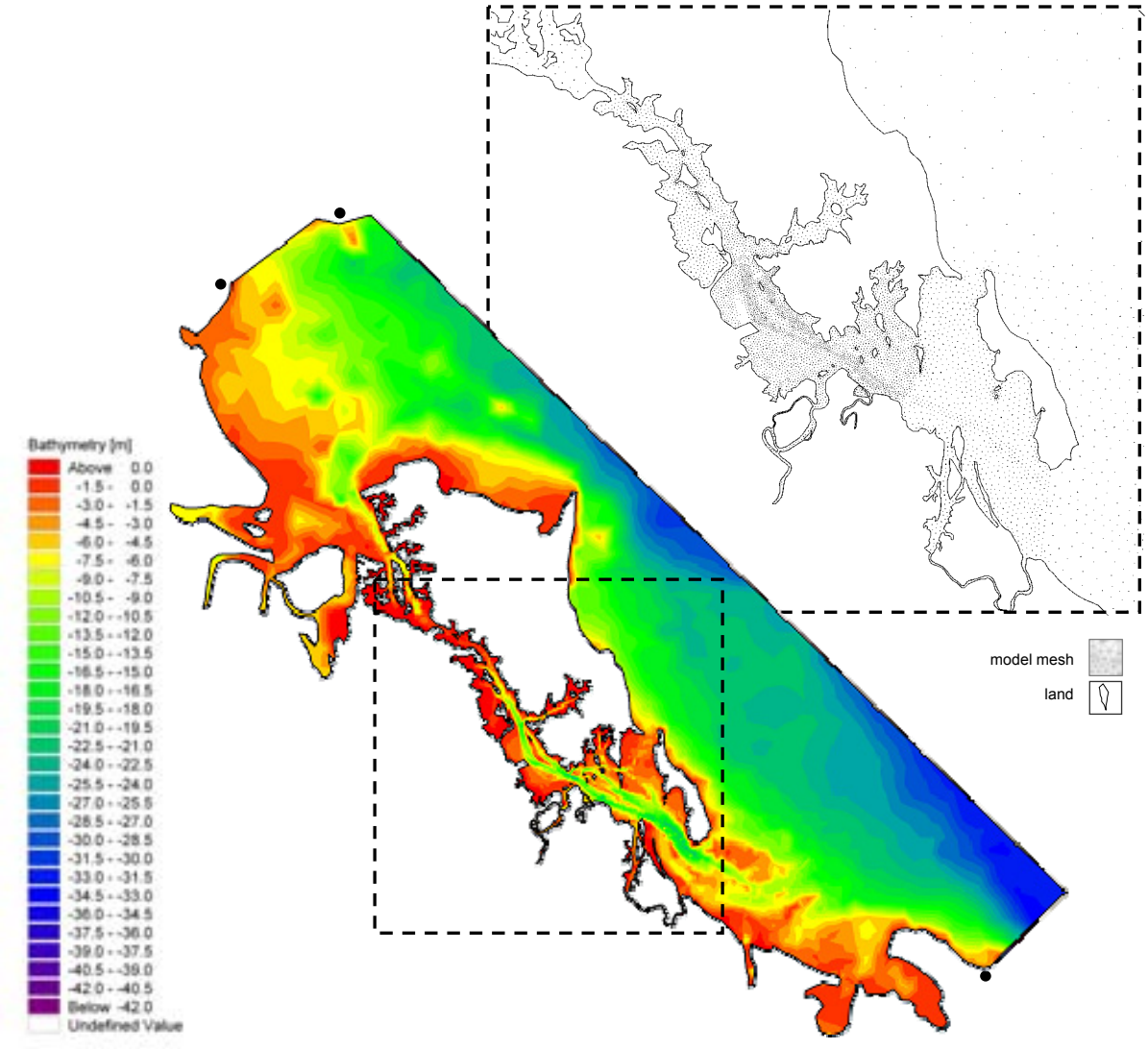


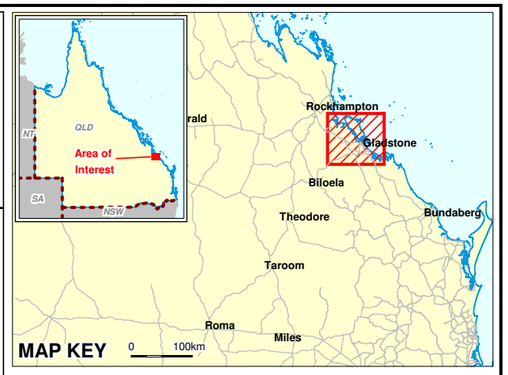
Figure 12.3 Port of Gladstone hydrodynamic model extent and bathymetry - Inset provides detail of the high-resolution flexible mesh.

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Fitzroy River
Raglan Creek
Curtis Island
Ramsay Crossing
The Narrows
Graham Creek
Connor Bluff
Laird Point
LNG facility site
Facing Island
Mount Larcom
Gladstone
Boyne Island
Tannum Sands
Colosseum Inlet
Benaraby
151.00
151.50
-23.50
-24.00

0 5 10km
SCALE - 1 : 300,000 (at A3)
Latitude/Longitude
Geocentric Datum of Australia 1994
N



LEGEND

- LNG facilty site
- Major drainage
- Road
- Coastline\ Reefs
- Curtis Coast Coastal Management Plan 2003 Planning Area

Habitat Areas
- Eucalypt woodland
- Eucalypt forest
- Coastal wetlands
- Seagrass

Dugong Protection Area
- Dugong protection area 'B'

Shorebirds and Turtles
- Major shorebird roost sites
- Major shorebird feed sites *
- Recorded turtle nesting beaches

* Indicates major feeding sites only; minor roosting sites occur throughout the Curtis Coast area.

Source Information

Curtis Coast RCMP Key Coastal Sites
Department of Environment and Resource Management (DERM) 2009
Dugong Protection Areas
Queensland Department of Primary Industries and Fisheries 2008
Shorebird Feed and Roosting Sites
Department of Environment and Resource Management (DERM) 2009
Turtle Nesting Sites
Department of Environment and Resource Management (DERM) 2009

AUSTRALIA PACIFIC LNG PROJECT

Volume 4 Chapter 12 Figure 12.4 Areas of high conservation value relevant to the LNG plant

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150.50

151.00

151.50

-23.50

-24.00

Fitzroy River

Raglan Creek

Balaclava Island

Curtis Island

Ramsay Crossing

Graham Creek

The Narrows

Connor Bluff

Laird Point

LNG facility site

Capricorn Group

Mount Larcom

Gladstone

Facing Island

Boyne Island

Tannum Sands

Colosseum Inlet

Benaraby

0 10 20km

SCALE - 1 : 500,000 (at A3)

Latitude/Longitude

Geocentric Datum of Australia 1994

N



LEGEND

- LNG facilty site
- Major drainage
- Road
- Coastline\ Reefs
- Curtis Coast Coastal Management Plan 2003 Planning Area
- Great Barrier Reef World Heritage Area
- Great Barrier Reef Marine Park (Great Barrier Reef Marine Park Authority)
- Great Barrier Reef Coast Marine Park (Queensland State Marine Park)

Queensland State Marine Park Zoning

- Conservation park
- General use
- Habitat protection
- Marine national park

Source Information

World Heritage Areas (Australia)
Australian Government Department of the Environment, Water, Heritage and the Arts 2009
Great Barrier Reef Marine Park
Great Barrier Reef Marine Park Authority 2009.
State Marine Parks (Quennsland)
Environmental Protection Agency 2009

AUSTRALIA PACIFIC LNG PROJECT

Volume 4 Chapter 12
Figure 12.5 Great Barrier Reef Marine Park Authority administrative boundaries and World Heritage Areas

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Gladstone Harbour

Gladstone Harbour extends from Ramsay Crossing in the north of The Narrows down to the northern tip of Tiber Point on Hummock Hill Island and around to Connor Bluff on Curtis Island, taking in the waters surrounding Facing Island as shown in Figure 12.1. GPC has jurisdiction over the Gladstone Harbour. The pilotage area includes all waters below the high water mark, including navigable waters of rivers and creeks. Auckland and Targinie channels are the existing navigable shipping channels in Gladstone Harbour that provide access into the Western Basin. Targinie channel, leading to the LNG facility, is shown in Figure 12.2 and currently has a maintained dredged depth of -10.6m below the lowest astronomical tide (LAT). Further dredging of Gladstone Harbour has been proposed as part of the Western Basin Master Plan and the Western Basin Dredging and Disposal Project. An EIS is currently being completed by GPC to gain approval for further dredging.

The North Passage and Targinie Channels are located within the Western Basin and provide marine access to and from the LNG facility. Consequently, potential impacts from LNG construction works and operations at Laird Point, upon these water bodies, need to be considered.

The Targinie channel as shown in Figure 12.2 is maintained to provide navigable access for 80,000 total deadweight (DWT) vessels to Fisherman's Landing. Capital dredging to widen this channel is planned in order to accommodate larger LNG ships. The channel presently merges with the Fisherman's Landing swing basin and berth area. From Targinie channel to The Narrows the naturally occurring depths are generally 8-10m or more below LAT and currents are strong through this section at 2 knots (Maritime Safety Queensland (MSQ) 2009a).

The North Passage channel refers to the shallower waterway between Curtis Island and the smaller (North and South) islands off-shore that are part of a long shoal running parallel and to the east of Targinie channel. The shoal can present a navigation hazard, even for small craft, and separates the North Passage from Targinie channel, the deeper channel that runs through the middle of the Western Basin. The existing depth of the North Passage channel is more or less 5m to LAT datum and is suitable for small craft sailing to and from The Narrows and Graham Creek

Environmental values

Gladstone falls within the Curtis Coast Regional Coastal Management Plan (EPA / QPWS 2003). Descriptions of physical coastal processes (Regional policy 2.2) and background in relation to water quality outcomes (Regional policy 2.4) are described below. The physical coastal processes include:

- Tides and currents
- Winds
- Waves
- Erosion prone areas
- Climate change
- Storm tide.

12.3.1 Tides

Tides in the Gladstone region are semi-diurnal with a diurnal inequality that becomes more pronounced as the tide enters the neap phase.

Tidal planes for locations within the Gladstone region are as given in Table 12.1 (MSQ 2009b).

Table 12-1 Tidal planes for Gladstone region

Location	Datum	HAT[1]	MHWS[1]	MHWN[1]	MSL[1]	MLWN[1]	MLWS[1]
South Trees Wharf	LAT[1] (m)	4.63	3.80	2.99	2.20	1.51	0.69
	AHD[1] (m)	2.42	1.59	0.78	-0.01	-0.7	-1.52
Gladstone (Auckland Point)	LAT (m)	4.83	3.96	3.11	2.34	1.57	0.72
	AHD (m)	2.56	1.69	0.84	0.07	-0.70	-1.55
Fisherman's Landing	LAT (m)	5.12	4.20	3.30	2.41	1.66	0.76
	AHD (m)	2.69	1.77	0.87	-0.02	-0.77	-1.67
The Narrows (Ramsay Crossing)	LAT (m)	6.17	5.08	4.01	3.01	2.07	1.00

[1] HAT- highest astronomical tide; LAT – lowest astronomical tide; MHWS - mean high water springs; MHWN - mean high water neaps; MSL - mean sea level; MLWN - mean low water neaps; MLWS - mean low water springs; AHD – Australian height datum

Tides undergo amplification as they move into Gladstone Harbour and into the Western Basin. From South Trees towards Fisherman's Landing there is a range amplification of approximately 11%, and at Ramsay Crossing the range amplifies by 31%.

The closest tidal monitoring site to the LNG facility site is located at Fisherman's Landing. Amplification of less than a few percent at peak spring tide compared to Fisherman's Landing, approximately three kilometres away is predicted at the Project site using the hydrodynamic model (refer to section 4.3 of Volume 5 Attachment 27). There is a predicted small but discernible difference (less than 10 minutes) in tidal phase difference between the LNG facility site and Fisherman's Landing. These findings are consistent with results from the Western Basin Dredging and Disposal Project EIS.

At times of MLWS tides at the LNG facility site, mud flats are exposed for a distance of 200-300m seawards from the mangrove line. During MHWS tides a high proportion of the existing coastal wetland behind the mangrove stands is inundated.

12.3.2 Currents

The hydrodynamic model (refer to section 4.3, Volume 5 Attachment 27) and the Western Basin Dredging and Disposal Project EIS hydrodynamic model results quantify currents at the LNG facility site.

In the Western Basin, within existing dredged channels, tidal currents are very strong on both the ebb and the flood tide cycles with velocities of 2-4 knots (1 to 2m/s) not uncommon for spring tides. The Narrows also exhibits strong tidal current velocities.

In the North Passage channel currents are not as strong as in the main channel leading to the Narrows. Currents in the deepest section of the existing North Passage channel during spring tides reach 0.5-0.6m/s. Tidal currents are substantially reduced over the shallower intertidal areas.

12.3.3 Marine water and sediment

Marine waters adjacent to the LNG facility site are described below in terms of salinity and water temperature, in addition to sediments and turbidity. More detail of the water quality associated with the LNG facility site is described in Volume 4 Chapter 10. Salinity and water temperature are particularly relevant to the potential impact assessment of the desalination plant brine discharge into the North Passage channel.

Salinity and water temperature

The estuary currents and level of natural turbulence result in a reasonably well-mixed water column in the deeper channels. Shallower waters over the tidal mud flats may experience less mixing and be subject to higher salinity and temperature values, due to increased solar radiation and evaporation in the summer months. Salinity within the estuary is also subject to variations due to freshwater inflows from creeks and rivers on a seasonal basis.

The variation in physicochemical water quality parameters within the receiving water body, at Calliope River from the Department of Environment and Resource Management (DERM) records are presented in Table 12.2.

Table 12-2 Physicochemical water quality parameters (DERM data 1996-2006)

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

[1]Derived from temperature and conductivity (conductivity at 25°C)

Marine water temperature and salinity varies throughout the year in the estuary as shown in Figure 12.6 and Figure 12.7 that was compiled from data monitoring results by DERM (1996–2006).

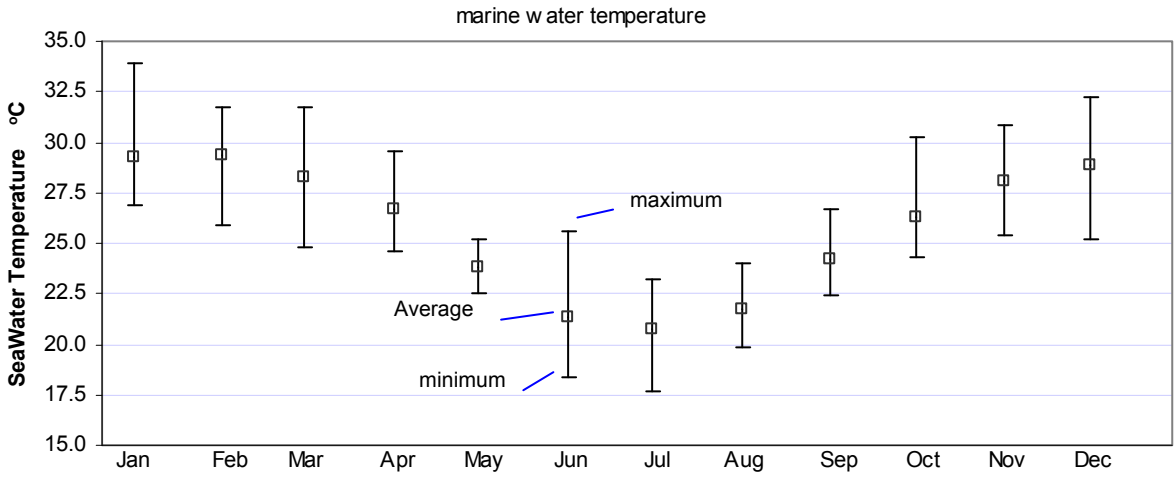


Figure 12.6 Seasonal variation of marine water temperature at Gladstone (Calliope River entrance), DERM 1996-2006

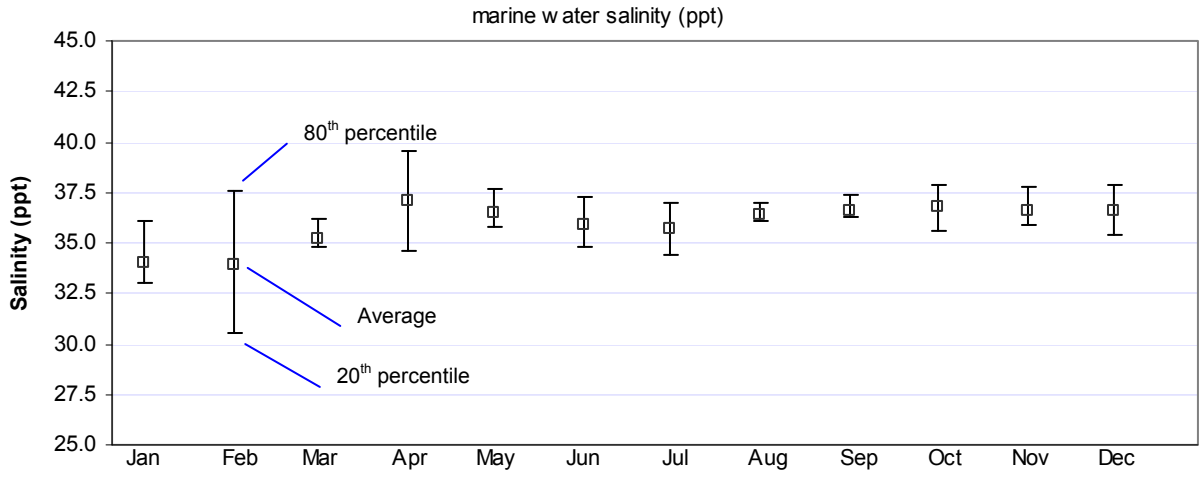


Figure 12.7 Seasonal variation of marine water salinity at Gladstone (Calliope River entrance), DERM 1996-2006

Sediments and turbidity

The deeper channels with stronger currents contain the coarser surficial sediments - mainly coarse sands and gravels, while the tidal flats were dominated by fine sands, silts and mud (Connell Hatch 2006).

Typical annual maintenance dredging quantities in Targinie channel are 15,000 to 20,000m^3.

At the LNG facility site, the material in the intertidal area behaves as a consolidated mud and remobilisation occurs only when higher waves combine with strong currents to exceed the critical bed shear stress.

Bore logs drilled to the north at The Narrows entrance indicate mud and silt material dominate near the surface. A sediment characterisation study was undertaken by WorleyParsons (2009) in direct relation to the proposed Australia Pacific LNG swing basin dredge location. Representative material from bore holes were analysed as part of this study and contained sediment particle size distribution characteristics very close to those across The Narrows entrance.

Sediments within the wetland regularly dry out during neap tides and consist of silts and mud that also contain organic material. After high tides inundate the wetland, or after rainfall events, the surface material becomes very soft and exhibits low bearing capacity. Figure 12.8 shows the type of sediments found throughout the wetland. The glossy appearance is typical of materials exhibiting higher plasticity.

Shoreward of the mangrove fringe, there is a low ridge of coarse sand, presumably deposited by run-off from the catchment and reworked and sorted by high tides and waves.

Once mobilised, silts and fine bed sediments within the vicinity of the proposed LNG plant are expected to have a net transport to the south-east towards the proposed swing basin and approach channel as a result of the slight dominance of the ebb tides.



Figure 12.8 Wetland sediments at the LNG facility site – high content of silts

Turbidity within the port reported by QGC (2009) exceeded Queensland water quality guidelines where a value of 6 nephelometric turbidity units (NTU) is indicated for enclosed coastal waters. Analysis of DERM (1996–2006) monitoring data at the entrance to Calliope Creek (station 132801) showed turbidity higher than this value during summer months at times after rainfall when stream run-off carries fine sediments to the estuary.

Figure 12.9 presents variation of turbidity throughout the year as measured at the Calliope Creek station.

At the LNG plant site, high natural turbidity is expected from run-off associated with Graham Creek and smaller tributaries where finer sediments accumulate around the thicker stands of mangrove and are washed out by overflowing water courses.

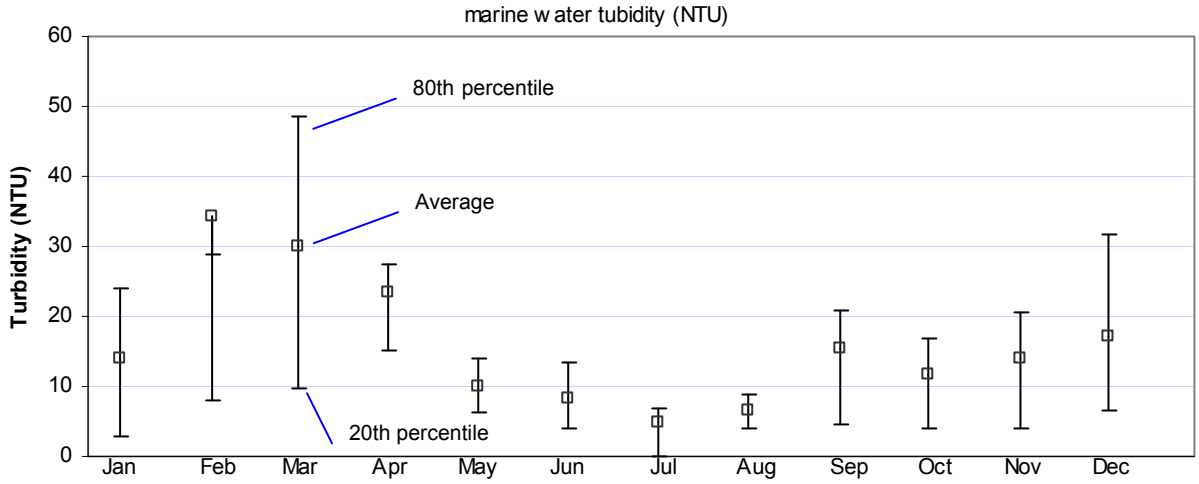


Figure 12.9 Seasonal variation of marine water turbidity at Gladstone (Calliope River entrance), DERM 1996-2006

12.3.4 Erosion prone areas

The shoreline either side of the proposed LNG plant site is lined with mangroves and vegetation or loose rock and cobbles in addition to exposed rock strata as in Figure 12.10. No sandy shorelines were observed during site inspections closer to the site, although Laird Point, where Graham Creek joins The Narrows, has a typical beach sand profile that is shaped by strong flowing tidal currents.

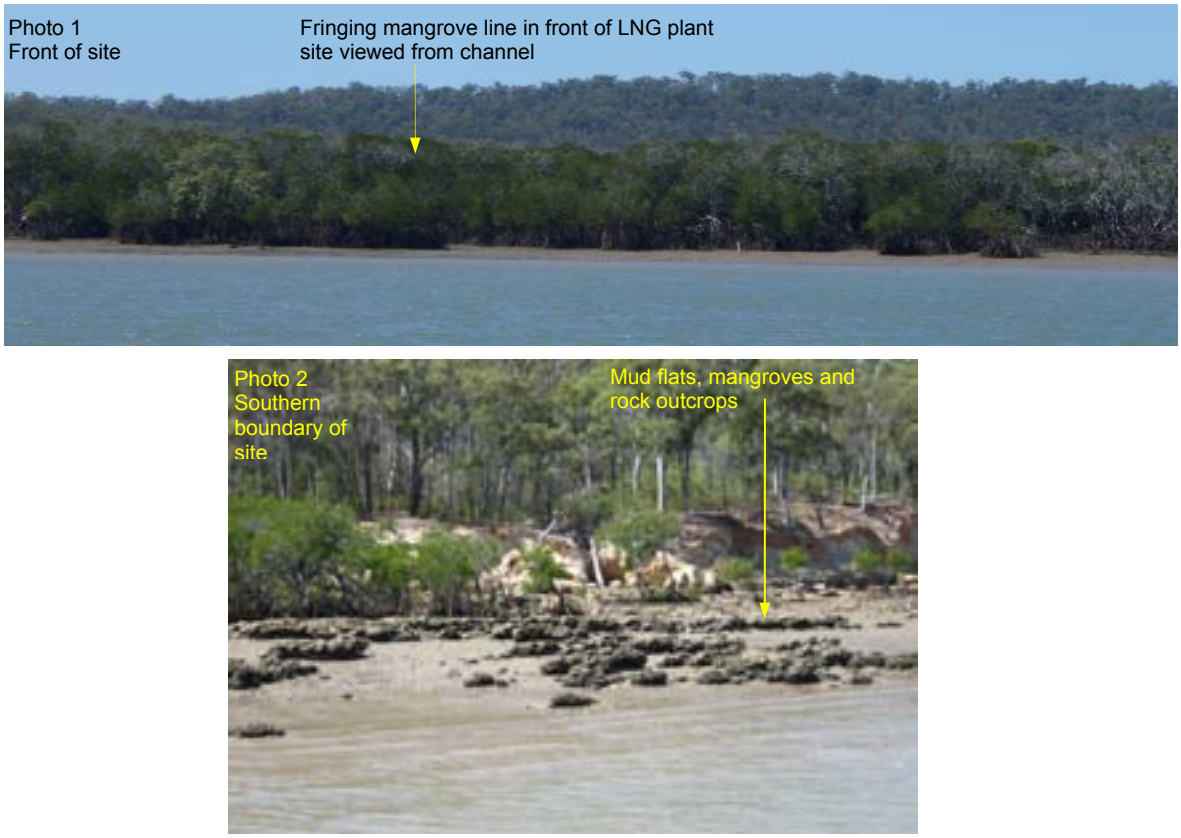


Figure 12.10 Shoreline types near the LNG facility site

12.3.5 Waves

Existing wave conditions in waters adjacent to the Australia Pacific LNG marine facilities are described in the Western Basin Dredging and Disposal Project EIS.

Gladstone Harbour is a sheltered estuary protected by large offshore islands facing the open sea and inside the southern Great Barrier Reef lagoon. Ocean swell arriving from the southeast is dissipated by the narrow channels, shoals, and islands inside the estuary before it can reach the Western Basin.

Local sea conditions can be active on occasions due to strong trade winds, extra-tropical low pressure systems, and cyclones. The longest wave fetches (the area in which waves are formed by a wind), inside Gladstone harbour, are aligned with the direction of the shipping channels but these are also of a limited distance for wave generation. The furthest fetch distances to the LNG facility are 6.5km from the south and 7.5km from the south-southeast. Water depths along these fetches vary due to shipping channels and sand shoals.

General wave conditions inside the Western Basin are calm to mild with significant wave heights typically less than 0.3m. Recent modelling of the day-to-day wave climate suggests for 80% of the year a significant wave height less than 0.3m (BMT WBM 2009a).

12.3.6 Flushing characteristics

Existing marine water quality is controlled largely by the flushing characteristics within Gladstone Harbour and this is described in the Western Basin Dredging and Disposal Project EIS and indicates good flushing characteristics are exhibited by the main channels of Gladstone Harbour.

Flushing time refers to the time required for water within a defined subregion to be exchanged with water from outside the subregion. The tidal flushing time was predicted following the e-folding time method (as described in Volume 5 Attachment 27) and is consistent with the Western Basin Dredging and Disposal Project EIS methodology that uses local e-folding times.

The Western Basin Dredging and Disposal Project EIS results, using a two month simulation, predict the advection and dispersion of the initial concentrations within the control area such that large concentration gradients result between Laird Point and Fisherman's Landing. The local e-folding times are in the order of about 37 days at Fisherman's Landing and approximately 42 days at the LNG facility site in the Western Basin Dredging and Disposal Project EIS.

12.3.7 Storm tide

Gladstone is within a region subject to tropical cyclone activity. A landmark study (Department of Natural Resources and Mines 2004) to determine the frequency of occurrence of storm tides for open waters in Queensland, including Gladstone, predicted elevated water levels for both present conditions and those where the implications of climate change are represented. The climate change scenarios are based upon a 50 year planning period that allows 0.3m for mean sea elevation. For open waters in Gladstone (Auckland Point) storm tide levels were predicted as in Table 12.3.

Table 12-3 Storm tide average recurrence interval for Gladstone

Average recurrence interval (ARI)	Storm tide level (m AHD)	Including climate change (m AHD)
100 year	2.82	3.33
500 year	3.51	4.18
1000 year	3.8	4.41

Simulations were undertaken to assess storm tide conditions at the LNG facility site from tropical cyclone wind fields (this approach does not constitute a comprehensive storm tide study at the site). East to west tracking tropical cyclone wind and pressure fields were generated and used to force the hydrodynamic model. This was based upon the parameterisation of a 30 year ARI design storm event selected from the analysis of tropical cyclones that have tracked within 250km of Gladstone. The time of the cyclone landfall was varied so the generated surge and tide (at the time of landfall) combined to produce a water level between the 100 year and 500 year ARI storm tide for Gladstone (refer to Table 12.3). Results for this event are summarised in Table 12.4 and the values in brackets indicate the percentage increase from the tide only case to the storm tide event.

The largest predicted hydrodynamic impact was associated with a tropical cyclone making landfall at Gladstone during spring flood tide conditions because tide and surge currents are combined. When a storm tide coincides with flood tide currents under present channel conditions, increases in current

speed of 20-30% could become apparent and, although of relatively short duration, there is a high likelihood morphological changes would occur to shoals and channel

Table 12-4 Predicted impact of a representative 30 year ARI tropical cyclone arriving during spring flood tide conditions resulting in 100 to 500 year ARI storm tide event

	Normal spring tide		Storm tide (cyclone landfall at time of flood tide)	
	High water level MSL (m)	Current speed (m/s)	Peak water level MSL (m)	Peak current speed (m/s)
Auckland Point	2.19	0.97	3.24 (+32.5%)	1.36 (+28.3%)
North Passage Island West	2.29	0.78	3.36 (+32.0%)	0.95 (+18.1%)
North Passage Island East	2.28	0.71	3.33 (+31.4%)	1.09 (+34.8%)

12.4 Proposed coastal development

Components of the LNG facility associated with potential impacts to the coastal environment are as follows:

- Jetties and product loading facilities
- MOF (excluding approach to MOF assessed by Western Basin Dredging and Disposal Project EIS
- Swing basin and approaches (assessed by Western Basin Dredging and Disposal Project)
- Reclamation and revetments
- Discharges from the LNG facility including seawater desalination plant brine, treated sewage wastewater and treated stormwater.

12.4.1 Jetty and ship berths

The jetty platform at each berth is proposed as a two-level structure consisting of a lower main deck and an elevated mezzanine deck. Loading arms would be supported by the lower deck, curbed to contain potential LNG spills and sloped to drain for LNG containment.

A trestle structure is proposed to connect to the shoreline and on-shore tanks.

A minimum water depth of -13m LAT is required at the berths in addition to any over-dredging depth, assumed as 0.3m. The Gladstone Port procedures (2009) stipulate that vessels alongside any berth must maintain a minimum of 0.5m under keel clearance.

The design allows for vessels ranging in size from a 125,000m^3 (285m overall length) to 217,000m^3 vessel (315m overall length).

12.4.2 Material offloading facility

The MOF is required to provide the following functions:

- Offload of modules for LNG trains

- Offload general construction materials from barges
- Support to load-out jetty construction.

The preliminary layout of the MOF is shown in Figure 12.11. A ramp will be the first element to be constructed, which will allow initial access to the island and simultaneous operations of the ramp with the construction of the wharf. One permanent dock capable of 2,500 tonne loads and crane access with roll-on/roll-off ramps to unload heavy equipment, modules and materials will be provided for all LNG trains.

Due to the soft sediments underlying the proposed MOF location, it is expected that dredging of this material would be required in order to prepare the site before construction commences. The quantity of dredged material to be removed is assumed to be approximately 100,000m^3. The volume will depend on the final configuration of the marine infrastructure, including the MOF, jetty and wharfs. Note that this does not include dredging required for the approach to the MOF which is described and assessed in the Western Basin Dredging and Disposal Project EIS (BMT WBM 2009b).

12.4.3 Swing basin and approaches

There are currently two location options being considered for the approach channel and swing basin layout described as follows and in reference to Figure 12.2:

- Option 1b has berths and swing basin at the western side of North Passage Island and this site is approached by vessels navigating Targinie channel
- Option 2a has berths and swing basin at the eastern side of North Passage Island and is approached by the proposed channel extension from the Santos and BG LNG sites. This is the preferred site for the Project's berths.

A minimum water depth of -13m LAT in the adjacent channels is required to accommodate the LNG/LPG vessels. It is noted vessel draft may be less than 12.2m, in practice, as the LNG may be less dense than found in other locations.

Design considerations have determined the swing basin diameter as 600m.

An approach channel to the MOF is also to be constructed and requires a finished dredge level of -8.5m LAT.

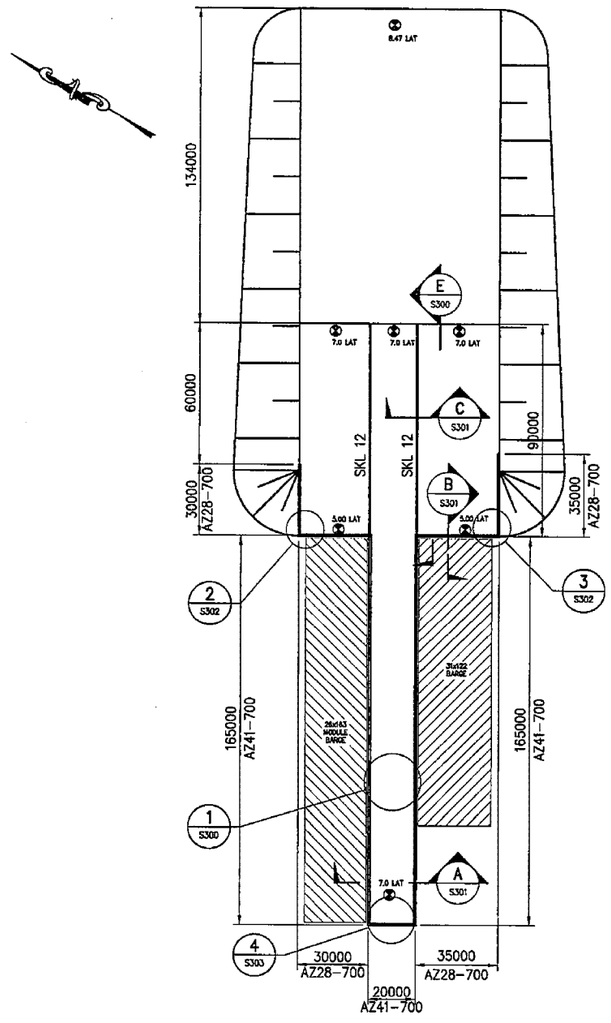
12.4.4 Reclaim area and revetments

The proposed LNG facility site is to be located within the reclaim area to be located on the intertidal mudflats to the south of Graham Creek. As a consequence of the low lying land within the site boundaries and the need to elevate the LNG plant to an appropriate level for engineering and environmental purposes, it is proposed to reclaim an area of approximately 39 hectares as shown in Figure 12.12.

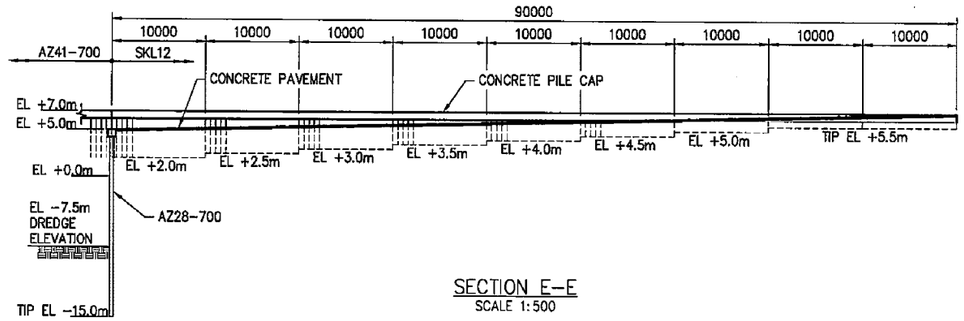
The reclamation area requires earthworks' fill material from higher ground within the LNG facility site boundaries in order to build the finished level to the design requirement of +6m above AHD. The volume of fill material required to achieve finished level is more than one million cubic metres.

Armour protection of the causeway and the MOF is proposed to prevent scour of the core material during high tides and breaking wave conditions, especially during storms.

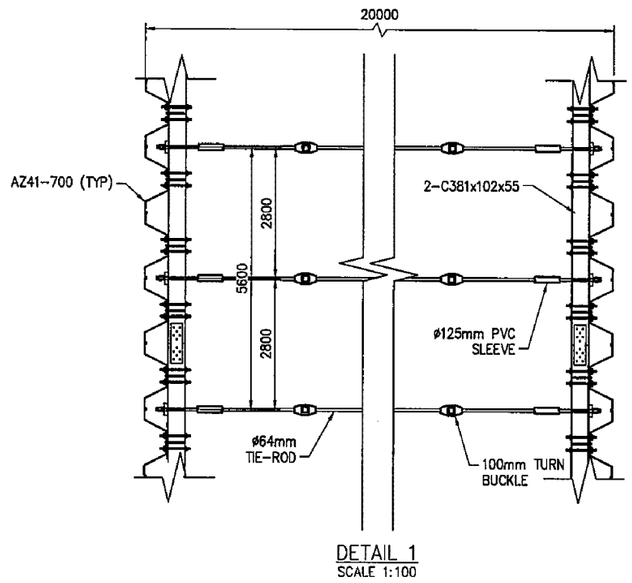
NOT FOR CONSTRUCTION



MOF PLAN
SCALE 1:2000



SECTION E-E
SCALE 1:500



DETAIL 1
SCALE 1:100

1000 0 5000 mm
1:100
10000 0 20000 mm
1:500
2000 0 10000 mm
1:2000

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DRAWN BY SB		DATE 12/22/09	
CHECKED BY SQ	AUSTRALIA PACIFIC LNG STUDY MARINE PRE-FEED OPTION 1B MOF DETAILS 1 OF 4	DRAWING NO. S300	
PROJECT ENGR RE			

Halcrow

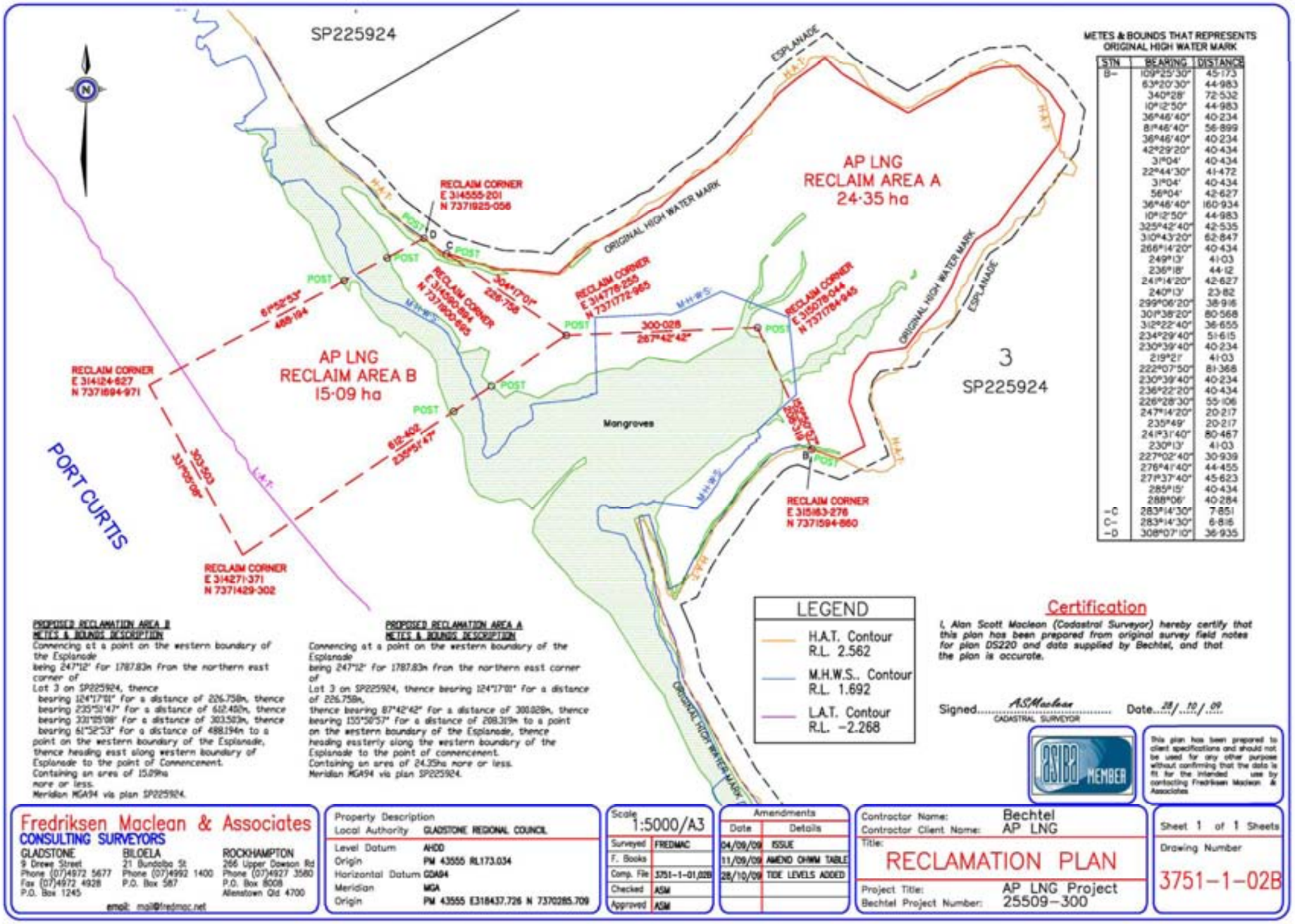
Source Information
Option 1B MOF Details
Figures supplied by client 12/01/2010

AUSTRALIA PACIFIC LNG PROJECT

Volume 4 Chapter 12
Figure 12.11 Plan view and profile seaward of proposed MOF

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METES & BOUNDS THAT REPRESENTS ORIGINAL HIGH WATER MARK

STN	BEARING	DISTANCE
B–	109°25'30"	45·173
	63°20'30"	44·983
	340°28'	72·532
	10°12'50"	44·983
	36°46'40"	40·234
	81°46'40"	56·899
	36°46'40"	40·234
	42°29'20"	40·434
	31°04'	40·434
	22°44'30"	41·472
	31°04'	40·434
	56°04'	42·627
	36°46'40"	160·934
	10°12'50"	44·983
	325°42'40"	42·535
	310°43'20"	62·847
	266°14'20"	40·434
	249°13'	41·03
	236°18'	44·12
	241°14'20"	42·627
	240°13'	23·82
	299°06'20"	38·916
	301°38'20"	80·568
	312°22'40"	36·655
	234°29'40"	51·615
	230°39'40"	40·234
	219°21'	41·03
	222°07'50"	81·368
	230°39'40"	40·234
	236°22'20"	40·434
	226°28'30"	55·106
	247°14'20"	20·217
	235°49'	20·217
	241°31'40"	80·467
	230°13'	41·03
	227°02'40"	30·939
	276°41'40"	44·455
	271°37'40"	45·623
	285°15'	40·434
	288°06'	40·284
–C	283°14'30"	7·851
C–	283°14'30"	6·815
–D	308°07'10"	36·935

PROPOSED RECLAMATION AREA B
METES & BOUNDS DESCRIPTION

Commencing at a point on the western boundary of the Esplanade being 247°12' for 1787.83m from the northern east corner of Lot 3 on SP225924, thence bearing 124°17'01" for a distance of 226.758m, thence bearing 235°51'47" for a distance of 612.402m, thence bearing 331°05'08" for a distance of 303.503m, thence bearing 61°52'53" for a distance of 488.194m to a point on the western boundary of the Esplanade, thence heading east along western boundary of Esplanade to the point of Commencement.
Containing an area of 15.09ha more or less.
Meridian MGA94 via plan SP225924.

PROPOSED RECLAMATION AREA A
METES & BOUNDS DESCRIPTION

Commencing at a point on the western boundary of the Esplanade being 247°12' for 1787.83m from the northern east corner of Lot 3 on SP225924, thence bearing 124°17'01" for a distance of 226.758m, thence bearing 87°42'42" for a distance of 300.028m, thence bearing 155°58'57" for a distance of 208.319m to a point on the western boundary of the Esplanade, thence heading easterly along the western boundary of the Esplanade to the point of commencement.
Containing an area of 24.35ha more or less.
Meridian MGA94 via plan SP225924.

LEGEND

- H.A.T. Contour R.L. 2.562
- M.H.W.S.. Contour R.L. 1.692
- L.A.T. Contour R.L. –2.268

Certification

I, Alan Scott Maclean (Cadastral Surveyor) hereby certify that this plan has been prepared from original survey field notes for plan DS220 and data supplied by Bechtel, and that the plan is accurate.

Signed..... A.S.Maclean ..... Date..28/.10/.09
CADASTRAL SURVEYOR

This plan has been prepared to client specifications and should not be used for any other purpose without confirming that the data is fit for the intended use by contacting Fredriksen Maclean & Associates

Fredriksen Maclean & Associates
CONSULTING SURVEYORS
GLADSTONE: 9 Drewe Street, Phone (07)4972 5677, Fax (07)4972 4928, P.O. Box 1245
BILOELA: 21 Bundalba St, Phone (07)4992 1400, P.O. Box 587
ROCKHAMPTON: 266 Upper Dawson Rd, Phone (07)4927 3580, P.O. Box 6008, Allenstown Qld 4700
email: mail@fredmac.net

Property Description	
Local Authority	GLADSTONE REGIONAL COUNCIL
Level Datum	AHDD
Origin	PM 43555 RL173.034
Horizontal Datum	GDA94
Meridian	MGA
Origin	PM 43555 E318437.726 N 7370285.709

Scale 1:5000/A3	
Surveyed	FREDMAC
F. Books	
Comp. File	3751-1-01.02B
Checked	ASM
Approved	ASM

Amendments	
Date	Details
04/09/09	ISSUE
11/09/09	AMEND CHWM TABLE
28/10/09	TIDE LEVELS ADDED

Contractor Name:	Bechtel
Contractor Client Name:	AP LNG
Title:	RECLAMATION PLAN
Project Title:	AP LNG Project
Bechtel Project Number:	25509–300

Sheet 1 of 1 Sheets
Drawing Number
3751–1–02B

Source Information
Reclamation Plan
Figure supplied by client 20/11/2009

AUSTRALIA PACIFIC LNG PROJECT

Volume 4 Chapter 12
Figure 12.12 Reclamation boundaries for the proposed LNG plant

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12.4.5 Seawater desalination

Freshwater for construction and operation of the LNG facility will be supplied from collected stormwater and desalinated seawater. Water demand for the LNG facility's service water system is mainly attributed to a potable water source during construction and operations, in addition to demineralised water required for amine make-up in the acid gas removal unit during plant operation. Service water will be provided through the operation of a seawater desalination unit to supply fresh water.

Potable water demand during construction varies from 1-35m^3/hr based upon peak workforce loading of 2,500 during 40 months and a water demand of 0.284m^3/person/day.

Water requirement during construction is similar for operating conditions with two-trains and has been estimated to be about 840m^3/day. With the expansion of the facility to four-trains water demand would increase to approximately 65m^3/h or 1500m^3/day (Bechtel 2009).

In converting the seawater intake stream to fresh water for process and potable water requirements, a waste stream is developed. The desalination brine reject is the residue from the desalination plant that is to be returned to the marine environment off-shore from the proposed LNG facility. The brine reject discharges are a function of the desalination unit efficiency and a freshwater recovery rate of approximately 40% is expected. Brine reject average flow rates are based upon a desalination recovery rate of 40% and for two and four-trains, the brine reject returned to the marine environment is 1,200 and 2,400m^3/day, respectively. This quantity will vary depending upon the efficiency of the recovery process that has been indicated between 35-40%.

Indicative brine reject characteristics are presented in Table 12.5.

Table 12-5 Indicative brine reject characteristics

Wastewater stream	Estimated characteristics	Units
pH	6 - 8	
Total dissolved solids	50,000 - 60,000	mg/L
Calcium	600-750	mg/L
Magnesium	2,000-2,500	mg/L
Potassium	600-800	mg/L
Sodium	19,000 -22,000	mg/L
Chloride	30,000-33,000	mg/L
Fluoride	1.5 -3	mg/L
Sulphate	4,000 -6,000	mg/L
Strontium	15-25	mg/L
Total suspended solids, average	<15	mg/L
Total suspended solids, maximum	40	mg/L
Silicone dioxide	1-2	mg/L
5 day biochemical oxygen demand	5 - 10	mg/L

Note: Based upon first pass desalination reject for two-train LNG facility

It has been assumed the brine reject temperature (after processing) will be comparable to the temperature of the ambient marine waters as these are the source for the desalination plant intake. The salinity of the brine reject is dependent upon the freshwater recovery rate and a slightly more saline waste stream is produced with an increased recovery rate. Consequently, the salinity of the brine reject has been based upon the salinity of the ambient marine waters and recovery rates that vary between 35-40%, resulting in a range of salinity from 53.1-67.5ppt.

The proposed location for the desalination system intake is the product loading facility via a passive intake screen attached to a jetty pier. This is over 600m from the discharge option in front of the MOF. The intake is well clear of the brine release initial mixing zone and under normal tide conditions the brine should be sufficiently mixed over the water column depth such that concentrations would be close to background levels. Consequently, recirculation of elevated brine concentrations back into the desalination intake would be avoided.

Intake rates required for the desalination system are low when compared to total flows in the North Passage channel and have no influence on the hydrodynamics. The impact of the intake on the marine ecology is assessed in Volume 4 Chapter 10.

12.4.6 Treated wastewater discharges

Wastewater streams from various processes and facilities will be treated on site to bring it in line with acceptable standards for irrigation or re-use. Using treated wastewater for on-site irrigation, to the extent possible, would reduce the quantity of discharge to marine waters.

It is estimated a maximum rate of 550m^3/day of construction waste sewage flow would be generated. Operation of a waste treatment plant on site was determined to be a more cost effective option than transporting the waste stream back to the mainland by truck for disposal.

Treated sewage effluent will be stored in a tank for dechlorination purposes prior to being used for irrigation purposes or discharged to Port Curtis. If it is discharged it is likely that treated sewage effluent will be discharged with the desalination plant brine (refer to below).

Use will be made of existing proven treatment technologies that are cost effective and prevent adverse water quality or other environmental impacts. Liquid waste limits for operational discharges would be developed from guidelines to ensure compliance with water quality objectives for fresh and marine water quality in Gladstone as outlined in Volume 4 Chapter 10.

12.5 Potential impacts

Assessment considered the potential impacts to coastal processes resulting from proposed dredging and reclamation in the Western Basin in order to then assess the additional potential impacts from proposed coastal components described in section 12.4. The impact assessment of the channels and swing basins is described in Western Basin Dredging and Disposal Project EIS and is not repeated here. However, information relevant to the establishment of the hydrodynamic model that includes the Western Basin developments is described below. This was used as a base from which assessments were made of potential impacts associated with the jetties, MOF, reclamation and revetments, and desalination brine discharge.

The Project's Option 1b and Option 2a model bathymetries were based upon the existing Western Basin bathymetry with modifications to represent the proposed works including:

- Dredged LNG shipping approach channels (-13.5 LAT)

- Dredged LNG berth and turning circle areas (-13.5 LAT)
- Material offloading facility (MOF) structure
- Dredged approach area to the MOF (-8.5 LAT).

Additional works proposed by GPC were also represented in the Project's Option 1b and Option 2a models including:

- Dredged LNG shipping channels (-13.5 LAT)
- Dredged LNG berths and turning circles (-13.5 LAT)
- Maintenance dredging for shipping channels, berths and turning circles
- Maintenance dredging for the MOF approach
- The Fisherman's Landing Northern Expansion reclamation.

The areas of the existing hydrodynamic model bathymetry modified to create Option 1b and Option 2a models are shown in Figure 12.13. The same modifications were also applied to the existing Western Basin bathymetry used in the wave model (refer to section 12.5.2).

12.5.1 Tides and currents

Potential changes to tidal water levels and currents from specific dredging and reclamation scenarios were assessed in the Western Basin Dredging and Disposal Project EIS and are not repeated in full here. The main conclusions from the EIS additional numerical model results (BMT WBM 2009b) that included changes due to Option 1b and 2a dredging are as follows:

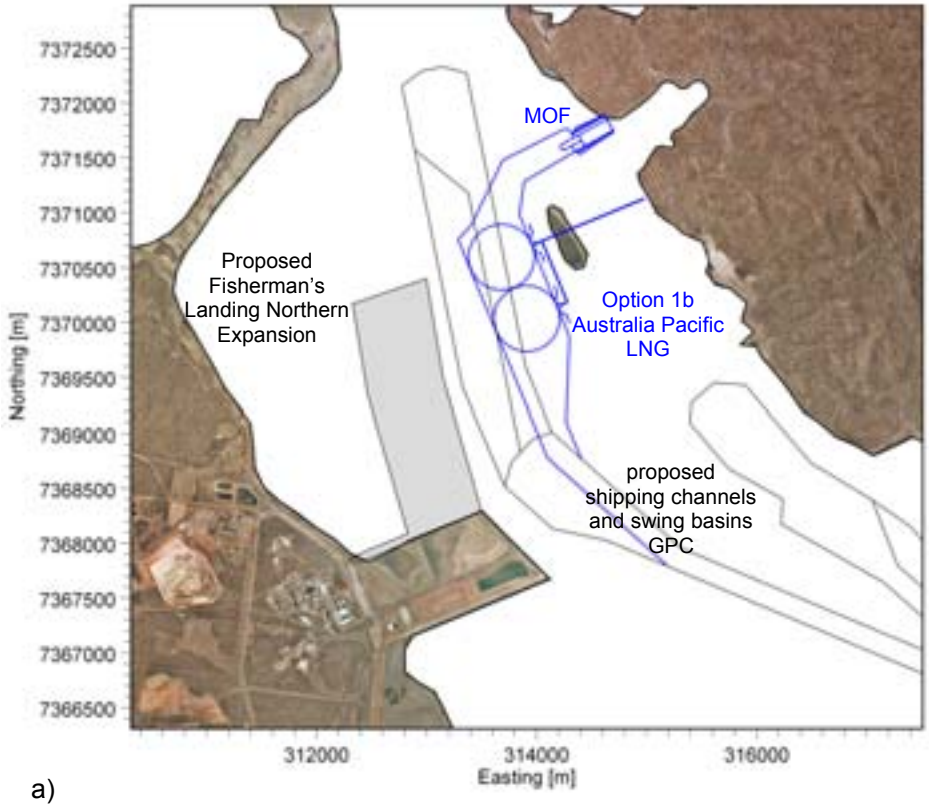
- The dredging and reclamation works will have negligible impact (1cm or less) on high tide levels throughout the area
- Water levels associated with the inclusion of Options 2a and 1b dredging are essentially the same as previous simulations of the fully developed dredging and reclamation options for the Western Basin
- In general, current velocities tend to decrease in dredged areas where the depths are greater following dredging and higher velocities are predicted upstream and downstream of the newly dredged areas where the higher flows enter and exit across the existing bathymetry.

For Option 1b:

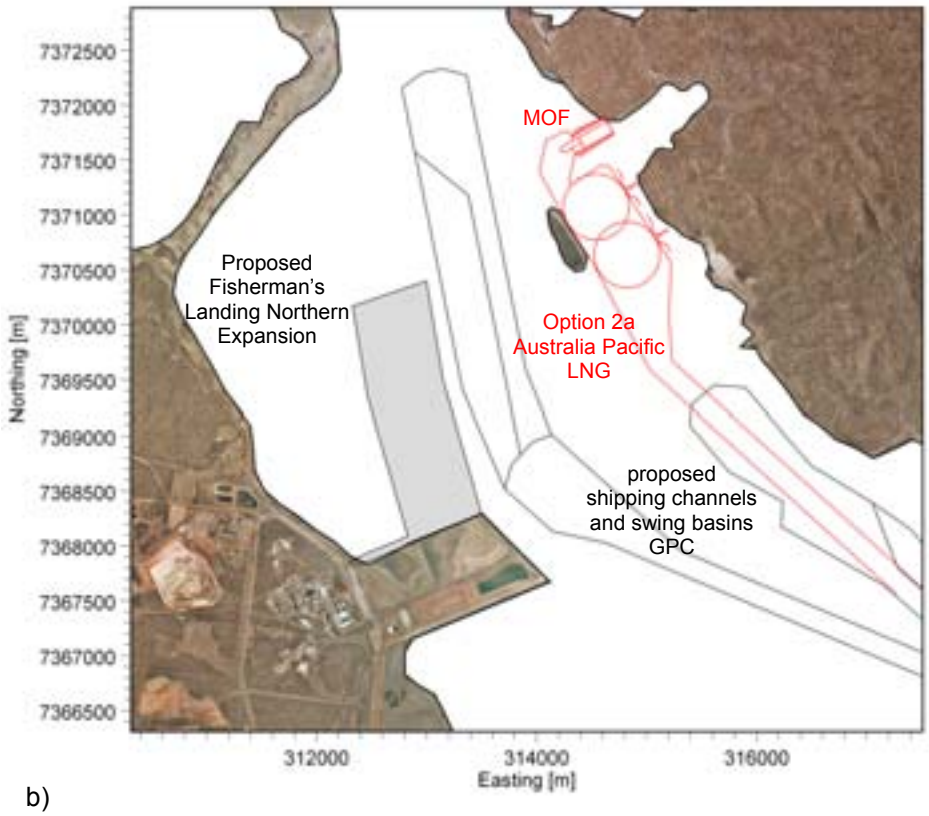
- In the MOF approach channel, velocities generally decrease although a slight increase is predicted where currents exit from the swing basin. Increases in velocity of up to 0.5m/s (ebb) are predicted on the shoals adjacent to the MOF channel upstream of North Passage Island.

For Option 2a:

- In APLNG Option 2a dredged area, velocities are predicted to decrease up to 0.4m/s (flood tide) and 0.5m/s (ebb tide). Current velocity in the MOF approach channel generally decreases
- Substantial increases in velocity (0.35m/s flood and 0.7m/s ebb) occur on the shoals upstream of North Passage Island as a result of increased flows there.



a)



b)

Figure 12.13 Changes to existing Western Basin bathymetry for hydrodynamic impact assessment; a) Option 1b, and b) Option 2a

12.5.2 Waves

Potential impacts to the wave conditions for the Western Basin were generally addressed in Western Basin Dredging and Disposal Project EIS. The following discusses potential impacts to wave conditions resulting from dredging Options 1b and 2a, and is consistent with the methodology used in Western Basin Dredging and Disposal Project EIS.

Potential impact to wave conditions at the proposed Australia Pacific LNG site were assessed by comparing predicted wave conditions using the existing Western Basin bathymetry with those incorporating modifications from reclamations and dredging, including Project Options 1b and 2a.

Model simulations used a 10-minute average wind speed of 36m/s, representing a 50 year ARI cyclonic wind speed for the Gladstone region (Australian/New Zealand Standard 1170.2:2002, Part 2: Wind actions)

Key findings from the wave modelling were:

- The reduced fetch from the westerly direction, resulting from proposed construction of the Fisherman's Landing expansion and reclamation, results in lower wave heights at a location north of North Passage Island. Wave heights for Option 1b are therefore smaller from westerly directions
- For Option 2a, simulations show increases in the significant wave height for the selected wind directions. The greatest modification to wave heights comes from the south easterly wind sector
- Option 2a is predicted to produce a greater incremental change on wave heights than Option 1b. In the proposed swing basin area (location 06 in the Western Basin Dredging and Disposal Project EIS) extreme waves from the south-south easterly direction are approximately 19% higher after dredging works.
- Incremental change to significant wave heights over the sand shoals to the north and south of North Passage Island are negligible due to Option 1b and 2a dredging works. Potential impacts to these sand shoals during extreme wave conditions are more likely to result from deepening Targinie channel.

The proposed GPC shipping channels and the Project's Option 2a berth/turning circle areas align with the south-easterly winds, providing deeper water for waves to propagate.

Figure 12.14 shows the predicted significant wave height contour map for the 50 year ARI wind speed from the south-south easterly direction for the existing and Option 2a case for comparison. Note in Figure 12.14b larger waves penetrating through the proposed Option 2a berth/turning circle area.

The local wave climate predictions in the Western Basin Dredging and Disposal Project EIS (refer to location 06) indicates the majority of waves reaching the undeveloped Western Basin (the base case) are from the south-south easterly direction. Option 2a dredging would have negligible impact on wave directions, but would allow more wave energy from the south-southeast to penetrate into this area due to increased depth. This potentially has an impact on shorelines around the proposed swing basin (refer to Section 12.5.7).

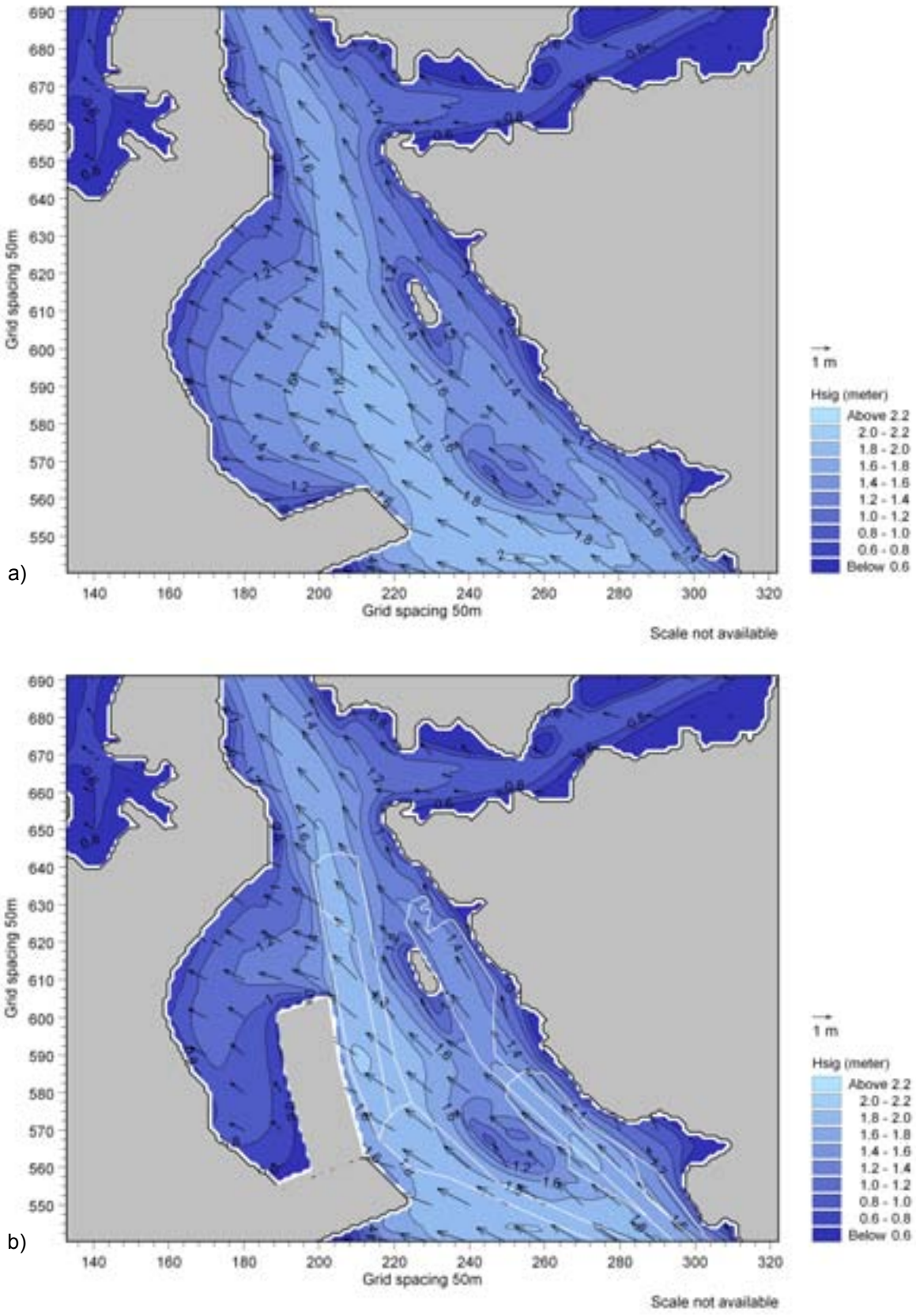


Figure 12.14 Predicted significant wave height contour and vector map 50 year ARI wind speed from the south-south easterly direction: a) existing case, b) Option 2a

12.5.3 Flushing characteristics

The overall flushing characteristic of the estuary is an important mechanism for maintaining water quality. The potential impact to the rate of natural flushing of the estuary is important to the assessment of turbid plumes and waste stream discharges. The potential impacts on flushing characteristics of the estuary were generally addressed in Western Basin Dredging and Disposal Project EIS. The following discusses the potential impacts to flushing characteristics resulting from dredging Options 1b or 2a, and is consistent with the methodology used in Western Basin Dredging and Disposal Project EIS.

The effect of the dredging Options 1b or 2a on the local flushing times within the study area was modelled using the methodology in Section 4.3.3, Volume Attachment 27.

Model bathymetry used in tidal flushing simulations incorporated dredging Option 1b or 2a in addition to the dredged channels and Fisherman's Landing Northern Reclamation. Capital dredging works associated with the Australia Pacific LNG Options 1b or 2a are predicted to marginally increase local flushing times as follows:

- Approximately three days for Option 1b, at a location within the swing basin to the east of North Passage Island
- Approximately five days within the swing basin area for Option 2a.

Model results are consistent with the Western Basin Dredging and Disposal Project EIS since current velocities will generally decrease in the areas that are dredged deeper. Without the inclusion of Option 1b or 2a, the Western Basin Dredging and Disposal Project EIS model results, based on the 'scenario 3' configuration, predict increases in local flushing times up to four days compared to the base case of no dredging or reclamations. The e-folding times increase towards Graham Creek and The Narrows.

Local flushing times in Graham Creek and The Narrows are naturally poor and are not significantly affected by dredging works in the Western Basin including the Australia Pacific LNG dredge Options.

The impacts to marine ecology associated with modified flushing times and potential water quality impacts are discussed Volume 4 Chapter 10.

12.5.4 Natural hazards and climate change

Natural hazards potentially affecting the coastal zone and the frequency of occurrence are addressed in the following sections and include the topics of:

- Storm surge and storm tide (severe weather induced extreme water levels)
- Tsunami
- Climate change (coastal impacts).

Storm tide

Storm tide water levels at the LNG facility's site were simulated using the hydrodynamic model with modified Western Basin bathymetry, including Australia Pacific LNG Options 1b and 2a. Other model parameters for the design storm were as described in section 12.3.7.

The peak water levels and current speeds in Table 12.6 are associated with an intense tropical cyclone arriving during spring flood tide conditions. Wave set-up, run-up and overtopping are not included in the analysis. The values in brackets in Table 12.6 indicate the percentage difference between the normal tide conditions and the storm tide conditions.

Table 12-6 Predicted storm tide impact for arrival on spring flood tide

	Normal spring tide		Storm tide (cyclone landfall at time of flood tide)	
	High water level MSL (m)	Current speed (m/s)	Peak water level MSL at berth (m)	Peak current speed at berth (m/s)
Auckland Point	2.19	0.97	3.24 (+32.5%)	1.36 (+28.3%)
Option 1b berth	2.30	0.66	3.42 (+32.8%)	0.83 (+20.0%)
Option 2a berth	2.29	0.33	3.40 (+32.4%)	0.49 (+31.7%)

The results in Table 12.6 indicate the Western Basin and the Australia Pacific LNG dredging works result in lower current speeds in the deeper channels and dredged areas, while storm tide water levels are not significantly modified compared to existing conditions. Compared to the undeveloped Western Basin scenario, the currents in the berth locations for Option 1b are reduced by 0.12m/s and for Option 2a, peak currents decrease by 0.6m/s.

Climate change

Warming of the atmosphere and the oceans is driving a range of other changes, some of which are not yet well understood, in the climate system and to coastal processes (Australian Government 2009). Under climate change, both mean conditions and extremes will change over a range of time scales. The Intergovernmental Panel on Climate Change (IPCC) is the authorative source on projections of sea-level rise. Conclusions about future sea-level rise in the IPCC's Third Assessment Report (TAR) (IPCC 2001) and Fourth Assessment Report (AR4) (IPCC 2007) were broadly similar. To assess the LNG facility's vulnerability to climate change, predictions have been gathered from the CSIRO, and the Queensland Government. CSIRO projections are available for years 2030, 2050 and 2070.

The CSIRO mid-level sea level rise projection of 0.47m by 2070 has been chosen as the basis for the impact assessment, representing a conservative estimate for the Project lifespan to 2050. This is one of the higher AR4 projections for estimated global sea-level rise (0.79m by 2100). Figure 12.15 shows sea-level rise projections to 2100 from the TAR and AR4 analysis.

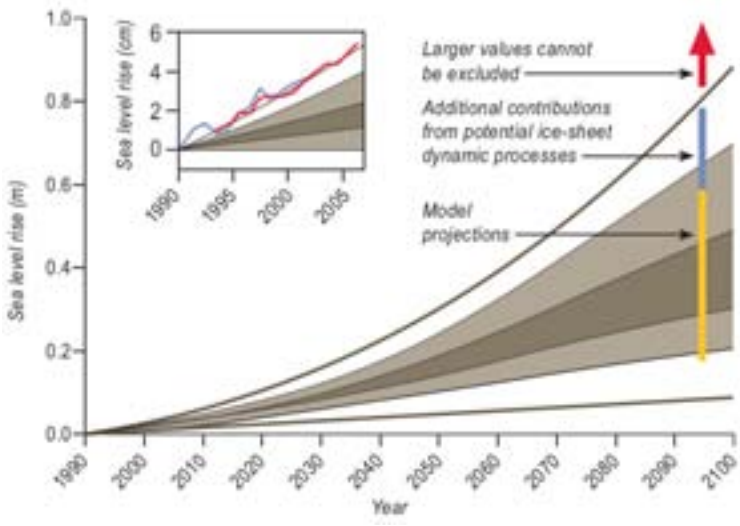


Figure 12.15 Projections of sea-level rise

The potential impact from seal level rise to the coastline at the LNG facility site would be low as design consideration has been given to elevating the reclaimed land level. Finished land level includes allowance for sea level rise adjustment based upon model projections (refer Volume 4, Chapter4).

Tsunami

The potential for impact by tsunami is considered to be very low considering the 30 year design life of the LNG facility and the top of reclamation level being proposed, approximately 6m AHD, is a sufficient height above HAT level of 2.7 metres.

Mitigative action would depend to a large extent upon sufficient warning to enable port procedures to be complied with, similar to cyclone warnings, requiring vessels to clear the pilotage area once given notice via broadcast on VHF channels 13 and 16. Port procedures stipulate that the Harbour Master may close the port, wholly or in part, or restrict the movement of vessels in the pilotage area, commensurate with the threat to the safety of shipping or the environment.

Tsunami warnings are issued by the Joint Australian Tsunami Warning Centre (JATWC) operated in Canberra by the Bureau of Meteorology (BOM) and GeoScience Australia. The major aim of the JATWC is to provide emergency managers with a minimum of 90 minutes warning of a likely tsunami impact to Australia. BOM uses its network of sea-level monitoring equipment including coastal sea-level gauges and DART™ buoys (deep-ocean tsunami detection buoys) and tsunami computer models to confirm the existence of a tsunami and estimate its likely intensity.

12.5.5 Marine structures

Marine structures proposed as part of the LNG infrastructure include the MOF and jetties as described within section 12.4.

For both Option 1b and 2a the MOF structure is proposed to be located at the northern end of the site and would extend across the intertidal area. In Option 2a the product loading facility jetty is just to the south of the existing wetland site and extends across intertidal area to the proposed swing basin and berth. Duplication of the first jetty would occur further to the south for the third and fourth trains.

In Option 1b the product loading facility jetty is much longer and extends from the LNG plant to the western side of North Passage Island, a distance of approximately one kilometre. Duplication would be confined to loading platform and dolphins for the four-train development. A trestle would be required to provide access from one loading platform to the other. In Option 1b the loading platforms are adjacent to the Targinie channel.

Potential impacts associated with the MOF and product loading facility jetty has been assessed as follows:

- Removal of intertidal area and mangroves. The intertidal area of approximately 15ha where the MOF facility is proposed would require removal of 260m of shoreline including mangroves
- Dredging of the MOF base to provide relatively firm strata for construction purposes and disposal of material
- Plumes associated with placement of rock armour protection and leaching of fine sediments
- Highly visible marine structures protruding into the coastal zone (see also Volume 4 Chapter 7)
- Restriction of recreational craft in North Passage channel
- Decommissioning of the MOF and jetties at the end of their operational life.

Option 1b requires a greater length of the trestle and associated product loading assets would require more over water structural assembly and treatments, and greater maintenance effort during the operational life.

The current design of the MOF structure protrudes almost normal to the shoreline and approximately 500m offshore, while the product loading facility jetty in Option 2a is proposed to end approximately 160m from the shoreline and would be a piled structure with frames about every 25m. Structures required in both options are expected to have a low potential for impact to coastal processes because sand transport activity is very low. In either option the piled product loading facility jetty would have minimal impact to current and wave conditions. There is a potential for finer sediments to be deposited at the MOF site because it is proposed as a solid structure and would create quiescent zones where material may accumulate.

Dredged material from the MOF would be transported to a GPC approved disposal site as part of the dredging works and would not be considered to have a significant impact.

Plumes associated with rock armour protection and building of the causeway will be limited because of the volume involved and would be insignificant compared to dredging works for example. Consequently, plumes from the causeway and MOF rock armour construction are considered as a minimal impact.

The potential visual amenity impact of both options is considered significant, but must be examined in context with the declared industry precinct and would also be subject to the viewing aspect. North Passage Island provides good screening for the site and for Option 2a structures. From the mainland side the island and the load out platform of Option 1b would be more prominent. Greater detail on visual amenity is provided in Volume 4 Chapter 7.

New signage or markers would be required to redirect recreational traffic around the product loading facility jetty and MOF in keeping with the exclusion zones and security requirements. Modifications to recreational craft navigation routes would be undertaken in liaison with GPC.

Where required, decommissioning of jetties at the end of their operational life would require dismantling and removal of assets above deck level to leave the structure essentially in skeleton form and to remain as marine habitat. Deconstruction of marine based structures, unless they themselves contain substances or treatments that can breakdown and present harmful impacts to the environment, would increase the overall potential for environmental harm. The decommissioning plan will consider any requirements for sediment sampling analysis and removal. Berths and approaches could be allowed to naturally in-fill over time.

12.5.6 Reclaim area

The reclaim area proposed for the site is described in section 12.4.4.

Construction of the reclaim area has the potential to generate some turbidity, but would be naturally mitigated to a large extent by the intertidal nature of the site. The proposed causeway would follow the seaward boundary of the reclamation, located behind the mangrove fringe. Once the causeway is constructed, the penetration of the tide into the mangrove creek would finish there. Furthermore, the mangrove fringe in front of the causeway would act to trap fine sediments and provide a natural silt barrier for low turbidity concentrations associated with the construction process. Sediment run-off can also be managed through engineered silt screens.

Water quality associated with the surface water and ground water seepage will be managed through geotextile fabric or similar to mitigate the potential impact to mangroves.

12.5.7 Swing basins and approaches

The assessment of dredging impacts to the swing basins and approach channels were part of the Western Basin Dredging and Disposal EIS. This section addresses the potential impact to local coastal processes.

Hydrodynamic modelling has shown there is a potential for increased sediment movement across the North Passage Island shoals (BMT WBM 2009b) and the swing basin layout and design is important with regard to the potential for erosion of North Passage Island and the intertidal zone in front of the LNG facility. LNG carriers that call to the port on a regular basis, and turn around in 24 hours, manoeuvre within the swing basin and potentially generate wave-wash during berthing. The swing basin is dredged to -13m LAT with batters designed to obtain sufficient vessel clearance. Australia Pacific LNG will continue to assess the swing basin design to mitigate the impact of wave action, whether generated by vessels or by local winds that has a potential to erode and collapse the tops of the batter slopes when combined with lower water levels. The depth of the swing basin allows low energy wave action to propagate, without dissipation, to the shoreline.

The rate at which erosion could occur would depend upon the occurrence of wave action in the swing basin and approaches in addition to the shoreline characteristics of North Passage Island and the inter-tidal area that are identified in Figure 12.16. Potential erosion will be identified and managed through monitoring of the shorelines surrounding the swing basin and be conducted on a regular basis to provide data on any morphological movements and to trigger mitigation, if necessary. Mitigation may include:

- Rock or mat protection to stabilise the shoreline and dissipate wave energy
- Measures to stabilise the North Passage Island shoreline, if required
- Reshaping of the upper batter slopes to induce wave breaking before the shoreline berm is reached.



Figure 12.16 North Passage Island and proposed swing basin aerial perspective

Potential for morphological changes to the shoals upstream and downstream of North Passage Island would also be monitored by hydrographic survey (as one option) on an annual basis for several years to determine if changes are occurring and to implement a management plan if the changes are significant.

12.5.8 Dredge plumes

Assessment of the dredge plumes resulting from the formation of the swing basins and navigation channels was addressed as part of Western Basin Dredging and Disposal Project EIS. It was noted the dredge plumes resulting from Australia Pacific LNG's Option 1b or 2a requirements would not result in potential impacts being any greater than those occurring for the other developments. This is based upon the assumptions made in the modelling scenarios about dredging equipment and its production rates (BMT WBM 2009b, Section 4.2).

Dredged material for MOF construction would be removed using a backhoe dredge to provide a construction base for the MOF. It is assumed that multiple barges, each with a capacity of 400m^3, would be used to dispose of the material to a nearby land reclamation. Turbid plumes associated with the dredging have been assessed using a hydrodynamic model (MIKE21 FM) coupled with a mud-transport capability.

The quantity of dredged material for MOF construction will be determined as the design progresses. For the purpose of the EIS, it was assumed that dredging of the MOF area would take 60 days and the model used a 10% spill rate from the backhoe bucket to generate the plumes. The fate of plumes is primarily a function of currents and settling velocity associated with the sediment types encountered. Sensitivity analysis of the upper and lower limits of material settling velocity was investigated to determine the effect to plume behaviour. Plume concentrations presented from model results are values above the natural background turbidity. The model details are provided in Volume 5 Attachment 27.

Figure 12.17 presents a spatial summary of the mean total suspended solids (TSS) concentration predicted to occur during the 60 day dredge program for lower sediment settling velocity range. MOF dredging is predicted to raise the TSS concentration within Gladstone Harbour and The Narrows, including Graham Creek.

Within Graham Creek and surrounding North Passage Island the mean TSS is predicted to elevate by more than 0.014kg/m^3 (14mg/L). North of the Graham Creek entrance, the predicted increase to the mean TSS within The Narrows is between 0.002kg/m^3 and 0.013kg/m^3 (2mg/L and 13mg/L). The plume is predicted to disperse beyond Fisherman's Landing to Auckland Point to be less than 0.005kg/m^3 (5mg/L). This is within the natural TSS variation in Gladstone Harbour (BMT WBM 2009a) and hence it is anticipated that there would be no long term impacts associated with elevated TSS during dredging operations.

Maximum TSS concentrations of up to 0.06kg/m^3 (60mg/L) are predicted to occur at the entrance to Graham Creek with TSS concentrations up to 0.04kg/m^3 (40mg/L) extending into the creek. Within The Narrows, maximum TSS concentrations above 0.015kg/m^3 (15mg/L) are predicted with higher concentrations (up to 0.03kg/m^3 or 30mg/L) occurring along the Curtis Island shoreline. In comparison, dredge plume modelling results in the Western Basin Dredging and Disposal Project EIS for scenario two (multiple plume sources including Trailer Suction Hopper Dredge overflow) predict maximum TSS concentrations of 28mg/L in Graham Creek adjacent to Laird Point and 53mg/L opposite Friend Point. The differences are dependent on the source locations of the dredge plumes.

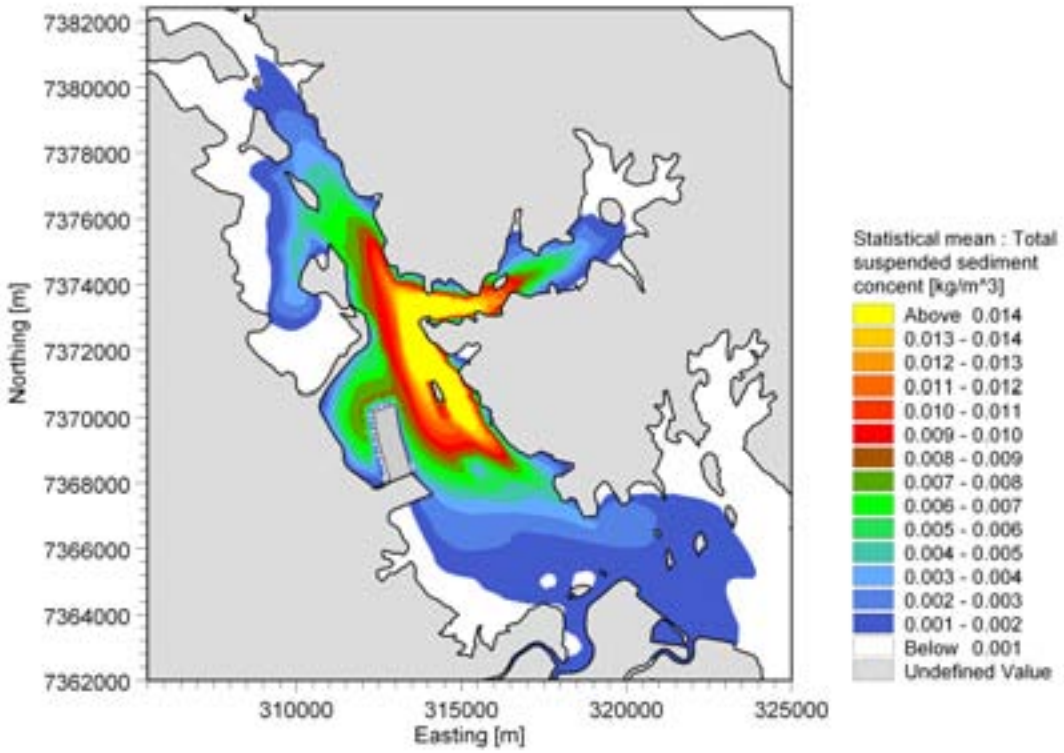


Figure 12.17 Statistical mean TSS concentration increase during the 60 day MOF dredging program

12.5.9 Desalination brine discharge

Seawater desalination will supply fresh water during both the construction and operational phases of the Project. Highest discharge flow-rates occur during the operational phase and the following assessment is based on these to provide a conservative approach.

Considering a fresh water recovery rate of approximately 40%, desalination brine (the waste by-product of the desalination system) would be discharged at an average flow-rate of 2,400m^3/day. In the near-field assessment the average flow for two-trains, and the maximum flow for four-trains was used to simulate the variation in discharge. An outfall and diffuser would be used to disperse the concentrated brine into the waters of North Passage channel.

The near-field assessment focuses on the dilution achieved with the diffuser design and the changes in the brine concentration before reaching the far-field. The far-field is used to assess the potential for accumulation of brine concentration within the marine environment as it advects with the tide.

Near-field assessment

Initial dilutions associated with the diffuser design were examined in the near-field assessment. Natural seawater characteristics at the entrance of the Calliope River (from DERM data, 1996-2006) that are considered to be representative of the waters in the Western Basin vary as shown in Table 12.7.

Table 12-7 Ambient marine water properties

	Minimum	20th percentile	Median	80th percentile	Maximum
Temperature (°C)	17.7	22.5	26.2	29.2	33.9
Conductivity (mS/cm)	29.9	52.7	55	56.6	60.5
Salinity[1] (ppt)	18.5	34.7	36.5	37.6	40.6

[1]Derived from temperature and conductivity (conductivity @ 25ºC).

Favourable conditions for discharge of desalination brine require the following characteristics:

- Sufficient depth for mixing to occur and an adequate distance from the shoreline
- Free flowing current conditions that would disperse the brine
- Available access for maintenance purposes
- Free from vessel contact and within the LNG facility marine lease area.

The brine reject is a negatively buoyant plume that, upon discharge from the diffuser, would sink to the bottom unless full mixing can be achieved with the ambient waters.

Spring and neap tide velocities were extracted from the hydrodynamic model (used for the far-field assessment) at the MOF location corresponding to the outfall diffuser position. These were analysed statistically, as shown in Table 12.8, to determine representative peak and slack tide current conditions. This could then be used in the near-field assessment to predict dilutions of the brine reject after discharge from the outfall diffuser.

Table 12-8 Ambient current statistics at MOF outfall site (dredged)

Statistic	Current speed (m/s)
5th percentile	0.04
10th percentile	0.07
20th percentile	0.13
50th percentile	0.26
80th percentile	0.39
90th percentile	0.51
95th percentile	0.64

The model predictions reflect the proposed conditions at the MOF after dredging works and swing basins have been completed. Slack tide current was simulated using the 5th percentile current speed.

Near field simulations were undertaken using the industry accepted CORMIX model to assess the initial mixing potential of the site options for the brine reject outfall.

Assumptions used in the near-field modelling were as follows

- The diffuser has been assumed to be perpendicular to the flood and ebb tidal current directions and is at least 1m below the LAT datum. Initial mixing relies upon the negatively buoyant plume to sink after discharge, while entrainment by tidal currents disperses the brine

- Minimum dredged levels at the MOF are -8.5m LAT. Simulations were conservatively based on shallower depths that represent existing conditions outside the MOF approach channel
- Six diffuser ports were used with a diameter of 50mm and spaced 2m apart over the diffuser length of 10m and oriented horizontally with the ambient current flow
- Spring and neap tide velocities as per Table 12.8 represented ambient conditions. Current velocity less than the 5th percentile value were used for slack water
- Scenarios undertaken for the modelling are presented in Table 12.9 and were assigned to average and maximum discharges of 16L/s and 36L/s, corresponding to average conditions for two-trains and maximum conditions for four-trains, respectively.

Table 12-9 CORMIX model scenarios

	Ambient			Brine reject characteristics				
Case	Salinity (ppt)	Temp (°C)	Density ρ (kg/m^3)	Salinity (ppt)	Temp T (°C)	Density ρ (kg/m^3)	Δρ (kg/m^3)	Excess discharge (mg/L)
1	34.5	22.5	1,023.7	53.1	23	1,037.7	14.0	18,600
2	36.5	26.2	1,024.1	56.2	26.7	1,038.9	14.8	19,700
3	37.5	29.2	1,023.9	57.7	29.7	1,039.0	15.1	20,200
4	40.5	33.9	1,024.5	62.3	34.4	1,040.7	16.2	21,800
5	34.5	22.5	1,023.7	57.5	23	1,041.1	17.4	23,000
6	36.5	26.2	1,024.1	60.8	26.7	1,042.4	18.3	24,300
7	37.5	29.2	1,023.9	62.5	29.7	1,042.6	18.7	25,000
8	40.5	33.9	1,024.5	67.5	34.4	1,044.6	20.1	27,000

In Table 12.9 the excess discharge is the brine content above normal seawater and will depend on the efficiency of the desalination process (35%-40%). The eight cases vary with ambient seawater salinity and temperature (refer to Section 12.3.3). It was assumed the brine reject temperature would be half a degree Celsius warmer by the time discharge through the outfall occurs, but note temperature difference has far less influence than the density difference between normal seawater and the concentrated brine.

Near-field results

The CORMIX results predict the brine discharge receives approximately 80:1 dilution within 5m of the diffuser and a dilution of 187:1 when the brine reaches the seabed (bottom impact) for the average discharge case (16L/s) associated with two-trains. Conditions of low water and slack tide are considered the worse case scenario for mixing of the brine discharge.

For the maximum brine discharge (36L/s) associated with four-trains at low water and slack tide, the CORMIX results predict a dilution of approximately 25:1 within 5m of the diffuser and a bottom impact dilution of 57:1.

Figure 12.18 contains the predicted dilution results from CORMIX for 16L/s and 36L/s discharges at low water slack tide conditions (cases one and eight), and corresponds to the lower and upper range of brine salinity, respectively.

The brine plume becomes vertically fully mixed in the near field and this carries on into the far field indicating that there is negligible likelihood of denser brine layers forming in the deeper swing basin.

CORMIX simulations for mid (0.3m/s) current speed, predict dilutions of 170:1 at 5m from the diffuser, and for peak (0.6m/s) current speed, predict dilutions of 380:1 at 5m from the diffuser. Bottom impact dilution for mid current speed is over 1100:1 and over 2500:1 for peak current speed.

In the near-field, it is concluded that there will be no discernible impact from the discharge of the brine reject to the water quality in the vicinity of the diffuser as dilutions are adequate at low water slack tide and there is full mixing over depth. Increasing tidal currents promote further near-field dilution. Potential impacts from other constituents in the brine discharge are assessed under marine ecology in Volume 4 Chapter 10.

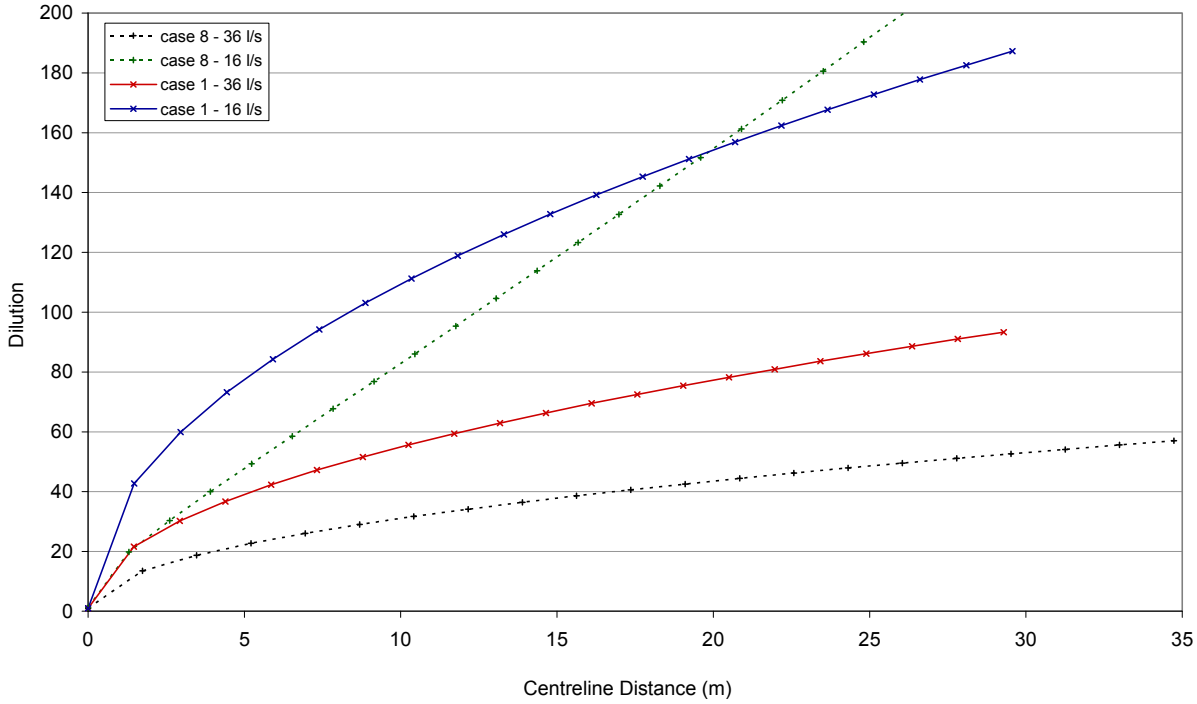


Figure 12.18 Near-field dilution with plume centreline distance from diffuser - worst case scenarios

Far-field analysis

Following the initial dilution from the diffuser, the brine is advected and dispersed by the tidal currents. Far-field modelling was used to determine if accumulation of the brine occurs within the adjoining waterways.

At the outfall discharge location a conservative tracer (representing the desalination brine) was entered into the model domain at a constant average rate corresponding to 2400m^3/day. The average discharge was simulated for a six month period. For all simulations the background salinity was assumed to be 36ppt and salinity increases less than 0.01ppt were not considered.

Modelling predictions indicate little difference in the mean increase in salinity as a result of including Option 1b and Option 2a. Laird Point and the entrance to Graham Creek are areas where salinity is predicted to accumulate with a marginal increase of approximately 0.05ppt.

Maximum salinity increases for both options were predicted as 0.08ppt close to Laird Point. Within The Narrows and Graham Creek, the maximum salinity predicted is 36.06ppt and 36.07ppt, respectively. Maximum increases in salinity of 0.11ppt occur for Option 1b on the east side of North Passage Island. Figure 12.19 shows the maximum salinity resulting from the six-month model simulation. Maximum salinity increases, for either Option, do not exceed 0.11ppt which is within ambient seawater variation. The potential impact from accumulation of salinity resulting from the LNG facility discharge is negligible.

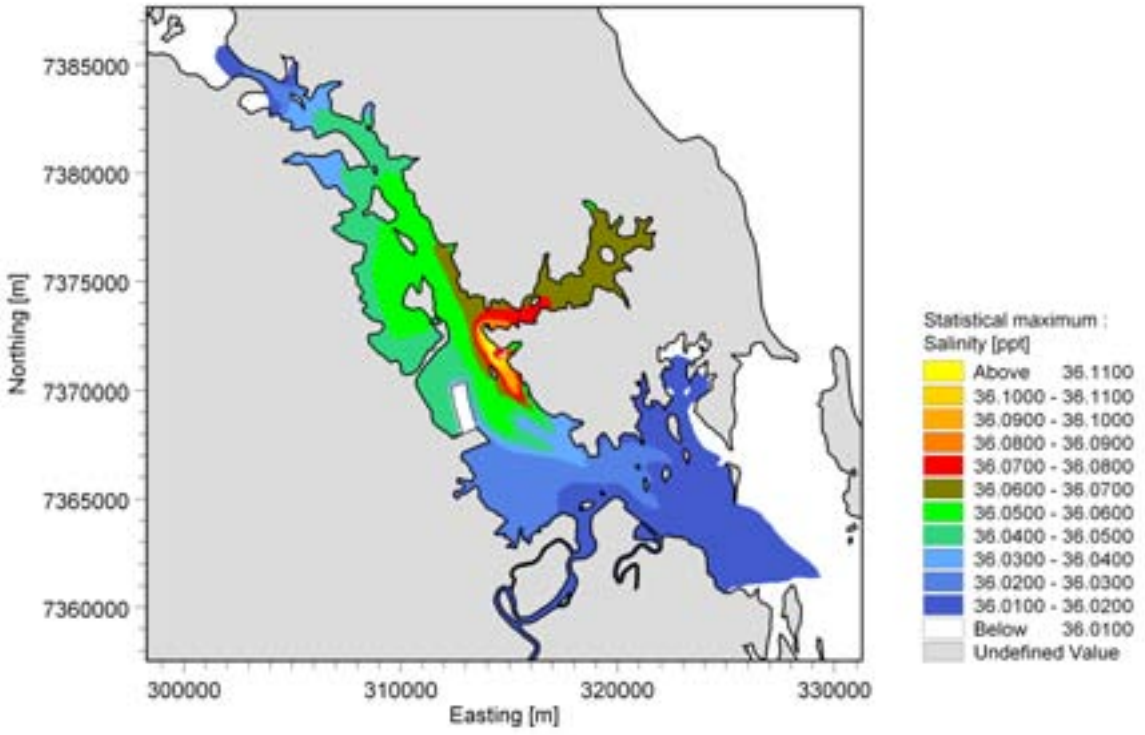


Figure 12.19 Option 1b – Desalination brine predicted statistical maximum salinity

Cumulative water quality impacts associated with the combined Australia Pacific LNG project, Queensland Curtis LNG (QCLNG) project, and Gladstone LNG (GLNG) project desalination brine discharges were also assessed.

Desalination brine discharge locations for the three LNG proponents are presented in Figure 12.20.

At each discharge location a conservative tracer (the desalination brine) was entered to the model domain at a constant rate corresponding to approximately:

- 2400m^3/day (27.8L/s) for Australia Pacific LNG
- 1440 m^3/day (16.7L/s) for QCLNG
- 1300 m^3/day (15.0L/s) for GLNG.

The location and discharge rate for GLNG and QCLNG reflect smaller LNG plant capacities and were obtained from BMT WBM (2009c) and BMT WBM (2009d), respectively. The combined desalination brine discharges were simulated for a six month period.

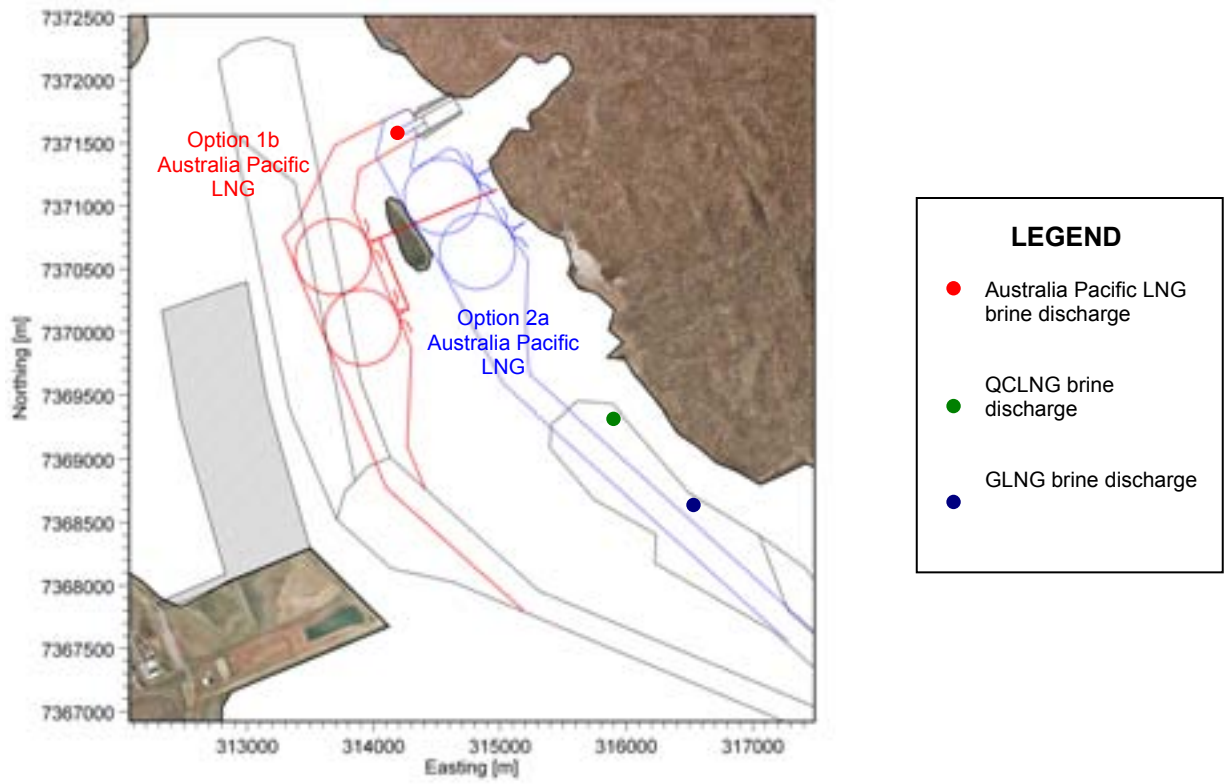


Figure 12.20 Desalination brine discharge locations for cumulative water quality impact assessment

The predicted cumulative mean salinity increase at the entrance to Graham Creek and along the Curtis Island shoreline from Laird Point to China Bay for Option 1b is approximately 0.06ppt and for Option 2a is approximately 0.05ppt.

For both Options 2a and 1b the maximum salinity close to Laird Point is predicted to exceed 36.11ppt and within The Narrows and Graham Creek the maximum salinity ranges between 36.06ppt and 36.09ppt. Figure 12.21shows the extent of the maximum salinity concentrations resulting from the cumulative brine discharges.

The predicted mean and maximum increases in salinity due to the cumulative discharges of desalination brine are well within the natural ambient salinity variations and would not be detrimental to the marine environment. Salinity tolerances for a range of marine fauna are summarised in Volume 4 Chapter 10.

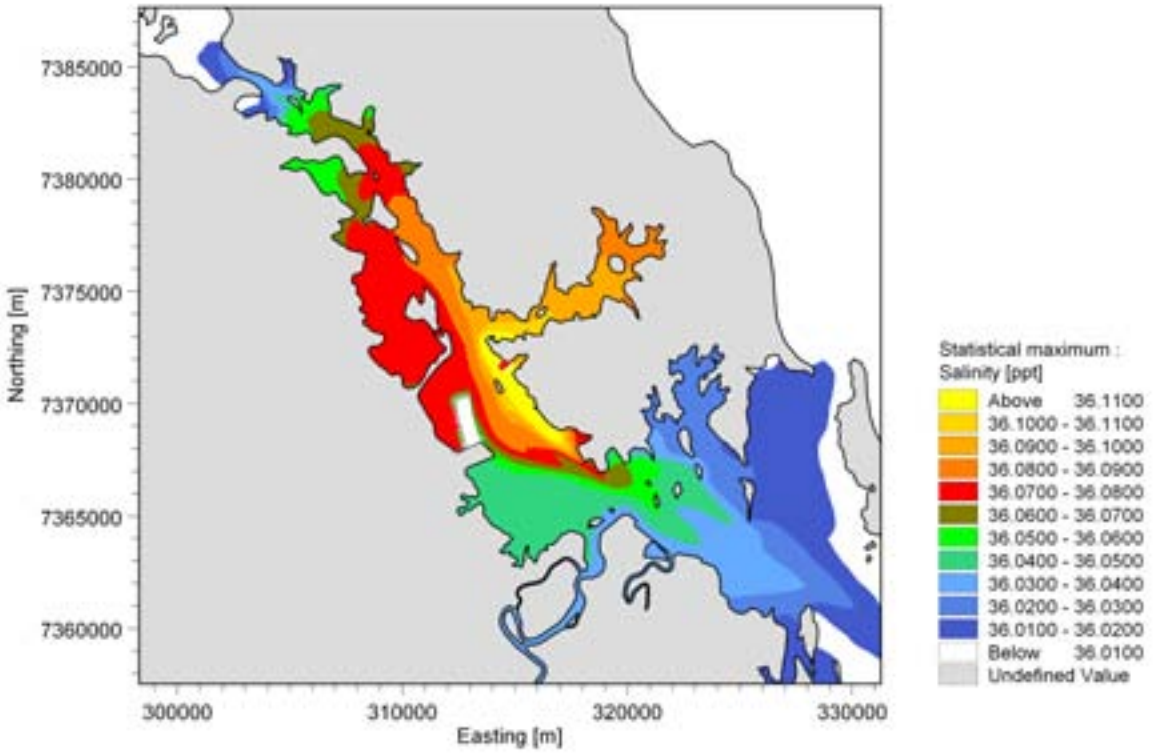


Figure 12.21 Option 1b – Cumulative desalination brine predicted statistical maximum salinity resulting from Australia Pacific LNG, GLNG, and QCLNG discharges

12.5.10 Siltation and maintenance of dredge areas

An indicative estimate of the annual siltation of the Australia Pacific LNG dredged areas and the average annual dredge maintenance requirements were modelled within the Gladstone Ports Corporation Western Basin EIS. Potential predicted impacts (BMT WBM 2009b) relevant to the Australia Pacific LNG marine options are summarised in this section. It is noted that the estimation of net sand transport potential and net siltation for Option 1b was based on the dredged area which is incremental to the dredging required for the channel that will service the proposed extension of the Fisherman's Landing area. Should this extension not otherwise proceed the dredged area for this option that is attributable to the ship access and berthing requirements of the Project, would be proportionally much larger. Hence, net sand transport potential and net siltation attributable to the Option 1b berthing arrangement would also be greater.

The Gladstone Ports Corporation Western Basin EIS (Section 3.3) assesses the in-filling of the swing basin and approaches, including the MOF approach, by segregating sand size particles and silts. It is predicted that the net sand transport potential in the Option 1b dredged area decreases due to the reduction in velocities. Annual sand transport into Option 1b swing basin and approaches ranges between 5,500 to 22,000m^3/year, and has a net siltation of 48,000m^3/year. Silt deposition rate for Option 1b is shown in Figure 12.22.

For Option 2a the predicted coarse material sedimentation is between 12,000m^3/year and 48,000m^3/year that includes sand from small zones of increased sand transport potential on the shoals between the MOF approach channel and the Laird Point swing basin upstream of North Passage Island due to the increased velocities in this area. The net silt deposition for Option 2a is 81,000m^3/year and is shown in Figure 12.23.

Maintenance quantities are a function of the sediment rates and the extent of the dredged area. The Western Basin Dredging and Disposal Project EIS concluded sedimentation rates of up to 0.08m/year were predicted to occur for Option 2a and within the approaches to the MOF for Option 1b. For siltation alone, a 0.3m over-dredging allowance should accommodate over three years of sedimentation between maintenance dredging campaigns. Additional over dredge depth allowance would need to be made for the coarse sized sediments or alternatively more regular maintenance dredging.

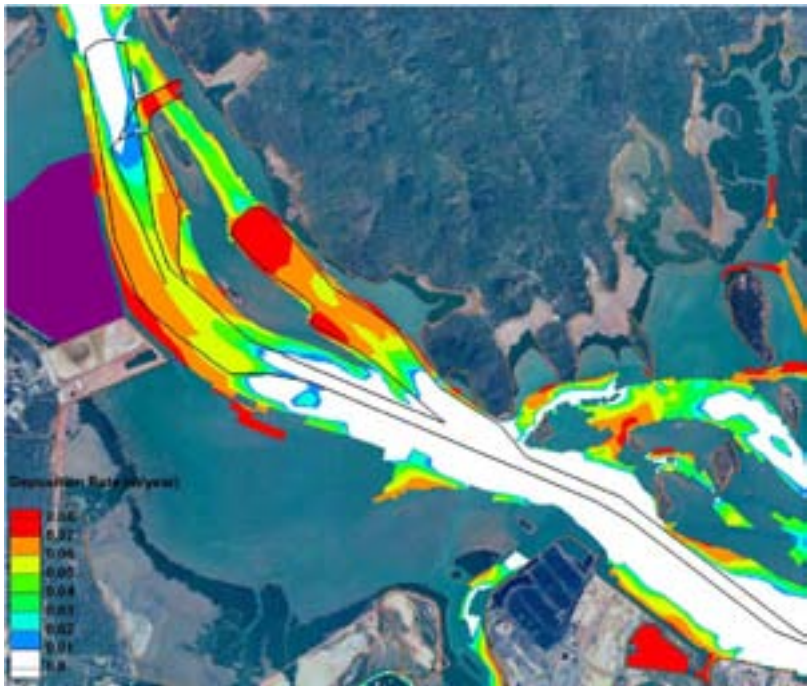


Figure 12.22 Option 1b silt deposition rates (BMT WBM 2009b)

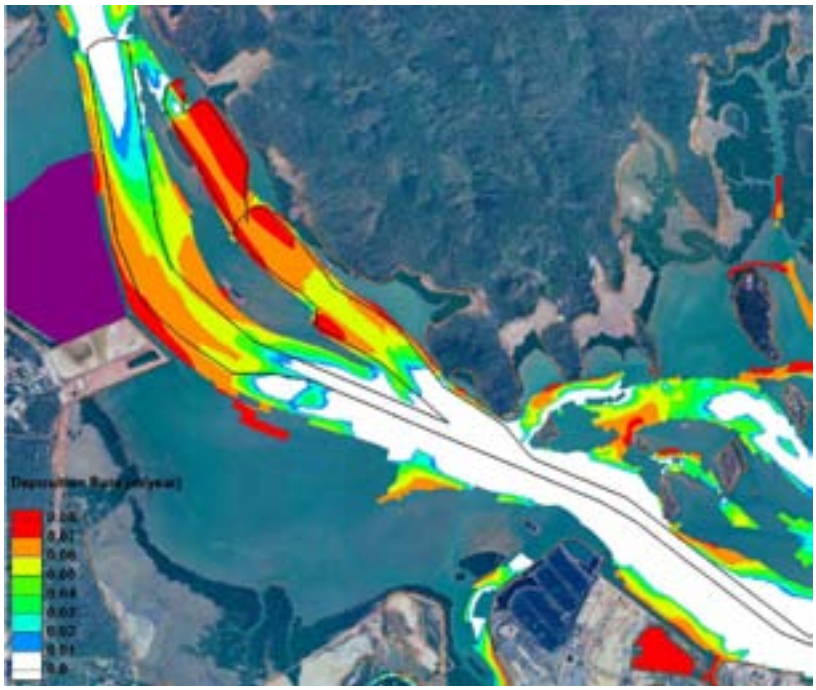


Figure 12.23 Option 2a silt deposition rates (BMT WBM 2009b)

12.6 Mitigation and management

The sustainability objectives for the environmental values identified within the coastal areas and the potential impacts to those values, in addition to the mitigation action proposed, is summarised in Table 12.10.

In addition, Table 12.10 includes the residual risk levels for coastal environment. A risk assessment has been undertaken to identify potential risks, causes and consequences from project components in the coastal zone. Mitigation measures to reduce the risk have been nominated and the residual risk has been calculated. Further details on the risk assessment methodology are provided in Volume 1 Chapter 4.

Table 12-10 Summary of environmental values, sustainability principles, potential impacts and mitigation measures

Environmental Values	Sustainability principles	Potential impact	Possible causes	Mitigation and management measures	Residual risk level
Sediment sink and source Dissipative barrier to erosive forces Recreational amenity Shore and sediment stabilisation Habitat for native plants Coastal landscapes	Minimising adverse environmental impacts and enhancing environmental benefits associated with Australia Pacific LNG's activities, products or services; conserving, protecting, and enhancing where the opportunity exists, the biodiversity values and water resources in its operational areas Identifying, assessing, managing, monitoring and reviewing risks to Australia Pacific LNG's workforce, its property, the environment and the communities affected by its activities	Receding shorelines Potential inundation Erosion of inter-tidal areas, and shoals Collapse or erosion of swing basin batter slopes Review of causeway armour protection and reclamation levels	Increased current velocities Sea level rise Storm tides Wind waves and vessel wash	Include allowance for sea level rise in design of reclamations and rock protection Monitor coastal processes and potential changes in morphology of shoals and inter-tidal areas.	Low
		Declining water quality and affect on marine ecology	Desalination brine discharge - hyper saline marine water, higher alkalinity, and inclusion of metals	Adequate diffuser design and favourable location for outfall discharge Minimise desalination quantities through recycling, conservation and alternate sources	Low
		Temporary water quality decline and affect on marine ecology	Turbidity plumes associated with dredging and construction of causeway revetments	Incorporate silt curtains where practical and match appropriate dredging plant to the task. Monitor water quality during dredge activities. Utilise approved reclamation areas for disposal rather than marine environment	Low

Environmental Values	Sustainability principles	Potential impact	Possible causes	Mitigation and management measures	Residual risk level
		Vegetation disturbance from MOF construction	Removal of mangroves for construction of MOF	Minimise area of disturbance and removal of vegetation	Low
		Modified hydrodynamics Potential siltation of dredged areas	Dredging Reduced current velocity due to dredging	Refer to Western Basin Dredging and Disposal Project EIS Over-dredge swing basin and approaches to provide siltation storage. Regular maintenance dredging to provide vessel access	Not assessed in this EIS
		Loss of inter-tidal mudflat	Reclamation of inter-tidal mudflat	Minimise reclamation footprint and maintain tidal creek and mangrove vegetation to the extent practical Manage water quality associated with surface water runoff and ground water seepage through clean fill material and geotexitile fabric or similar	Moderate
		Erosion of North Passage Island shoreline	Swing Basin dredging and vessel wash	Refer to Western Basin Dredging and Disposal Project EIS Monitor North Passage Island shoreline and prepare management plan for long term sustainability	Not assessed in this EIS
		Disturbance of shoreline, and inter-tidal area adjacent to LNG Facility	Decommissioning of MOF and jetties	Remove operational components (including plant and equipment) and leave sub-structure in place as marine habitat Sediment sampling and analysis within swing basin and approaches to conform to management plan. Dredge to restore contaminated sediment areas and allow to naturally infill over time	Low

12.7 Commitments

In relation to the coastal environment, Australia Pacific LNG will:

- Continue to address potential impacts from the dredging and reclamation associated with the construction of the materials offloading facility and include mitigation in the design
- Develop and implement a dredge management plan for construction and ongoing maintenance of the materials offloading facility to reduce potential impacts
- Implement monitoring to identify shoreline and near shore impacts resulting from modified hydrodynamics
- Continue dispersion modelling to optimise the design of liquid discharges from the LNG facility to the marine environment.

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