11 COASTAL ENVIRONMENT

This chapter details the existing coastal environment that may be affected by the LNG Component of the Project in the context of State Coastal Zone reports, State Coastal Management Plan (SCMP), the Curtis Coast Regional Coastal Management Plan (CCRCMP). The chapter also describes potential impacts on environmental values as defined by the *Environment Protection Act 1994* (Qld), and outlines measures for preserving and protecting these values.

Baseline information on water quality, both in seas and estuaries below the limit of tidal influence, is provided. The interaction of freshwater flows with marine waters is also discussed in the context of their significance to marine flora and fauna adjacent to the Project area.

The environmental values of the coastal seas in the affected area are described in terms of:

- pH, suspended solids, nitrogen and phosphorus
- values identified in the Environmental Protection Policy (Water) 1997
- the SCMP and CCRCMP
- the results of an assessment of physical and chemical characteristics of sediments in relation to the areas to be dredged
- the potential impacts of sediment quality on the marine environment.

This chapter also encompasses the physical processes of the adjacent marine environment, including:

- currents, tides, wave action and storm surges
- the environmental values of the coastal resources of the affected area in terms of the physical integrity and morphology of landforms created or modified by coastal processes
- the results of hydrodynamic investigations, including:
  - physical properties of the sediments likely to be dredged
  - sediment dynamics and tidal flows and pathway
  - existing silt ratio patterns
  - sediment dynamics on the influence of tides, waves, currents and turbidity.

The relationship of physical processes to marine flora and fauna, as well as to biological processes and recreational and commercial fisheries productivity, has also been considered, along with the connection between currents, wave actions and extreme events and their influence.

Modelling has been undertaken to identify the potential impacts of the Project as well as appropriate mitigation measures.

This chapter should be read in conjunction with *Volume 1*, *Volume 5, Chapters 7, 8, 9* & *15* and *Volume 6*.

To facilitate an understanding of the Project coastal environment, the following assessment reports have been prepared:

- Marine Water Quality Assessment (refer *Appendix 5.9*).
- Coastal Processes and Modelling (refer *Appendix 5.10*).
- Initial 3D Hydrodynamic Assessment (refer *Appendix 5.11*).
- Coastal Legislation and Policy Assessment (refer *Appendix 5.12*).

11.1 DESCRIPTION OF PROJECT ENVIRONMENTAL OBJECTIVES

The Project environmental objective for coastal environment is: to protect as much as practicable the coastal environment from Project activities that may impact on ecological health, public amenity or safety.

11.2 RELEVANT LEGISLATION

Key legislation, policy and planning documentation investigated included:

- the SCMP, CCRCMP and other requirements of the *Coastal Protection and Management Act 1995* (Qld)
- environmental values under the *EP Act* (Qld), specifically as they relate to the Australian and New Zealand Guidelines for Fresh and Marine Waters (ANZECC 2000) and the EPP (Water)
- the Department of Employment, Economic Development and Innovation (DEEDI) Guidelines for Marine Areas (most notably FHMOP 004, Dredging, Extraction and Spoil Disposal Activities)
- the Queensland State Planning Policy 2/02 for Planning and Managing Development Involving Acid Sulfate Soils 2002
- the National Ocean Disposal Guidelines for Dredged Material and the Commonwealth *Environment Protection (Sea Dumping) Act 1981*.

For each planning/policy document, an assessment has been undertaken of the relevance to development associated with the Project and the degree of consistency between the policy outcomes and the Project. The Project's consistency with Commonwealth, state, regional and local plans for the Project area is detailed in *Appendix 1.7*.

11.3 METHODOLOGY

The following methodology for the Coastal Environment Assessment was used:

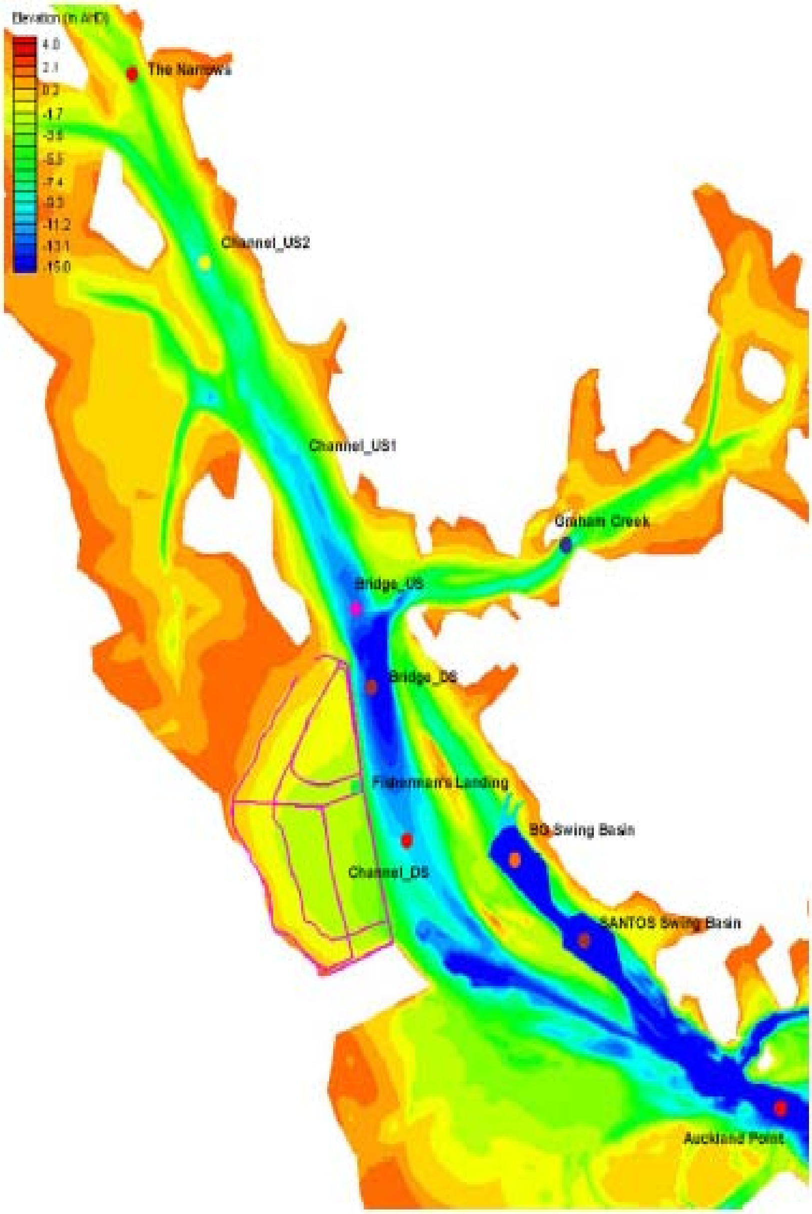
- identification of the relevant coastal and marine policy and planning instruments
- identifying whether the environmental impacts of the Project (primarily through review of the key findings from other technical coastal assessment reports) accord or achieve consistency with policy objectives and outcomes for the coastal zone as identified in the relevant policy and planning instruments
- identification of the likely assessment and permit requirements under Commonwealth and State legislation that will be required following release and acceptance of the EIS for the Project to proceed
- collation and review of existing baseline water quality data
- collection of additional locally specific baseline water quality data, conducted in 2008
- hydrodynamic and advection-dispersion numerical modelling to assess the potential impacts of the construction and operation of the proposed facility on receiving water quality. The existing two-dimensional (2D) hydrodynamic model of Port Curtis was used to undertake this assessment.

A number of scenarios were simulated:

1. QGC Scenario, used as the reference case for the assessment of hydrodynamic impacts of the various reclamation options and which included:
   - the proposed swing basins (both QGC and Santos) dredged as per the layout provided in late-2008
   - the proposed Materials Offloading Facility (MOF), also as per the layout provided late-2008
   - the proposed bridge (for which QGC is not the proponent) with abutments
   - the corresponding approach road from the south-west.
2. FL153 - QGC Scenario plus Fisherman's Landing reclamation FL153
3. FL1b - QGC Scenario plus Fisherman's Landing reclamation FL1b
4. FL2 - QGC Scenario plus Fisherman's Landing reclamation FL2

The boundaries of the water level results were extracted at the locations shown in *Figure 5.11.1* and an analysis of low- and high-water behaviours was undertaken for each scenario.

Figure 5.11.1 Water Level Results Extraction Locations



In scenarios **2** to 4, the model was reconfigured by inactivating relevant cells within the model mesh (as proposed), rather than refining or realigning model meshes and elements along the proposed reclamation areas. Due to their preliminary nature, none of these scenarios include potential dredging at the proposed Fisherman's Landing berths or widening/deepening of Targinie Channel. They do include the proposed Santos and QGC approach channels and swing basins.

The simulations described above were conducted for a 14-day representative neap-spring tidal cycle, and the model results were interrogated in order to determine relevant impacts of the proposed reclamation options on tidal hydraulics, relative to the QGC reference case.

Detailed 3D hydrodynamic modelling was also undertaken.

11.4 DESCRIPTION OF ENVIRONMENTAL VALUES

This section identifies the following coastal resource values:

- Areas of State Significance (Natural Resources)
- Key Coastal Sites
- Environmental Values of Water.

This section also discusses the policy context and applicability of guidelines and SPP 2/02 to support the impact assessment on:

- Fish habitat
- Acid sulfate soils
- Ocean Disposal.

11.4.1 Areas of State Significance (Natural Resources)

Figure 5.11.2 depicts the principal Areas of State Significance that could be affected by the Project, such as coastal wetlands, intertidal mangrove, saltmarsh areas along the coastline of Curtis Island and at Laird and Friend points, as well as endangered regional ecosystems (RE).

11.4.2 Key Coastal Sites

The main development elements of the Project also fall within various key coastal sites (KCS) defined within the CCRCMP. These are shown in *Figure 5.11.3* and include:

- KCS #1 (Curtis Island – relevant to the proposed LNG plant and associated infrastructure situated above the high-water mark including the footings of the proposed bridge and submarine pipeline)
- KCS #2 (The Narrows – relevant to the footings of the proposed bridge and submarine pipeline)
- KCS #5 (Targinie remnant vegetation – relevant to the pipeline on the mainland)
- KCS #6 (the Port of Gladstone – relevant to capital dredging associated with the Swing Basin and access channel and future dredge spoil placement).

QUEENSLAND CURTIS LNG
A BG Group business

ERM

Environmental Resources Management Australia Pty Ltd

Project: Queensland Curtis LNG Project

Client: QGC - A BG Group business

Drawn: JB | Volume 5 | Figure 5.11.2

Approved: GB | File No: 0086165b_EIS_CP_CDR001_F5.11.2

Date: 18.05.09 | Revision: 2

Title: Curtis Coast Regional Coastal Management Plan Areas of State Significance (Natural Resources)

Disclaimer:
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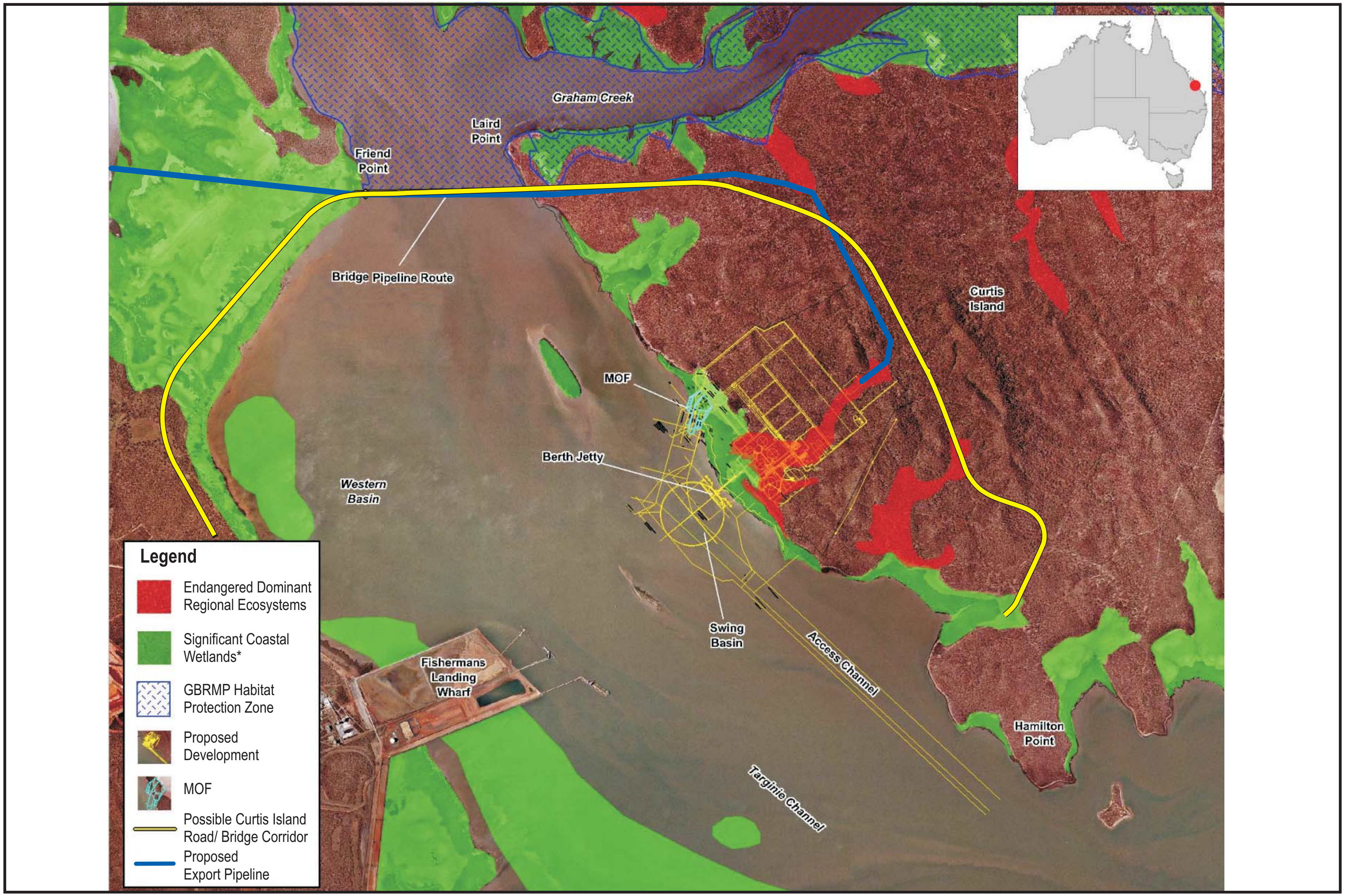


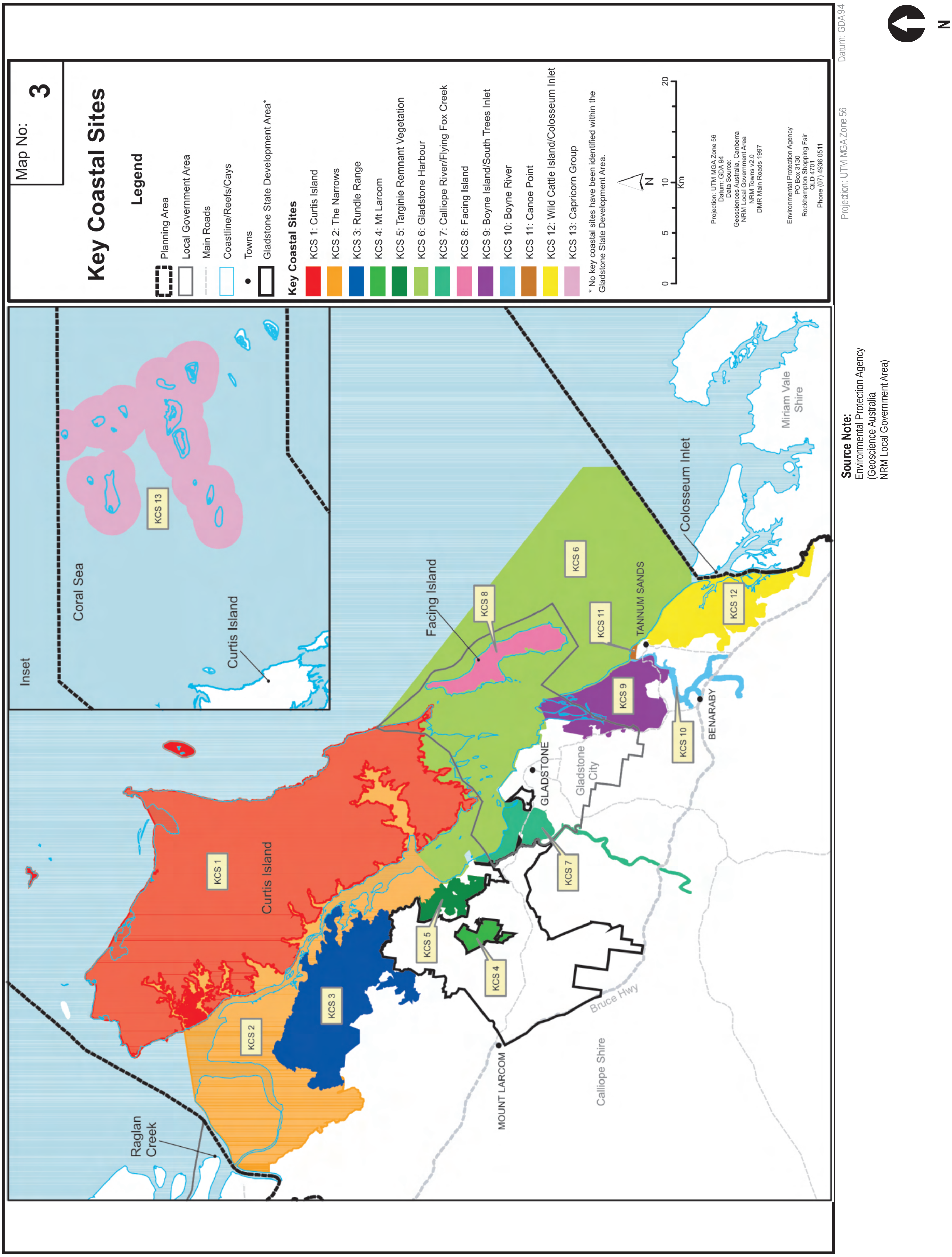
Note:
* Significant coastal wetlands includes seagrass beds

Source Note:
BMT WBM
(EPA Regional Ecosysmtems 2003
Curtis Coast Regional Coastal Management Plan 2003 (Wetlands))
Curtis Island Road/ Bridge Corridor - Connell Wagner
ML Design Pipeline Revision D supplied by Unidel Energy
and Infrastructure (Qld) on 13/02/2009

Projection: UTM MGA Zone 56
Datum: GDA94

0 1 2 km

N



QUEENSLAND CURTIS LNG A BG Group business	Project: **Queensland Curtis LNG Project**	Title: **Curtis Coast Regional Coastal Management Plan** **Key Coastal Sites**
	Client: **QGC - A BG Group business**	
ERM Environmental Resources Management Australia Pty Ltd	Drawn: JB — **Volume 5** — **Figure 5.11.3** Approved: GB — File No: 0086165b_EIS_CP_CDR002_F5.11.3 Date: 06.02.09 — Revision 0	Disclaimer: Maps and Figures contained in this Report may be based on Third Party Data, may not to be to scale and are intended as Guides only. ERM does not warrant the accuracy of any such Maps and Figures.

The desired coastal outcomes, as well as the significant coastal resources and their values within each of the KCS, are presented in *Table 5.11.1.*

Table 5.11.1 Key Coastal Sites Desired Coastal Outcome and Significant Coastal Resources and Values

KCS	Desired Coastal Outcomes	Significant Coastal Resources and Values
KCS #1 **Curtis Island**	Planning for future development appropriately identifies and takes into consideration the values of areas of high conservation significance, including the cumulative impacts of associated development on these values Planning for future development considers the design and location of development ensuring any impacts on the scenic coastal landscape values associated with the island are minimised	Endangered and Of Concern RE Adjacent significant coastal wetlands associated with The Narrows, Graham Creek and the Port of Gladstone Coastal ranges providing a significant scenic coastal landscape feature able to be viewed from the mainland and forming part of the coastal landscape Part of a strike ridge system that runs along the western side of Curtis Island Cultural heritage values associated with Graham Creek Outdoor recreational opportunities including fishing and bush walking Hamilton Point, which has been identified for possible future port expansion
KCS #2 **The Narrows**	This key coastal site is given the highest level of protection in recognition of its near-pristine state and significant coastal resources and their values Protection of the area’s integrity and ecological functioning from incompatible development, land uses and activities Maintenance of the mangrove fringe bordering The Narrows and associated waterways to protect scenic amenity and water quality Maintenance of World Heritage values associated with the area’s outstanding coastal landscape values, including its scientific value as an indicator of past geomorphological processes and scenic amenity values Monitoring of water quality to detect any adverse impacts on marine and estuarine biodiversity from contaminants including suspended solids.	Being within the Great Barrier Reef World Heritage Area Recognition as an area of national significance through its listing on the Australian Heritage Commission Register of National Estate Recognition as an area of international significance through its World Heritage listing Recognition in the Directory of Important Wetlands for its significance (along the entire waterway area) Distinctive geological features such as Balaclava Island, Kangaroo Island, Targinie Creek Graham Creek, significant as important indicator of past geomorphological processes An uncommon passage landscape that is one of only five narrow tidal passages separating large Continental islands from mainland Australia A large area of relatively undisturbed coastal wetland habitat including mangroves, claypan, mudflats and saltmarsh Habitat for a range of significant Migratory shorebirds, many of which are Rare and Threatened, including the beach stone-curlew and great-billed heron Coastal wetlands that are critical to the maintenance of regional fish and crustacean populations Significant cultural heritage values associated with The Narrows, Cattle Crossing and

KCS	Desired Coastal Outcomes	Significant Coastal Resources and Values
		Ramsay Crossing Indigenous traditional owner cultural resources
KCS #5 **Targinie Remnant Vegetation**	Conserve and appropriately manage biodiversity including the values associated with remnant vegetation, while allowing for development in suitable areas Maintenance of viable networks of wildlife habitat including the importance of this area in contributing to a bioregional wildlife corridor and in providing wildlife linkages to the coast Preservation of endangered RE Protection of rare and threatened species including the chain fruit *Alyxia magnifolia*	Large areas of intact remnant vegetation containing Endangered and Of Concern RE and other significant coastal habitats such as creeks and waterways flowing to The Narrows Biodiversity values associated within the overlap of two bioregions: Brigalow Belt and South-East Queensland and part of a bioregional wildlife corridor Remnant vegetation that provides an important habitat link to the coast Rare and endangered species including the chain fruit *Alyxia magnifolia* Significant landscape values associated with the coastal ranges Indigenous traditional owner cultural resources Identified key mineral resources associated with the Stuart oil shale resource that are of importance to the state More than 500 ha of State Forest
KCS #6 **Port of Gladstone**	Management of the harbour providing for a range of uses, while ensuring conflicts are managed and adverse impacts on coastal resources and their values are minimised. Continued development of the Port of Gladstone in an ecologically sustainable manner, avoiding the location of port infrastructure in areas of high conservation significance where possible Coordination of management approaches among land and marine resource managers in relation to monitoring the health of the harbour in regards to water quality, managing increasing vessel use and minimising impacts to shorebirds, turtles and dugong	Marine areas that are within the Great Barrier Reef World Heritage Area Marine areas that are within the extensive significant coastal wetlands listed in the Directory of Important Wetlands, including mangroves, claypans and seagrass beds providing critical habitat for a range of terrestrial and marine species Critical habitat for many shorebirds and seabirds (listed on either JAMBA or CAMBA) and turtles Significant scenic coastal landscape, public access and biodiversity values Indigenous traditional owner cultural resources A natural deep-water harbour providing for the internationally significant economic activities of the Port of Gladstone Tourism values associated with the Gladstone Marina and outdoor and nature-based recreational opportunities within the Port of Gladstone, including fishing, diving and sailing Recreational values associated with the harbour and adjacent areas for activities such as boating, fishing and sailing

11.4.3 Environmental Values of Water

The *EP Act* (Qld) and subordinate EPP (Water) provide for the management of surface water quality in Queensland. Specific environmental values and water quality objectives under the EPP have not been declared for the receiving waters of The Narrows and Port Curtis Region, although guidelines for the Central Coast Queensland Region are set out in the Queensland Water Quality Guidelines (2006), prepared under the policy. These provide values for waters in the region (refer *Table 5.11.2*) including those in Port Curtis and adjoining waterways.

As shown in the *Table 5.11.2* , the main focus of the water-quality guidelines are on physicochemical parameters, noting that the Queensland Water Quality Guidelines (2006) refer back to the National Water Quality Guidelines (Australia and New Zealand Environment and Conservation Council) in relation to toxicants.

Table 5.11.2 Queensland Water Quality Guideline Values for Waters in the Project Area

Parameter	Units	Water Body Type		
		Enclosed Coastal[1]	Mid Estuarine[2]	Lowland Stream[3]
Ammonia Nitrogen	µg/L	6	10	20
Oxidised Nitrogen	µg/L	3	10	60
Organic Nitrogen	µg/L	180	260	420
Total Nitrogen	µg/L	200	300	500
Filterable Reactive Phosphorus (FRP)	µg/L	6	8	20
Total Phosphorus	µg/L	20	25	50
Chlorophyll *a*	µg/L	2	4	5
Dissolved Oxygen (% saturation)	lower	90	85	85
	upper	100	100	110
Turbidity	NTU	6	8	50
Secchi	m	1.5	1	NA
Suspended Solids	mg/L	15	20	-
pH	Lower	8	7	6.5
	upper	8.4	8.4	7.5

11.4.4 Fish Habitat

In the context of policies and guidelines for marine areas promulgated by the Department of Employment, Economic Development and Innovation (DEEDI), FHMOP 004, Dredging, Extraction and Spoil Disposal Activities, is relevant to the Project.

The Policy objectives are to guarantee the protection of Queensland's fisheries resources and habitats while ensuring, enabling and contributing to ecologically sustainable industry and economic development. They include:

- ensuring the minimisation of adverse impacts, including direct or indirect damage, to fisheries resources through dredging activities (i.e. extractive

1 Port Curtis

2 Waters at the lower end of Boat Creek would be classified as Mid Estuarine up to the point of the in-stream weir

3 Upstream of the weir, the waters would be classified as Lowland Stream

industry, navigational dredging, dredging for waterway management, dredging for development and spoil disposal)

- achieving optimum community, economic and other benefits from fisheries resources
- ensuring equitable access to fisheries resources
- providing all stakeholders (e.g. extractive industry/dredge operators, community, fishing industry, government agencies, landholders, developers, consultants, River Improvement Trusts, educators and non-government organisations) with a clear statement on the Department's position with regard to the assessment of permit applications for dredging activity
- encouraging the protection and enhancement of fisheries resources
- providing an assessment process to achieve the above.

Dredging activities associated with the Project are characterised, using the terminology of the FHMOP 004, as:

- Navigational dredging (associated with the shipping access channels and Swing Basin)
- Development dredging (associated with the trenching of the submarine pipeline)
- Spoil disposal activities (associated with the placement of dredged material in the proposed Western Basin reclamation area).

In general, the policy states that the DEEDI will not oppose proposals for navigational dredging, dredging for development and spoil disposal activities where:

- there are clearly no (or very minimal) immediate or foreseeable, permanent adverse impacts on fisheries resources
- there has been a Whole of Government approval for a development to proceed and Fisheries Group comments are sought (negotiation and mitigation still apply)
- there are demonstrated fisheries related benefits
- there are essential community benefits (including maintenance of navigational channels and beach replenishment programs).

The DEEDI caveat on the above is that:

- appropriate mitigation measures have been agreed to by the Proponent and by the Fisheries Group
- appropriate arrangements have been negotiated with the Fisheries Group to avoid potential disruption of fishing activities
- where requested by the Lead Agency, plans to undertake a monitoring program have been developed with reference to the impact of dredging activity on the surrounding fish and habitats

- spoil placement is undertaken on terrestrial land or at a designated spoil disposal site (or at an alternative site agreed to by the Fisheries Group)
- where a proposal involves works that will require future maintenance dredging (e.g. construction of marinas or canal developments), details of locations for future disposal of dredged spoil have been identified
- all other necessary approvals have been obtained and conditions specified under any other relevant Act or law are adhered to
- all other reasonable options have been explored and eliminated.

11.4.5 Acid Sulfate Soils State Planning Policy (SPP)

The SPP for Planning and Managing Development Involving Acid Sulfate Soils (2/02) sets out the requirements for development and works involving disturbance of actual or potential acid sulfate soils as a result of extraction or filling activities within the coastal zone.

In terms of the coastal environment, the main potential acid sulfate soil management issues associated with the Proposal include:

- filling and excavation of coastal land (including any on-site drainage works) associated with the construction of the LNG Facility and associated infrastructure on Curtis Island, including the extent to which any excavated material needs to be treated prior to re-use or disposal
- mobilisation of potentially acidic groundwater through actual acid sulfate soil material as a result of the filling and surcharging of land associated with ground treatment and construction
- potential oxidation of excavated material from the seabed associated with trenching of the submarine pipeline (noting that the risk of impact will largely depend on whether the material is removed from the marine environment prior to re-use to fill the excavated trench)
- filling and excavation of coastal land associated with the construction of the proposed bridge footings and access roads
- dredging of material from land below high-water, particularly if the material is to be placed on land above the high-water mark, as envisioned in the reclamation site in the Western Basin, given that the material has greater potential to oxidise once removed from the marine environment.

11.4.6 National Ocean Disposal Guidelines/ National Assessment Guidelines for Dredging

The National Ocean Disposal Guidelines for Dredged Material (NAGD), revised in February 2009 and re-named the National Assessment Guidelines for Dredging (NAGD), outline the requirements for at-sea placement of dredged material in Australia.

Given that the future proposed placement site in the Western Basin for dredged material associated with the Project is within State waters, an approval under the *Environment Protection (Sea Dumping) Act 1981* (Cth) will not apply to the future activity. Nonetheless, the guidelines will be relevant under other approval requirements, including sea-dumping approvals under the *IPA/Coastal Act*. In this context, the NAGD are identified as relevant considerations under the State Coastal Management Plan (refer Policy 2.1.8) and other policy instruments discussed previously.

The NAGD outline two relevant processes for future dredged material placement associated with the Project, including:

- requirements and studies associated with the selection of a suitable disposal site
- the sediment quality sampling and analysis process to ensure the marine sediment to be dredged is uncontaminated and suitable for marine disposal.

11.5 IMPACT ASSESSMENT

11.5.1 Introduction

The area that has been used for the coastal processes assessment includes those lands or waters that could be affected by the proposed Project in the Port Curtis region, including the Port of Gladstone, The Narrows, the mainland coast around Fisherman's Landing Wharf and the south-western coastline of Curtis Island.

This chapter uses terminology to describe areas that follows definitions provided in Queensland coastal statutes:

- The "coast" refers to the area within or neighbouring the foreshore.
- The "foreshore" is defined as the area between the high- and low-water mark.
- The "high-water mark" is defined as the ordinary high-water mark at spring tides.
- "Tidal waters" include the sea and any part of a harbour including tidal rivers, creeks and associated wetlands ordinarily within the ebb and flow of the tide at spring tides (i.e. Mean High Water Springs or MHWS).

11.5.2 Impact on Coastal values

Table 5.11.3 identifies the main components of the Project identified as having a potential impact on the coastal environmental values of the Port of Gladstone.

Table 5.11.3 Project Components and Impact on Coastal Environmental Values

Project Component	Impact on Coastal Environmental Values
LNG Facility (above the high-water mark)	Coastal ecology, water quality (principally through stormwater discharges) and drainage patterns will be subject to natural coastal processes such as erosion and flooding due to their location within or neighbouring the foreshore
LNG marine facilities including MOF and LNG loading/propane uploading jetty (below the high-water mark)	Potential direct (e.g. construction phase sediment plumes) and indirect (e.g. changes in tidal flushing) impacts on tidal hydraulics, water quality and coastal habitats, including from the proposed wastewater discharge from the reverse-osmosis desalination and sewage treatment plants from the vicinity of the MOF jetty
Proposed road and export pipeline routes (below the high-water mark)	Direct (e.g. construction phase sediment plumes) and indirect (e.g. changes in tidal flushing) impacts on tidal hydraulics, water quality and coastal habitats
Curtis Island Bridge	Direct impact on overall tidal water movement patterns, with secondary impact on marine water quality and coastal ecology through placement of the associated access roads to and from the proposed bridge
Access road extending north from Landing Road	Direct impact on overall tidal water movement patterns, with secondary impact on marine water quality and coastal ecology through placement of the associated access roads to and from the proposed bridge
Construction of Ferry Terminal, fabrication and laydown areas at Auckland Point	Direct (e.g. construction phase sediment plumes) and indirect (e.g. changes in tidal flushing) impacts on tidal hydraulics, water quality and coastal habitats
Operation of Ferry Terminal, RG Tanna Coal Terminal, Alf O'Rourke Drive	Direct (e.g. construction phase sediment plumes) and indirect (e.g. changes in tidal flushing) impacts on tidal hydraulics, water quality and coastal habitats

Volume 5, Chapter 6 describes proposed options for management of dredged material placement (generated from the capital dredging of the proposed Swing Basin and shipping access channels). These options are various configurations of a proposed reclamation area north of the existing Fisherman's Landing Wharf in the Western Basin of Port Curtis.

A range of coastal management issues associated with proposed future shipping operations that have potential direct and indirect impact on coastal processes and resources are addressed in *Volume 5* and include:

- ballast water management (*Chapter 15*)
- controlling the introduction of exotic organisms (*Chapters 8* and *15*)
- maritime safety and navigation (*Chapter 15*)
- vessel-based waste management *(Chapter 15*).

11.5.3 Consistency with Coastal Management Plans

The Queensland *Coastal Protection and Management Act 1995* (the *Coastal Act*) authorises the preparation of a State and regional coastal management plans. The plans are statutory instruments (deemed to be State Planning

Policies) and, as such, are key documents to be considered in the context of assessing the Project in terms of the future approval requirements under the Act and other legislation.

In particular, many of the key development aspects of the Project are situated in, on or over the Coastal Management District (CMD) declared over tidal lands and waters in the Project area. The statutory approval requirements and enforcement mechanisms under the Act apply to development and activities within the CMD.

The SCMP and CCRCMP apply to the Project on the basis of its location in the coastal zone. The plans outline a range of outcomes that are supported by underlying principles and policies relevant to coastal management. Within this hierarchy, the policy statements in the plans are those most relevant to the assessment of the Project.

11.5.4 Policy Outcome Assessment

Table 5.11.4 outlines and discusses applicable policies from the plans relating to the various Project Components, as well as consistency with the desired policy outcome and other measures. This section also assesses key coastal sites affected by the Project.

Table 5.11.4 Coastal Management Plans and Outcomes Relevant to the Project

Policy No.	Relevance to the Project	Compliance/Consistency with Policy Outcomes
2.1.1	This policy identifies Areas of State Significance (social and economic). The integrity and functioning of these areas are to be protected from incompatible land uses under the policy	On the western side of the Port of Gladstone, the Gladstone State Development Area (GSDA) and Fisherman's Landing Wharf are both nominated in the Regional Coastal Plan as Areas of State Significance (social and economic). The Project is compatible with the management intent for these areas and unlikely to negatively impact on their current/future functioning. It is noted that there will be an increase in LNG tanker shipping movements in and out of the proposed LNG jetty/terminal once the LNG Plant is operational. As such, a range of navigational, port operational and logistical issues and arrangements will need to be made with the Gladstone Ports Corporation and Maritime Safety Queensland Regional Harbour Master
2.1.2	This policy seeks to consolidate urban development on the coast through best-practice coastal settlement pattern and design principles	As an industrial use of land, the proposed isolated location of the LNG Facility on Curtis Island and associated wharf facilities minimises direct impacts on neighbouring urban communities and other recreational users of the foreshore that exist elsewhere in the study area
2.1.3	This policy seeks to ensure coastal-dependant land uses (e.g. that require a foreshore location to function) are given priority over non-dependent uses	The LNG Facility is a coastal-dependant use in the context of the need to ensure the LNG storage and processing facility is in close proximity to the wharf facility and export vessels. In this context, the proposed location of the facility on Curtis Island is consistent with this policy

Policy No.	Relevance to the Project	Compliance/Consistency with Policy Outcomes
2.1.5	This policy outlines requirements for establishment and siting of maritime infrastructure	The Project will involve several structures (e.g. jetties, terminals, etc.) that are considered to be maritime infrastructure. For the most part, the proposed maritime infrastructure abuts freehold land or is in the wet lease area associated with the LNG Facility and therefore consistent with the policy (e.g. not connecting to State coastal land). For any infrastructure placed on State coastal land (e.g associated with the proposed bridge, access roads and pipeline), a resource entitlement will be needed from the Department of Environment and Resource Management (DERM) authorising the lodgement of an application and to define future tenure requirements
2.1.8	This policy seeks to ensure all dredging and related activity is to be appropriately located and sustainably managed to avoid or minimise adverse impacts on coastal resources and their values The SCMP also requires that the dredged material placement site must provide the best coastal management outcome, having regard to the nature of the spoil, the cost of alternative sites and potential impacts on coastal resources and their values Dredged material placement activities are required to avoid adverse impacts on Areas of State Significance (natural resources) (see policy 2.8.3). Where offshore placement is proposed, the SCMP requires that dredging and dredge material disposal activities comply with the National Ocean Disposal Guidelines for Dredged Material, 2002	Based on the hydrodynamic and coastal assessments, in the context of the specific assessment criteria in the policy, the proposed dredging: • will not result in direct impact on the ability of the site or adjoining land to function as a barrier protecting lands from coastal waters • will maintain beach or foreshore stability • is not expected to directly impact on natural coastal processes that supply sand to beaches • will maintain the stability of the dredging area, noting the possibility of some direct impact from sedimentation at the Swing Basin and MOF over time • will maintain water quality, excepting short-term impacts from dredging that are within the bounds of natural variability of the system and localised within the Swing Basin and channel area (refer policy 2.4) • is not expected to directly impact groundwater levels of underlying aquifers and coastal wetlands • will maintain the local drainage regime on the site and adjoining areas • will not cause unacceptable risk to existing land uses from coastal hazards In general, the intention to place dredged material as a large reclamation in the Western Basin of Port Curtis will need to be assessed in the context of this policy, including the likely direct, indirect and cumulative impacts on coastal natural resources and the suitability of the material for marine placement in accordance with the NAGD
2.1.9	This policy seeks to ensure reclamation of coastal waters are necessary and appropriate for coastal management	Minor reclamation is proposed as part of the construction and operation of the Project in relation to the MOF jetty. This reclamation is seen as acceptable given it is associated with a coastal-dependant land use with a positive regional impact and will ensure the infrastructure is protected from natural coastal processes and erosion

Policy No.	Relevance to the Project	Compliance/Consistency with Policy Outcomes
2.1.10	This policy seeks to ensure that the diversity and quality of tourism and recreational opportunities in the coastal zone are protected	The construction and operation of the Project is not expected to have significant negative impacts on the regional tourism industry or on recreational activities given the largely industrial use and likely future intensification of such use in the Port of Gladstone area for a range of LNG facilities. As outlined above, a range of navigational, port operational and logistical issues and arrangements will need to be made with the Gladstone Ports Corporation and Maritime Safety Queensland Regional Harbour Master to ensure vessel safety in the harbour and shipping channel areas.
2.1.16	This Regional Coastal Management Plan policy seeks to ensure land-based infrastructure is designed, located and constructed to avoid detrimental impacts on coastal resources and their values	In the context of this policy, the proposed LNG Facility: • is largely situated outside the erosion-prone area, but will contain development elements (e.g. the proposed bridge and marine infrastructure) that are required to be situated within the area and protected from coastal processes (see policy 2.2 below). Where practicable, associated infrastructure such as access roads (that do not require a coastal location to function) should be situated outside the erosion-prone area • largely avoids areas of high conservation significance, with the exception of some areas of coastal vegetation and marine plants (see policy 2.8) • will not have significant direct or indirect impacts on water quality or hydrodynamics (see policy 2.1.8) associated with dredging and wastewater discharge (see policy 2.4) • may have negative minor impact on public access and usability of coastal waters and coastal landscape values, given the establishment of the Swing Basin, marine terminal and MOF structure will occur in an area that is currently in a predominantly natural state. These matters are discussed in greater detail in Volume 8 of the EIS
2.2	The suite of policies outline the need to consider climate change and coastal hazards in the context of future decision making on the coast, and the need to avoid placement of infrastructure in the erosion-prone area	There is no specific erosion-prone area width defined by DERM plans SC 3379 or SC 3380 for Curtis Island, so the erosion-prone area at the location of the LNG Facility is defined as an area 40 m from high-water mark or HAT (whichever is the greater). In the context of the RCMP, it is noted that the Project area is not identified as a 'priority area' (as defined by the plan) for erosion management The bulk of the LNG Facility itself would be situated outside the erosion-prone area, with only essential infrastructure (between the plant and the berth/MOF) situated in the area of concern. This is not seen as contrary to coastal management policy outcomes, as the facility is a coastal-dependant land use and there are no practicable alternatives Accordingly, protection measures will need to be

Policy No.	Relevance to the Project	Compliance/Consistency with Policy Outcomes
		incorporated into the design to take into account the erodibility of the land and likely inundation during coastal storm events, including rising sea levels and increased intensity of coastal storms as a result of climate change. Coastal mangroves and other vegetation should be retained as much as is practicable as an additional buffer against natural coastal processes On the western mainland coast, it is likely that the proposed bridge and access road would be partially located in the erosion-prone area, given the low-lying nature of the coastal wetlands (with the erosion-prone area extending to HAT in such areas). Measures will also need to be taken to protect this infrastructure from coastal processes
2.3.1	This policy seeks to ensure no net loss of public access to the foreshore or public usability of coastal waters	The construction and operation of the Project will have a minor direct impact on public access and usability of coastal waters, given the establishment of the Swing Basin, marine terminal and MOF structure will occur in an area that is currently in a predominantly natural state. The usage of the site and impacts are discussed in greater detail in the social impact assessment section of the EIS Temporary access restrictions will need to be enforced during the construction stage for health and safety reasons, and more permanent access restrictions will apply as part of the establishment and enforcement of security areas for the LNG berth during operation
2.4	The suite of policies under this section of the Plan deal with the management of water quality through wastewater discharges, storm and groundwater management and acid sulfate soils	There are no scheduled Environmental Values and Water Quality Objectives under the EPP (Water) for waters in the Project area. The Queensland Water Quality Guidelines 2006 provide regional water quality guidelines for nutrients, sediments and other physic-chemical parameters for the Central Coast region that are relevant In the context of wastewater releases, the operation of the LNG plant will involve a direct discharge of contaminants to coastal waters through the sewage treatment and reverse-osmosis plants. Potential impacts of these discharges on marine ecology are discussed in *Volume 5, Chapter 8.* Stormwater issues and management measures will need to be addressed as part of the operational EMP/Site-Based Management Plan for the facility. Best-practice measures will need to be employed during construction activities to avoid or minimise soil erosion and sedimentation into coastal waters, given the climatic and geomorphological nature of the Project area
2.5/ 2.6	The suite of policies under these sections of the Plan identify Areas of State Significance for Indigenous Traditional Owners and cultural heritage and seeks to	Significant cultural heritage values are identified in the Regional Coastal Management Plan being associated with The Narrows, Cattle Crossing and Ramsay Crossing. Cultural heritage values are also associated with Graham Creek on Curtis Island Engagement with the relevant Aboriginal Parties as

Policy No.	Relevance to the Project	Compliance/Consistency with Policy Outcomes
	provide for their conservation and management	part of the EIS through a Cultural Heritage Management Plan under the *Aboriginal Cultural Heritage Act 2003* is the most appropriate means of identifying and ensuring appropriate management of these values in the context of the Project. This issue is addressed in *Volume 8* of the EIS
2.7	The suite of policies under this section of the Plan identifies Areas of State Significance (scenic coastal landscapes) and seeks to provide for their protection	Curtis Island is recognised within the coastal plan as providing a significant scenic coastal landscape feature able to be viewed from the mainland and forming part of the coastal landscape. Retention of native vegetation and mangroves along the coastline will assist in retaining some of these landscape values, but it is likely there will be a negative direct impact on visual amenity. Likewise, the proposed bridge between Friend Point and Laird Point is likely to result in negative direct impact on visual amenity. This is further discussed in *Volume 5, Chapter 16*
2.8	This suite of policies identifies and seeks to conserve and manage Areas of State Significance (natural resources) and regionally important coastal habitats mapped under the Regional Coastal Management Plan	The broad intention of this suite of policies is to avoid, minimise and mitigate impacts to natural coastal resource values. Based on mapping contained in the CCRCP (refer *Figure 5.11.2* and *Figure 5.11.3*), the principal Areas of State Significance that could be affected by the Proposal are coastal wetlands and, in particular, intertidal mangrove and saltmarsh areas along the coastline of Curtis Island and at Laird and Friend Points. These could be impacted through construction of the LNG Facility, access roads and the proposed bridge. RE mapping also shows an area of Endangered RE that will be disturbed by the establishment of the proposed LNG Facility on Curtis Island (e.g. within the footprint of the Facility). Sparse seagrass may also exist throughout the sub-tidal areas of the planning area, but has not been specifically mapped or observed in abundance within or near key development areas of the Project such as the submarine pipeline alignment. Further information on the baseline coastal values of the area and how they are impacted by the Project are described in *Volume 5, Chapter 8* Based on the location of the infrastructure and the location of mapped resources within the RCMP, there is expected to be local disturbance from the development elements. Accordingly, the detailed design and construction methodology will need to take into account how any impacts to coastal wetlands and vegetation can be further avoided or minimised in accordance with best practice. If unavoidable, the impacts to the coastal endangered RE and to marine plant communities will need to be addressed through an offset or similar measure It should be noted that the discussion above does not apply to the proposed reclamation of land in the Western Basin associated with dredged material placement. This area has a range of mapped sub-

Policy No.	Relevance to the Project	Compliance/Consistency with Policy Outcomes
		tidal and inter-tidal marine vegetation that is declared as Significant Coastal Wetlands under the RCMP. Accordingly, the disturbance/removal of these natural resources will need to be assessed as part of a separate impact assessment process

11.5.5 Key Coastal Sites Assessment

Table 5.11.5 outlines the assessment against the Coastal Management Plan outcomes.

Table 5.11.5 Coastal Management Plan Outcomes Relevant to the Project

KCS	Desired Coastal Outcomes	Significant Coastal Resources and Values	Assessment
KCS #1 **Curtis Island**	Planning for future development appropriately identifies and takes into consideration the values of areas of high conservation significance, including the cumulative impacts of associated development on these values Planning for future development considers the design and location of development, ensuring any impacts on the scenic coastal landscape values associated with the island are minimised	Endangered and of concern RE Adjacent significant coastal wetlands associated with The Narrows, Graham Creek and the Port of Gladstone Coastal ranges providing a significant scenic coastal landscape feature able to be viewed from the mainland and forming part of the coastal landscape Part of a strike ridge system that runs along the western side of Curtis Island Cultural heritage values associated with Graham Creek Outdoor recreational opportunities including fishing and bush walking Hamilton Point, which has been identified for possible future port expansion	It is recognised in the key coastal site designation that, although this coastal locality is undeveloped, there is significant potential for future development associated with port and industrial expansion Gladstone Ports Corporation Strategic Plan identifies part of this coastal locality for future port development by 2025 Given the desired coastal management outcomes sought, future development of this coastal locality as part of the Project (and other projects) needs to be planned and managed in an ecologically sustainable manner to avoid significant impact on the area's biodiversity and coastal landscape values Further assessment is in *Volume 5*, *Chapters 5*, *7*, *8*, *9* and *16*, and *Volume 8*
KCS #2 **The Narrows**	This key coastal site is given the highest level of protection in recognition of its near-pristine state and significant coastal resources Protection of the area's integrity and	Being within the Great Barrier Reef World Heritage Area Recognition as an area of national significance through its listing on the Australian Heritage Commission Register of National Estate Recognition as an area of international significance	It is important to ensure development proposed as part of the Project in this key coastal site avoids or minimises negative impacts on natural values to the greatest extent practicable, and that all reasonable alternatives to the location of the

KCS	Desired Coastal Outcomes	Significant Coastal Resources and Values	Assessment
	ecological functioning from incompatible development, land uses and activities Maintenance of the mangrove fringe bordering The Narrows and associated waterways to protect scenic amenity and water quality Maintenance of World Heritage values associated with the area's outstanding coastal landscape values, including its scientific value as an indicator of past geomorphological processes and its scenic amenity values Monitoring of water quality to detect any adverse impacts on marine and estuarine biodiversity from contaminants, including suspended solids.	through its World Heritage listing Recognition in the Directory of Important Wetlands for its significance (along the entire waterway area) Distinctive geological features such as Balaclava Island, Kangaroo Island, Targinie Creek and Graham Creek, which are significant as important indicators of past geomorphological processes An uncommon passage landscape that is one of only five narrow tidal passages separating large Continental islands from mainland Australia A large area of relatively undisturbed coastal wetland habitat including mangroves, claypan, mudflats and saltmarsh Habitat for a range of significant Migratory shorebirds, many of which are rare and Threatened, including the beach stone-curlew and great-billed heron Coastal wetlands that are critical to the maintenance of regional fish and crustacean populations Significant cultural heritage values associated with The Narrows, Cattle Crossing and Ramsay Crossing and Indigenous Traditional Owner cultural resources	infrastructure in the key coastal site, such as the alignment of the submarine pipeline, have been fully explored Further assessment is in *Volume 5, Chapters 3*, *4*, *5*, *7*, *8*, *9* and *16* and *Volume 8*
KCS #5 **Targinie Remnant Vegetation**	Conserve and appropriately manage biodiversity, including the values associated with remnant vegetation, while allowing for development in suitable areas Maintenance of viable networks of wildlife habitat, including the importance of this area in contributing to	Large areas of intact remnant vegetation containing endangered and of concern RE and other significant coastal habitats such as creeks and waterways flowing to The Narrows Biodiversity values associated within the overlap of two bioregions: Brigalow Belt and South-East Queensland and part of a bioregional wildlife corridor	The Pipeline has been routed to minimise direct impacts on remnant vegetation, any essential habitat and State Forest, with a 40 m RoW, which also minimises direct impact on the oil shale resource area Further assessment is in *Volume 5, Chapters 5*, *7* and *16*.

KCS	Desired Coastal Outcomes	Significant Coastal Resources and Values	Assessment
	a bioregional wildlife corridor and in providing wildlife linkages to the coast Preservation of endangered RE Protection of rare and Threatened species including the chain fruit *Alyxia magnifolia*.	Remnant vegetation that provides an important habitat linkage to the coast Rare and Endangered species including the chain fruit *Alyxia magnifolia* Significant landscape values associated with the coastal ranges Indigenous Traditional Owner cultural resources Identified key mineral resources associated with the Stuart oil shale resource that are of importance to the state More than 500 ha of State Forest	
KCS #6 **Port of Gladstone**	Management of the harbour providing for a range of uses, while ensuring conflicts are managed and adverse impacts on coastal resources and their values are minimised Continued development of the Port of Gladstone in an ecologically sustainable manner, avoiding the location of port infrastructure in areas of high conservation significance where possible. Coordination of management approaches among land and marine resource managers in relation to monitoring the health of the harbour in regards to water quality, managing increasing vessel use and minimising impacts to shorebirds, turtles and dugong	Marine areas that are within the Great Barrier Reef World Heritage Area marine areas that are within the extensive Significant Coastal Wetlands listed in the Directory of Important Wetlands, including mangroves, claypans and seagrass beds providing critical habitat for a range of terrestrial and marine species Critical habitat for many shorebirds and seabirds (listed on either JAMBA or CAMBA) and turtles Significant scenic coastal landscape, public access and biodiversity values Indigenous Traditional Owner cultural resources A natural deep-water harbour providing for the internationally significant economic activities of the Port of Gladstone Tourism values associated with the Gladstone Marina and outdoor and nature-based recreational opportunities within the Port of Gladstone and adjacent areas for activities including fishing, diving and sailing	A critical issue for the Port of Gladstone is providing for future port and industrial expansion while ensuring significant negative impacts to coastal resources and their values are avoided Given the predicted impacts from the Project, it is generally consistent with the desired coastal outcomes for this key coastal site, assuming construction and operation are managed in an ecologically sustainable manner Further assessment is in *Appendix 1.7*; *Volume 5*, *Chapters 5*, *7*, *8*, *9*, *15*, *16* and *Volume 8*.

11.5.6 Environmental Values of Water Assessment

The water quality assessment report[4] (refer *Appendix 5.9*) provides a summary of water quality data for Port Curtis. A summary of outcomes is provided below.

11.5.6.1 *Baseline existing water quality data collation and review*

Key review outcomes were as follows:

- Port Curtis is a well connected estuary that allows dissolved material to be dispersed relatively evenly, however, material does not as readily leave the estuary to the offshore environment. This reduced flushing time is likely to contribute to the anomalous bioaccumulation of some metals in the biota (animal and plant life) of Port Curtis.
- The characters of the estuarine waters within Port Curtis are generally close to seawater.
- Nutrient, total organic carbon and biochemical oxygen demand concentrations appear generally low, consistent with high-quality estuarine water.
- Water clarity as defined by Secchi disc visibility is generally poor, being less than 2 m. Similarly, turbidities and suspended solids concentrations are moderate. Turbidity increases with depth and tidal velocity.
- Low *chlorophyll a* concentrations are characteristic of Port Curtis waters.
- Elevated metal concentrations can exist within the port.
- Trace element, cyanide and phenol concentrations do not appear to be elevated above typical seawater or the ANZECC guideline concentrations.[5]

When compared with relatively stringent water quality guidelines, water quality is generally good, though spatially variable. Some metal concentrations are high in places, and water quality objective may be exceeded at times.

11.5.6.2 *Baseline water quality data collection*

Water quality data collection snapshot surveys were undertaken in Port Curtis adjacent to the proposed LNG Facility to collect locally specific data. The following suite of measurements was undertaken:

- hand-held (YSI) physical water quality profiles
- water quality and sediment grab samples.

Key findings were as follows:

- Turbidity increases with depth and tidal velocity, most likely due to bottom sediment re-suspension.

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4 BMT WBM, 2009. Proposed QCLNG Facility EIS. *Marine Water Quality Assessments.*

5 Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC) (2000)

- pH and temperature are relatively uniform with depth (observed during both campaigns), with evidence of only slight thermal stratification.
- Salinity appears to be responsive to rainfall and associated inflow events.
- Catchment-derived pollutants may enter the area (either locally or remotely) with freshwater inflows.

11.5.7 *Hydrodynamic and Advection-Dispersion Numerical Modelling*

A hydrodynamic and advection-dispersion study was undertaken combining field assessments, mathematical modelling and expert interpretation in order to determine the significance of potential hydrodynamic and water quality changes, and also to guide potential management action interventions. [6] Assessment results are summarised below and included in full in *Appendix 5.9*[7] and *Appendix 5.11*[8].

11.5.7.1 *Hydrodynamic Impacts*

The following features were included in the hydrodynamic mesh to represent proposed works associated with the QCLNG Project, as well as other projects in the region:

- dredging of the QCLNG and GLNG swing basins
- dredging of access channels to the QCLNG Swing Basin (and proposed jetty) from existing Gladstone shipping channels (Targinie Channel) and proposed works to enable access to the adjacent GLNG project
- removal of shoals and other dredging works in and around the Clinton Channel
- construction of a proposed bridge from Friend Point/Kangaroo Island to Curtis Island, including relevant abutments
- an approach road to the proposed bridge, which crosses intertidal mud flats, was also included in a limited number of simulations.

The hydrodynamic impacts of the proposed works were found to have a negative minor direct impact, other than in the immediate vicinity of the

6 The assessment reported is relative only to the reference case. Results should be interpreted accordingly with the limitations associated with the modelling. The model bathymetry and calibration status in and around the Fisherman's Landing area and associated tidal flats is uncertain, and as such the results from the model in this area should be treated with caution and not be relied on for detailed assessments. This applies to the reference case, as well as the various reclamation options. The proposed features included in the reference case (dredging, reclamation and bridge) are based on layouts provided in late 2008. The dredging at Wiggins Island and the Targinie Channel widening has not been included in this assessment. This is likely to have a minor or nil effect on predicted results, as this is a relative assessment. The model mesh along the reclamation option layouts is relatively coarse. This is sufficient for a broad level impact assessment. However, subsequent modelling and assessment of the detailed characteristics of a preferred reclamation option should see mesh refinement in this area, in order to provide more robust hydrodynamic impact results.

7 BMT WBM, 2009. Proposed QCLNG Facility EIS – Marine Water Quality Assessment (unpublished report, R.B17241.002.00.doc

8 BMT WBM, 13 Feb 2009. Preliminary Hydrodynamic Assessment of Fishermans Landing Reclamations (unpublished memorandum)

proposed Swing Basin, where significant dredging will change velocities quite considerably.

11.5.7.2 Tidal Hydraulics

The extent of the tidal hydraulic system considered included the whole of the estuarine waters of Port Curtis and connected rivers/inlets. Tides propagate into the port from the south (south of Facing Island), east (between Facing Island and Curtis Island) and the north (from Keppel Bay into The Narrows). This results in complex interactions with the tidal waves meeting near the centre of The Narrows.

The large tidal range and extensive intertidal banks, mangrove and saltpan areas result in changes to the available storage areas at different tidal elevations. These changes cause the estuary to exhibit non-linear behaviour for tides of large range (i.e. tidal flow velocities and rate of rise and fall vary greatly depending on the extent of coverage of the saltpans and mangroves).

Tidal variations in this area are reasonably well understood from extensive recordings and analyses by the Queensland Government, and accurate predictions are available for Standard and Secondary ports in the region. The tidal times, heights and planes are published for the Standard Port of the Port of Gladstone at Auckland Point[9].

Secondary tidal planes are also published for a variety of locations in Port Curtis, such as The Narrows (Boat Creek and Ramsay Crossing) to the north. These, together with tidal planes for Fisherman's Landing obtained separately from Maritime Safety Queensland, are presented in *Table 5.11.6* as heights above the local Lowest Astronomical Tide (LAT) level.

Table 5.11.6 Gladstone Region Tidal Planes (m LAT)

Tidal Plane	Gladstone (Standard Port)	Fisherman's Landing	The Narrows (Boat Creek)	The Narrows (Ramsay Crossing)
Highest Astronomical Tide (HAT)	4.69	4.97	5.44	6.00
Mean High Water Springs (MHWS)	3.91	4.14	4.52	5.02
Mean High Water Neaps (MHWN)	3.06	3.24	3.53	3.95
Mean Level (ML)	2.35	2.439	2.68	3.01
Australian Height Datum (AHD)	2.268	2.429	-	-
Mean Low Water Neaps (MLWN)	1.52	1.61	1.73	2.00
Mean Low Water Springs	0.67	0.71	0.73	0.93

9 Maritime Safety Queensland. Port of Gladstone: Port Procedures & Information for Shipping. (April 2009)

Tidal Plane	Gladstone (Standard Port)	Fisherman's Landing	The Narrows (Boat Creek)	The Narrows (Ramsay Crossing)
(MLWS)				
Lowest Astronomical Tide (LAT)	0.00	0.00	0.00	0.00

Based on the above, the mean spring tidal range for Gladstone is 3.24 m, the mean neap tidal range is 1.54 m and the maximum tidal range is 4.69 m. The tidal range amplifies as it travels north with the range at Fisherman's Landing being approximately 6 per cent greater than at Gladstone (Auckland Point), and the range at Boat Creek in The Narrows being 17 per cent greater. As such, it is estimated that the tidal range at the site of the proposed LNG berths is about 6 per cent greater than at the Standard Port site (Auckland Point).

Due to the large tidal storage areas and the amplification effect on water levels, good tidal flushing and large tidal velocities exist within Port Curtis. Typically observed spring tide velocities within dredged shipping channels are up to around 2.0 m/s.

11.5.7.3 Tidal Flushing Impacts

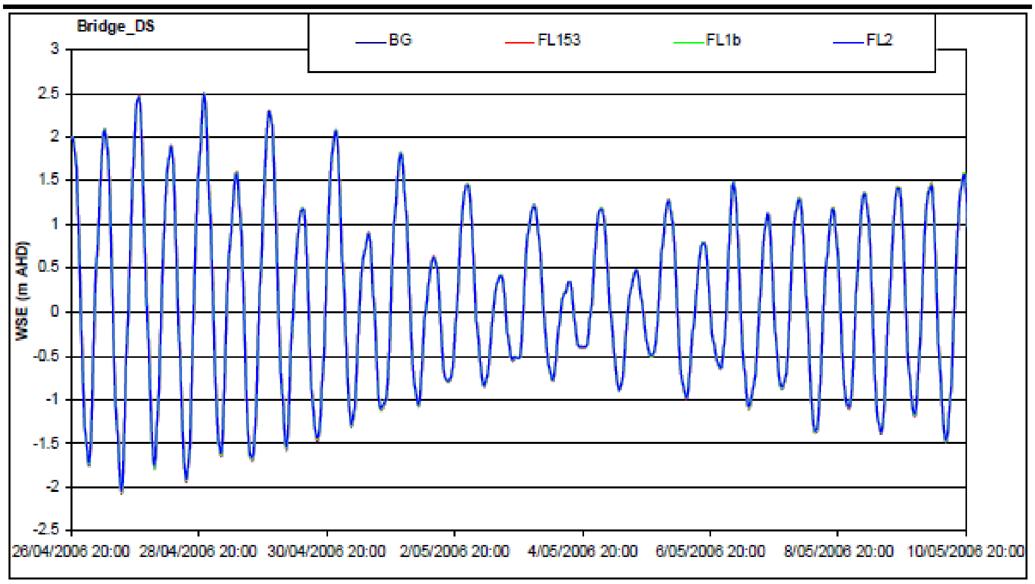
Tidal flushing times for the pre- and post-Project cases were estimated. In most cases, however, even though the model was run for a 45-day period, the required definitive 'e-folding' value (equivalent to 37 per cent flushing) was not reached and, as such, definitive flushing times cannot be reported. There were negligible direct impacts on flushing behaviour with and without the QCLNG Project.

11.5.7.4 Tidal Water Levels

Time series of water levels predicted downstream of the proposed bridge for each scenario were developed (refer *Figure 5.11.4* as an example).

An analysis of low- and high-water behaviours was undertaken for each scenario. Maximum changes at the selected locations are predicted to be in the order of 5 cm or less, with low-water changes the greatest. The maximum change was observed for The Narrows for reclamation option FL2, with low-water surface elevations (WSE) being increased by 4.5 cm compared to the QGC Reference Case.

Figure 5.11.4 Predicted Water Surface Elevation (WSE) Downstream of Bridge



For this specific low tide, other reclamation options impacts are as follows:

- FL2: low tide increased by 4.5 cm (i.e. from -1.733 m AHD to -1.688 m AHD)
- FL153: low tide increased by 3.5 cm (i.e. from -1.733 m AHD to -1.698 m AHD)
- FL1b: low tide increased by 2.8 cm (i.e. from -1.733 m AHD to -1.705 m AHD).

A 30-minute time shift in phasing of tides was also observed between the Reference Case and the various reclamation options at the high- and low-tide times. This phase shift was, however, not regular. Regardless, the model timestep is 30 minutes, so phase shifts of this order and smaller are difficult to resolve.

Overall changes in water surface elevations between the various reclamation cases and the QGC Reference Case are greatest during mid-ebb tides (rather than at low- or high-water). Differences of up to 11 cm are predicted within the main channel north-west of the QGC Reference Case Swing Basin, for example. However, these are largely due to the phase shift described previously.

Figure 5.11.5 shows an example of this change in water surface elevation within the main channel. All tidal ranges are reduced by the various reclamation options, with low waters being higher and high waters being lower than the QGC Reference Case.

Figure 5.11.5 Time series of WSE Within the Main Channel

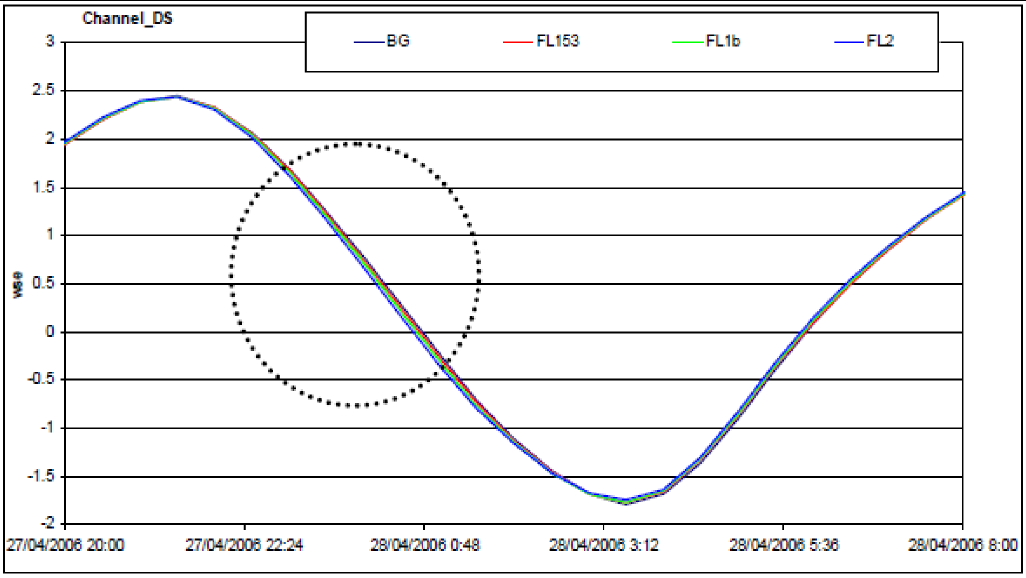


Table 5.11.7 summarises the percentage change in tidal range for a spring tide at all extraction locations, relative to the QGC scenario. The spring tide range is reduced by up to 1 per cent within the main channel to the north-west of the proposed QGC Swing Basin for the FL2 reclamation option.

Table 5.11.7 Percentage Change in Tide Range-Spring Tide

	FL153	FL1b	FL2
The Narrows	-0.2%	-0.5%	-0.9%
Channel US2	-0.3%	-0.5%	-0.8%
Channel US1	-0.3%	-0.5%	-0.8%
BdgUS	-0.3%	-0.5%	-0.9%
Graham Creek	-0.3%	-0.5%	-0.8%
QGC Basin	-0.4%	-0.6%	-0.9%
BdgDS	-0.3%	-0.5%	-0.9%
Channel DS	-0.4%	-0.7%	-1.0%[10]
Santos Basin	-0.3%	-0.6%	-0.9%
Auckland Point	-0.2%	-0.4%	-0.5%

Similarly, *Table 5.11.8* presents these same percentages as calculated over a neap tide. The neap tide range is reduced by up to 1.3 per cent in The Narrows for the FL2 reclamation option. Option FL153 is predicted to have the least direct impact on tidal water levels at the selected extraction locations.

10 Maximum change.

Table 5.11.8 Percentage Change in Tide Range – Neap Tide

	FL153	FL1b	FL2
The Narrows	-0.2%	-0.7%	-1.3%[11]
Channel US2	-0.1%	-0.5%	-1.1%
Channel US1	-0.1%	-0.5%	-1.0%
BdgUS	-0.1%	-0.5%	-1.1%
Graham Creek	-0.1%	-0.4%	-0.9%
QGC Basin	-0.2%	-0.6%	-1.0%
BdgDS	-0.1%	-0.5%	-1.1%
Channel DS	-0.3%	-0.6%	-1.2%
Santos Basin	-0.2%	-0.5%	-1.0%
Auckland Point	-0.2%	-0.4%	-0.8%

11.5.7.5 Tidal Velocities

Contour plots of predicted velocity magnitude impacts were created for a snapshot of typical spring ebb and spring flood tide conditions respectively. They are presented in *Figure 5.11.6* to *Figure 5.11.11*, with velocity magnitude changes given by the colour bars.

Absolute velocity directions (not differences) for the reclamation cases have also been plotted on those figures. The impacts vary in space and intensity with time. In particular, the greatest direct impacts around Fisherman's Landing and the main channel areas are not co-temporal.

To illustrate this, two different plots are presented for all scenarios, which correspond to two different times within the tidal cycle. The times presented are not necessarily the same for all scenarios, but have been chosen to illustrate the greatest direct impacts near the reclamations and channels.

General patterns show decreases in velocity magnitudes downstream (south-east) of the Fisherman's Landing reclamation site(s), within the main channel. Clearly, velocities induced by the proposed channels within various reclamation options (those that involve islands) are greater than those at the same locations in the QGC scenario, due to channelling of tidal flows.

11 Maximum change.

Similarly, some significant residual velocities around the northern end of the FL153 scenario reclamation area are predicted. These are most likely due to the alteration of the flow path required to fill (and drain) the tidal storage behind the reclamation area. In the QGC case, this filling (or draining) was achieved primarily by relatively low-flow velocities across the intertidal areas, whereas in scenario FL153 this filling (or draining) occurs by flow around the northern end of the reclamation area and back southwards again, generating strong currents around the reclamation area.

Figure 5.11.6 Velocity Magnitude Impacts – FL153 – Ebb Tide

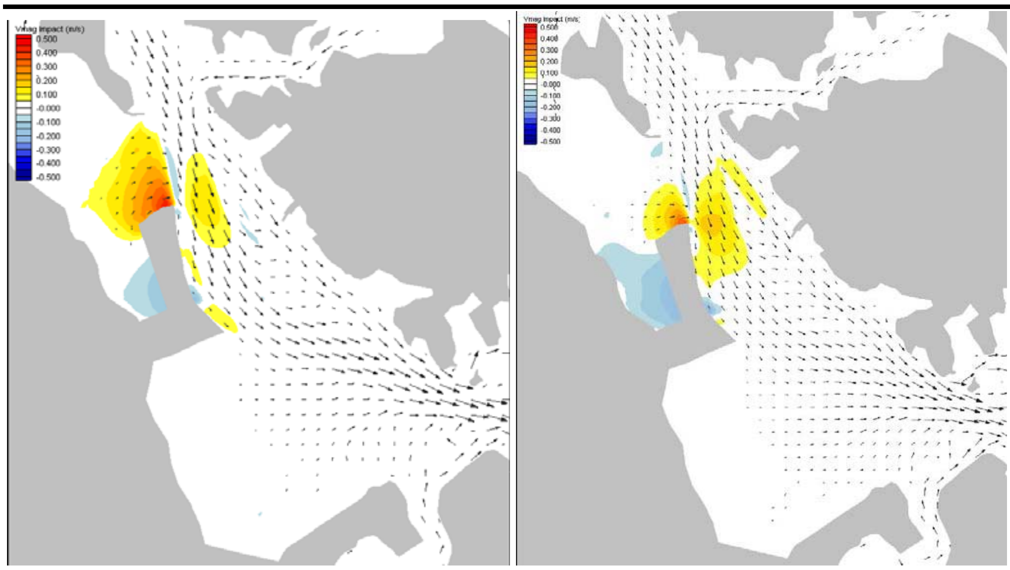


Figure 5.11.7 Velocity Magnitude Impacts – FL1b – Ebb Tide

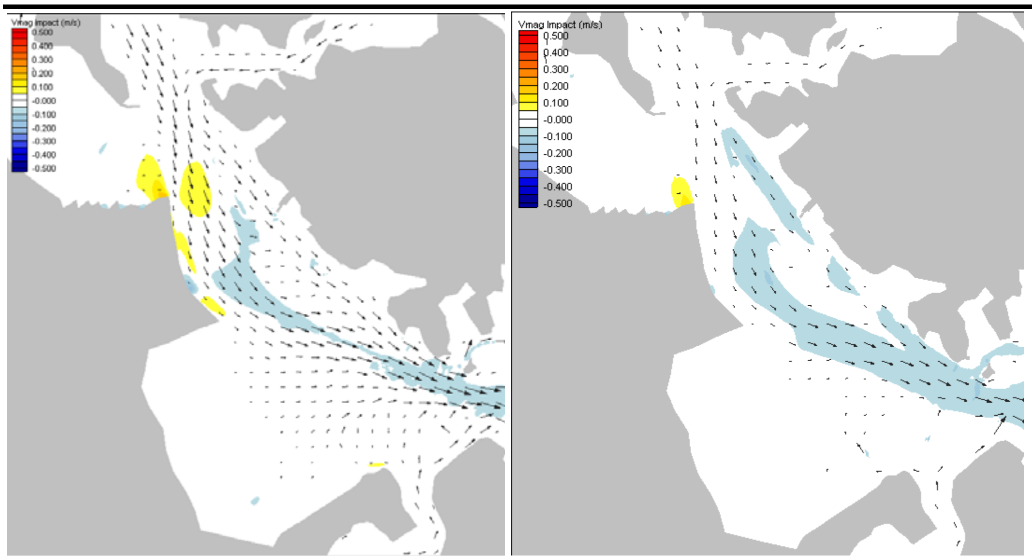


Figure 5.11.8 Velocity Magnitude Impacts – FL2 – Ebb Tide

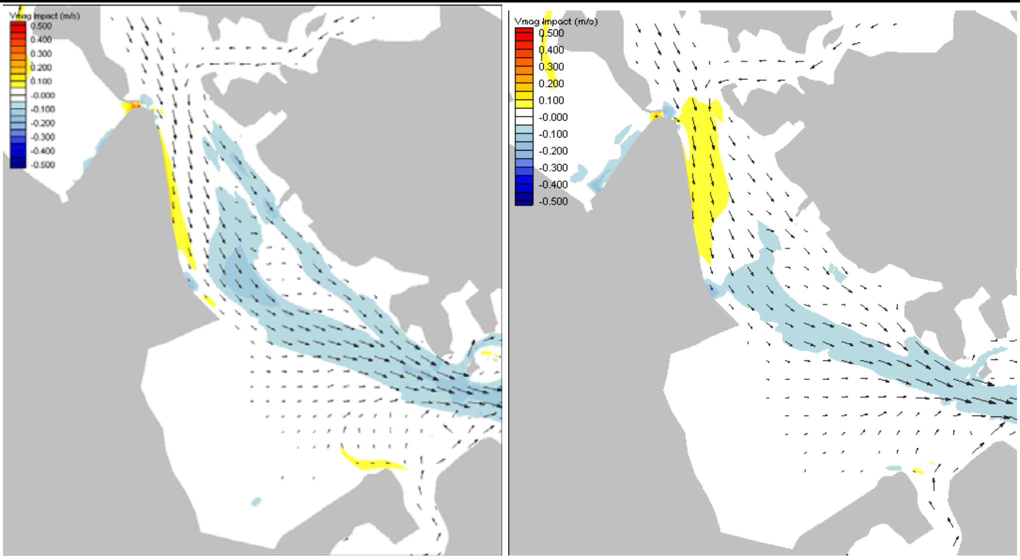


Figure 5.11.9 Velocity Magnitude Impacts – FL153 – Flood Tide

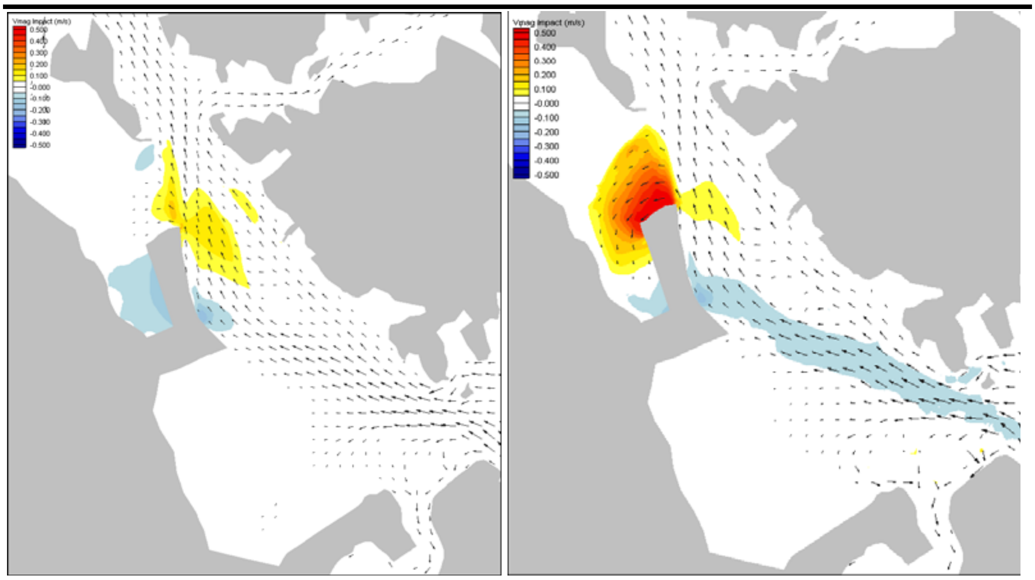


Figure 5.11.10 Velocity Magnitude Impacts – FL1b – Flood Tide

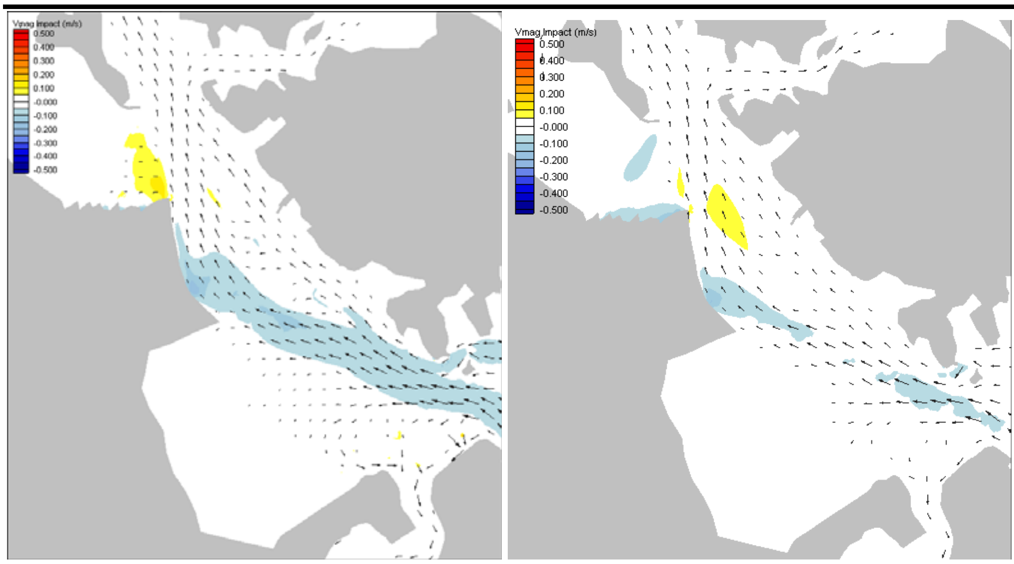
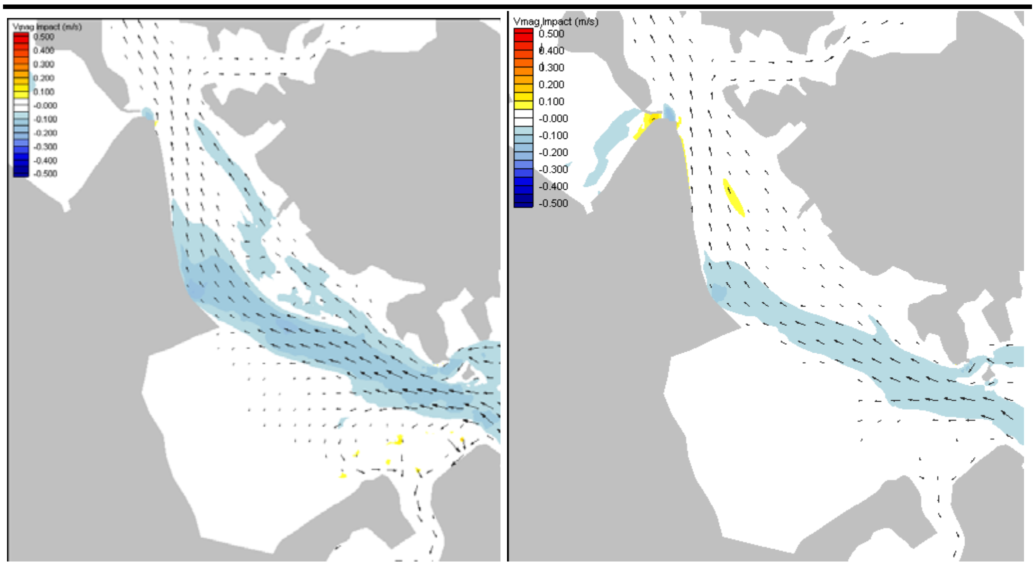


Figure 5.11.11 Velocity Magnitude Impacts – FL2 – Flood Tide



A percentile analysis was also performed on velocity magnitudes for all scenarios. *Figure 5.11.12* to *Figure 5.11.16* present the results of this analysis at selected time series extraction locations within Port Curtis. The impact of the various reclamation options (relative to the reference case) is negligible upstream (north) of the proposed bridge. Within the QGC and Santos swing basins, the occurrence of velocity magnitudes greater than 0.20 m/s is predicted to be increased by approximately 4 per cent to 6 per cent, the maximum change being predicted for reclamation FL2.

Figure 5.11.12 Velocity Magnitude Percentiles – The Narrows

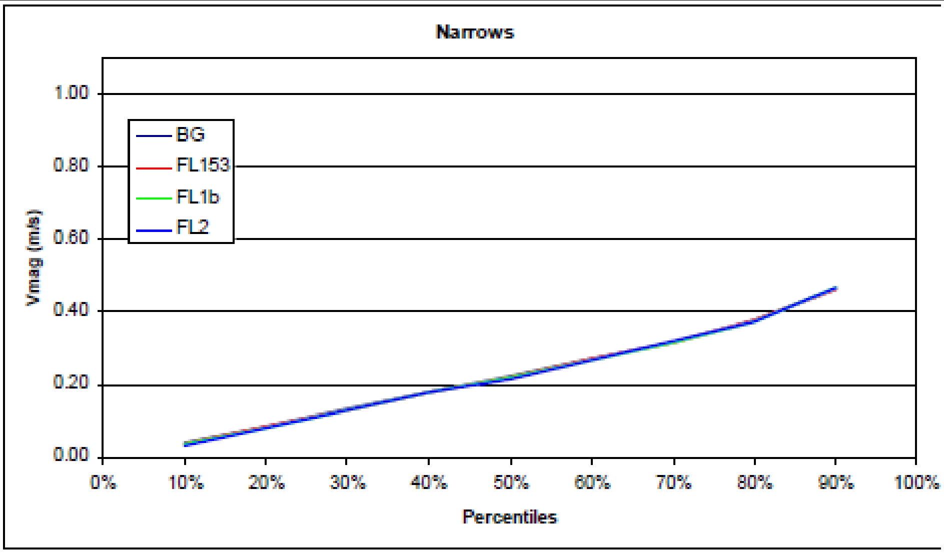


Figure 5.11.13 Velocity Magnitude Percentiles – Downstream of Bridge

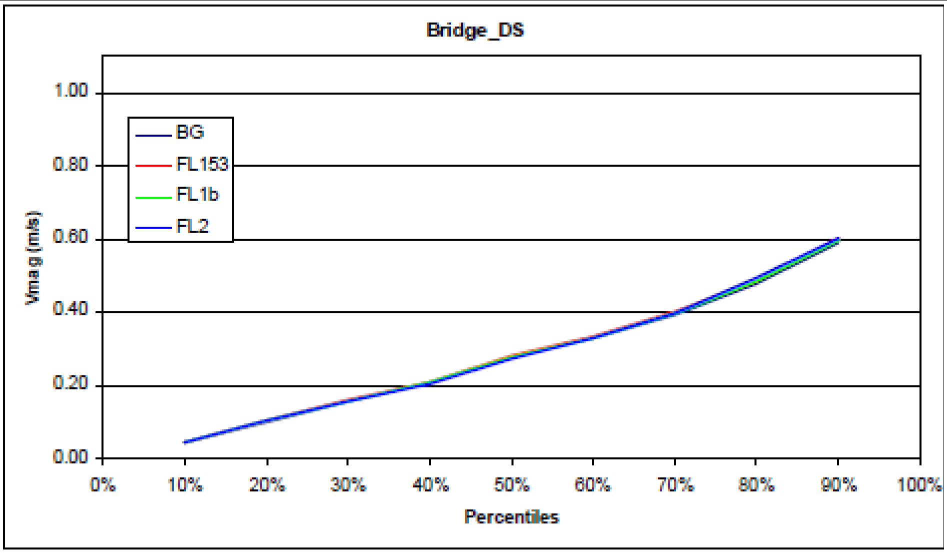


Figure 5.11.14 Velocity Magnitude Percentiles – QGC Swing Basin

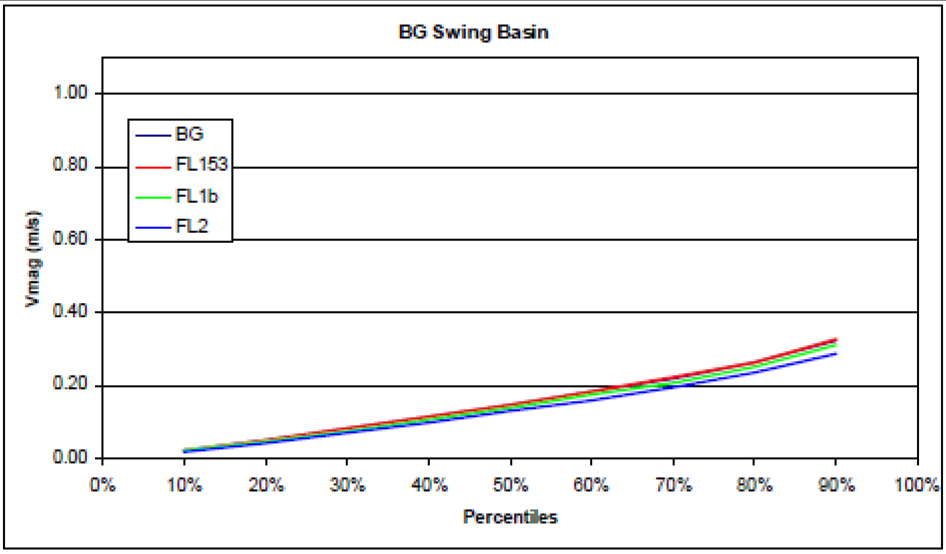


Figure 5.11.15 Velocity Magnitude Percentiles – Santos Swing Basin

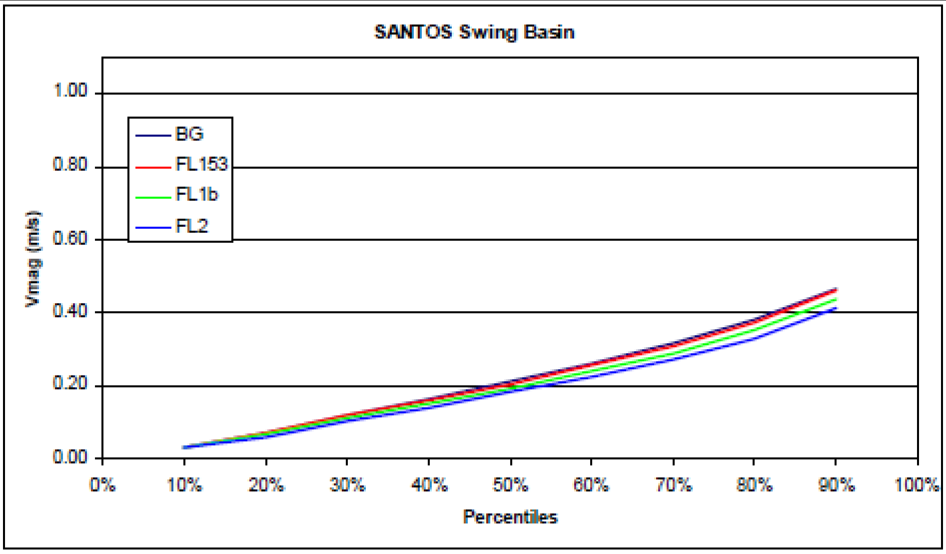
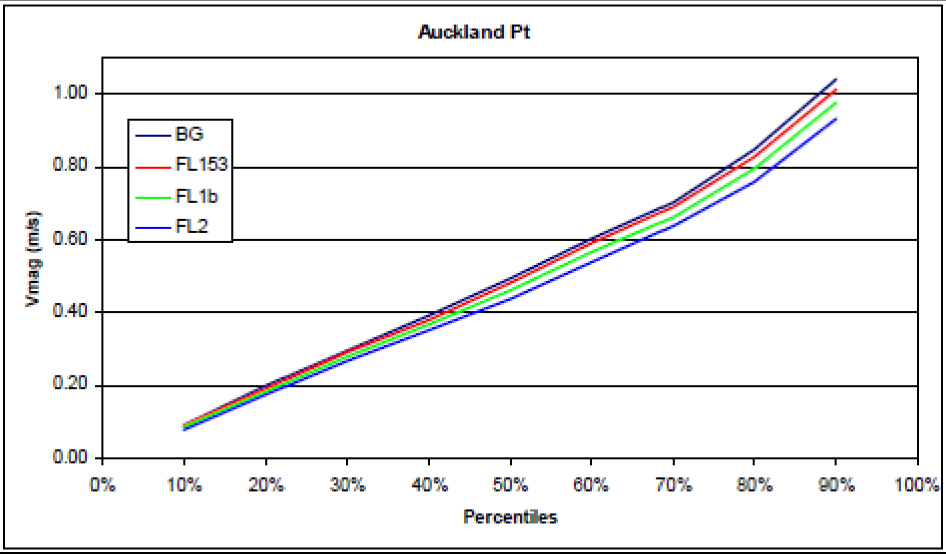


Figure 5.11.16 Velocity Magnitude Percentiles – Auckland Point



11.5.7.6 *Tidal Flows*

Flows through Port Curtis were assessed for each scenario along four profiles, as shown in *Figure 5.11.17*.

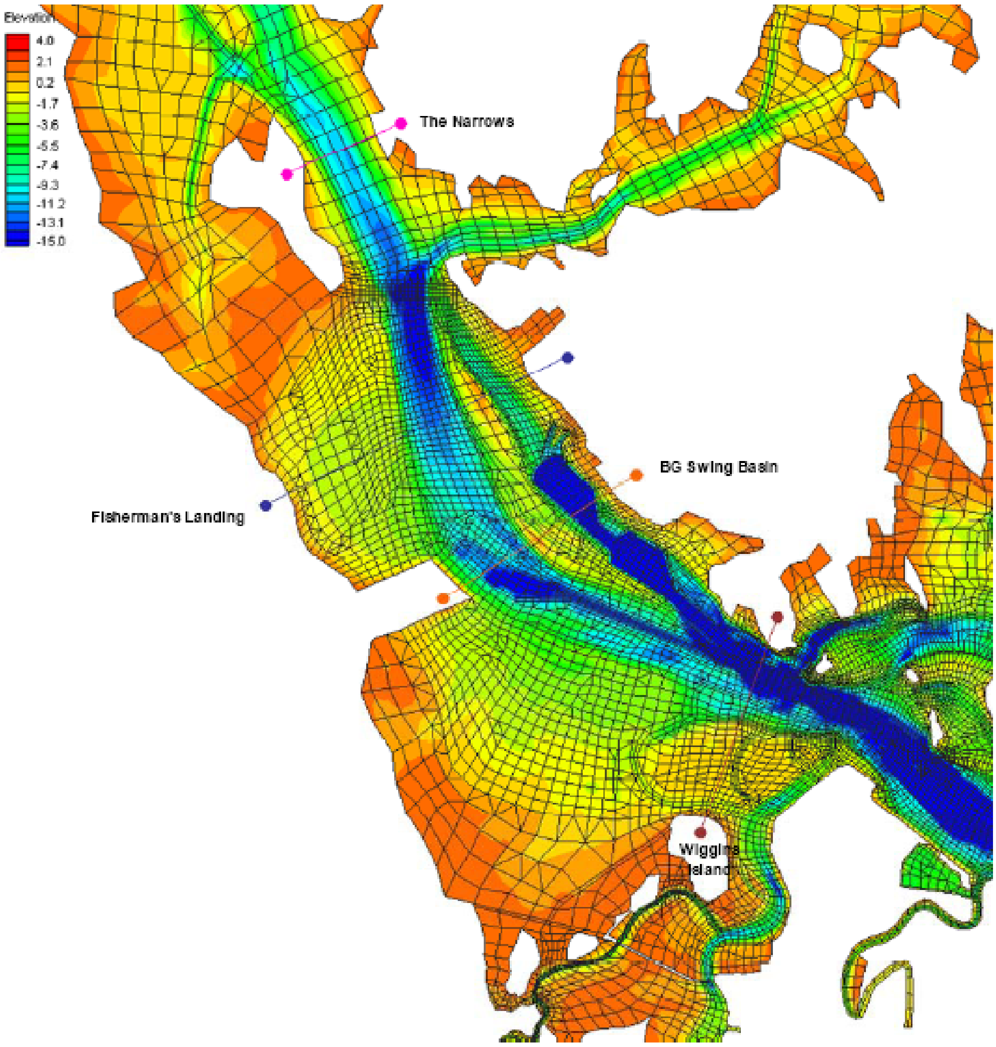
Table 5.11.9 presents the percentage change in maximum flow rate predicted (over the entire simulation period) along these profiles for each reclamation option, compared to the reference case. Increases of up to 25 per cent are predicted along the Fisherman's Landing profile for option FL153. These changes in maximum flow propagate upstream into The Narrows, but with a reduced influence. These increases are dominated by the induced circulations around the northern end of the reclamation. Decreases of up to 20 per cent are predicted along the QGC Swing Basin profile for scenario FL2, consistent with a reduced tidal prism and the reduced velocities presented earlier.

Table 5.11.9 Percentage Change in Maximum Flow

	Narrows	FL	QGC	Wiggins
FL153	1%	25%	-4%	-2%
FL1b	3%	16%	-10%	-6%
FL2	5%	0%	-20%	-13%

It is noted that the Fisherman's Landing transect is directly impacted by the proposed filling and reclamation for each option. In particular, scenario FL2 shows a zero per cent change in flow rates for this transect. However, all the flow has to transit through a reduced section – by nearly 50 per cent in width – given the proposed filling of the entire Fisherman's Landing area.

Figure 5.11.17 Flow Extraction Profiles



Time series of flows through the selected profiles are also shown in *Figure 5.11.18* to *Figure 5.11.21* for each scenario. The major changes in flow rates are predicted at peak ebb and flood tides, and this is demonstrated in Figure 5.11.22, which is temporal zoom of predicted flow data through the Fisherman's Landing transect.

Figure 5.11.18 Flow Time Series through The Narrows Profile

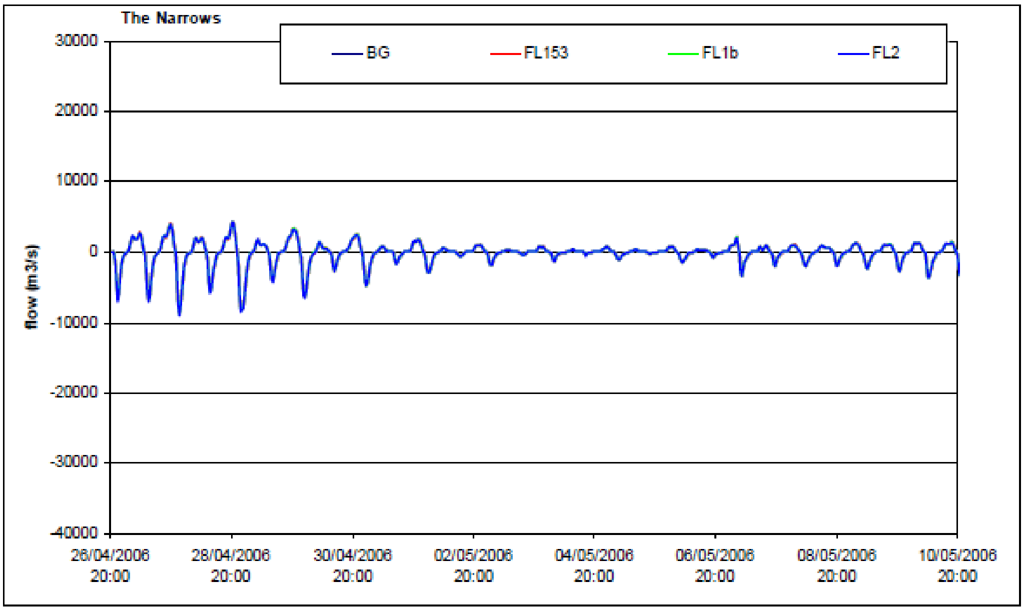


Figure 5.11.19 Flow Time Series through Fisherman's Landing Profile

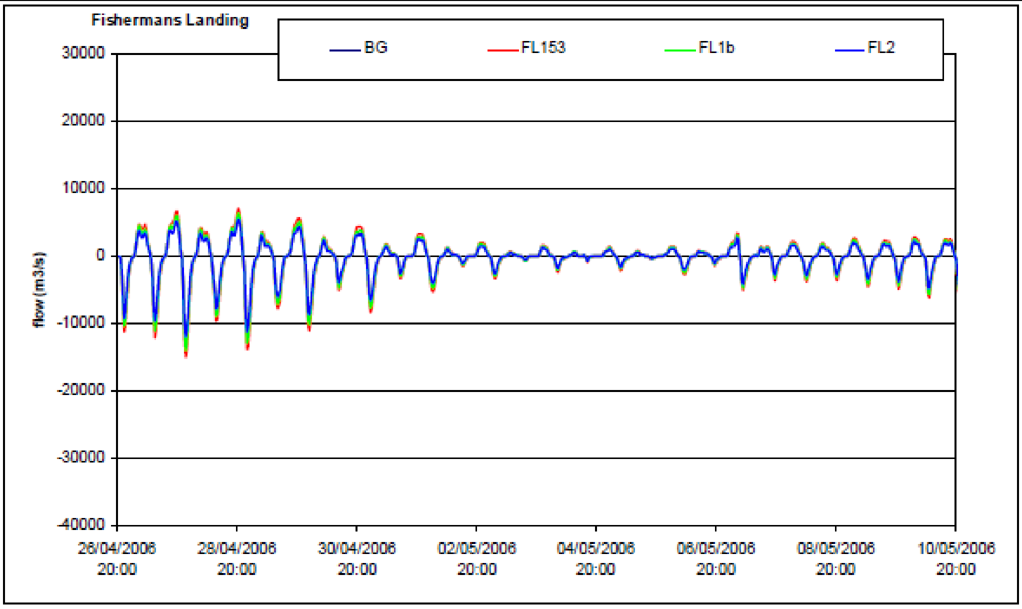


Figure 5.11.20 Flow Time Series through QGC Swing Basin Profile

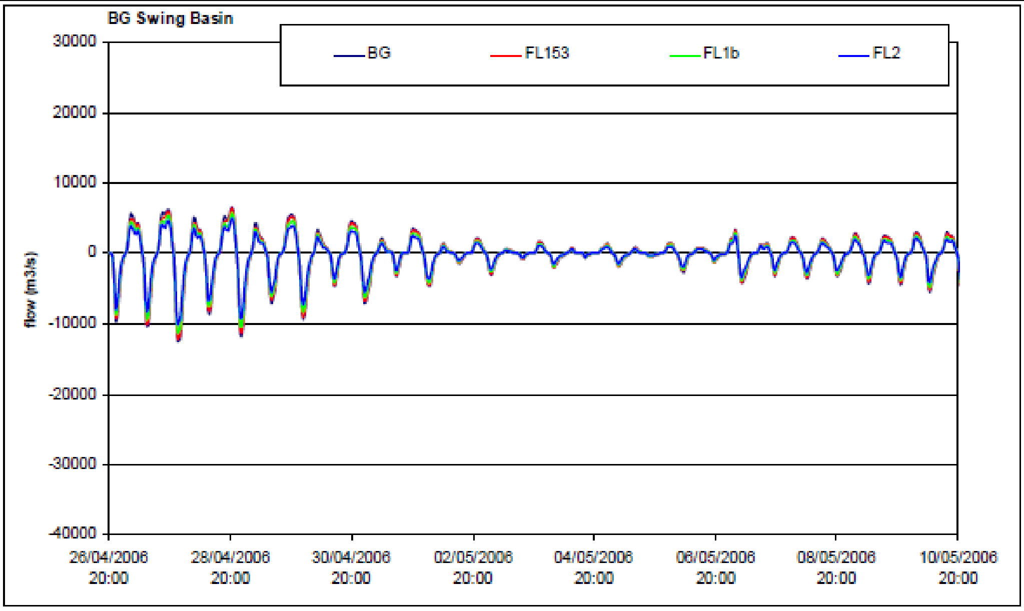


Figure 5.11.21 Flow Time Series through Auckland Point Profile

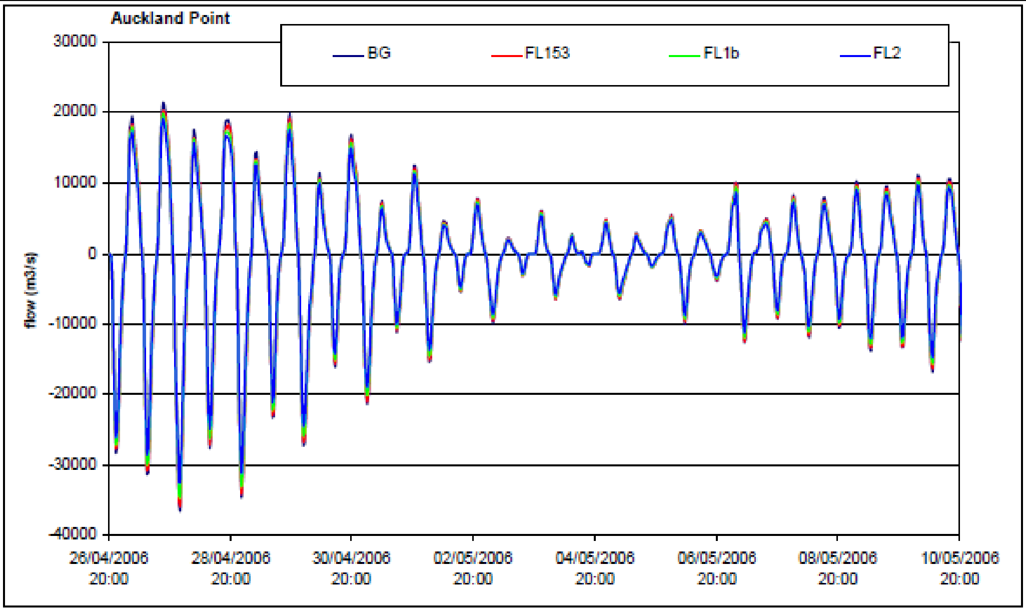
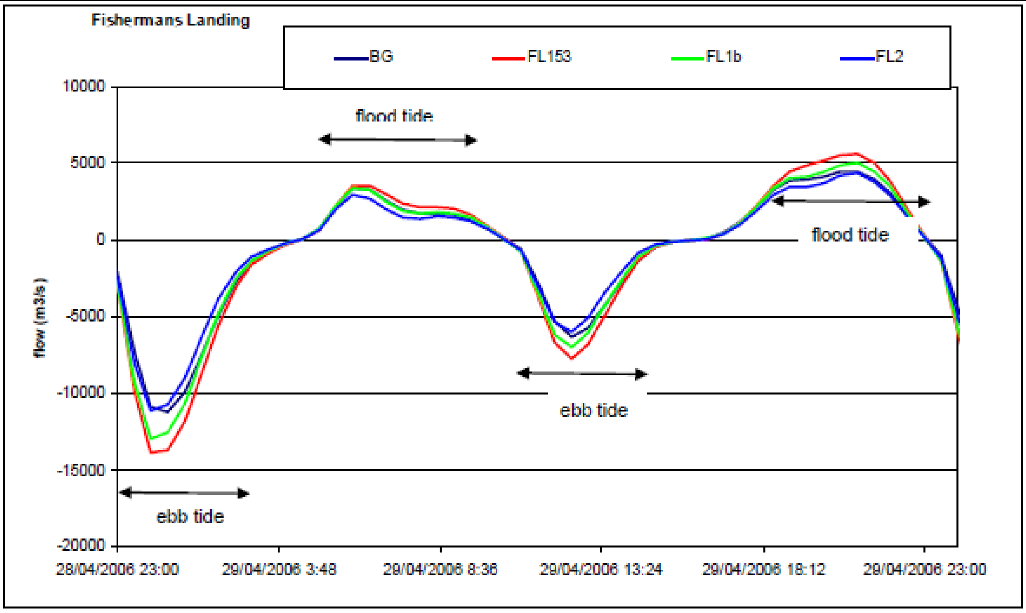


Figure 5.11.22 Flow Time Series through Fisherman's Landing Profile – Zoom



11.5.8 Coastal Process Assessment

A coastal process assessment was undertaken addressing associated potential impacts of the Project on water levels, waves, shoreline behaviour and potential siltation. Assessment results are summarised below and are included in full in *Appendix 5.10.*[12]

11.5.8.1 Elevated Water Levels

Water levels along the coast during cyclones may be substantially higher than normal tides due to storm surge effects. Storm surges are increases in water level caused by onshore wind stresses and reduced atmospheric pressure. The storm tide level is the result of tide plus surge. The surge may peak at any stage of the tidal cycle. Hence, abnormally high storm tide levels may result from extreme surge peaks coinciding with moderate to high tides, or moderate surges coinciding with high tides. The probability of an extreme surge peak coinciding with a spring high tide is low.

A comprehensive study[13] of storm tide probabilities in the Yeppoon region was undertaken for the Beach Protection Authority and the nearest calculation sites for this study were at the Fitzroy River entrance and at Cape Capricorn on Curtis Island. The calculated 100-year ARI storm tide levels (excluding wave set-up) at these sites were 3.5 m AHD and 2.9 m AHD respectively. Any storm surge on the open coast will propagate into Port Curtis and also be influenced by local processes.

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12 BMT WBM, 2009. *Proposed QCLNG Facility EIS – Coastal Process Assessments* (unpublished report, R.B17241.004.00.coastal.doc

13 Blain Bremner and Williams (1985).

A more recent comprehensive study by the Queensland Government[14] examined storm tide vulnerability and potential increases in sea level from greenhouse and more intense cyclonic effects on coastal communities. The report included calculated storm tide levels at Gladstone and incorporated more detailed modelling on a near-shore grid of approximately 550 m, which extended into Port Curtis.

The predicted storm tide levels in the region from the study are listed in *Table 5.11.10* for various recurrence intervals, excluding wave-set up and climate-change effects.

Table 5.11.10 Peak Storm Tide Levels (Present Day 2003)

Location	Storm Tide level (m AHD)[15]		
	100 year ARI	**500 year ARI**	**1000 year ARI**
Gladstone	2.82	3.51	3.8
Tannum Sands	2.50	3.05	3.31

There is some increase in the predicted storm tide level moving into Port Curtis from the south. The resolution of the model (approximately 550 m) is such that not all features could be accurately represented. Nevertheless, the trend is consistent with the increase of the normal astronomical tide. On this basis, it is anticipated that a further small increase will occur to the LNG site. A 6 per cent increase (similar to the astronomical tide amplification) gives storm tide levels of about 2.99 m, 3.72 m and 4.03 m AHD for 100-year, 500-year and 1000-year ARI events respectively.

The above storm tide levels do not contain provisions for sea-level rise due to greenhouse effects, other climate-change influences or wave set-up and run-up. Wave set-up and run-up only occur near or at the shoreline and therefore will not influence levels at the berths. Onshore facilities are in protected locations where wave conditions and any associated set-up/run-up will be minimal. An additional allowance of 0.1-0.2 m for wave set-up will be adequate. With respect to climate change, this is addressed in *Volume 5 Chapter 2*.

It is reported[16] that global sea level rise is projected to be 18 cm to 59 cm by 2100 relative to 1990 levels. These projections do not include a contribution from ice flow rates, however, if these were to continue to grow linearly with global warming then the upper ranges of sea level rise would increase by a further 10 cm to 20 cm (by 2100 relative to 1990) (IPCC, 2007). There is an acknowledged risk that the contribution of ice sheets to sea level rise this century may be substantially higher than this.

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14 Queensland Climate Change and Community Vulnerability to Tropical Cyclones: Ocean Hazards Assessment – Stage 3 Report", (James Cook University, 2004).

15 Queensland Climate Change and Community Vulnerability to Tropical Cyclones: Ocean Hazards Assessment – Stage 3 Report", (James Cook University, 2004).

16 IPCC (2007) The Fourth Assessment Report of the International Panel on Climate Change (2007).

The climate models predict that there will be a significant regional variation in future sea level rise, predominantly due to spatial variations in the contribution made by ocean thermal expansion.

Reported predictions[17] indicate that future sea-level rise along the eastern Australian coastline may be up to 12 cm greater than the global average by 2100.

In summary, the total mean sea level rise along the eastern Australian coastline is estimated to be in the range 28 cm to 91 cm by 2100. This will occur gradually at first and continue to accelerate from the historic rate of 1.7 mm per year and then more rapidly as 2100 is approached.

The potential implications for storm tide statistics of the following three specific greenhouse scenarios[18] were considered:

- combined effect of an increase in Maximum Potential Intensity (MPI) of 10 per cent and a poleward shift in tracks of 1.3 degrees
- increase in frequency/intensity of tropical cyclones of 10 per cent
- mean sea level rise of 300 mm.

The mean sea level rise component has an almost linear effect on the resultant storm tide levels while the increase in cyclone frequency/intensity has negligible impact. The combined increase in intensity and poleward shift in tracks becomes increasingly significant with large return periods.

The resultant storm tide levels predicted with the combined greenhouse scenarios are presented in *Table 5.11.11*.

Table 5.11.11 Peak Storm Tide Levels (combined greenhouse scenarios over 50-year planning period)

Location	Storm Tide level (m AHD)[19]		
	100-year ARI	500-year ARI	1000-year ARI
Gladstone	3.33	4.18	4.51
Tannum Sands	2.95	3.64	3.94

The report[20] emphasises that the chosen values in the greenhouse scenarios are not necessarily endorsed, although care has been taken to propose reasonable values. The intention is to demonstrate the sensitivity of the storm tide frequency curves to climate-change scenarios.

17 CSIRO (2007).

18 James Cook University, 2004. Queensland Climate Change and Community Vulnerability to Tropical Cyclones: Ocean Hazards Assessment - Stage 3.

19 Queensland Climate Change and Community Vulnerability to Tropical Cyclones: Ocean Hazards Assessment – Stage 3 Report", (James Cook University, 2004).

20 James Cook University, 2004. Queensland Climate Change and Community Vulnerability to Tropical Cyclones: Ocean Hazards Assessment - Stage 3

It should be noted the use of 0.3 m for mean sea level rise is also supported by other Queensland Government policies, though it should be further noted that this value was derived for a 50-year planning period. For a 100-year planning period, a mean sea level rise based on IPCC (2007) of 55 cm (mid range) to 91 cm (high-range) is considered to be an appropriate allowance. The mid-to-high range storm tide levels for combined greenhouse scenarios over a 100-year planning period are provided in *Table 5.11.12*.

Table 5.11.12 Peak Storm Tide Levels (combined greenhouse scenarios over 100-year planning period)

Location	Storm Tide level (m AHD)[21]		
	100-year ARI	500-year ARI	1000-year ARI
Gladstone	3.58/3.94[22]	4.43/4.79	4.76/5.12
Tannum Sands	3.20/3.56	3.89/4.25	4.19/4.55

The choice of a 50-year or 100-year planning period should be based upon an assessment of the component lifetime, risk of failure and options for future adaptation to changing climate conditions.

When choosing between mid- and high-range values, the precautionary principle was applied in weighing up the risk of failure and options for future adaptation. Adopting the above greenhouse scenarios with a further 6 per cent allowance for amplification to the LNG site gives a 100-year ARI design storm tide level of 3.53 to 4.18 m AHD, including allowances for future climate change (mid-range or high-range). This is approximately 0.54 to 1.19 m higher than the 100-year ARI design storm tide level of 2.99 m AHD referred to above.

It is not expected that the jetty or MOF facilities (solid or piled) will have any significant direct impact on water levels at the LNG Facility site.

11.5.8.2 Wave Climate

Wave action can be important directly through its influence on structures as well as indirectly for coastal processes, through its influences on currents and in mobilising bed sediments.

Facing Island and Curtis Island effectively protect the site from ocean-generated sea and swell waves. As such, it is in a sheltered estuarine environment and only exposed to locally generated waves within Port Curtis. The largest fetches for the LNG berths are to south-west to south-east and north-west.

21 James Cook University, 2004. Queensland Climate Change and Community Vulnerability to Tropical Cyclones: Ocean Hazards Assessment - Stage 3

22 Mid-range/high-range sea level rise by 2100.

These fetch distances are all relatively short and confined to less than 10 km. Although not directly in line with longer fetches, there may be some propagation of wind waves along the deeper channels to the south-east.

Wave modelling has been undertaken with the potential for offshore swell penetration into the harbour as well as locally generated sea waves under cyclonic conditions being assessed using the SWAN wave modelling software. Both scenarios used an adopted peak water level of 3.43 m AHD, representing approximately the 100-year ARI storm tide level, with allowances for climate change influences. Although this is 0.1 m lower than the elevated water levels calculated above, this value was used because it is consistent with previous studies in the area, and the level difference will have negligible impact on the wave heights calculated.

The modelling indicated that there is essentially no ocean swell penetration to the site, as long-period ocean swells are generally blocked by Facing Island and the southern boundary of the harbour westwards from South Trees Inlet. Swell does not propagate far enough into the Port of Gladstone to have a significant direct impact at the location of the proposed LNG Facility.

Local wind waves were modelled for non-cyclonic conditions based on local wind records. For cyclonic conditions, a wind speed of 50 m/s and a variety of wind directions were adopted, with a water level of 3.43 m AHD, approximately corresponding to a 100-year ARI storm tide.

The non-cyclonic wave assessment is summarised in *Table 5.11.13* and indicates that, at a nearshore location with a bed level at -4.5m AHD, significant wave heights do not exceed 0.6 m for 99.5 per cent of the time, with 64 per cent coming from the 150-degree sector. A further 9 per cent comes from the adjacent sectors of 120 and 180 degrees.

For cyclonic conditions, significant wave heights at the proposed LNG Facility were found to be greatest for winds from the south-westerly quadrant, due to the relatively unconstricted fetch in this direction. The 50 m/s wind generated significant wave heights (Hs) of between 2.5 m and 3 m, depending on direction, in the channel offshore from the LNG Facility. No assessment was made of the annual exceedance probability of the combinations of wind speed, direction and water level for cyclonic conditions.

Table 5.11.13 Wave Occurrence at Nearshore site (-4.5m AHD)

% Time	**Direction**											
Hs	0	60	90	120	150	180	210	240	270	300	330	Total
<0.1	6.2			2.4	23.8	0.7		0.6	0.3	2.5	3.6	40.0
0.1-0.3		0.9	0.3	1.6	29.6	4.1	3.0	4.0	1.2	0.1	3.4	48.2
0.3-0.5			0.0	0.0	9.8	0.2	0.2	0.5	0.1		0.1	10.9
0.5-0.7	0		0.0	0.0	0.8	0.0	0.0	0.0	0.0		0.0	0.8
0.7-0.9					0.0	0.0		0.0				0.0
0.9-1.1					0.0	0.0						0.0
>1.1					0.0	0.0						0.0
Total	6.2	0.9	0.3	4.0	64	5.0	3.2	5.1	1.6	2.6	7.1	100

It is not expected that the jetty or MOF facilities (solid or piled) will have any significant direct impact on wave conditions at the site.

11.5.8.3 Coastal Processes

The shoreline at the site is characterised by fringing mangroves with a flat intertidal zone. There are no sandy beaches or dunes at the site or along the adjacent shoreline. The presence of mangroves along the western shoreline of Curtis Island and at the proposed LNG Facility site indicates that the coastal processes are generally benign and conducive to the settling of fine silts.

The ambient condition (non-cyclonic) wave analysis indicated that at a nearshore location with a bed level at -4.5m AHD, the dominant wave direction is from 150 degrees. The wave heights are low, with about 98 per cent less than 0.3 m Hs. This combination of low wave height with a direction that is predominantly parallel to the shore indicates that there will be very low sediment transport activity associated with these waves. This provides an environment suitable for mangrove growth as exhibited.

In cyclonic conditions a much more adverse scenario is anticipated, however, this will have only a short-term impact, and it is expected that sediment movement will be constrained by the build up of mangroves during ambient periods.

The main jetty and wharf facilities at the site are to be piled seaward of the fringing mangroves. Accordingly, these structures will not have any significant direct impact on waves, currents and shoreline processes at or adjacent to the LNG Facility.

The MOF structure extends across the intertidal flats at an angle to the mangrove shoreline, with a seaward protrusion of about 125 m perpendicular to the mangrove fringe. The possibility of the structure being completely solid or piled predominantly seaward of the mangrove fringe is being considered. The seaward end of the structure is landward of the Lowest Astronomical Tide mark with a dredged approach channel. The dredging also extends along both sides of the structure.

Neither the solid or piled options for the MOF are expected to have any significant direct impact on shoreline processes adjacent to the LNG Facility. As outlined above, any longshore sediment transport activity is low and there are no sandy beaches. The predominantly piled option will have negligible direct impact on prevailing wave conditions and associated processes. The solid option will generate small localised zones of reduced waves on either side, depending on the direction of approach.

Currents in the shallow intertidal area are low, and the solid option as well as the adjacent dredging will create localised quiescent zones. As such, there may be small localised sediment build up adjacent to MOF facilities and siltation of the dredged areas.

11.5.8.4 Potential Siltation

History of Dredging and Siltation

Knowledge of the history of dredging and siltation is important with respect to the potential mobility of the sediments and potential build-up of silt. The nearby Targinie and Clinton channels, as well as the Fisherman's Landing Swing Basin and berth pockets, are maintained at various depths for navigation purposes.

Maintenance dredging is typically carried out in the Port on an annual basis in different areas as needed. *Table 5.11.14* presents details of maintenance dredging in the vicinity of the LNG Facility site over the past seven years, as determined from dredge log details provided by the Port of Brisbane Corporation (which undertakes the dredging). Various capital (development) dredging works have also been carried out during this period.

The relatively small quantities of maintenance dredging reflect the negligible siltation. This in turn indicates that there is limited sediment transport and/or that the currents/ship movements are sufficient to keep the sediments in suspension and not settle out in the dredged areas.

Table 5.11.14 Historic Dredging Quantities

Location	Dredging Quantities (m3)						
	2007	**2006**	**2005**	**2004**	**2003**	**2002**	**2000**
Clinton Berths	3800	7600	10,300 (3 berths)	9700 (5 berths)	3150 (3 berths)	-	2000 (2 berths)
Clinton Bypass Channel	3900	2500	800	14,500	DEV+ MAIN[23]	-	DEV+ MAIN[24]
Clinton Swing Basin	4200	4300	5300	7800	400	-	1000
Targinie Ch	14,600	17,600	12,300	42,500	DEV[25]	DEV[26]	3600
Targinie Swing Basin	4400	3900	1900	-	-	-	-
Fisherman's Landing Berth	-	1900	-	-	1400	6500	600

Examination of historical hydrographical surveys also confirms that, in general, siltation of the channels and Swing Basins occurs at a rate of around 1 to 5 cm/annum. At a couple of siltation "hotspots", for instance, a section of the Targinie Channel adjacent to the passage island shoals, build up may occur at a slightly higher rate of up to about 10 cm/annum.

Sediment Characteristics and Mobility

Data on the nature of the seabed sediments and those to be dredged have been obtained through previous studies and further specific investigations for this Project. The sediments in the main channel/berth area to be dredged are a mixture of gravels, sands, silts and clays. The surface sediments in the high current areas are typically the coarser fractions, with the finer particles being swept away.

The shallower intertidal areas are again a mixture of sands and silts, with fine soft silts dominating in the lower current/wave energy areas. Mobilisation and transport of bed sediments may occur as a result of the combined action of waves and currents. The influence of waves is affected by water depth. Wave orbital velocities decrease with depth depending on the wave period (and thus wave length). Shorter period waves have less influence at greater depth.

The short period/low wave height conditions in the port are such that wave action does not play a significant role in sediment transport processes in the deeper channels. However, the small waves can be important in mobilising the

23 32,0000.

24 46,400.

25 95,000.

26 38,0000.

fine sediments in shallower areas. Vessel movement also has potential to mobilise sediments. Once mobilised, these fine sediments are carried by the prevailing currents and will settle typically in areas of lower wave/current energy and/or when prevailing conditions moderate.

11.5.8.5 *Sand Transport Potential*

The potential for sand transport under tidal current action has been estimated by applying the Meyer-Peter-Muller bed load formula (Nielsen, 1992) to the simulated hydrodynamic results. It should be noted that the sediment transport potential calculations assume that the bed is uniformly mobile with a sand-sized sediment grain size of 1 mm and, hence, do not account for the presence of non-erodible rocky outcrops.

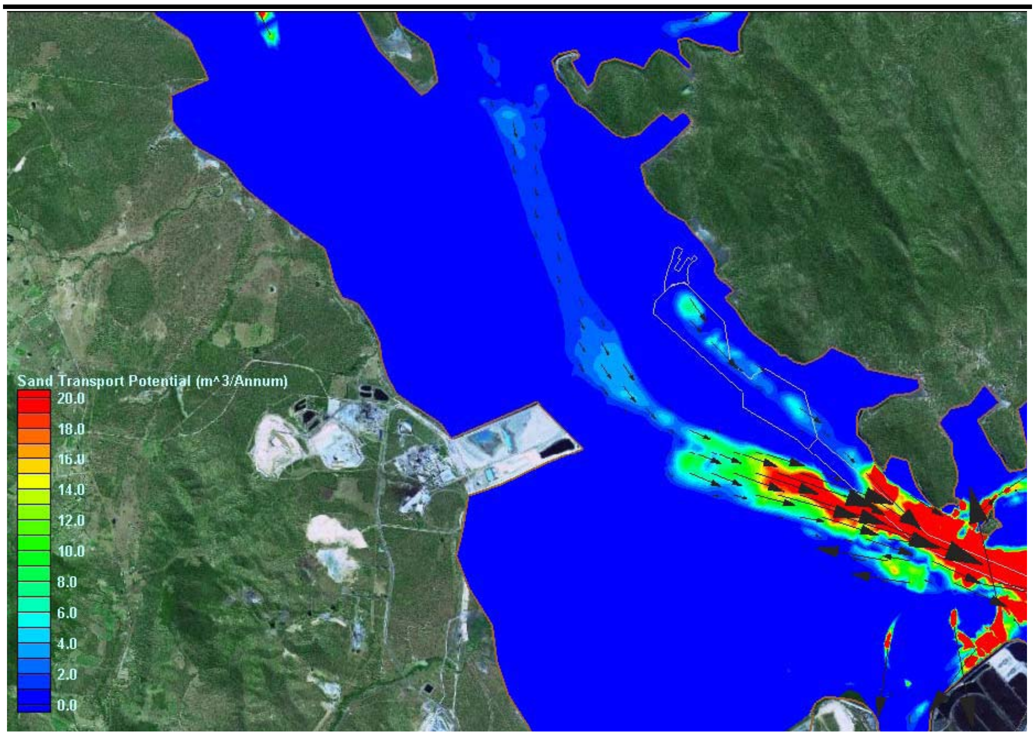
During large spring tides, the strong ebb tide currents generate a high sediment transport potential to the south-east. The flood tide currents are somewhat weaker and generate less sediment transport potential. The potential for sand transport in the vicinity of the proposed QGC Swing Basin is similar to the adjacent Fisherman's Landing Swing Basin area, and is considerably lower than experienced at the Clinton Wharves further to the south-east, where currents are constricted between Hamilton Point and the Calliope River mouth.

Net sand transport potential was estimated by averaging the results over a 14-day spring-neap tidal cycle. The results for the base case are shown in *Figure 5.11.23*. The net sand transport is generally in the ebb tide direction due to the above-mentioned asymmetry in the tidal currents.

The developed case model includes dredging of the QGC Swing Basin and MOF, dredging of the Santos Swing Basin and dredging of the approach channel to these two proposed LNG facilities. The predicted changes to the tidal velocities are reflected in the instantaneous sediment transport potentials. Dredging generally increases the overall conveyance, reduces velocities and, therefore, also reduces bed shear stresses and sediment transport potential. In areas outside the dredging where velocities increase, the transport potential also increases.

Figure 5.11.24 shows that there will be little or no sand transport potential in the dredged QGC Swing Basin. There will be an increase in the potential transport into the Swing Basin area on the north-western side due to the increased flow conveyance created by the dredging. Similarly, the sand transport potential into the proposed Santos Swing Basin area is slightly increased in the developed case.

Figure 5.11.23 Base Case Sand Transport Potential



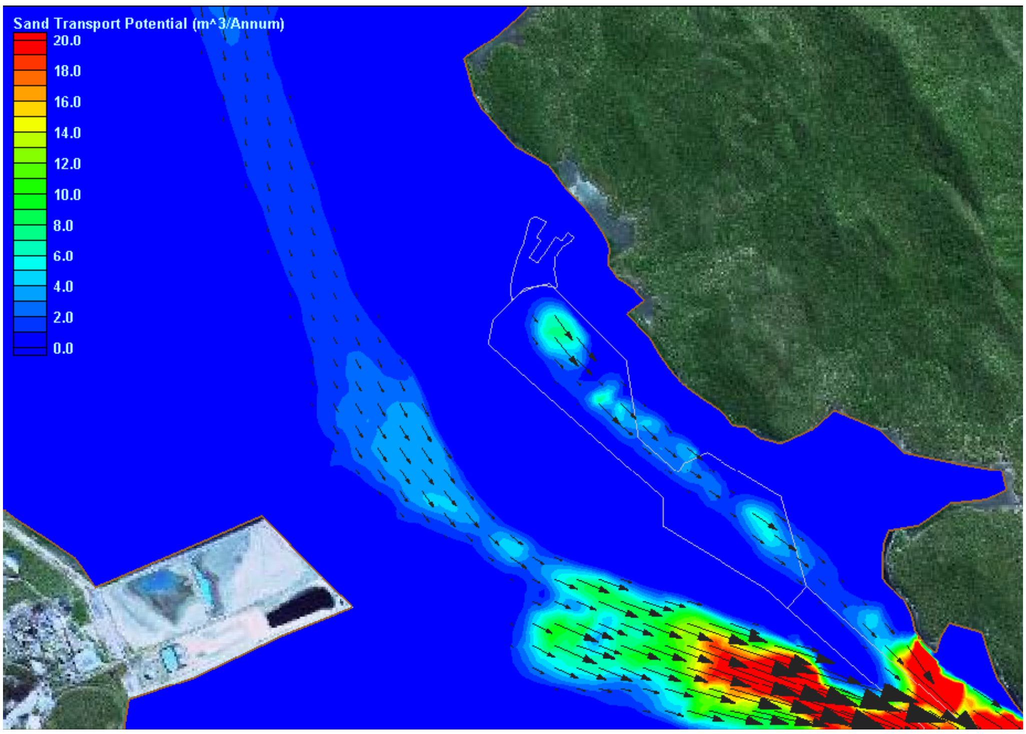
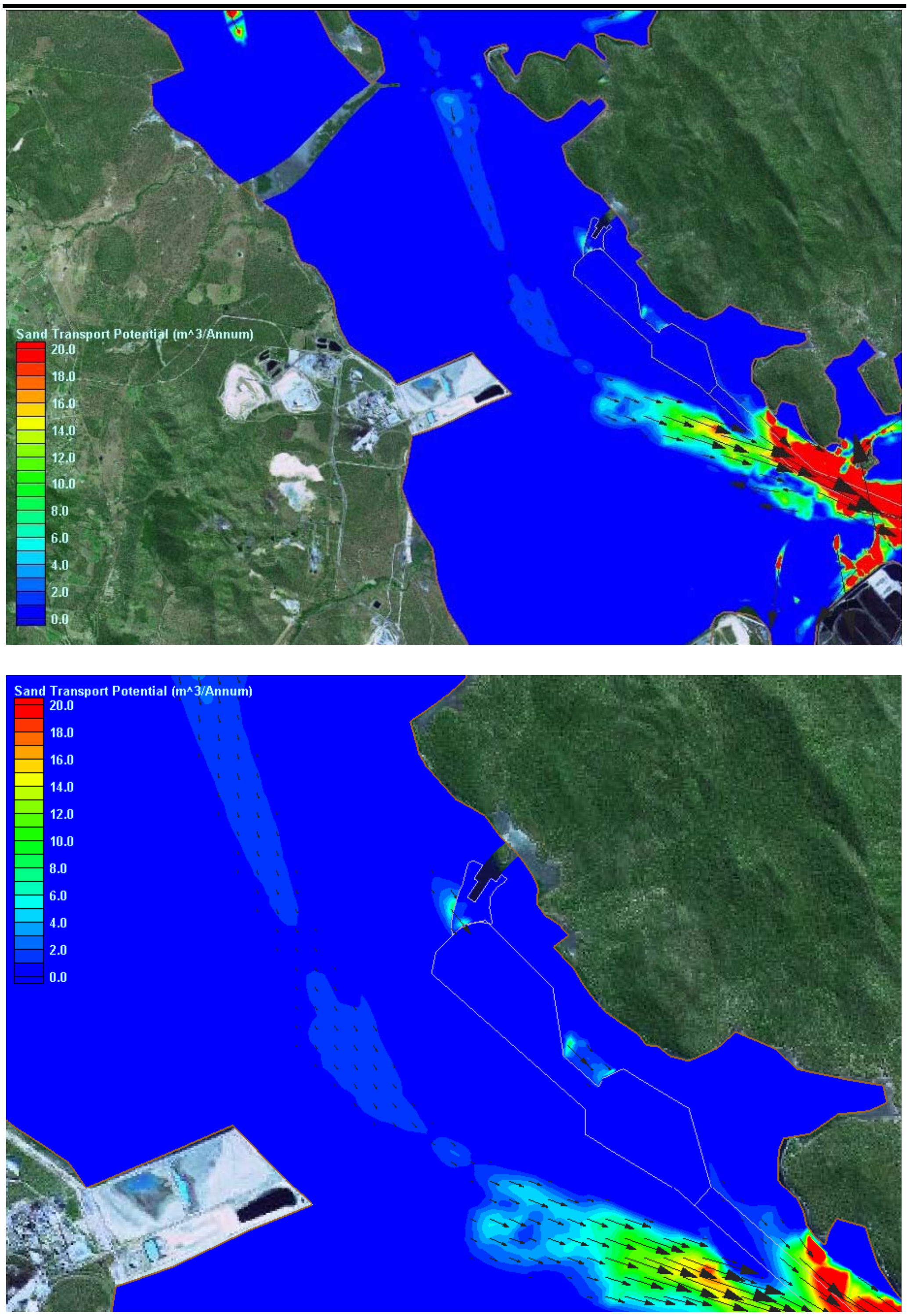


Figure 5.11.24 Developed Case Sand Transport Potential



The modelled sedimentation (sand-sized material only) of a number of existing and proposed dredged areas has been summarised in *Table 5.11.15*. The net sedimentation volumes for the existing Targinie Channel and Targinie Swing Basin are generally consistent with the annual dredging volumes shown in *Table 5.11.14.*

The developed case sedimentation rate into the existing Targinie Channel and Targinie Swing Basin are both reduced relative to the base case. This is due to the increased conveyance of the dredged northern channel and hence reduction in tidal flow velocities in the southern Targinie channel.

Predicted sedimentation rates in the Santos Swing Basin and approach channel are generally lower than existing dredged areas further to the south-east (refer *Table 5.11.14*).

Table 5.11.15 Modelled Net Sedimentation of Dredged Areas

Location	Modelled Net Sedimentation (m3/annum)	
	Base	Developed
Targinie Channel	33,000 (16,000-66,000[27])	30,000 (15,000-60,000)
Targinie Swing Basin	2700(1300-5400[28])	1100 (600-2200)
QGC Swing Basin (and MOF)	-	1000 (500-2000)
Santos Swing Basin	-	1000(500-2000)
QGC/Santos Approach Channel	-	2600 (1300-5200)

11.5.8.6 Silt Deposition

The potential for mobilisation and deposition of fine silts has also been examined through assessment of bed shear stresses. Bed shear stresses less than about 0.2 N/m2 will generally result in deposition of fine silts in suspension while higher stress will re-suspend and keep fine sediments in suspension.

During neap tides, the bed shear stresses in the channel are typically at or below the threshold for deposition. However, during spring tides, the stresses are much greater and as such the fine sediments will not be stable in the long term. This is consistent with observations of limited fine material in the main channel. As could be expected in the shallower, less dynamic areas where velocities are lower, the bed shear stresses are typically low and this is consistent with the natural deposition of fine material in these areas.

To assess the potential for silt deposition, bed shear stresses were calculated over a full (two-week) spring-neap tidal cycle throughout the hydrodynamic model domain. Maximum bed shear stresses due to tidal currents will correlate inversely with the likelihood of silt deposition. The spatial distribution of the maximum bed shear stress is shown for both the base and developed

27 Likely error bounds.

28 Likely error bounds.

cases in *Figure 5.11.25* and *Figure 5.11.26* respectively. Time series have been extracted at a number of points within existing and proposed dredged areas, which are shown in *Figure 5.11.27*. The time series results are shown in *Figure 5.11.28* through to *Figure 5.11.31*(spring tide to neap tide).

In all areas, the shear stresses fall below the threshold for deposition of suspended sediments for varying times during neap tides. During spring tides, moderate-to-very high shear stresses occur through the main channel areas.

Key findings are as follows:

- In the existing Fisherman's Landing Swing Basin, moderate shear stresses presently occur, minimising the potential for fine-silt deposition. These shear stresses are predicted to reduce slightly with the developed case dredging as a result of the reduction in velocities. As such, it is predicted there will be a potential increase for fine-silt deposition with minor direct impact due to the Project.
- In the proposed QGC Swing Basin, bed shear stresses are significantly reduced by the proposed dredging. Over most of the Swing Basin area, moderate bed shear stresses are still experienced during spring tide flows, which will limit the potential for silt deposition.
- Very low tidal energy conditions and hence bed shear stresses are predicted in the western extremity of the QGC Swing Basin, and as a result this area will probably experience higher levels of fine-sediment deposition.
- Low tidal energy conditions and hence bed shear stresses are predicted in the eastern berth area of the QGC Swing Basin. As a result this area will probably experience fine-sediment deposition, however, regular shipping movements could tend to mobilise fine sediment and reduce the siltation potential.
- Very low tidal energy conditions and hence bed shear stresses are predicted in the MOF dredged areas. As a result, it could be expected that these areas will experience higher levels of fine-sediment deposition. Furthermore, the landward portions of the dredged areas are in the intertidal zone and hence even small wave chop may mobilise fine sediments on the shallow areas adjacent, increasing the siltation potential. This may be offset by regular vessel movements tending to remobilise fine sediments.

Figure 5.11.25 Base Case maximum bed shear stress (due to tidal currents)

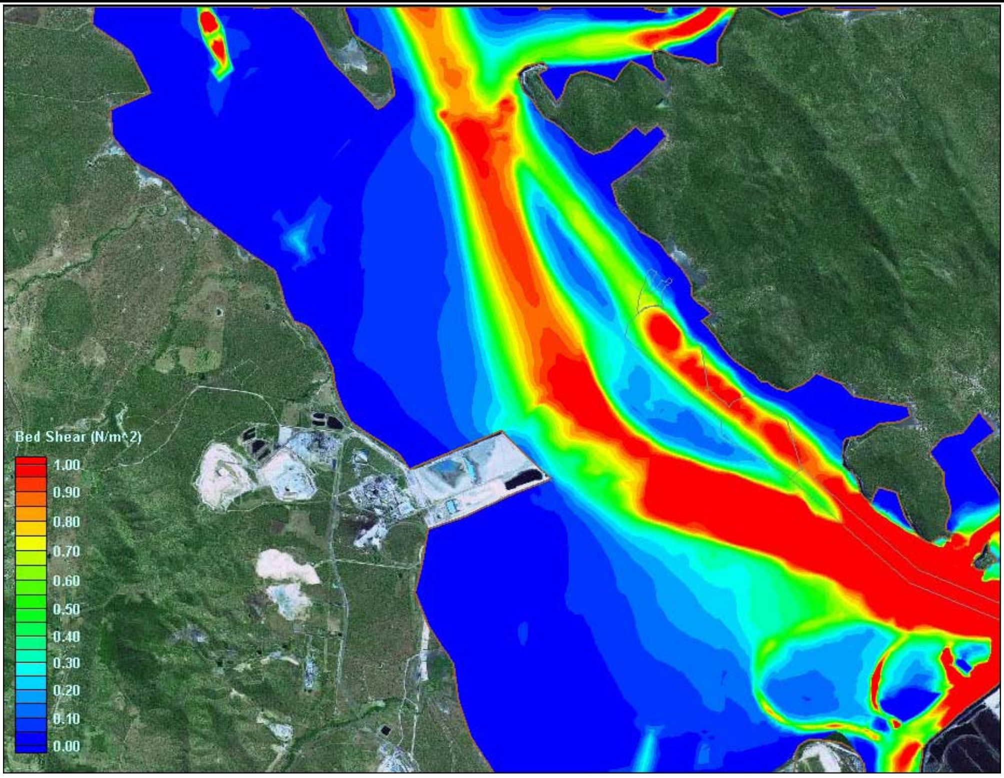
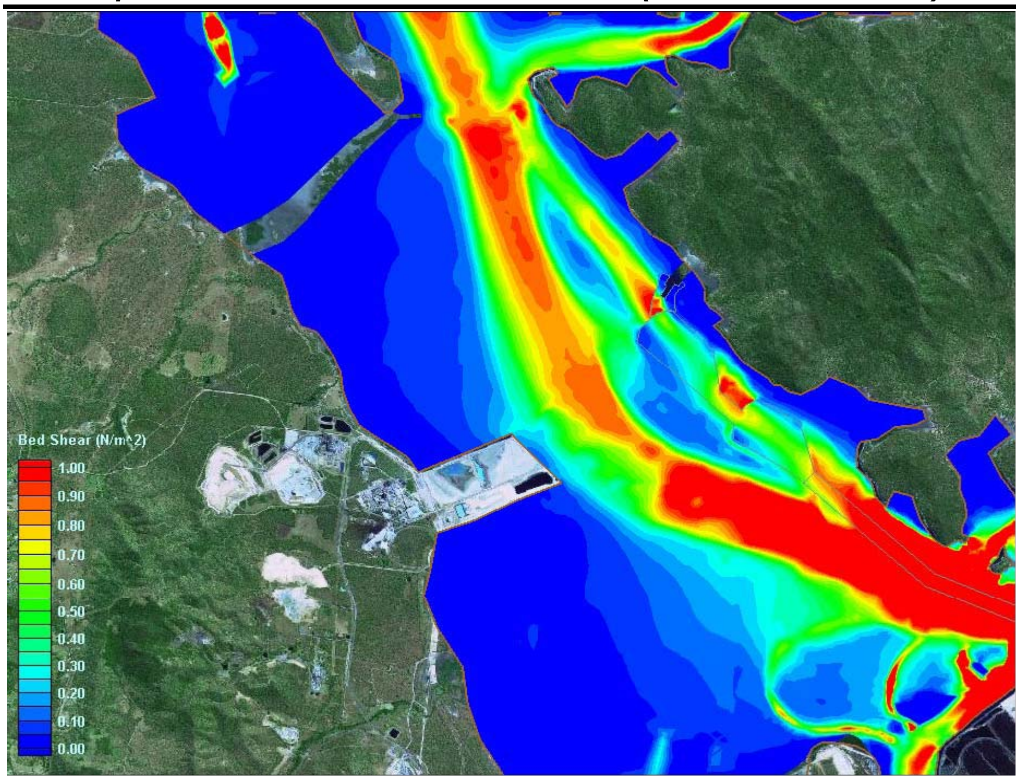


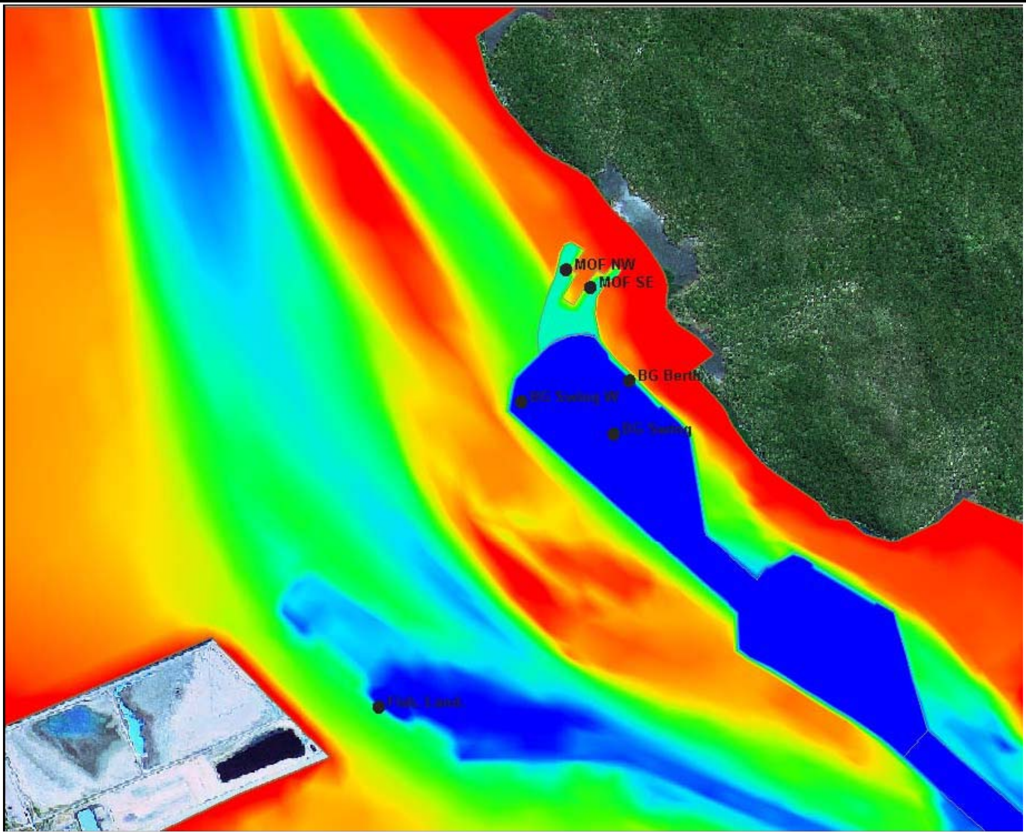
Figure 5.11.26 Developed Case maximum bed shear stress (due to tidal currents)



11.5.8.7 *Reverse Osmosis Concentrate Discharge Impacts*

Near- and far-field numerical modelling of the proposed discharge of a brine waste stream from a desalination facility associated with the Project was undertaken. Both modelling activities found that potentially there is negligible direct impact on local salinity due to this discharge (refer *Appendix 5.9*).[29]

Figure 5.11.27 Bed shear stress time series locations within existing and proposed dredged areas



29 BMT WBM, 2009. Proposed QCLNG Facility EIS. *Marine Water Quality Assessments.* (unpublished report, R.B17241.002.00

Figure 5.11.28 Fisherman's Landing bed shear stress

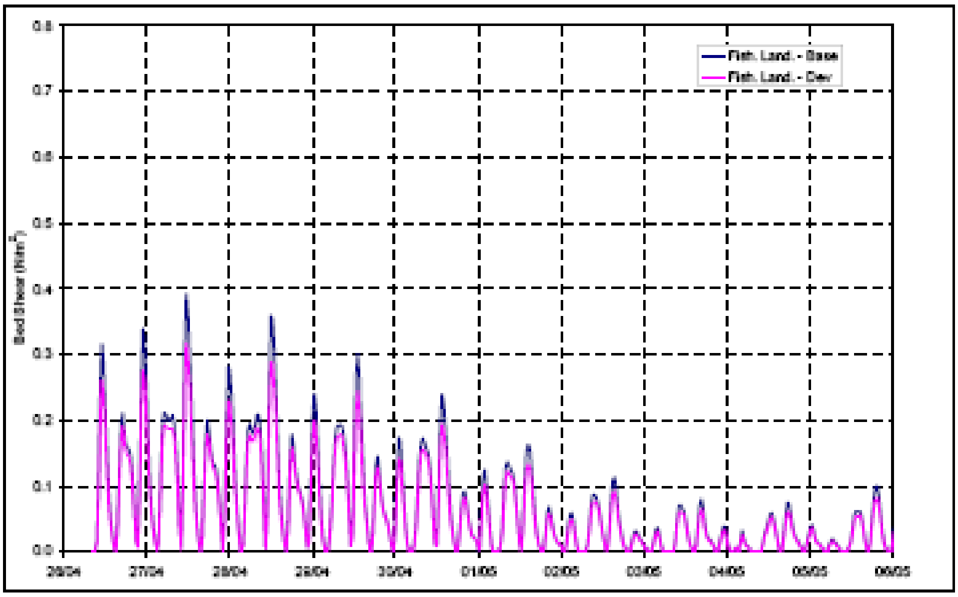


Figure 5.11.29 QGC Swing basin (centre) bed shear stress

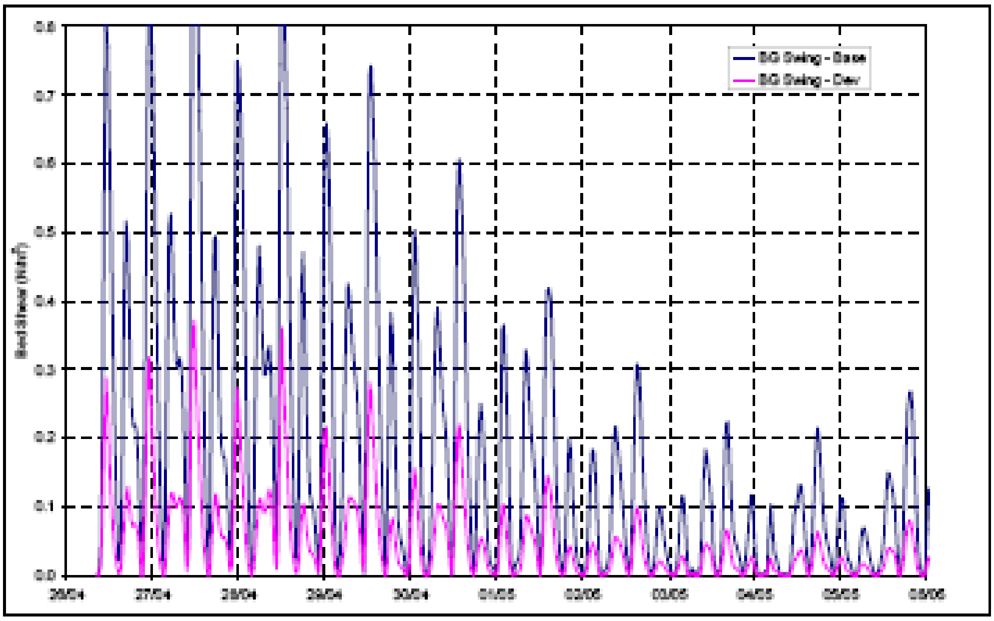


Figure 5.11.30 Western side of QGC Swing basin bed shear stress

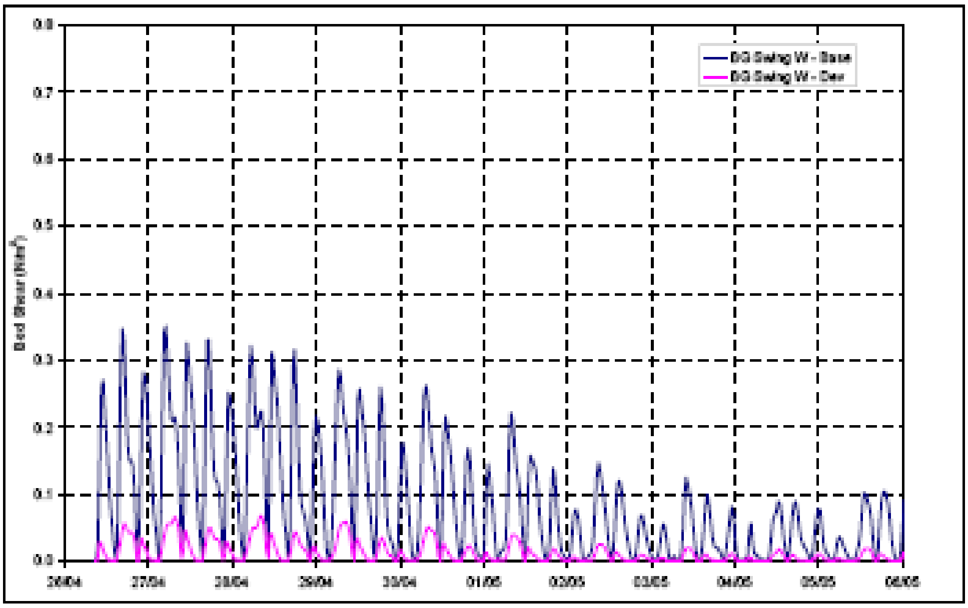


Figure 5.11.31 QGC Berth bed shear stress

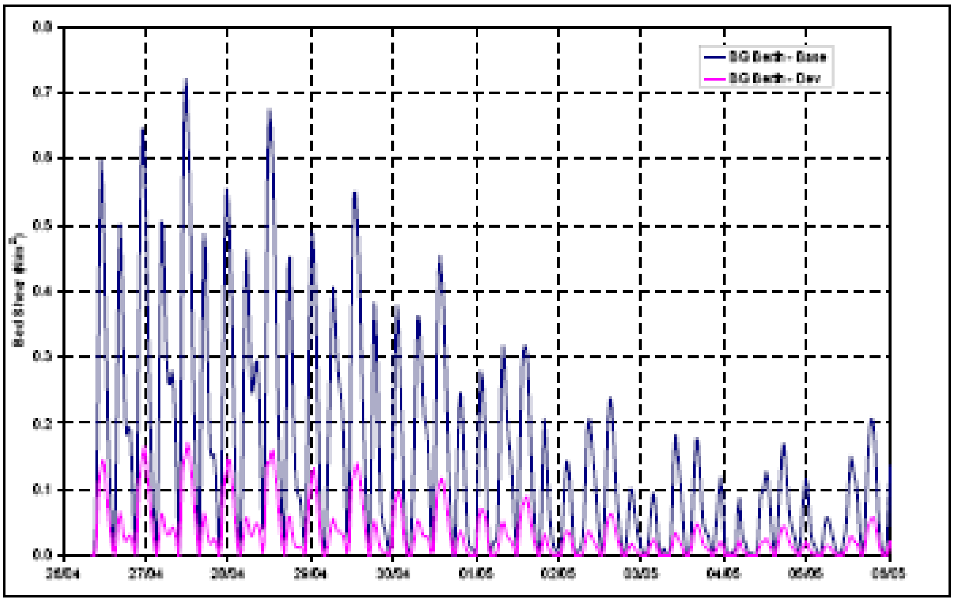


Figure 5.11.32 North-western side of the QGC MOF bed shear stress

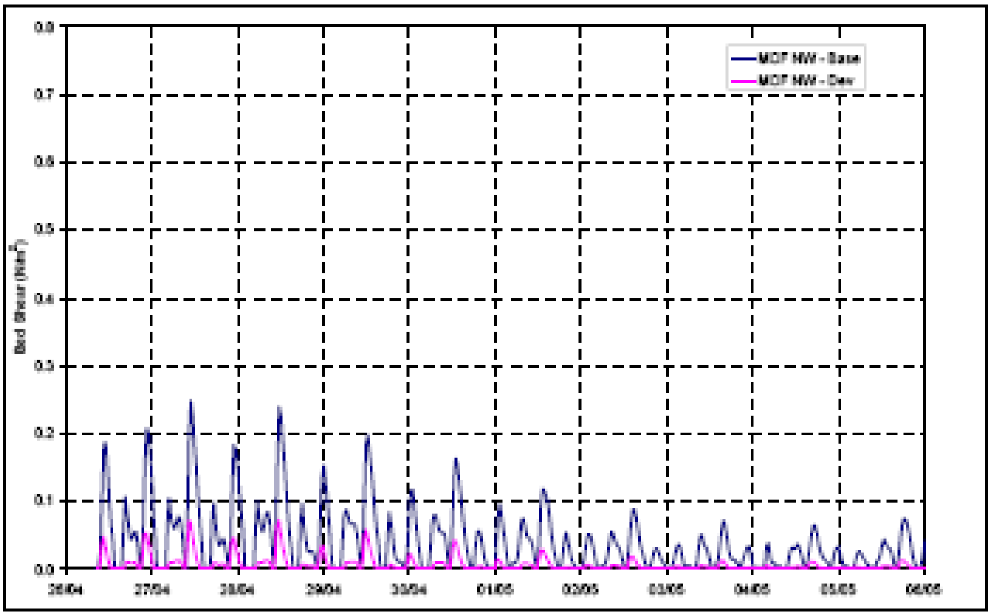
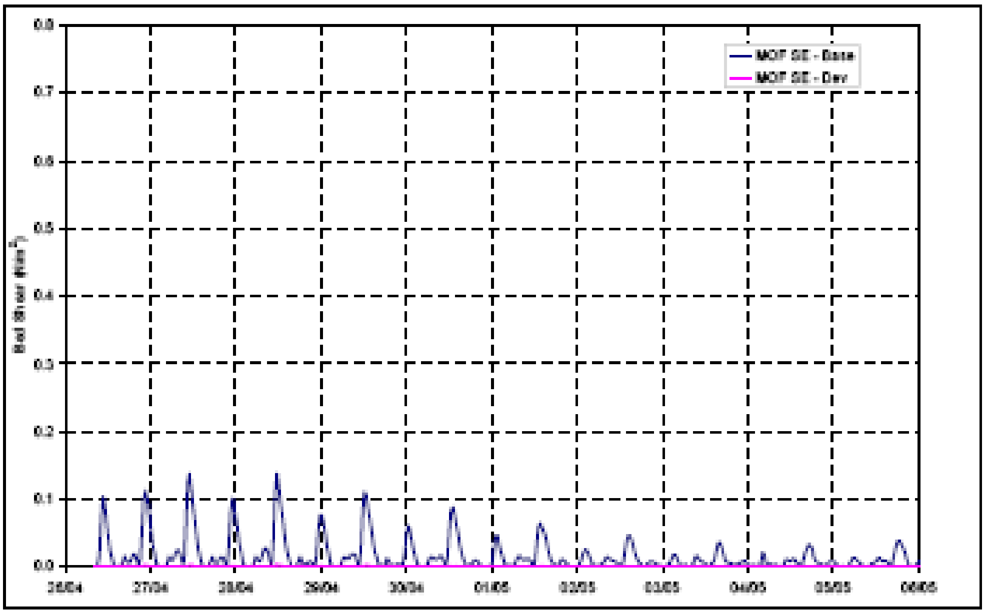


Figure 5.11.33 South-eastern side of the QGC MOF bed shear stress



11.5.8.8 Construction Stage Sediment Assessments

Sediment plume dispersion analyses were executed for representative swing basin dredging, bridge and pipeline construction activities using the far-field model. Appropriate sediment re-suspension rates were estimated for the scenarios.

In the case of swing basin dredging, greater concentrations were realised during neap tides, where dispersion was less as a result of reduced tidal velocities. An immediate impact zone of around several hundred metres in scale was identified during these times and, outside this area, maximum additional TSS concentrations of approximately 25 mg/L were predicted (over ambient). These values are in the order of the natural variability of TSS concentrations across the site. Concentration increases during spring tides were generally less than during neap tides.

Similar behaviour was observed in the model results for the proposed bridge and pipeline construction scenarios. The immediate impact zones were, again, in the order of hundreds of metres in dimension during neap tides (and considerably smaller during spring tides), with maximum additional TSS concentrations outside this zone of 15 to 17 mg/L.

Some accumulation of sediment due to the MOF may occur as the dredging nears completion, if the MOF is constructed parallel to dredging works.

11.5.8.9 Maintenance Dredging Requirements

The highly variable nature of the sediments and the prevailing processes makes quantification of siltation rates and maintenance dredging requirements complex. A semi-quantitative approach has been adopted based on historical dredging records and interpretation of siltation mechanisms/potential as described above for sand-sized sediments (refer *Section 11.5.8.5*) and fine sediments (refer *Section 11.5.8.6*).

The analysis undertaken suggests that the propensity for deposition of sand-sized material in the proposed dredged areas is similar to that in the adjacent existing dredged areas (i.e. Targinie Swing Basin and Channel). The estimated rate of sand-sized sediment deposition in the QGC Swing Basin and MOF dredged area is up to 2000 m3/annum under ordinary tidal flow conditions (refer *Table 5.11.15*). The QGC/Santos approach channel may similarly experience deposition of sand-sized sediment at a rate of up to 2600 m^3/annum (refer *Table 5.11.15*).

Another effect of the proposed dredging for the QGC and Santos swing basins and approach channel is a likely decrease in the rate of sand-sized sediment depositing in the Targinie Swing Basin, and to a lesser extent in the Targinie Channel (refer *Table 5.11.15*).

The analysis of bed shear stress suggests that sub-sections of the QGC Swing Basin and MOF basin will be prone to accelerated deposition of fine-silt material as a consequence of the low-energy hydrodynamic regime that will occur following dredging. This is in contrast to other existing dredged areas within the Port of Gladstone, which generally experience sufficiently high bed shear stresses during spring-tide current flows to mobilise deposited silt material. Because of this difference, the rate of siltation in these existing facilities cannot be used to indicate the likely rate of fine-material siltation in the proposed dredge footprint.

Quantification of the likely rates of silt deposition within the proposed dredge areas is being undertaken as a part of a separate scope of works for Gladstone Ports Corporation and QGC.

11.5.8.10 *Key Findings from the Assessments*

The following key findings from the water quality assessment as summarised in *Appendix 5.12*[30] are relevant:

- The hydrodynamic impacts of the proposed works were found to have a negative minor direct impact, with the exception of in the immediate vicinity of the proposed dredged Swing Basin, where the significant dredging will change velocities with a negative moderate direct impact.
- Tidal flushing times for the pre- and post-Project cases were estimated. In most cases, however, even though the model was run for a 45-day period, the required definitive 'e-folding' value (equivalent to 37 per cent flushing) was not reached and, as such, definitive flushing times could not be reported. There were negligible direct impacts on flushing behaviour with and without the Project.
- Near- and far-field numerical modelling of the proposed discharge of a brine waste stream from a desalination facility associated with the Project was undertaken. Both modelling activities found that there is negligible direct impact on local salinity due to this discharge.
- Sediment plume dispersion analyses were executed for representative Swing Basin dredging, bridge and pipeline construction activities using the far-field model. Appropriate sediment re-suspension rates were estimated for the scenarios.
- In the case of Swing Basin dredging, greater concentrations were realised during neap tides, where dispersion was less as a result of reduced tidal velocities. An immediate impact zone of the order of several hundred metres in scale was identified during these times and, outside this area, maximum additional TSS concentrations of approximately 25 mg/L were predicted (over ambient). These values are in the order of the natural variability of TSS concentrations across the site. Concentration increases during spring tides were generally less than during neap tides.
- Similar behaviour was observed in the model results for the bridge and pipeline construction scenarios. The immediate impact zones were again in the order of hundreds of metres in dimension during neap tides (and considerably smaller during spring tides) with maximum additional TSS concentrations outside this zone of 15 to 17 mg/L.

Based on these findings, the impacts to hydrodynamics and marine water quality from the Project are characterised as being short-term (related to construction stages), with major local impacts from the dredging works with

30 BMT WBM 2009. *QCLNG Project draft EIS – Coastal Legislative and Policy Assessment*. (unpublished report, R.B17241.003.01.legislation.doc)

increased TSS. These increases are within the bounds of natural variability of the system and are not expected to have any significant direct impacts on marine environmental values of water, and the environmental values of the Project area will be protected.

11.5.9 *Fish Habitat Assessment*

The Legislative and Policy Assessment (*Appendix 5.12*) notes that in order to be consistent with the DEEDI policy FHMOP 004, the following measures will be integrated into the detailed design and implementation of the Project:

- Consultation with DEEDI in terms of the characterisation of potential impacts on fish habitats from the dredging activity, noting that the water quality/hydrodynamic modelling assessment has shown dredging and discharge direct impacts to be minor and short-term.
- An EMP that addresses:
  a) the timing of the works in order to consider avoidance of important local biological processes such as seagrass flowering, fish migration and fish spawning periods where practicable
  b) incorporation of appropriate buffers between the works and waterway banks, marine vegetation and tidal lands that are identified as being sensitive/significant from a fish habitat perspective
  c) monitoring of turbidity and total suspended solids from dredging activities and appropriate contingency measures if performance standards set for these parameters in the monitoring plan are exceeded (e.g. suspending or relocating dredging works until tidal/winds conditions are more favourable, installation of silt curtains or similar measures that assist to reduce turbidity from dredging/spoil placement operations where such measures are practicable and efficient).

Compared to the dredging, the impacts of dredged material placement proposed in the Western Basin has potential significant impact on fish habitats, given the known seagrass assemblages, mangroves and saltmarsh resources that occur in that area. This is discussed in further detail in *Volume 5, Chapter 8* and *Volume 6*.

In addition to the habitat loss or degradation associated with large-scale reclamation, as outlined in the policy, marine sediments to be dredged will need to be sampled and analysed in accordance with the National Ocean Disposal Guidelines and SPP for acid sulfate soils to ensure the dredged material is appropriate for marine placement and environmental risks from oxidation of potential acid sulfate materials is negligible.

11.5.10 *Acid Sulfate Soils SPP*

Discussion on acid sulfate soils is contained in *Volume 5, Chapter 4* and Mitigation in *Volume 11*.

11.5.11 National Ocean Disposal Guidelines/National Assessment Guidelines for Dredging

This EIS is not seeking approval for marine placement. Consistency with the requirements of the NAGD/National Assessment Guidelines for Dredging in terms of site selection and sediment quality sampling and analysis will be determined at a later date if this changes.

11.5.12 Assessment of Other Regional and Local Plans and Strategies relating to Coastal Resources

Table 5.11.16 identifies a range of other more broadly focused regional and local plans, and strategies that apply to coastal resources in the Project area, and where these are addressed under other relevant sections of the EIS.

Table 5.11.16 Coastal Resource Planning Policy Consistency

Coastal Resource Planning Policy Document	Section in which Addressed
Gladstone State Development Area (GSDA) Development Scheme	*Appendix 1.7; Volume 5, Chapter 5*
Curtis Coast Regional Coastal Management Plan (CCRCMP)	*Appendix 1.7; Volume 1, Chapters 5, 6 & 7; Volume 4, Chapters 7 & 8; Volume 5, Chapters 7,8, 9, 10 & 11; Volume 6, Chapter 4; Volume 8*
Port of Gladstone - Protection and Enhancement Strategy 2003	*Appendix 1.7; Volume 5, Chapter 5*
Central Queensland Strategy for Sustainability: 2004 and Beyond	*Appendix 1.7; Volume 3, Chapters 3, 4, 5, 7, 8, 9, 10 and 11; Volume 4, Chapters 3, 4, 5, 7, 8, 9* *Volume 5, Chapters 3, 4, 5, 7, 8, 9, 10 & 11 and Volume 8*
SPP 1/92 Development and conservation of agricultural land	*Volume 5, Chapter 4 & 5*
SPP 1/03 Mitigating the adverse impacts of flood, bushfire and landslide	*Appendix 1.7*
Former Calliope Shire and Gladstone City Planning Schemes	*Volume 5, Chapter 5*
Central Queensland Regional Growth Management Framework (CQRGMF) **Central Queensland – A New Millennium)**	*Volume 3, Chapters 3, 4, 6, 7, 8, 9, 10, 12 & 16; Volume 4, Chapters 3, 4, 6, 7, 8, 9, 10, 11 & 15* *Volume 5, Chapters 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 & 17; Volume 7*
Gladstone Port Authority Land Use Plan 1995	*Volume 5, Chapter 5*
Gladstone Port Corporation 50-year Strategic Plan	*Volume 5, Chapter 5*
Australia and New Zealand Guidelines for Fresh and Marine Water Quality (ANZGFMWQ)	*Appendix 1.7*
Queensland Water Quality Guidelines	*Appendix 1.7*

Coastal Resource Planning Policy Document	Section in which Addressed
(QWQG)	

11.6 CUMULATIVE IMPACT

Based on the findings of the hydrodynamics and marine water-quality assessment, the impacts to hydrodynamics and marine water quality can be characterised as being short-term (related to construction phase), and there will be major local impacts from the dredging works such as increased TSS. These increases are within the bounds of natural variability of the system and are not expected to have any significant cumulative impacts on marine environmental values of water.

The cumulative impact of dredge spoil placement on coastal natural resources and the reclamation in the Western Basin of Port Curtis will need to be considered in the GPC Port of Gladstone Western Basin Strategic Dredging and Disposal Project.

11.7 MANAGEMENT AND MITIGATION MEASURES

The following management and mitigation measures are proposed in relation to the coastal process aspects of the Project:

- Best-practice techniques should be adopted for dredging and pipeline construction activities in order to minimise the extent and duration of sediment plumes, which may otherwise be generated during the construction phase of the Project.

11.8 CONCLUSION

The LNG Component of the Queensland Curtis LNG (QCLNG) Project is compatible with the management intent of the Curtis Coast Regional Coastal Management Plan (CCRCMP) and is unlikely to negatively impact on the current and future functioning of the area.

There will be an increase in LNG tanker shipping movements in and out of the proposed jetty/terminal once the LNG Facility is operational. However, the proposed isolated location of the LNG Facility on Curtis Island and associated wharf facilities minimises direct impacts on neighbouring urban communities as well as other recreational users of the foreshore in the Project area.

The LNG Facility is a coastal-dependant use in the context of the need to ensure the LNG storage and processing facility is in close proximity to the wharf facility and export vessels. In this context, the proposed location of the facility on Curtis Island is consistent with the CCRCMP policy.

11.8.1.1 Dredging

Based on the hydrodynamic and coastal assessments, in the context of the specific assessment criteria in the CCRCMP policy, the proposed dredging (for which QGC is not the proponent):

- will not result in direct impact on the ability of the site or adjoining land to function as a barrier protecting lands from coastal waters
- will maintain beach or foreshore stability
- is not expected to directly impact on natural coastal processes that supply sand to beaches
- will maintain the stability of the dredging area, noting the possibility of direct impact from sedimentation at the Swing Basin and MOF over the long term
- will maintain water quality, excepting short-term impacts from dredging that are within the bounds of natural variability of the system and localised within the Swing Basin and channel areas
- is not expected to directly impact groundwater levels of underlying aquifers and coastal wetlands
- will maintain the local drainage regime on the site and adjoining areas
- will not cause unacceptable risk to existing land uses from coastal hazards.

Implications of dredge material placement and the future intention to place dredged material as a large reclamation in the Western Basin of Port Curtis will need to be assessed in the context of the CCRCMP policy, including the likely direct, indirect and cumulative impacts on coastal natural resources and the suitability of the material for marine placement in accordance with the National Ocean Disposal Guidelines, as part of the GPC's Port of Gladstone Western Basin Strategic Dredging and Disposal Project.

Minor reclamation is proposed as part of the construction and operation of the LNG Facility in relation to the MOF jetty. This reclamation is seen as acceptable, given it is associated with a coastal-dependant land use with a positive regional impact and will ensure the constructed infrastructure is protected from natural coastal processes and erosion.

11.8.1.2 LNG Facility

The LNG Facility:

- is largely situated outside of the erosion-prone area but will contain associated marine infrastructure required to be within the area and protected from coastal processes. Where practicable, associated infrastructure such as access roads (that do not require a coastal location to function) should be situated outside of the erosion-prone area
- largely avoids areas of high conservation significance (e.g. Areas of State Significance, natural resources), with the exception of some areas of

coastal vegetation and marine plants

- will not have significant direct or indirect impacts on water quality or hydrodynamics associated with dredging and wastewater discharge
- may have negative minor impact on public access and usability of coastal waters and coastal landscape values, given that the establishment of the Swing Basin, marine terminal and MOF structure will occur in an area that is currently in a predominantly natural state. These matters are discussed in greater detail in the *Volume 8* of the EIS.

In the context of the CCRCMP, the Project area is not identified as a “priority area” for erosion management. The bulk of the LNG Facility itself will be situated outside the erosion-prone area, with only essential infrastructure (between the plant and the berth/MOF) situated in the area of concern. This is not seen as contrary to coastal management policy outcomes, on the basis that the facility is a coastal-dependant land use and there are no practicable alternatives to re-location of the infrastructure.

On the western mainland coast, it is likely that the proposed bridge and access road (not part of the QCLNG Project Reference Case) will be partially located in the erosion-prone area, given the low-lying nature of the coastal wetlands at this location (with the erosion-prone area extending to HAT in such areas). In the unlikely event the proposed bridge and access road were to become part of the Reference Case, measures would need to be taken to protect this infrastructure from coastal processes.

Temporary access restrictions will need to be enforced during the construction stage, for health and safety reasons, and more permanent access restriction will apply as part of the establishment and enforcement of security areas for the LNG berth during operation.

In the context of wastewater releases, the operation of the LNG Facility will involve a direct discharge of contaminants to coastal waters through the sewage-treatment and reverse-osmosis plants. Potential impacts of these discharges to marine ecology are discussed in *Volume 5, Chapter 8.*

Stormwater issues and management measures will be addressed as part of the operational EMP/Site-Based Management Plan for the facility. Best-practice measures will need to be employed during construction activities to avoid or minimise soil erosion and sedimentation into coastal waters, given the climatic and geomorphologic nature of the Project area.

Significant cultural heritage values are identified in the CCRCMP associated with The Narrows, Cattle Crossing and Ramsay Crossing. Cultural heritage values are also associated with Graham Creek on Curtis Island. Engagement with the relevant Aboriginal Parties as part of the EIS through a CHMP under the *Aboriginal Cultural Heritage Act 2003* is the most appropriate means of identifying and ensuring appropriate management of these values in the context of the Project (refer *Volume 8, Chapter 9*).

Curtis Island is recognised within the CCRCMP as providing a significant scenic coastal landscape feature able to be viewed from the mainland and forming part of the coastal landscape. Retention of native vegetation and coastal mangroves along the coastline will assist in retaining some of these landscape values, but it is likely that there will be negative direct impact on visual amenity from the interruption of an otherwise undeveloped coastal landscape. Likewise, the proposed bridge between Friend Point and Laird Point is likely to have negative direct impact on visual amenity.

Based on the mapping contained in the CCRCMP, the principal Areas of State Significance that could be impacted are coastal wetlands and, in particular, intertidal mangrove and saltmarsh areas along the coastline of Curtis Island and at Laird and Friend Points. These may be directly impacted through construction of the LNG Facility, access roads and the proposed bridge. Mapping also shows an area of Endangered RE that will be disturbed by the establishment of the LNG Facility on Curtis Island.

Sparse seagrass may also exist throughout the sub-tidal areas of the planning area, but has not been specifically mapped or observed in abundance within or near key development areas of the LNG Facility, such as the submarine pipeline alignment. Based on the location of the infrastructure and the location of mapped resources within the CCRCMP, there is expected to be local disturbance from the development elements to these values. Accordingly, the detailed design and construction methodology will need to take into account how any impacts to coastal wetlands and vegetation can be further avoided or minimised in accordance with best practice. If unavoidable, the impacts to the coastal Endangered RE area and to marine plant communities will need to be addressed through an offset or similar measure.

Given the predicted direct, indirect and cumulative impacts from the LNG Facility, it is generally consistent with the desired coastal outcomes for CCRCMP Key Coastal Sites, assuming construction and operation are managed in an ecologically sustainable manner.

Key findings from the water-quality assessment include:

- The hydrodynamic impacts of the proposed works were found to have a negative minor direct impact, with the exception of in the immediate vicinity of the proposed dredged Swing Basin, where the significant dredging will change velocities, with a negative moderate direct impact.
- Tidal flushing times for the pre- and post-Project cases were estimated. In most cases, however, even though the model was run for a 45-day period, the required definitive 'e-folding' value (equivalent to 37 per cent flushing) was not reached and, as such, definitive flushing times could not be reported. There were negligible direct impacts on flushing behaviour with and without the Project.
- Near- and far-field numerical modelling of the proposed discharge of a brine waste stream from a desalination facility associated with the Project was undertaken. Both modelling activities found that there would be negligible direct impact on local salinity due to this discharge.

- Sediment plume dispersion analyses were executed for representative Swing Basin dredging, proposed bridge and pipeline construction activities using the far-field model. Appropriate sediment re-suspension rates were estimated for the scenarios.
- In the case of Swing Basin dredging, greater concentrations were realised during neap tides, where dispersion was less as a result of reduced tidal velocities. An immediate impact zone of the order of several hundred metres in scale was identified during these times and, outside this area, maximum additional TSS concentrations of approximately 25 mg/L were predicted (over ambient). These values are in the order of the natural variability of TSS concentrations across the site. Concentration increases during spring tides were generally less than during neap tides.
- Similar behaviour was observed in the model results for the proposed bridge and pipeline construction scenarios. The immediate impact zones were again in the order of hundreds of metres in dimension during neap tides (and considerably smaller during spring tides), with maximum additional TSS concentrations outside this zone of 15 to 17 mg/L.

Based on these findings, the impacts to hydrodynamics and marine water quality from the Project are characterised as being short-term (related to construction stages), with major local impacts from the dredging works with increased TSS. These increases are within the bounds of natural variability of the system and are not expected to have any significant direct impacts on marine environmental values of water, and the environmental values of the Project area will be protected. A summary of the impacts outlined in this Chapter are provided in *Table 5.11.17*.

Table 5.11.17 Summary of Impacts for Coastal Environment

Impact assessment criteria	Assessment outcome
Impact assessment	Negative
Impact type	Direct and secondary
Impact duration	Short-term for impacts to hydrodynamics and marine water quality
Impact extent	Local
Impact likelihood	High

Overall assessment of impact significance: minor. The proposed LNG Facility and associated Ancillary Infrastructure are unlikely to significantly affect current and future functioning of the coastal environment and are compatible with the management intent of the CCRCMP, the Gladstone Ports Corporation 50-year Strategic Plan and the Gladstone State Development Area.