15. COASTAL PROCESSES

This chapter describes the existing coastal process values of the study area within Port Curtis and surrounding waters, including the Calliope River, assesses the potential impacts of the project on existing coastal processes and describes the measures Arrow Energy will implement through project design, construction and operation to address identified impacts on these coastal process values.

This chapter is based upon information in Appendix 8, Coastal Processes, Marine Water Quality, Hydrodynamics and Legislation Assessment, which provides the results and analyses of desktop studies and field investigations.

The objectives for coastal processes are based on the legislative context, with the aim of protecting the existing coastal process values. Objectives are set out in Box 15.1.

Box 15.1 Objectives: Coastal processes

- To avoid or reduce potential adverse effects on coastal processes resulting from the project.
- To identify mitigation strategies to reduce adverse effects on coastal processes to an acceptable level.

Marine water quality is discussed in Chapter 16, Marine Water Quality and Sediment.

15.1 Legislative Context and Standards

This section describes the Commonwealth and state legislation, guidelines and policies designed to protect coastal process values during project construction, operation and decommissioning. These provide the framework within which the coastal processes impact assessment was undertaken.

15.1.1 Commonwealth Legislation and Guidelines

Relevant Commonwealth legislation and guidelines relating to project construction and operation phases include:

- *Great Barrier Reef Marine Park Act 1975*. The act provides for the protection of environmental, biodiversity and heritage values pertaining to the Great Barrier Reef. Although the project is not located within the boundaries of the Great Barrier Reef Marine Park, the study area is in close proximity to the park and impacts from project activities may extend into the park.
- National Assessment Guidelines for Dredging (DEWHA, 2009a). Coming under the *Environment Protection (Sea Dumping) Act 1981*, these guidelines provide the framework within which project-related dredging activities will occur. They are intended to provide greater certainty about the assessment and permitting process as well as provide some guidance on opportunities for longer-term strategic planning.

15.1.2 State Legislation, Plans, Policies and Guidelines

State legislation and policies relevant to the protection of coastal process values during the construction and operation phases include:

- *Environmental Protection Act 1994*. The act provides for the protection of Queensland's environment while allowing for ecologically sustainable development. Subordinate to the act are:

- The Environmental Protection Regulation 2008, which lists category A and B environmentally sensitive areas that are protected and may be potentially impacted by the project, as well as regulating environmentally relevant activities. Activities associated with the project, such as dredging, are environmentally relevant activities under this regulation.

- The Environmental Protection (Water) Policy 2009, which provides for the management of surface water quality in Queensland, while allowing for ecologically sustainable development. The policy provides a framework that identifies environmental values for aquatic ecosystems and for human uses of those ecosystems. Environmental values in accordance with the policy have not been scheduled for the Port Curtis region. They are proposed to be adopted for Curtis Island basin and coastal waters by December 2013.

• *Coastal Protection and Management Act 1995*. This act regulates the protection, conservation, rehabilitation and management of coastal resources and biodiversity, and guides decisions on land use in the coastal zone in order to safeguard life and property from coastal hazards. Relevant statutory instruments developed under the act are:

  - The State Coastal Management Plan 2001 (DERM, 2002a), which sets out procedures to effectively protect and manage Queensland's coastal zones.

  - The Curtis Coast Regional Coastal Management Plan 2003 (EPA, 2003), which describes how the coastal zone in the region (including the whole project study area) is to be managed within the policy framework of the State Coastal Management Plan.

  At the time of writing, the Queensland Coastal Plan 2011 (DERM, 2011a) had been approved by the state government, but is not yet in force. Upon adoption of this plan, the Curtis Coast Regional Coastal Management Plan and the State Coastal Management Plan will be superseded.

• *Sustainable Planning Act 2009*. The act provides a framework to integrate planning and development assessment so that the effects of development are managed in a way that is ecologically sustainable.

• *Fisheries Act 1994*. The act provides for the management, use and protection of fisheries resources and fish habitats in a way that is ecologically sustainable. Under the act, marine plants, including seagrass, salt couch and mangroves, are protected from being intentionally removed, damaged or destroyed. The establishment of marine infrastructure and associated dredging will need to comply with the act and will require a permit to disturb such areas.

• *Petroleum (Submerged Lands) Act 1982*. This act requires an application for a permit to the extent that any part of the tunnel and pipeline occurs in the 'Adjacent Area' as defined in the schedule to the act.

• Fish Habitat Management Operational Policy 004: Dredging, extraction and spoil disposal activities (Hopkins & White, 1998). The policy aims to protect Queensland's fisheries resources and habitats while ensuring, enabling and contributing to ecologically sustainable industry and economic development.

• State Planning Policy 2/02: Planning and managing development involving acid sulfate soils 2002. This policy sets out the planning and assessment criteria for developments that may disturb acid sulfate soils in coastal areas.

15.2 Assessment Method

This section describes the assessment method used for the coastal processes impact assessment. The study method has adopted the significance (sensitivity and magnitude) approach.

The study area encompasses coastlines and waters that may be directly disturbed by project activities including the waters of Port Curtis bounded to the south and east by South Channel, Facing Island and North Channel, and extending into The Narrows (Figure 15.1). The Calliope River, which drains into Port Curtis, has also been included in the study area. Any project-related impacts that may occur outside the project areas have also been assessed.

15.2.1 Baseline Assessment

The Gladstone region hosts a number of industrial developments, which affect existing conditions in Port Curtis. A number of projects have recently taken a financial investment decision to commence construction. These projects are the Queensland Curtis LNG Project, the Gladstone LNG Project and the Yarwum Alumina Refinery Expansion Project, all of which have completed separate environmental impact assessments. The impacts from existing developments and predicted impacts from these three projects were taken into consideration when characterising baseline conditions.

The assessments undertaken are described in detail in Appendix 8, Coastal Processes, Marine Water Quality, Hydrodynamics and Legislation Assessment, and are summarised below:

- Literature review and site inspection. Available data characterising coastal processes in the study area was compiled and a site investigation was performed to identify key features and coastal processes.

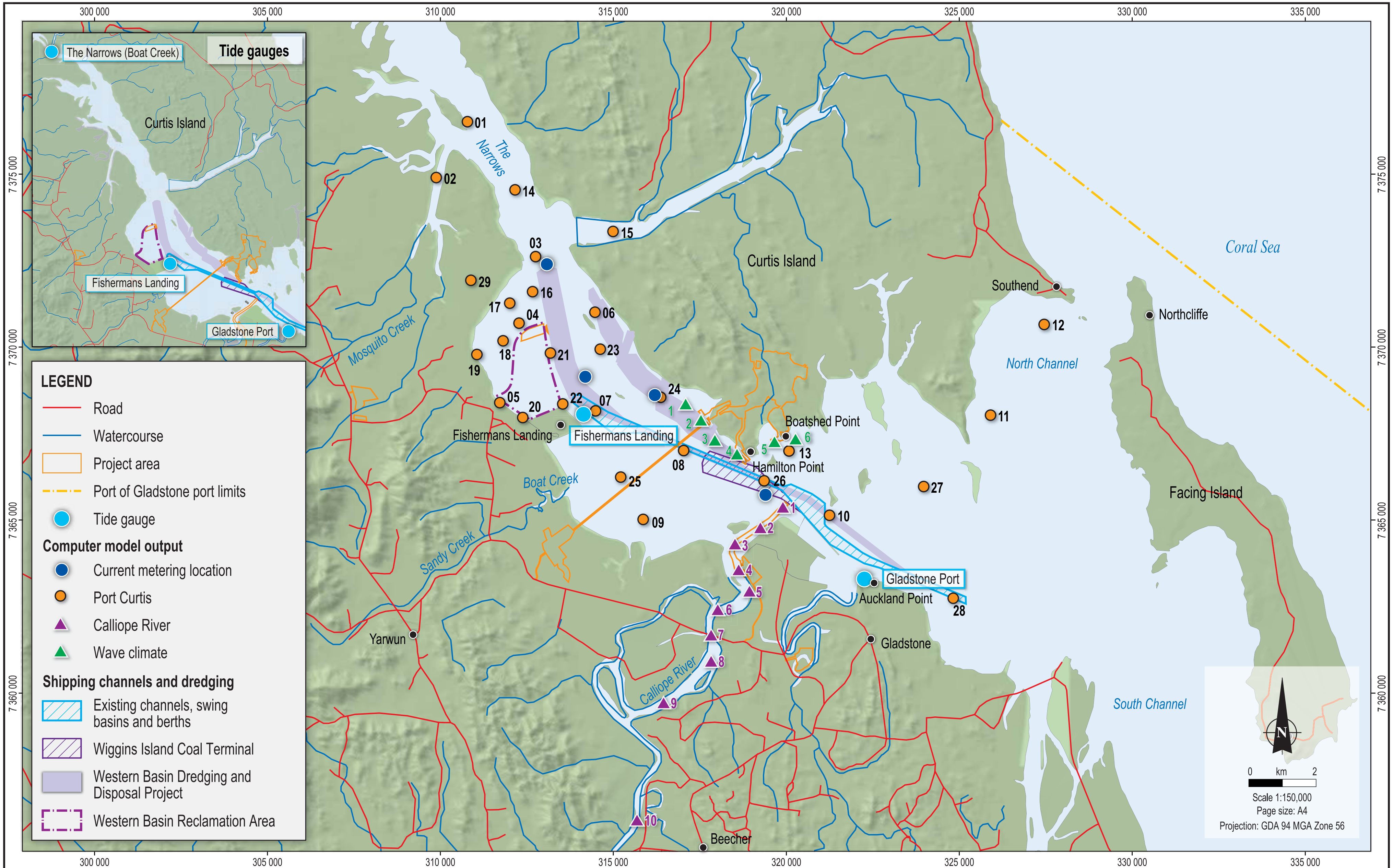
- Wave climate assessment. Computer modelling of day-to-day wave action and extreme event waves was performed using site-specific data to simulate baseline conditions and predict impacts.

- Extreme water levels assessment. Existing regional storm tide studies and guidelines were reviewed to characterise extreme storm tide water levels in the study area, both for existing conditions and future conditions associated with climate change. This information was used to predict impacts.

- Sediment transport and siltation assessment. Computer modelling was used to establish existing sediment transport processes within Port Curtis and to assess impacts.

- Shoreline processes assessment. The findings of all of the assessments were combined to establish existing conditions and to estimate potential impacts on coastal processes.

Twenty-nine representative locations in Port Curtis and ten representative locations in the Calliope River were selected for computer modelling to assess impacts on coastal processes. These locations are shown on Figure 15.1.



Source:
Place names, roads and watercourses from DME.
Project area and digital elevation model from Coffey Environments.
Wave climate, time series and model outputs from BMT WBM. Tide gauge from Marine Safety Queensland.
Western Basin Dredging Master Plan from Gladstone Ports Corporation.
Port of Gladstone port limits digitised by Coffey from Gladston Ports Corporation figure (accuracy may be compromised).

coffey environments

Date: 25.11.2011
MXD: 7033CA_07_GIS114_v1_4
File Name: 7033_07_F15.01_GIS_FT

Arrow Energy

Arrow LNG Plant

arrow energy go further

Port Curtis oceanographic monitoring and computer model output locations

Figure No: **15.1**

15.2.2 Significance Assessment

The marine infrastructure for the project (i.e., the mainland launch site, materials offloading facility (MOF) and personnel jetty, LNG jetty and dredging works to support this infrastructure) will be constructed during a major expansion of the Port of Gladstone. Port expansion works include the Western Basin Dredging and Disposal Project (WBDD Project) dredging and land reclamation activities (GHD, 2009a) and installation of marine facilities associated with other LNG developments on Curtis Island and Fishermans Landing. These projects are listed below and have all been assessed under separate environmental impact statements:

- WBDD Project.
- Fishermans Landing Northern Expansion project.
- Gladstone LNG Project Fishermans Landing.
- Queensland Curtis LNG Project.
- Australia Pacific LNG Project.
- Gladstone LNG Project.

Project impacts have been assessed within the context of wider development by comparing cumulative and project impacts to cumulative impacts without project impacts. Cumulative impacts are defined as those associated with the WBDD Project and the LNG developments described above. Impacts have been assessed using this method to provide relevant context and allow comparison between project-specific impacts and those associated with the wider port development activities.

The modelling carried out for the project (as presented in Appendix 8, Coastal Processes, Marine Water Quality, Hydrodynamics and Legislation Assessment) included a dredge area that has already been assessed as part of the WBDD Project EIS. This 33 ha area, designated as the LNG jetty swing basin, is located directly offshore from the LNG jetty. Once dredged to -13 m LAT, it will allow LNG carriers to manoeuvre safely during berthing activities.

At the time of the modelling, the demarcation between project-specific dredging activities and the WBDD Project dredging activities was uncertain. The modelling and subsequent assessment therefore presents a worst-case prediction of project impacts on coastal processes. The actual impacts of dredging for the Arrow LNG Plant will be considerably less in the vicinity of marine infrastructure off Curtis Island than those identified in the modelling and assessed in this chapter.

The significance approach has been used to assess project impacts on coastal processes. This approach considers existing environmental values and the sensitivity of these values to change. Impacts, which may affect environmental values, are identified and assessed in terms of potential magnitude. The significance of impacts on an environmental value is determined by the sensitivity of the value itself and the magnitude of changes it experiences.

Environmental Values

As defined in the Environmental Protection Act, environmental values are a measure of how we value the environment; and can be a quality or physical characteristic of the environment that is conducive to ecological health, public amenity or safety.

The two areas assessed in this chapter are Port Curtis and the Calliope River. The state of the coastal zone as reported in the State of the Environment Report 2007 (EPA, 2008a) was referred to when developing the environmental values of these areas. The State of the Environment Report 2007 refers to the State Coastal Management Plan 2001 (DERM, 2002a) and Curtis Coast Regional Coastal Management Plan 2003 (EPA, 2003). These documents make up the State of the Coastal Zone reports and together provide the context against which environmental values in

Port Curtis and the Calliope River were assessed. Environmental values may include use of the coastline, seafloor and waterways for relaxation, conservation, water sports and recreational or commercial fishing purposes. These environmental values are difficult to measure as the actual value placed on each aspect is subjective and will differ from person to person.

Coastal processes are the set of mechanisms that operate along a coastline, bringing about various combinations of sediment erosion, transportation and deposition. These mechanisms include tidal cycle, wave climate, water currents and extreme events such as storm tides. Project-related impacts on these mechanisms are assessed in this chapter. Changes to these mechanisms can affect the physical environment (e.g., coastlines and waterways), biological ecosystems (e.g., mangrove and seagrass habitats) and, in turn, impact the environmental values.

Sensitivity of environmental values is defined through five key attributes:

- Conservation status.
- Intactness.
- Uniqueness or rarity.
- Resilience to change.
- Replacement potential.

The criteria for determining the sensitivity of an environmental value are defined in Table 15.1.

Table 15.1 Sensitivity of environmental value – coastal processes

Sensitivity	Description
Very high	A coastal process that is: • In a site or area that has international environmental significance (e.g., World Heritage listing, Ramsar listing). • Entirely undisturbed by existing developments (i.e., intact). • Unique or rare. • Very sensitive to change (i.e., very easily disturbed or interrupted). • Serving a function that cannot be replaced or substituted.
High	A coastal process that is: • In a site or area that has national environmental significance (e.g., national wetland of significance, core habitat for nationally listed species, area supports greater than 1% of a national population of a species, the Great Barrier Reef Marine Park). • Mostly undisturbed by existing developments (i.e., mostly intact). • Rare. • Sensitive to change (i.e., easily disturbed or interrupted). • Serving a function that is difficult to replace or find elsewhere.
Medium	A coastal process that is: • In a site or area that has state environmental significance (e.g., national park, high ecological value waters, state marine park conservation zone). • Somewhat undisturbed by existing developments (i.e., partly intact). • Somewhat rare. • Somewhat sensitive to change, (i.e., can be disturbed or interrupted). • Serving a function that is not easily replaced or found elsewhere.
Low	A coastal process that is: • In a site or area with regional or local significance. • Somewhat disturbed by existing developments (i.e., not intact). • Not very rare. • Not sensitive to change (i.e., is not easily disturbed or interrupted).

Table 15.1 Sensitivity of environmental value – coastal processes (cont'd)

Sensitivity	Description
Low (cont'd)	• Serving a function that can be replaced or found elsewhere.
Negligible	A coastal process that is: • In a site or area with limited or no significance (e.g., already degraded). • Not intact at all and has been totally disturbed by existing developments. • Not rare at all. • Totally insensitive to change, (i.e., cannot be disturbed or interrupted). • Serving a function that is easily replaced or found elsewhere.

The three criteria used for assessing the magnitude of an impact on a coastal process are:

- Geographical extent.
- Duration.
- Severity of each impact.

The criteria for determining the magnitudes of an impact are defined in Table 15.2.

Table 15.2 Magnitude of impact – coastal processes

Magnitude of Impact	Description
Very high	Very large, widespread, long-term or irreversible changes to existing coastal processes. A long-term or irreversible change in water current speeds/water levels/wave heights/sediment transport rates greater than 30% of existing magnitudes over an area spanning more than 10 km.
High	Widespread long term changes to existing coastal processes. A long-term change in water current speeds/water levels/wave heights/sediment transport rates greater than 20% of existing magnitudes over an area spanning more than 1 km.
Medium	Significant changes to coastal processes confined to a limited area. A change in water current speeds/water levels/wave heights/sediment transport rates greater than 10% of existing magnitudes over an area spanning more than 100 m.
Low	Minor local changes in coastal processes. A change in water current speeds/water levels/wave heights/sediment transport rates less than 10% of existing magnitudes over an area spanning less than 100 m.
Negligible	Undetectable or insignificant changes to coastal processes.

The significance of an impact on an environmental value is determined by the sensitivity of the value itself and the magnitude of the change it experiences, as displayed in Table 15.3.

Table 15.3 Significance matrix - coastal processes

	Sensitivity of Environmental Value				
Magnitude of impact	**Very High**	**High**	**Medium**	**Low**	**Negligible**
Very High	Major	Major	High	Moderate	Minor
High	Major	High	Moderate	Moderate	Minor
Medium	High	Moderate	Moderate	Minor	Negligible
Low	Moderate	Moderate	Minor	Minor	Negligible
Negligible	Minor	Minor	Negligible	Negligible	Negligible

15.3 Existing Environment and Environmental Values

This section summarises the existing physical characteristics and coastal processes that may be affected by the project in the context of coastal values identified in Section 15.2.2 and environmental values as defined by the Environmental Protection Act and environmental protection policies for Port Curtis and surrounding waters.

15.3.1 Physiography

Port Curtis is a shallow coastal basin, situated directly offshore from the city of Gladstone within the greater Port of Gladstone as shown in Figure 15.1. Port Curtis is separated from the Coral Sea by Facing and Curtis islands, which protect the port from ocean swells.

Connections to the Coral Sea exist via South Channel to the south of Facing Island, North Channel between Facing and Curtis islands and The Narrows, which extends some 40 km to the northwest and separates Curtis Island from the mainland.

The Calliope River flows into Port Curtis and is one of the few remaining waterways in Queensland where major water-retaining infrastructure does not interrupt environmental flows to the coast. Boyne River and Auckland and South Trees inlets also discharge into Port Curtis and, to the south, discharge is from the connected waterways of Colosseum Inlet, Seven Mile Creek and Rodds Bay (see Figure 1.1). Northward, Grahams Creek and a number of smaller tributaries discharge to The Narrows.

Extensive intertidal flats appear at low tide and large intertidal mangrove and saltpan areas are inundated during high tides. Water depths have been modified by the development of shipping channels, land reclamation and coastal armouring.

15.3.2 Tides

Tides propagate into Port Curtis from South Channel, North Channel and The Narrows. This results in complex interactions, with tidal flows from the north and south meeting near the centre of The Narrows.

Tides in Port Curtis are semi-diurnal, with two high and low tides per day. Tide tables for the area are published by Maritime Safety Queensland and are based on extensive recordings and analyses at a number of locations in Port Curtis. Table 15.4 details tidal statistics for Gladstone Port, Fishermans Landing and The Narrows at Boat Creek.

The funnelling effect of The Narrows means that spring and neap tidal ranges increase with distance north, i.e., the tidal range at Fishermans Landing is approximately 6% greater than at Gladstone Port, and the tidal range at Boat Creek in The Narrows is almost 17% greater than at Gladstone Port.

The large tidal range and extensive intertidal banks, mangrove and saltpan areas in Port Curtis result in non-linear changes to the available water storage areas at different tidal elevations. These in turn are an important factor in the tidal hydrodynamic behaviour of Port Curtis.

Within the Calliope River, the tidal cycle influences water levels up to 25 km upstream of the river mouth. A bar at the entrance to the river significantly reduces the tidal prism, i.e., the ability of water to leave the river during ebb tide is reduced due to the bar acting as a natural dam.

Table 15.4 Tidal statistics

Parameter		Location		
		Gladstone Port	Fishermans Landing	The Narrows at Boat Creek
Highest astronomical tide (m)		4.83	5.12	5.60
Lowest astronomical tide (m)		0.00	0.00	0.00
Mean water level (m)		2.34	2.41	2.68
Australian height datum (m)		2.27	2.43	No data
Spring tides	Mean high water (m)	3.96	4.20	4.58
	Mean low water (m)	0.72	0.76	0.79
	Tidal range (m)	3.24	3.44	3.79
Neap tides	Mean high water (m)	3.11	3.30	3.59
	Mean low water (m)	1.57	1.66	1.79
	Tidal range (m)	1.54	1.64	1.80

Note: Water levels are reported as height above lowest astronomical tide.

15.3.3 Water Currents

The hydrodynamic model developed and validated for the WBDD Project EIS (GHD, 2009a) was adapted for use in this assessment and, in conjunction with direct measurements, characterises existing conditions.

Water currents are controlled by the tidal cycle. The large tidal storage areas and the amplification effect on water levels mean good tidal flushing and large current speeds exist within Port Curtis. Typical spring tide current speeds within dredged shipping channels can reach 2 m/s.

Water currents are substantially reduced over the shallower intertidal areas of Port Curtis. The high water current speeds in the deeper sections of Port Curtis assist in maintaining the harbour as a natural, deep water port.

15.3.4 Waves

Port Curtis is protected from ocean generated waves by Facing and Curtis islands. The resulting sheltered environment is only exposed to wind driven waves generated within Port Curtis itself. In the study area, the longest fetches (the area in which wind driven waves are formed) do not exceed 10 km in length, meaning that wind driven waves do not build to large heights.

Details of the computer model developed to characterise the wave climate in Port Curtis for both day to day and extreme events are provided in Appendix 8, Coastal Processes, Marine Water Quality, Hydrodynamics and Legislation Assessment.

Day to Day Wave Climate

The day to day wave climate was modelled at six locations offshore from Hamilton Point and Boatshed Point in the vicinity of project marine infrastructure. Modelling results indicate that, at all sites, the dominant wave direction is from the southeast. Significant wave heights (defined as the average wave height, trough to crest, of the largest one-third of waves) never exceed 0.9 m and are less than 0.3 m for 80% of the year.

Extreme Waves

Gladstone lies in a region prone to tropical cyclones. Modelling was used to assess the wave climate during cyclonic conditions. Results show that long-period ocean swells during cyclonic conditions are blocked from entering the study area by Facing Island and the mainland coastline south of South Trees Inlet.

Cyclonic wind generated waves within Port Curtis were modelled and show that significant wave heights can reach 2.45 m.

15.3.5 Extreme Water Levels

During cyclones, water levels at the coast may be substantially higher than normal due to storm surge effects. Storm surges are increases in water level caused by onshore cyclonic winds pushing on the ocean surface and reduced atmospheric pressure.

Storm tides are the combined effect of normal tides and storm surges acting together to increase water levels. Storm surges may peak at any stage of the tidal cycle. The highest storm tide levels are the result of storm surge peaks coinciding with high water during spring tides. The probability of a storm surge peak coinciding with a spring high tide is low.

An ocean hazard assessment undertaken by James Cook University (Hardy et al., 2004b) for open waters in Queensland (including Gladstone) estimated storm tide water levels for present day climatic conditions, and also for future conditions affected by climate change.

The climate change scenarios were based upon a 50 year planning period that allows for a future increase in mean sea level of 0.3 m. Table 15.5 shows estimated storm tide levels in Gladstone, both for present day and future climatic conditions.

Table 15.5 Storm tide average recurrence intervals at Gladstone

Average Recurrence Interval	Present day Storm Tide Level (m AHD)	Storm Tide Level Including Climate Change (m AHD)
100 year	2.82	3.33
500 year	3.51	4.18
1,000 year	3.80	4.51

15.3.6 Sediment Transport and Coastal Processes

Mobilisation and transport of seafloor sediments occur due to the combined action of waves and water currents, or by water currents alone. The influence of waves is diminished as water depth increases. Low wave heights in Port Curtis mean wave action does not play a significant role in sediment transport processes in parts of the port, e.g., shipping channels.

Small waves can be important in mobilising fine sediments in the shallower parts of Port Curtis. Once mobilised, these fine sediments are carried in suspension by prevailing water currents and will settle again in areas where wave and water current energy is less, or when prevailing conditions abate.

Typical seafloor sediments in the deeper parts of the study area are a mixture of gravels, sands, silts and clays. In areas with strong prevailing water currents, seafloor sediments are typically comprised of coarser material because finer particles are transported away by water currents. The shallower intertidal areas are a mixture of sands and silts, with fine soft silts dominating areas where water currents and wave energies are lowest.

The Hamilton Point shoreline near the LNG jetty consists of a 10 m wide beach composed of silty sand that steeply slopes offshore into deeper water. At the southern end of Hamilton Point, the shoreline is of a similar character with a narrower (approximately 5 m wide) beach profile, with some fringing mangroves. The shoreline along Boatshed Point is rockier and slopes steeply offshore.

Between the more exposed headlands, the embayed areas are lined with mangroves and flat intertidal zones consisting of fine cohesive sediments. The silty nature of the beaches and the presence of mangroves in the embayments indicate that the wave and current regime and associated coastal processes are generally benign along this shoreline.

To the west of Hamilton Point, low significant wave heights, in combination with a wave direction parallel with the shoreline, mean that sediment transport activity associated with these waves is minimal. To the east of Hamilton Point and at Boatshed Point, the exposed parts of the coastline are rockier and reflect the greater exposure to prevailing waves and increased sediment transport.

Although infrequent and short in duration, cyclonic conditions result in a much more energetic wave environment. The increased sediment transport during these extreme conditions is counterbalanced by the build up of mangroves and cohesive sediment during day to day conditions.

A review of the fluvial geomorphology of the Calliope River was conducted during environmental impact assessment process for the Wiggins Island Coal Terminal (Connell Hatch, 2006). Except during major flood events, sediment transport processes are governed by tides. While riverbed sediment particles displace locally on each tidal cycle, they remain within the estuary.

15.3.7 Sensitivity of Environmental Values

Port Curtis is somewhat disturbed by human activity, and coastal processes in the study area are not particularly unique or easily disturbed. While equivalent conditions occur elsewhere, the port does have regional significance. A conservative approach has been adopted whereby the attribute with the highest sensitivity has been selected as the factor in determining the overall sensitivity. This approach has resulted in an overall sensitivity ranking for the coastal processes in Port Curtis as low.

The same assessment approach was applied to the regionally significant but somewhat disturbed Calliope River. Conditions in the river are not very rare or easily disturbed and can be found in estuaries along the east coast of Queensland. Based on existing conditions, the overall sensitivity of the hydrodynamics and sediment transport processes in the Calliope River is low.

15.4 Issues and Potential Impacts

This section describes the issues and potential impacts on coastal processes arising from project construction and operation. The project will perform dredging works during construction to facilitate installation of marine facilities. Maintenance dredging will occur during operation to maintain shipping access to marine infrastructure sites on Curtis Island and the mainland.

Project specific dredging locations are limited to the following:

- The mainland launch site (either at launch site 1 or launch site 4N).
- The MOF and personnel jetty (either at Boatshed Point or Hamilton Point South).
- The LNG jetty.

While the Arrow LNG jetty swing basin will be dredged as part of the WBDD Project, it has been included in the modelling carried out for Curtis Island dredging and provides a worst case assessment of impacts in this area of Port Curtis.

All dredge spoil will be placed in the Western Basin Reclamation Area. The reclamation area was assessed under the WBDD Project EIS and the design of the area allows for placement of material dredged during project construction and operation.

Project facilities with a marine component are likely to be:

- The feed gas pipeline mainland tunnel entry site, which will be located in an area subject to tidal inundation.
- The mainland launch site where a number of pylons will be driven into the seafloor to support floating pontoons and rigid wharf structures as well as some revetment (i.e., shoreline armouring) installed to prevent erosion of the shoreline at this location.
- The MOF and personnel jetty, which will extend into Port Curtis, and some revetment along the shoreline.
- The LNG jetty, which will extend 250 m into Port Curtis from a shoreline protected by revetment. The jetty will sit on subsea piles embedded into the seafloor. A number of LNG jetty breasting dolphins and mooring dolphins will be installed on piles driven into the seafloor.

The feed gas pipeline will cross Port Curtis in a tunnel bored beneath the seafloor. The construction and operation of the pipeline will not impact on coastal processes other than those at the mainland tunnel entry site where some upper tidal storage volume will be lost (see Section 15.4.1). Other impacts on coastal processes are not expected as this site is above mean spring high tide level (see Appendix 8, Coastal Processes, Marine Water Quality, Hydrodynamics and Legislation).

All impacts in this section have been assessed in the context of cumulative impacts associated with the major port expansion works, i.e., by comparing cumulative and project impacts against cumulative without project impacts.

The sensitivity ranking for both Port Curtis and the Calliope River has been assessed as low**.** This ranking has been used in the impact assessment in conjunction with the magnitude of impact to determine the overall significance of impacts for each environmental aspect.

15.4.1 Impacts to Tides and Water Currents

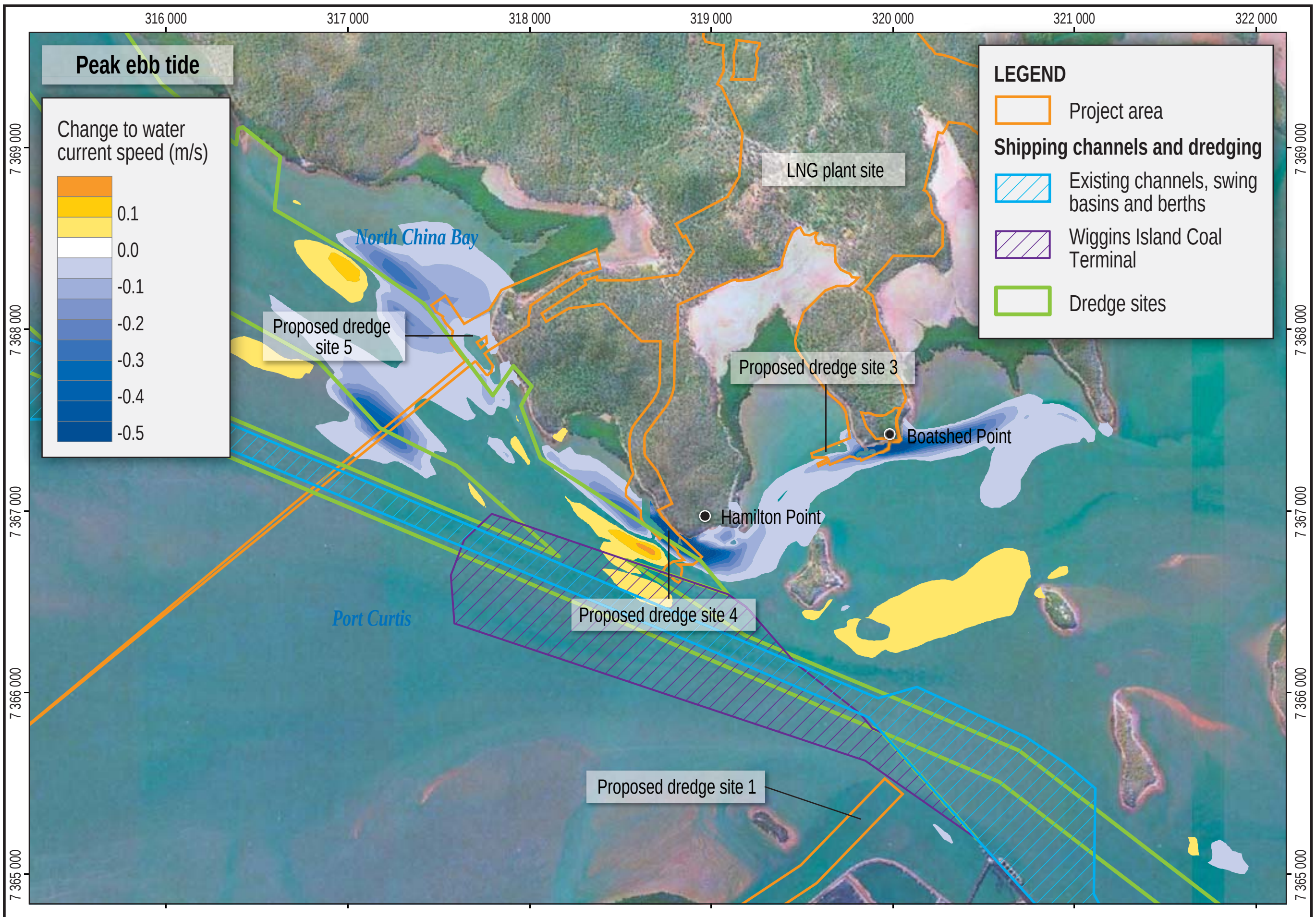
Dredging activities and the installation of marine infrastructure could change the existing tidal regime and water current patterns in Port Curtis, which, in turn, may affect sediment transport and shoreline processes. Similarly, dredging works and the marine components of launch site 1 in the Calliope River have the potential to alter tidal patterns and sediment transport in the river.

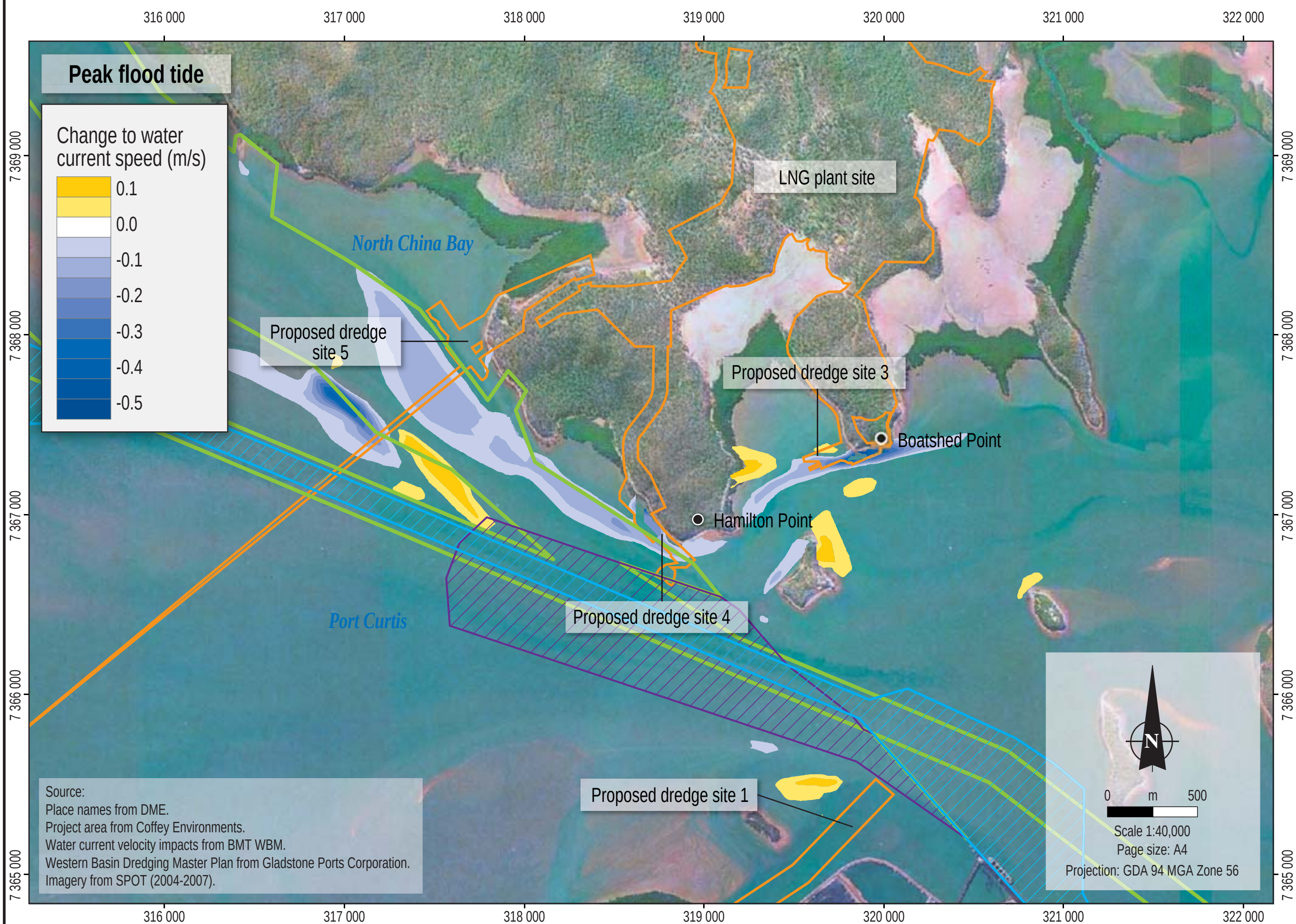
Port Curtis

Computer modelling shows that project activities will not have any effect on water levels (i.e., tides) in Port Curtis, either within the study area or outside the study area. The magnitude of impact to tides is therefore negligible and the resulting significance of impacts is **negligible**.

Figure 15.2 shows project related changes to water current speeds during peak flood and peak ebb tidal conditions when impacts will be greatest.

Water current speeds in the vicinity of the LNG jetty swing basin decrease by a maximum of 0.50 m/s during flood tides and 0.43 m/s during ebb tides, (i.e., decreases of 44% and 40%, respectively).





coffey environments	Date: 25.11.2011 MXT: 7033CA_07_GIS115_v1_3 File Name: 7033_07_F15.02_GIS_GL	Arrow Energy Arrow LNG Plant	arrow energy go further	Water current speed impacts	Figure No: 15.2

During ebb tides, current speeds will decrease by no more than 0.9 m/s (86% decrease) adjacent to Hamilton Point South MOF and personnel jetty and they will decrease by up to 0.6 m/s (92% decrease) offshore Boatshed Point MOF and personnel jetty during the same period. Additional small changes to current speeds will occur further offshore from Curtis Island.

These changes to current speeds occur over a distance not exceeding 1 km, with smaller changes occurring over greater distances. Impacts on water current speeds from North China Bay to Hamilton Point are largely associated with the WBDD Project dredging activities in the LNG jetty swing basin (see Section 15.2.2) and the magnitude of actual impacts from project specific dredging at this location will be less than those shown on Figure 15.1 and assessed here.

Construction of the feed gas pipeline mainland tunnel launch site and tunnel spoil disposal area will result in the loss of some upper tidal storage volume. The resulting impacts on tidal hydrodynamics in Port Curtis will be small as the majority of the area that will be lost is above mean spring high tide level.

Overall, a medium magnitude of impact on water currents in Port Curtis is predicted to occur, resulting in a **minor** significance of impact.

Calliope River

Computer modelling indicates that water levels in the Calliope River will not be affected at high tide. Low tide water levels during spring tides will be lower at some locations by up to 0.8 m. Changes in water level will occur from the mouth of the river upstream to site 10 and will be greatest from sites 2 to 8 (Figure 15.1).

The resulting magnitude of predicted impacts has been assessed as very high and the resulting significance of impacts on water levels in the Calliope River is **moderate**.

During ebb spring tides, changes to current speeds are predicted to increase by up to 0.6 m/s (72% increase) at the mouth of the newly dredged channel and decrease by up to 0.7 m/s (60% decrease) to the west of the new channel. Under flood spring tidal conditions, current speeds are predicted to increase by up to 0.6 m/s (59% increase) to the west of the dredged channel and decrease by up to 0.7 m/s (42% decrease) within the dredged channel along its eastern bank.

A very high magnitude of impacts on current speeds in the Calliope River is predicted to occur, resulting in a **moderate** significance of impacts.

15.4.2 Impacts to Waves

Computer modelling was used to predict impacts due to project activities in Port Curtis to the day to day wave climate and also to extreme waves. An assessment on the wave climate in the Calliope River was not performed as waves do not occur in the river.

Day to Day Wave Climate

The day to day wave climate will not be affected at four of the six assessment locations offshore from the LNG site from North China Bay to Boatshed Point. Effects at sites 3 and 4 are as follows:

- Site 3 located midway between the LNG jetty and Hamilton Point South MOF and personnel jetty – significant wave heights from the southeast will be reduced by 1.5%.
- Site 4 located offshore of the Hamilton Point South MOF and personnel jetty – significant wave heights from the east southeast will increase slightly by 1.5%.

The MOF and personnel jetty will be constructed as a solid structure extending into Port Curtis. This solid intrusion offshore will reduce overall wave action in the immediate vicinity on either side of the structure.

The magnitude of impacts on the wave climate in Port Curtis has been assessed as low, resulting in **minor** significance of impacts.

Extreme Waves

Modelling shows that project infrastructure will not affect wave heights during extreme events. The influence of the LNG jetty swing basin will increase significant wave heights by up to 0.15 m during cyclone events. The magnitude of impact on extreme waves is medium, and the significance of impacts is **minor**.

15.4.3 Extreme Water Levels

Project activities will not affect extreme water levels resulting from cyclonic conditions such as storm tides, either under current or future climatic conditions. The magnitude of impacts on extreme water levels is negligible, and the resulting significance of impacts is **negligible**.

15.4.4 Sediment Transport and Deposition and Shoreline Processes

Impacts on sediment transport and shoreline processes, both in Port Curtis and the Calliope River, are described below.

Port Curtis

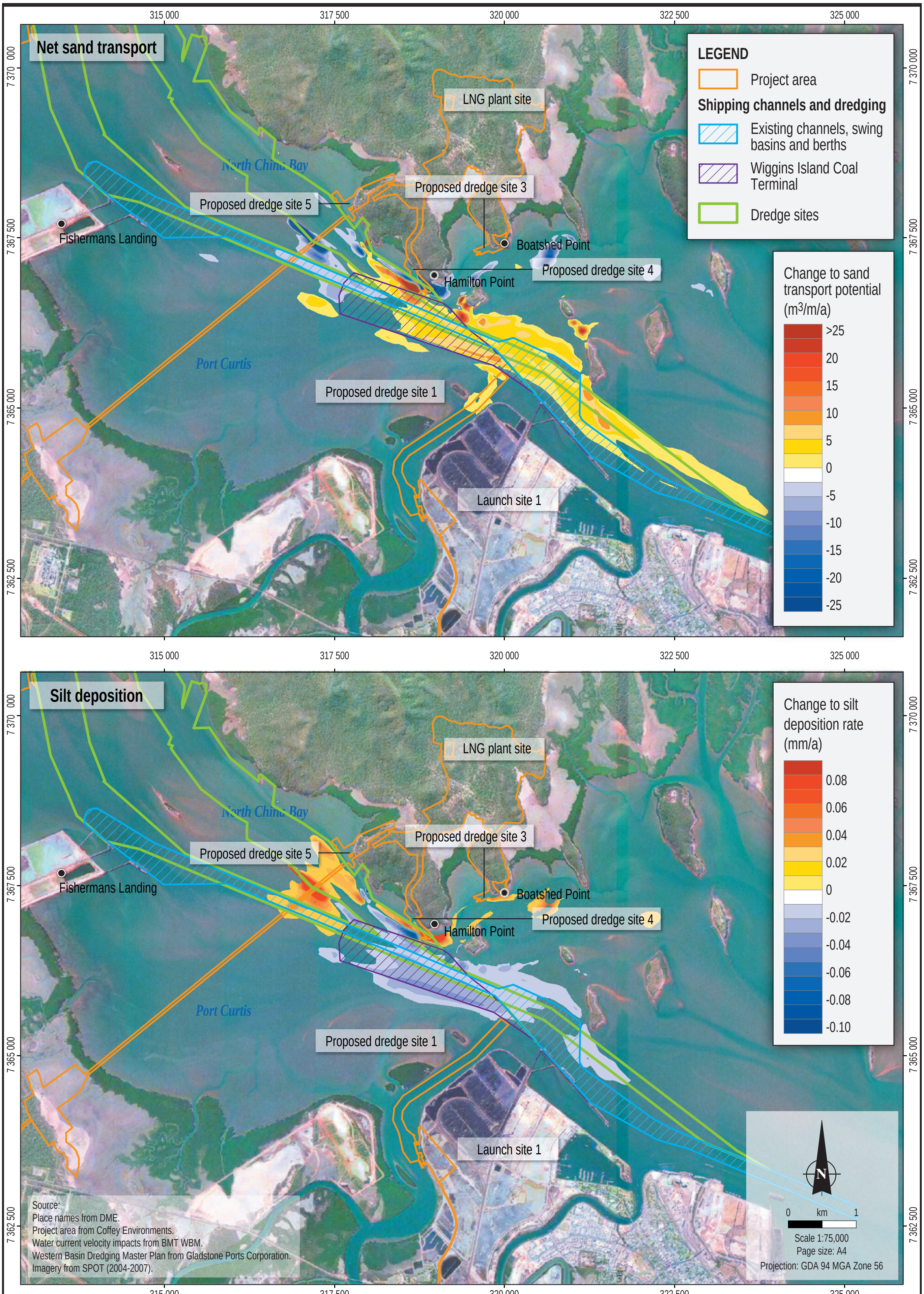
Longshore sediment transport does not occur at Hamilton Point South or at Boatshed Point. The presence of the MOF and personnel jetty at these locations is not expected to have a major impact on shoreline processes. The MOF and personnel jetty will reduce wave action on either side of the structure, leading to a small, localised buildup of silt.

Modelled project impacts on net silt deposition and sand transport is shown in Figure 15.3 and indicates that the LNG jetty swing basin will be prone to accelerated deposition of fine material due to changes in the hydrodynamic regime following dredging. During operation, approximately 10,000 m^3 of material will require removal every year to maintain navigable depths in the LNG jetty swing basin.

Sand transport will increase from adjacent to the Hamilton Point South MOF and personnel jetty to the southeast. Sand transport will decrease in and around the LNG jetty swing basin and to the east of Boatshed Point.

The magnitude of predicted impacts on sediment transport and deposition and shoreline processes in Port Curtis is medium and the resulting assessment of significance of impacts on sediment transport and shoreline processes in Port Curtis is **minor.**

These impacts are largely due to dredging activities to create the LNG jetty swing basin, which will occur as part of the WBDD Project (see Section 15.2.2). The magnitude of impacts resulting from project-specific dredging will therefore be less than those shown in Figure 15.3 and assessed here.



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File Name: 7033_07_F15.03_GIS_GL

Arrow Energy

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Net sand transport and silt deposition impacts

Figure No: 15.3

Calliope River

Upstream impacts, including project effects on flooding and geomorphology, are described in Chapter 13, Surface Water Hydrology and Water Quality.

Dredging at the mouth of the Calliope River will alter existing bed shear stress magnitudes and rates of sediment transport and deposition. Bed shear stress governs the ability of a river to transport sediment down current (either in suspension or as bed load). Modelled changes to bed shear stress magnitudes during peak ebb and flood spring tides are shown in Figure 15.4.

Areas where shear stress is reduced will likely experience increased sediment deposition and, conversely, those with increased shear stress will experience reduced sediment deposition.

Modelling predicted that maintenance dredging during operation will be required at the northeastern extent of the dredged channel and in the middle reach of the channel.

The magnitude of impacts on sediment transport and shoreline processes in the Calliope River is high (i.e., rates of sediment deposition will differ by at least 20%), resulting in an assessment of significance of sediment transport and shoreline processes in the Calliope River as **moderate.**

15.4.5 Summary of Impacts

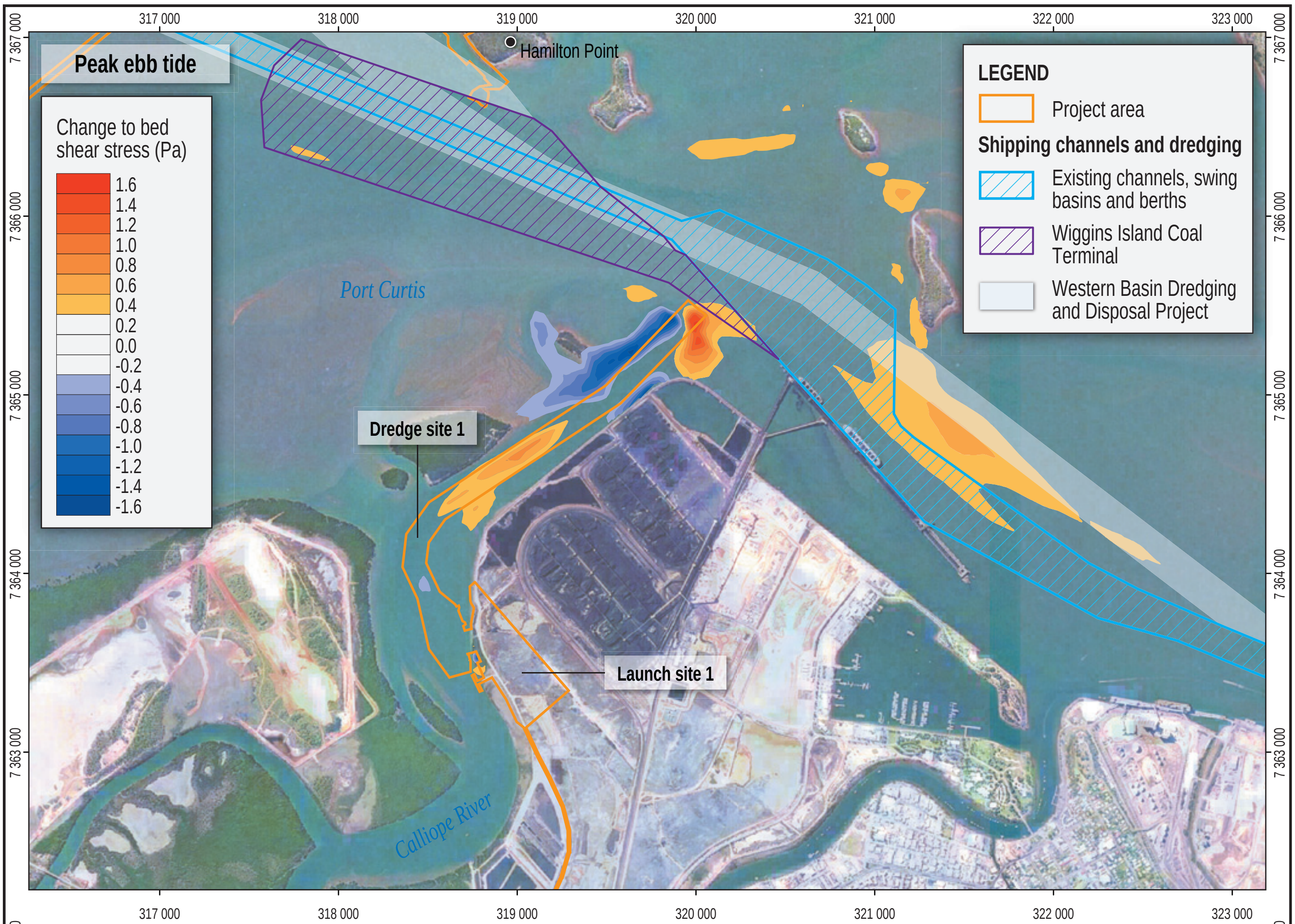
Table 15.6 summarises the predicted magnitude of impact and assessment of significance of impacts for each environmental aspect assessed, with the sensitivity of each value.

Table 15.6 Significance of impacts on coastal processes

Aspect	Area	Sensitivity of value	Magnitude of impact	Significance of impact
Tides and water level	Port Curtis	Low	Negligible	Negligible
	Calliope River	Low	Very high	Moderate
Water currents	Port Curtis	Low	Medium	Minor
	Calliope River	Low	Very high	Moderate
Day to day wave climate	Port Curtis	Low	Low	Minor
	Calliope River	Not applicable	Not applicable	Not applicable
Extreme event waves	Port Curtis	Low	Medium	Minor
	Calliope River	Not applicable	Not applicable	Not applicable
Extreme water levels	Port Curtis	Low	Negligible	Negligible
	Calliope River	Low	Negligible	Negligible
Sediment transport and deposition and shoreline processes	Port Curtis	Low	Medium	Minor
	Calliope River	Low	High	Moderate

15.5 Avoidance, Mitigation and Management Measures

Other than dredging activities in the Calliope River, impacts are all predicted to be minor or negligible. Much of the mitigation that would otherwise have been required has been avoided through design. For example, the feed gas pipeline mainland tunnel entry site and tunnel spoil disposal area has been sited largely above mean spring high tide level so that resulting impacts on hydrodynamics in Port Curtis will be negligible.



coffey environments	Date: 27.09.2011 MXT: 7033CA_07_GIS115_v1_2 File Name: 7033_07_F15.04_GIS_JO	Arrow Energy Arrow LNG Plant	arrow energy go further	Calliope River bed shear stress impacts	Figure No: 15.4

Avoidance, mitigation and management measures proposed to manage the impacts on coastal process values arising from the construction of the project's marine infrastructure are:

- Stabilise the shoreline, where required, at the high tide level where marine infrastructure is installed. [C15.01]
- Develop a dredge management plan that considers the appropriate water and sediment monitoring data (e.g. current WBDD Project data) and will include: [C15.02]
  - Requirements for monitoring of water quality. [C15.03]
  - Actions to be taken to minimise impacts of dredging on sensitive areas should water quality monitoring data show performance criteria are exceeded. Finalise specific actions in the dredge management plan. [C15.04]

During operation:

- Implement management measures from the dredge management plan to address impacts from maintenance dredging. [C15.05]

During decommissioning:

- Decommission the LNG jetty and loading facilities in a similar fashion to the LNG Plant. Dismantle the LNG jetty and cut the piles off at the seafloor. Remove the structure and piles as scrap. Remove debris from the concrete deck and building foundations for disposal on land. [C15.06]
- Leave the MOF and shore protection works at the LNG jetty (local benthic habitat and associated flora and fauna will have adapted to its presence over the operational life of the project). [C15.07]
- Only demolish the mainland launch site if another use is not identified. [C15.08]

15.6 Residual Impacts

The avoidance, mitigation and management measures are assumed to have been implemented during the impact assessment; therefore residual impacts are the same as those described in Section 15.4, Issues and Potential Impacts.

15.7 Inspection and Monitoring

The dredge management plan will specify water quality and marine ecology monitoring requirements (also see Chapter 16, Marine Water Quality and Sediment, and Chapter 19, Marine and Estuarine Ecology) including those to assess the impact of maintenance dredging in the Calliope River

Other inspections and monitoring will be undertaken in accordance with Arrow's Health, Safety and Environmental Management System and will reflect project approval requirements directed by government departments. During operation, inspections will be undertaken at regular intervals to check that mitigation measures are effective in reducing the magnitude of impacts.

Gladstone Ports Corporation will carry out maintenance dredging of shipping channels within Port Curtis that are to be used by the project. The dredge management plan for these activities will be developed by the Gladstone Ports Corporation and will apply to any dredging activities in the LNG jetty swing basin.

15.8 Commitments

The measures (commitments) that Arrow Energy will implement to manage impacts on coastal processes are set out in Table 15.7.

Table 15.7 Commitments: Coastal processes

No.	Commitment
C15.01	Stabilise the shoreline, where required, at the high tide level where marine infrastructure is installed.
C15.02	Develop a dredge management plan that considers the appropriate water and sediment monitoring data (e.g. current WBDD Project data) and will include:
C15.03	• Requirements for monitoring of water quality.
C15.04	• Actions to be taken to minimise impacts of dredging on sensitive areas should water quality monitoring data show performance criteria are exceeded. Finalise specific actions in the dredge management plan. Common with Chapter 16, Marine Water Quality and Sediment and Chapter 19, Marine and Estuarine Ecology.
C15.05	Implement management measures from the dredge management plan to address impacts from maintenance dredging.
C15.06	Decommission the LNG jetty and loading facilities in a similar fashion to the LNG Plant. Dismantle the LNG jetty and cut the piles off at the seafloor. Remove the structure and piles as scrap. Remove debris from the concrete deck and building foundations for disposal on land.
C15.07	Leave the MOF and shore protection works at the LNG jetty (local benthic habitat and associated flora and fauna will have adapted to its presence over the operational life of the project).
C15.08	Only demolish the mainland launch site if another use is not identified.