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Proposed QCLNG Project EIS

Coastal Process Assessments

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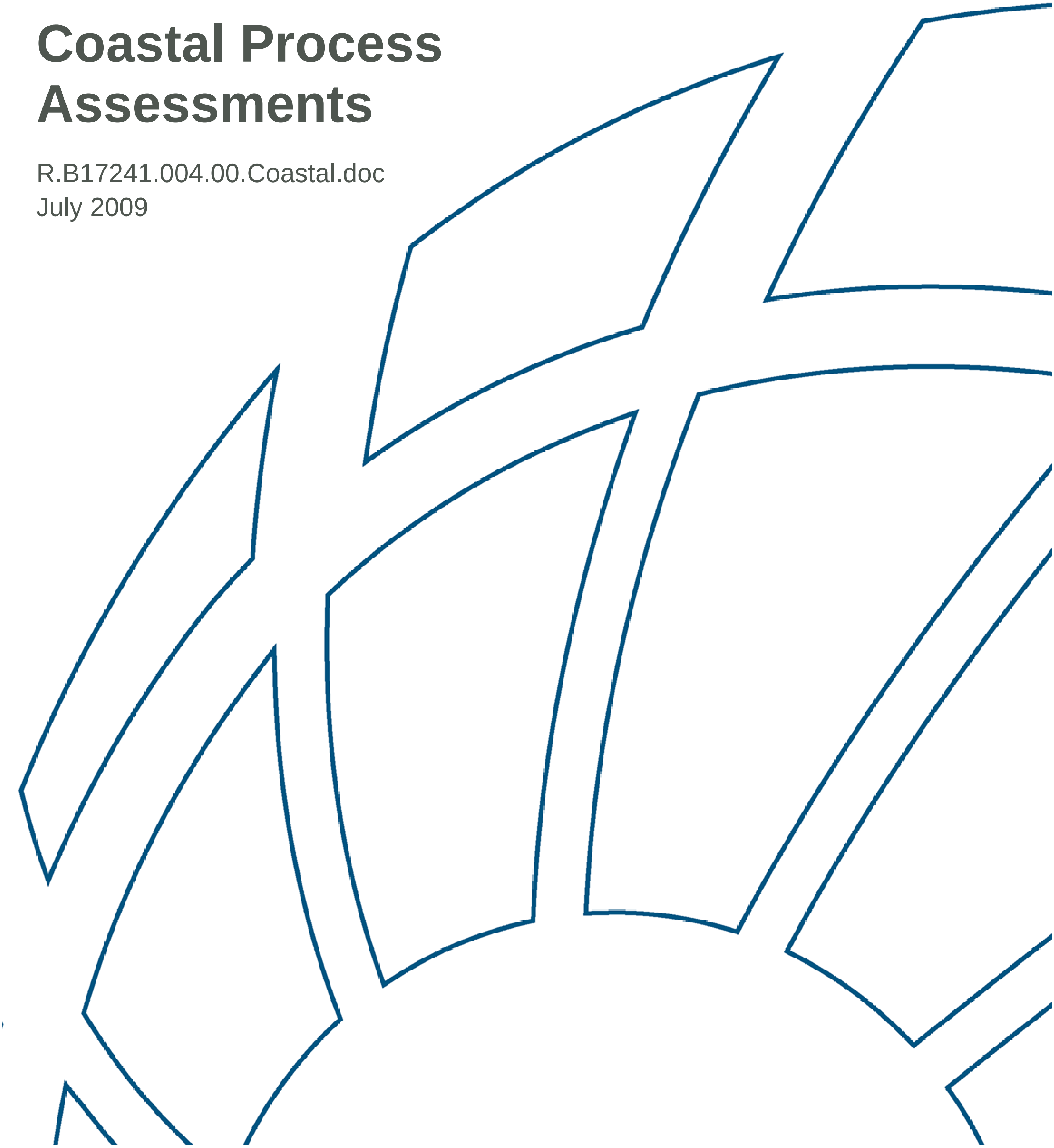

Proposed QCLNG Project EIS

Coastal Process Assessments

Prepared For:	ERM
Prepared By:	BMT WBM Pty Ltd (Member of the BMT group of companies)

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Title :	Proposed QCLNG Project EIS – Coastal Process Assessments
Author :	Craig Witt; Malcolm Andrews; Dr Ian Teakle; Joris Jorissen
Synopsis :	This report documents the coastal process assessments and associated potential impacts (mainly water levels, waves, shoreline behaviour and potential siltation) due to the construction of onshore facilities and dredging of a swing basin and associated channels for a LNG facility in the western port area of Gladstone.

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1 INTRODUCTION

BMT WBM was commissioned by ERM on behalf of QGC (a British Gas (BG) group business) to execute technical studies to inform the EIS of a proposed LNG facility on Curtis Island, Queensland. This report documents the coastal process assessments and associated potential impacts (mainly water levels, waves, shoreline behaviour and potential siltation) due to the construction of onshore facilities and dredging of a swing basin and associated channels.

2 GENERAL DESCRIPTION

The proposed QGC LNG facility is located on the west coast of Curtis Island opposite the existing Fisherman's Landing reclamation The Port of Gladstone has been established in the naturally sheltered waters of Port Curtis behind Facing and Curtis Islands to the east and north. Port Curtis is connected to the ocean via a major opening to the south of Facing Island (South Channel), a smaller opening between Facing and Curtis Islands (North Channel) and "The Narrows" which extend some 40 km to the north behind Curtis Island.

The Calliope and Boyne Rivers as well as Auckland and South Trees Inlets discharge into the central section of the Port. Further to the south are the connected waterways of Colosseum Inlet, Seven Mile Creek and Rodds Harbour while Grahams Creek and a number of smaller tributaries connect to The Narrows.

These extensive waterway areas and a large tidal range result in significant current velocities in some areas. The high tidal velocities generally assist in maintaining Gladstone harbour as a natural, deep-water port. However a navigation channel has been established and is maintained to provide access for larger draft vessels.

The Port area also contains a number of smaller islands and has extensive areas of inter-tidal flats, which become exposed at low water. For very low tides, some areas reduce to several narrow meandering channels. There are also very large intertidal mangrove and saltpan areas in Port Curtis, which are inundated at higher tide levels.

The proposed LNG facilities are somewhat isolated from other facilities in the harbour and will be the most northern development to date. Dredging will be required for the approaches, berths and swing basin as described elsewhere.

A short causeway and jetty facilities as well as a MOF will extend out across the relatively narrow intertidal flats and mangrove fringes of Curtis Island.

It is expected that all dredge material associated with the local dredging for the facility will be placed within dredged material reclamation areas in the Fisherman's Landing region. As such, there will be no offshore disposal of dredge material and no need for detailed consideration of the processes at the Port's offshore spoil ground. Assessment of the reclamation areas is being carried out separately for GPC and QGC under a separate scope of works.

Accordingly of importance to this project are the coastal processes operating within western Port Curtis as outlined in the following sections.

3 TIDAL HYDRAULICS

An understanding of the tidal hydrodynamics is important not only for the project design in terms of tide level variations and current speeds/directions but also for its controlling influences on flushing and sediment transport processes. The project involves channel / swing basin dredging and minor MOF reclamation works and it is necessary to understand the potential direct impacts these may have on tidal hydraulic processes as well as any follow on effects for water quality and sedimentation.

The extent of the tidal hydraulic system considered in the context of this study includes the whole of the estuarine waters of Port Curtis and connected rivers/inlets as described above. Tides propagate into the port from the south (south of Facing Island), east (between Facing and Curtis Islands) 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 Gladstone Harbour at Auckland Point (Maritime Safety Queensland, 2009). 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 3-1 as heights above the local Lowest Astronomical Tide (LAT) level.

Table 3-1 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 (MLWS)	0.67	0.71	0.73	0.93
Lowest Astronomical Tide (LAT)	0.00	0.00	0.00	0.00

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

Further understanding and detailed assessment of the tidal hydraulic processes of Port Curtis and in the vicinity of the site have been obtained through hydrodynamic modelling and targeted data collection. BMT WBM has undertaken a range of 2D and 3D hydrodynamic assessments for the proposed development. Descriptions of the 2D hydrodynamic model and associated impacts of the proposed works on tidal hydraulics are provided in the separate "Marine Water Quality Assessments" report. Further detailed 3D hydrodynamic modelling has also been undertaken as described in the "Initial 3D Hydrodynamic Assessments" report. Results from these separate reports are referenced and drawn upon as necessary as part of this study component.

4 ELEVATED WATER LEVELS

Water levels at 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 of storm tide probabilities in the Yepoon region was undertaken for the Beach Protection Authority by Blain Bremner and Williams (1985). 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 3.5m AHD and 2.9m AHD respectively. Any storm surge on the open coast will propagate into Port Curtis and be influenced by local processes as well.

A more recent comprehensive study by the Queensland Government examines storm tide vulnerability and potential increases in sea level from Greenhouse and more intense cyclonic effects on coastal communities. The report “Queensland Climate Change and Community Vulnerability to Tropical Cyclones: Ocean Hazards Assessment – Stage 3 Report”, (James Cook University, 2004) includes calculated storm tide levels at Gladstone. This study incorporated more detailed modelling on a nearshore grid of approximately 550m, which extended into Port Curtis.

The present day (2003) predicted storm tide levels in the region from the abovementioned study are listed in Table 4-1 for various recurrence intervals excluding wave-set up and climate change effects.

Table 4-1 Peak Storm Tide Levels (Present Day 2003)

Location	Storm Tide Level (m AHD)		
	100 year ARI	500 year ARI	1000 year ARI
Gladstone	2.82	3.51	3.80
Tannum Sands	2.50	3.05	3.31

Source: Queensland Government (2004)

It can be seen that there is some amplification (increase) in the predicted storm tide level moving into Port Curtis from the south. The resolution of the model (approximately 550m) is such that not all features would be accurately represented. Nevertheless, the trend is consistent with the amplification of the normal astronomical tide. On this basis, it could be anticipated that a further small amplification would occur to the LNG site. A 6% increase (similar to the astronomical tide amplification) gives storm tide levels of about 2.99m, 3.72m and 4.03m 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 should be minimal. An additional allowance of 0.1 to 0.2m for wave set-up would be adequate.

With respect to climate change, there is significant scientific opinion that baseline changes to climate may occur within the design life of much of our coastal and ocean community infrastructure. However, despite the growing body of scientific literature and knowledge, there are still no definitive predictions of its effects or potential impacts.

For example, there are still uncertainties as to the actual magnitude and rate of rise of mean sea level as a result of thermal expansion of the oceans and melting of glaciers and ice-sheets. This has lead to various scenarios being adopted by the Intergovernmental Panel on Climate Change (IPCC). They are based on the range of model results available and dependent upon the amount of future emissions assumed. The Institution of Engineers Australia, National Committee on Coastal and Ocean Engineering recommends that these values be used for planning and design.

IPCC (2007) The Fourth Assessment Report of the International Panel on Climate Change (2007) reports that global sea level rise is projected to be 18–59 cm by year 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 to 20 cm (by year 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.

The climate models predict that there will be a not-insignificant regional variation in future sea level rise, predominantly due to spatial variations in the contribution made by ocean thermal expansion. Predictions reported by the CSIRO (2007) 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 28–91 cm by the year 2100. This will occur gradually at first as we continue to accelerate from the historic rate of 1.7 mm per year and then more rapidly as the year 2100 is approached.

The Queensland Government Ocean Hazards Assessment Study referred to above, examined the potential implications for storm tide statistics of three specific Greenhouse scenarios:

- Combined effect of an increase in Maximum Potential Intensity (MPI) of 10% and a poleward shift in tracks of 1.3°
- Increase in frequency/intensity of tropical cyclones of 10%
- Mean Sea Level rise of 300mm.

The mean sea level rise component (c) has an almost linear effect on the resultant storm tide levels while the 10% increase in cyclone frequency/intensity (b) has negligible impact. The combined increase in intensity and poleward shift in tracks (a) becomes increasingly significant with large return periods.

The resultant storm tide levels predicted with the combined Greenhouse scenarios are presented in Table 4-2.

Table 4-2 Peak Storm Tide Levels (Combined Greenhouse Scenarios 50 year Planning Period)

Location	Storm Tide Level (m AHD)		
	100 year ARI	500 year ARI	1000 year ARI
Gladstone	3.33	4.18	4.51
Tannum Sands	2.95	3.64	3.94

Source: Queensland Government (2004)

The abovementioned report emphasises that the chosen values in the Greenhouse scenarios are not necessarily endorsed, although care has been taken to propose reasonable values. The intention was to demonstrate the sensitivity of the storm tide frequency curves to climate change scenarios.

It should be noted the use of 0.3m 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 have been derived and are provided in Table 4-3.

Table 4-3 Peak Storm Tide Levels (Combined Greenhouse Scenarios 100 year Planning Period)

Location	Storm Tide Level (m AHD)		
	100 year ARI	500 year ARI	1000 year ARI
Gladstone	3.58/3.94*	4.43/4.79	4.76/5.12
Tannum Sands	3.20/3.56	3.89/4.25	4.19/4.55

*Mid-range/High-range sea level rise by 2100.

The choice of a 50- 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 should be applied in weighing up the risk of failure and options for future adaptation.

Adopting the above Greenhouse scenarios with a further 6% allowance for amplification to the LNG site gives a 100 year ARI design storm tide level of 3.53 to 4.18m AHD including allowances for future climate change (mid-range or high-range). This is approximately 0.54 to 1.19m higher than the present day (2003) 100 year ARI design storm tide level of 2.99m AHD referred to above.

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

5 WAVE CLIMATE

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

Facing and Curtis Islands 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. These fetch distances are all relatively short and confined to less than 10km. 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 as part of this present study 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 3.43m AHD representing approximately the 100 year ARI storm tide level with allowances for climate change influences. Although this is 0.1m lower than the elevated water levels calculated above this value was used as it is consistent with previous studies in the area and the level difference will have no appreciable effect 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 impact at the location of the proposed LNG facilities.

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 3.43m AHD approximately corresponding to a 100 year ARI storm tide.

The non-cyclonic wave assessment is summarised Table 5-1 below and indicates that, at a nearshore location with a bed level at -4.5mAHD, significant wave heights do not exceed 0.6m for 99.5% of the time with 64% coming from the 150 degree sector. A further 9% comes from the adjacent sectors of 120 and 180 degrees.

Table 5-1 Wave Occurrence at nearshore site (-4.5mAHD)

%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%	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%
Total	**6.2%**	**0.9%**	**0.3%**	**4.0%**	**64.0%**	**5.0%**	**3.2%**	**5.1%**	**1.6%**	**2.7%**	**7.1%**	**100.0%**

For cyclonic conditions significant wave heights at the proposed LNG facility were found to be greatest for winds blowing from the south-westerly quadrant due to the relatively unconstricted fetch in this direction. The 50 m/s wind generated significant wave heights (H_s) between 2.5 - 3.0m, depending on direction, in the channel offshore from the facility. In general the spectral peak period (T_p) of incident waves generated by such a cyclonic wind would be around 5s. No assessment was made of the annual exceedance probability of the combinations of wind speed, direction and water level for cyclonic conditions.

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

6 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 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 -4.5mAHD, the dominant wave direction is from 150 degrees. The wave heights are low with about 98% being below 0.3m Hs. This combination of low wave height with a direction which is predominantly shore parallel indicates that there will be very low sediment transport activity associated with these waves. This provides an environment suitable for mangrove growth as exhibited.

The cyclonic condition presents a much more adverse wave condition, however this will be infrequent and short in duration. It is expected that sediment movement during these conditions 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 impact on waves, currents and shoreline processes at or adjacent to the site.

The MOF structure extends out across the intertidal flats at an angle to the mangrove shoreline with a seaward protrusion of about 125m perpendicular to the mangrove fringe. Consideration is being given to the structure being completely solid or piled predominantly seaward of the mangrove fringe. 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.

Both the solid and piled options for the MOF are not expected to have any significant impact on shoreline processes adjacent to the site. As outlined above, any longshore sediment transport activity is low and there are no sandy beaches. The predominantly piled option would have minimal impact on prevailing wave conditions and associated processes. The solid option would 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 would create localised quiescent zones. As such, there may be small localised sediment build up adjacent to MOF facilities and siltation of the dredged areas as discussed below.

7 POTENTIAL SILTATION

7.1 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 likely future siltation rates. 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 7-1 presents details of maintenance dredging in the vicinity of the site over the last seven years as determined from dredge log details provided by the Port of Brisbane Corporation (who undertake the dredging). Various capital (development) dredging works have also been carried out during this period.

Table 7-1 Historical Dredging Quantities

Location	**Dredging Quantities (m^3)**						
	2007	**2006**	**2005**	**2004**	**2003**	**2002**	**2000**
Clinton Berths	3,800	7,600	10,300 (3 berths)	9,700 (3 berths)	3,150 (3 berths)	-	2,000 (2 berths)
Clinton Bypass Ch.	3,900	2,500	800	14,500	DEV+MAINT[1]	-	DEV+MAINT[4]
Clinton Swing Basin	4,200	4,300	5,300	7,800	400	-	1,000
Targinnie Ch.	14,600	17,600	12,300	42,500	DEV[2]	DEV[3]	3,600
Targinnie Swing	4,400	3,900	1,900	-	-	-	-
Fisherman's Landing Berth	-	1,900	-	-	1,400	6,500	600

Source: Port of Brisbane Corporation 1) 320,000 2) 95,000 3) 380,000 4) 46,400
Notes: Development is extra to maintenance
All volumes are in-situ cubic metres (tons dry/1.3)

The relatively small quantities of maintenance dredging reflects minimal siltation. This in turn is an indicator 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. Examination of historical hydrographic 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 Targinnie Channel adjacent to the passage island shoals, siltation may occur at a slightly higher rate of up to around 10 cm/annum.

7.2 Sediment Characteristics and Mobility

Data on the nature of the seabed sediments and those to be dredged have been obtained through previous investigations 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 inter tidal 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 by the combined action of waves and currents. The influence of waves is affected by water depth. Wave orbital velocities decrease with depth in a manner which depends directly 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 find sediments in the shallower areas. Once mobilised, these fine sediments are carried in suspension by the prevailing currents and will settle again typically in areas of lower wave/current energy and/or when prevailing conditions moderate.

7.3 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 detailed in the Marine Water Quality report. 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 1mm and hence do not account for the presence of non-erodable rocky outcrops.

During large spring tides, the strong ebb tide currents generate a high sediment transport potential to the southeast. 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 7-1. The net sand transport is generally in the ebb tide direction due to the abovementioned asymmetry in the tidal currents.

The developed case model includes dredging of the QGC Swing Basin and MOF as per layouts provided late last year, dredging of the Santos Swing Basin and dredging of the approach channel to these two proposed facilities. The predicted changes to the tidal velocities discussed in the separate Marine Water Quality and Initial 3D Hydrodynamics reports are reflected in the instantaneous sediment transport potentials. Dredging generally increases the overall conveyance, reduces velocities and therefore also reduces bed shear stresses and resulting sediment transport potential. In areas outside the dredging where velocities increase, the transport potential also increases.

The developed case sediment transport potential results in Figure 7-2 show 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 induced by the dredging. Similarly the sand transport potential into the proposed Santos Swing basin area is slightly increased in the developed case.

The modelled sedimentation (sand-sized material only) of a number of existing and proposed dredged areas has been summarised in Table 7-2. The net sedimentation volumes for the existing Targinie Channel and Targinie Swing Basin are generally consistent with the annual dredging volumes shown in (Table 7-1).

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 (Table 7-1).

Table 7-2 Modelled Net Sedimentation of Dredged Areas

Location	Modelled Net Sedimentation (m^3/annum)	
	Base	Developed
Targinie Channel	33,000 (16,000-66,000*)	30,000 (15,000-60,000)
Targinie Swing Basin	2,700 (1,300-5,400*)	1,100 (600-2,200)
QGC Swing Basin (and MOF)	-	1,000 (500-2,000)
Santos Swing Basin	-	1,000 (500-2,000)
QGC/Santos Approach Channel	-	2,600 (1,300-5,200)

* Likely error bounds.

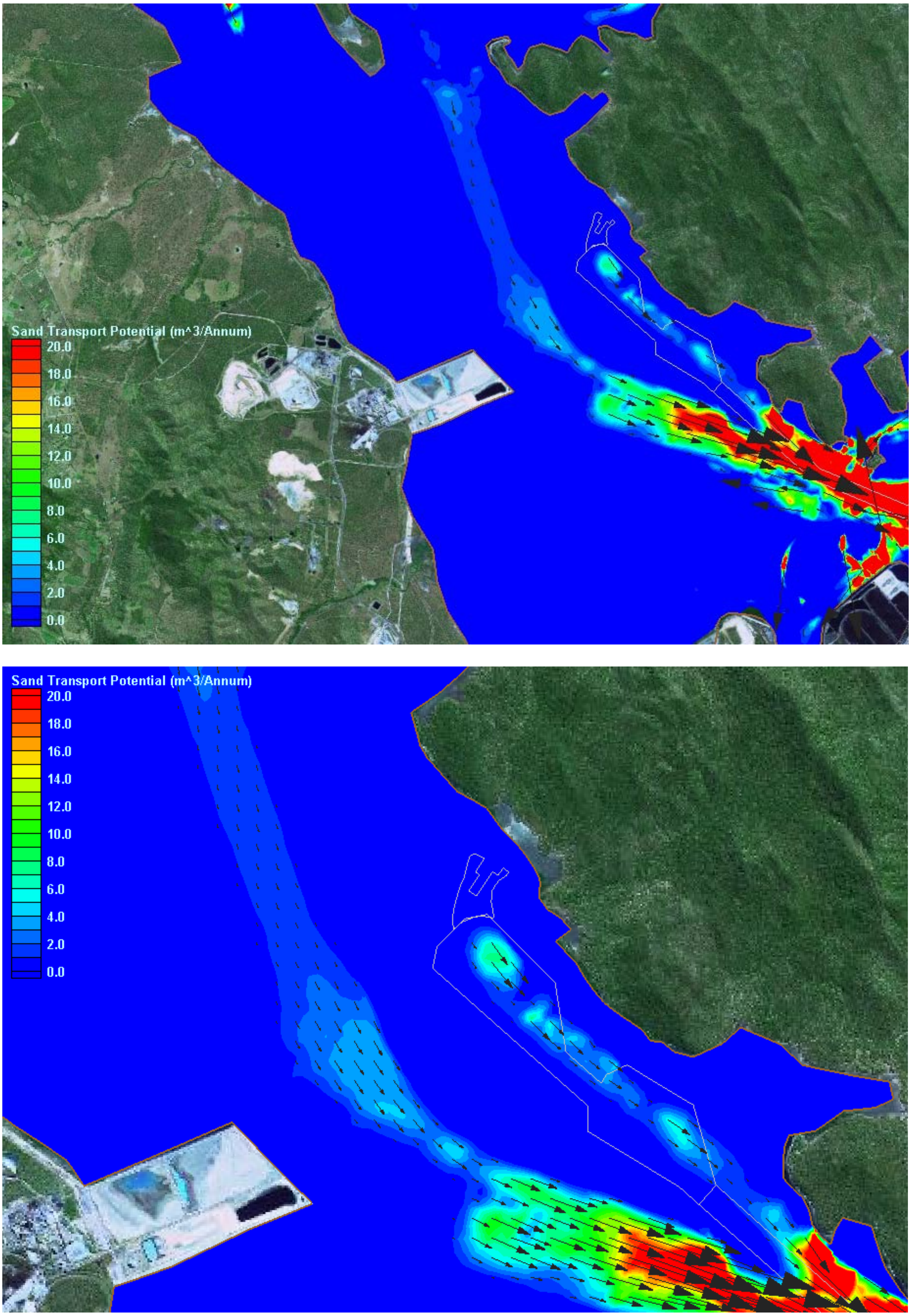

Figure 7-1 Base Case Sand Transport Potential

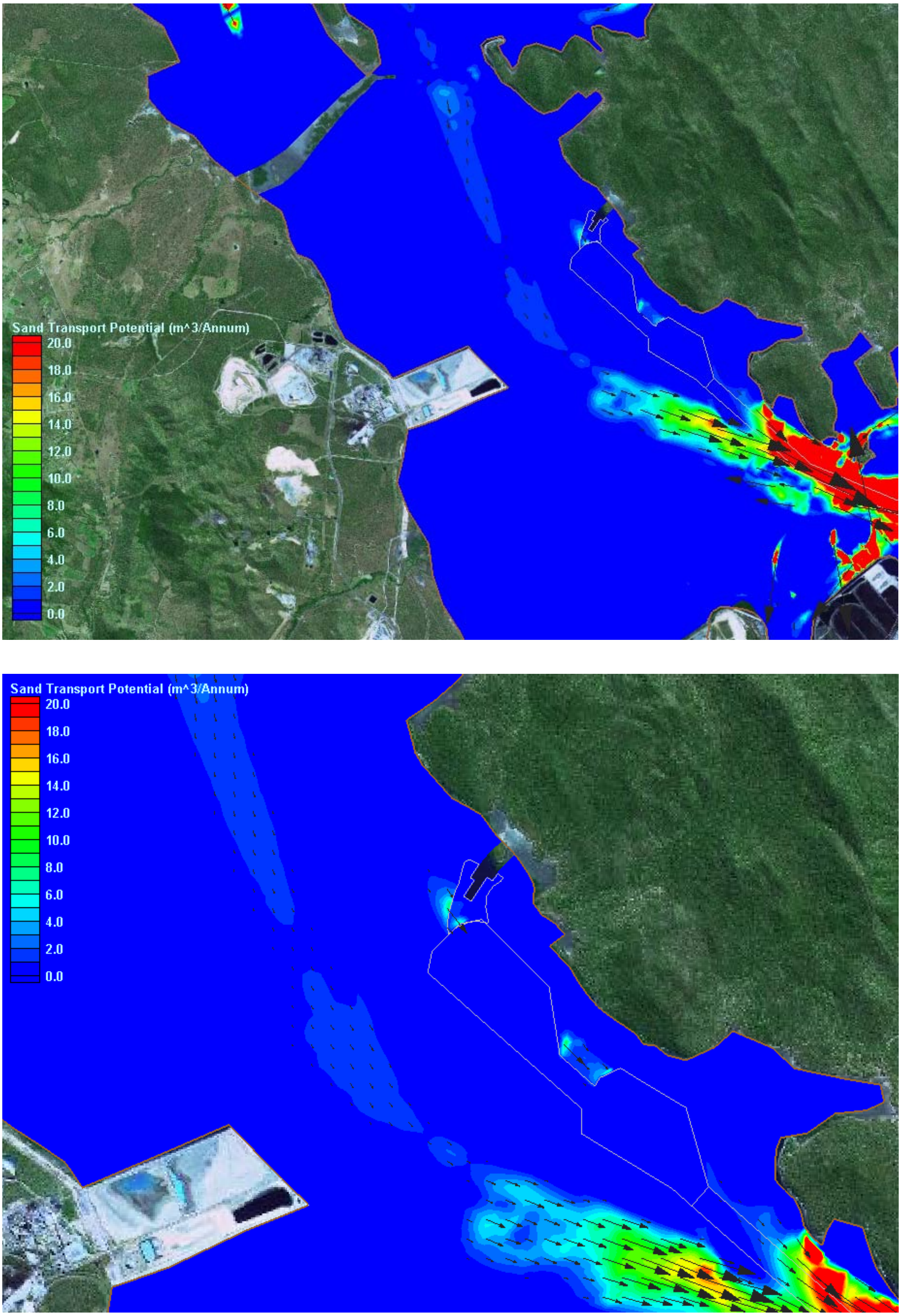

Figure 7-2 Developed Case Sand Transport Potential

7.4 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/m^2 will generally result in deposition of fine silts in suspension while higher stress will resuspend 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 (2 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 cases in Figure 7-3 and Figure 7-4 respectively. Time series have been extracted at a number of points within existing and proposed dredged areas which are shown in Figure 7-5. The time series results are shown in Figure 7-6 through to Figure 7-9 (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 that the potential for fine silt deposition may increase marginally due to the proposed development;
- 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, and 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.

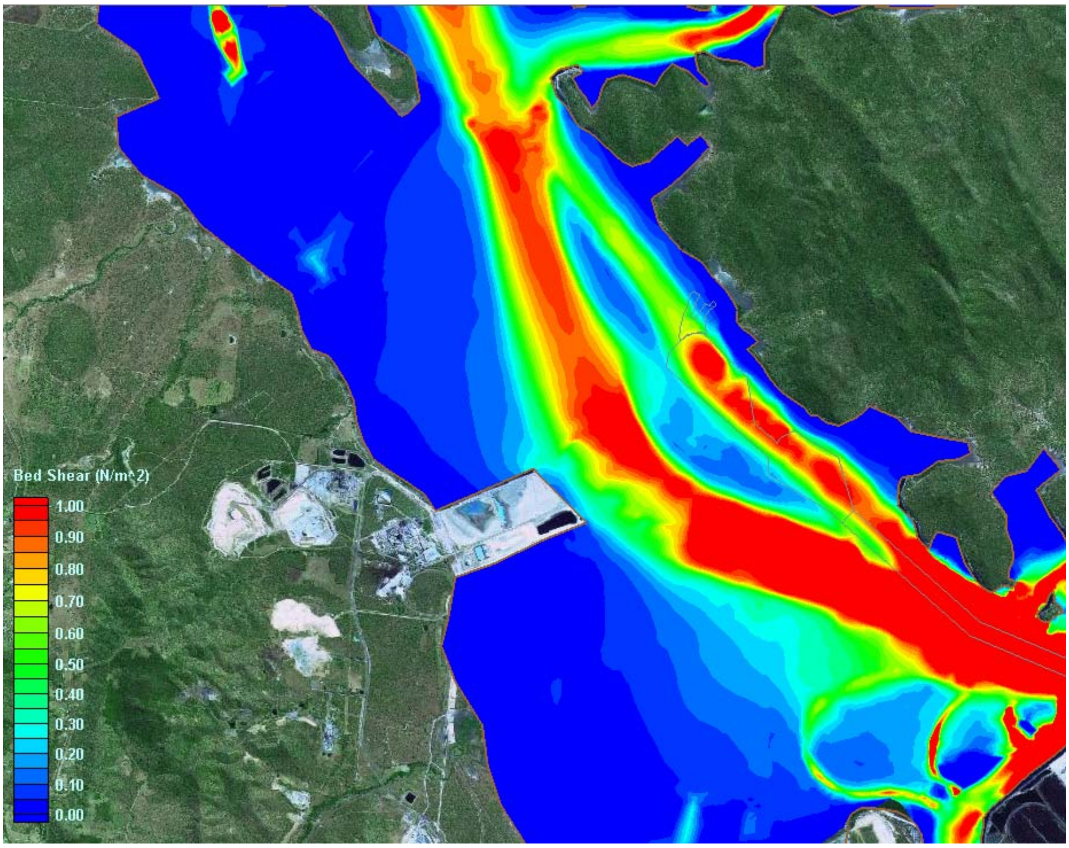

Figure 7-3 Base Case maximum bed shear stress (due to tidal currents).

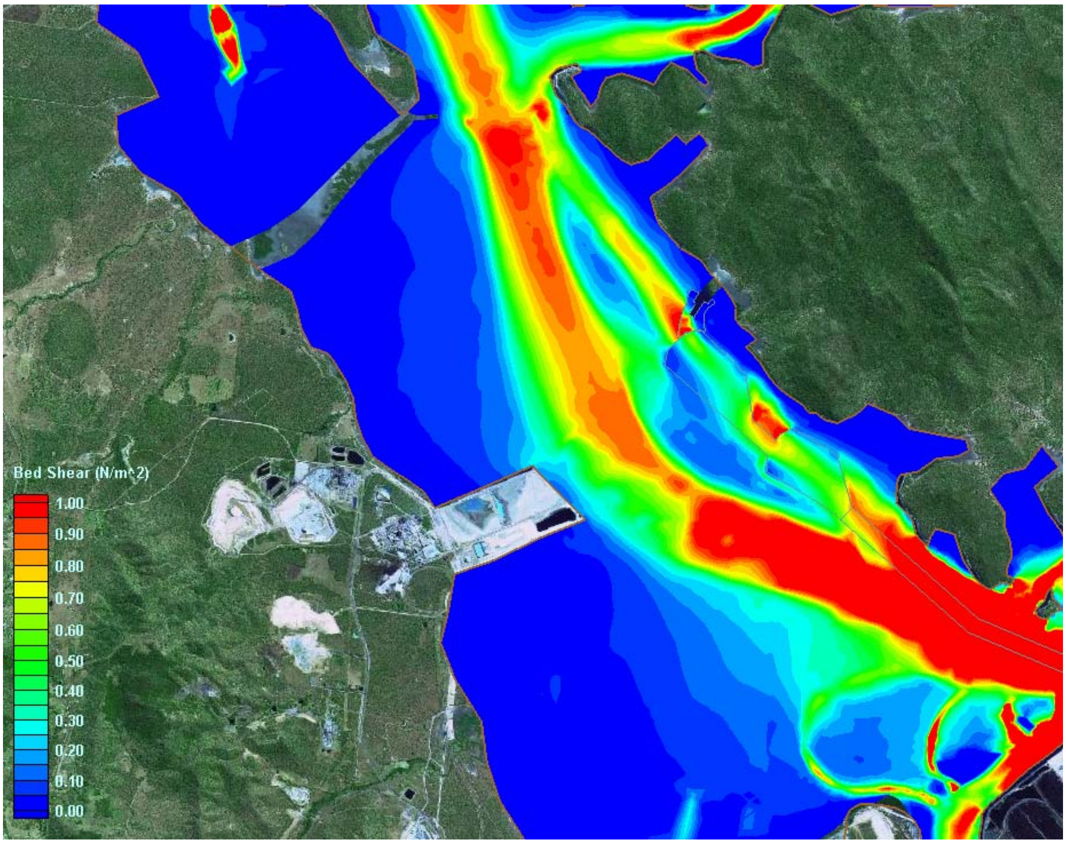

Figure 7-4 Developed case maximum bed shear stress (due to tidal currents).

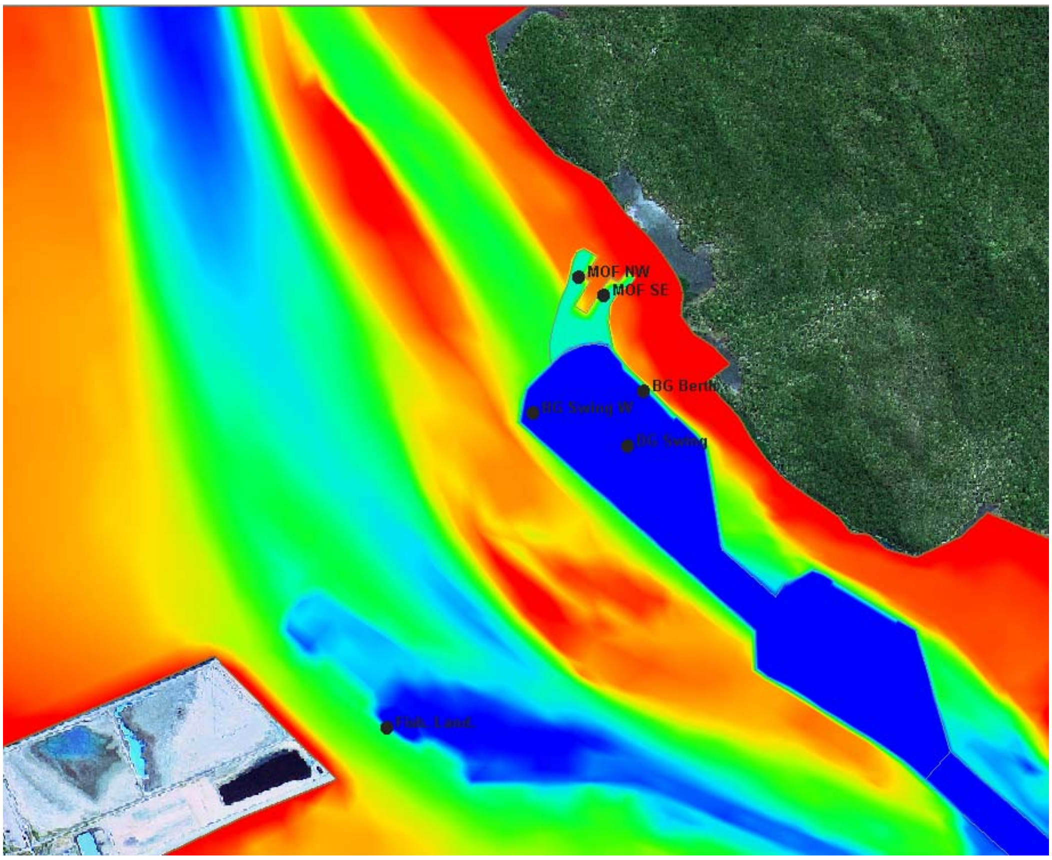

Figure 7-5 Bed shear stress timeseries locations.

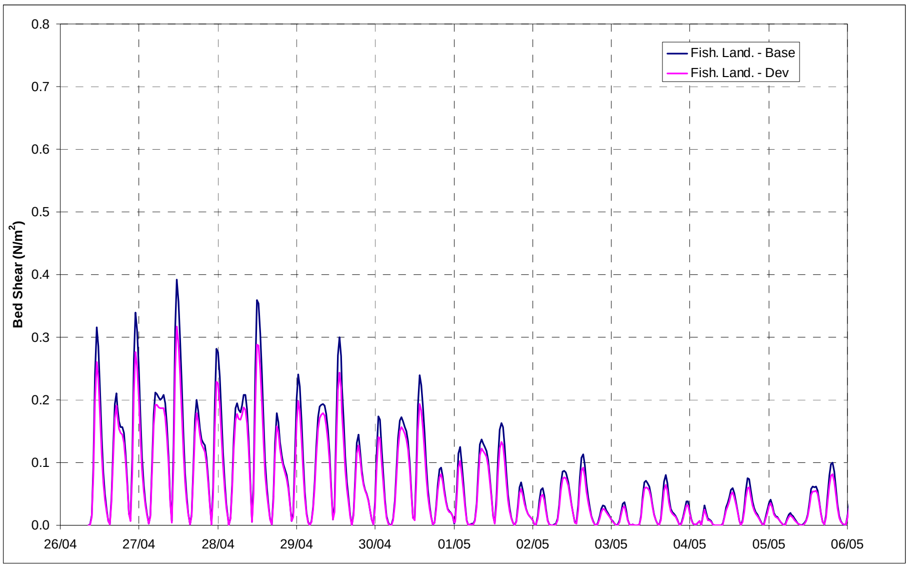

Figure 7-6 Fisherman's Landing bed shear stress.

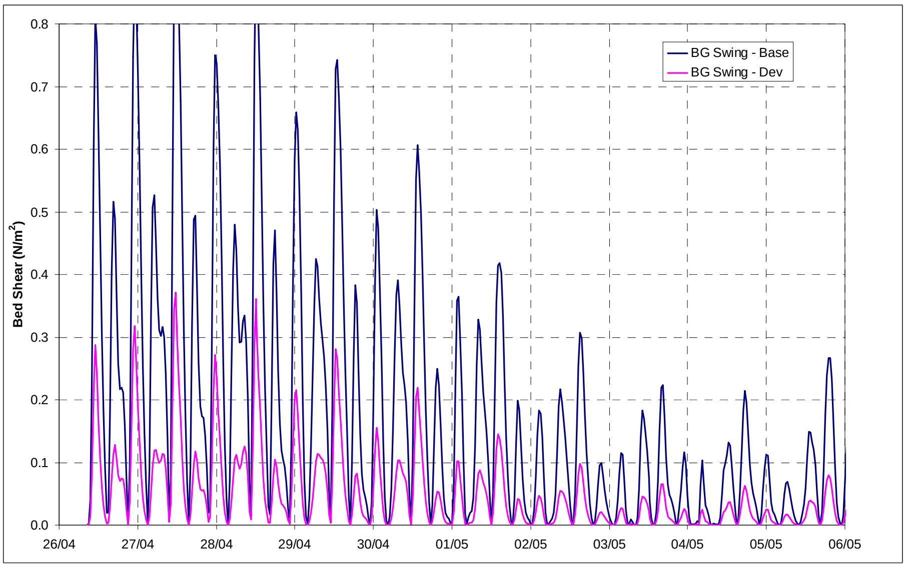

Figure 7-7 QGC swing basin (centre) bed shear stress.

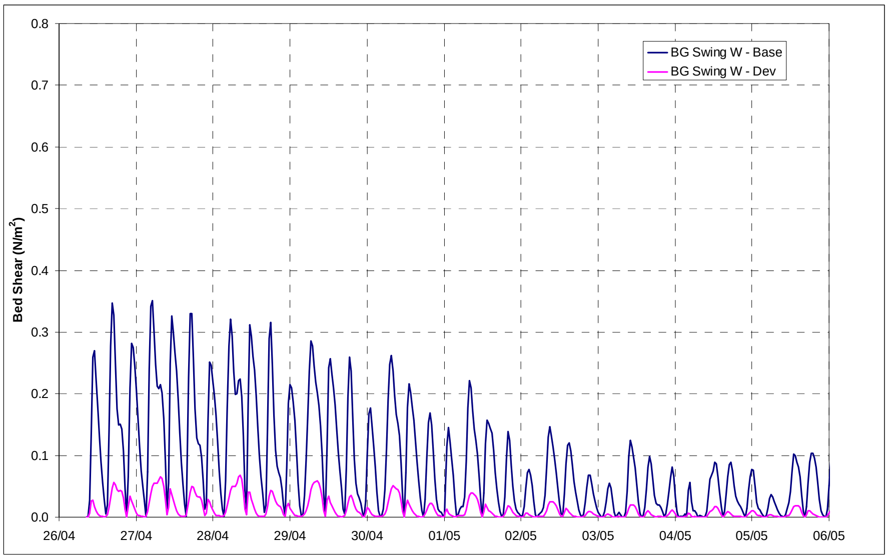

Figure 7-8 Western side of QGC Swing Basin bed shear stress.

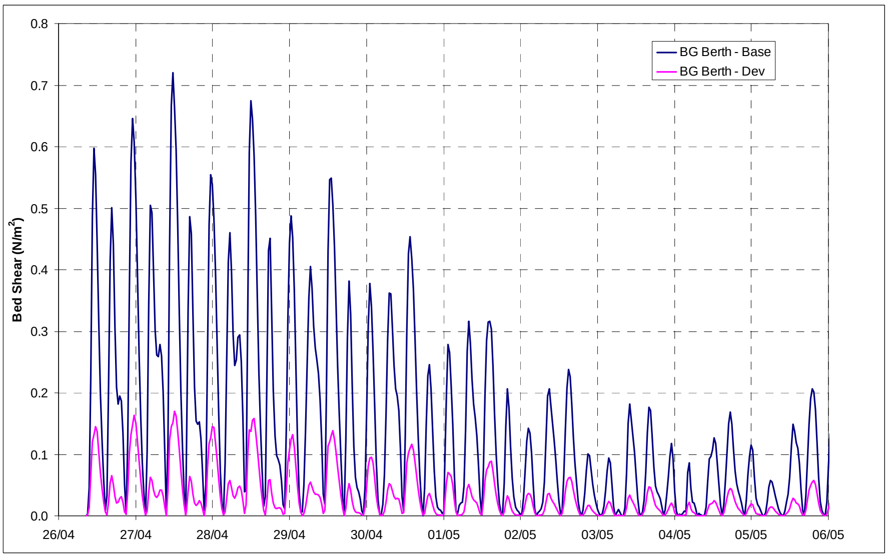

Figure 7-9 QGC berth bed shear stress.

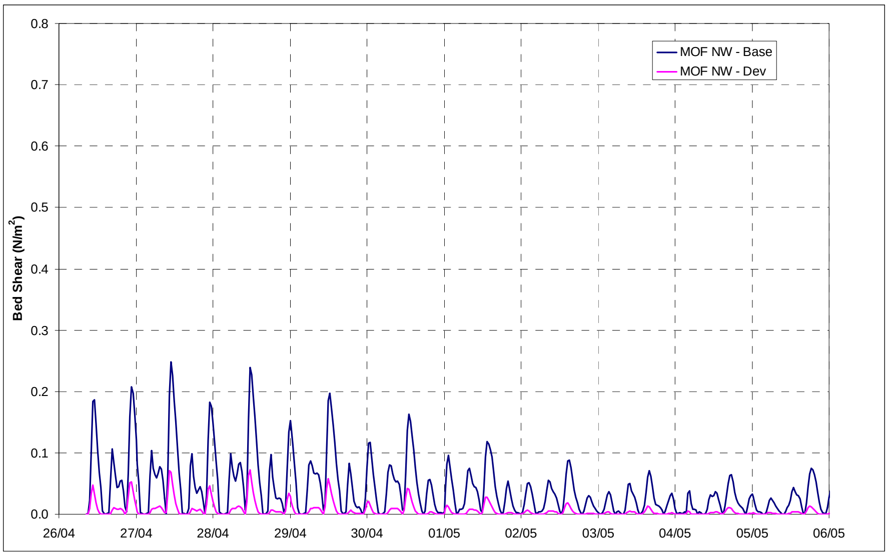

Figure 7-10 North-western side of the QGC MOF bed shear stress.

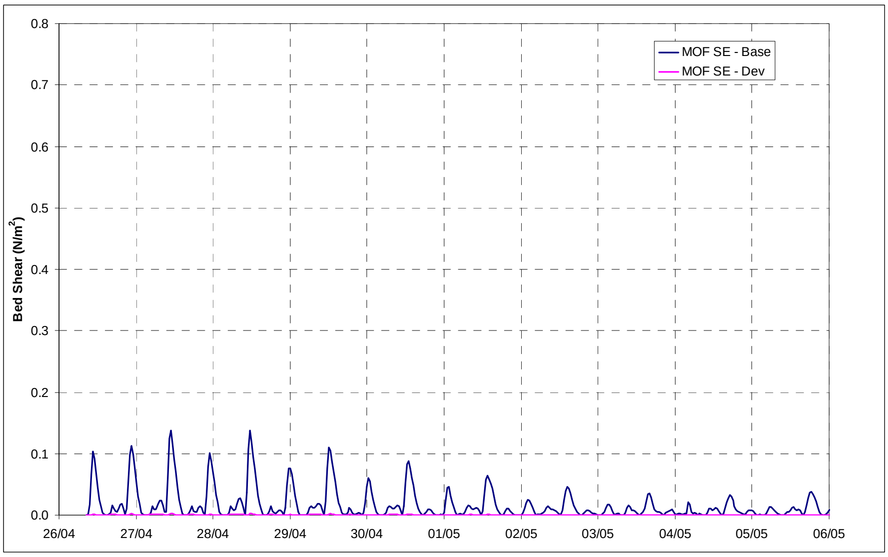

Figure 7-11 South-eastern side of the QGC MOF bed shear stress.

7.5 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 (Section 7.3) and fine sediments (Section 7.4).

The analysis undertaken suggests that the propensity for deposition of sand-sized material in the proposed dredged areas is similar to the adjacent existing dredged areas i.e. Targinie swing basin and the Targinie Channel. The estimated rate of sand-sized material deposition in the QGC swing basin and MOF dredged area is up to 2,000 m^3/annum under ordinary tidal flow conditions (Table 7-2). The QGC/Santos approach channel may similarly experience deposition of sand-sized sediment at a rate of up to 2,600 m^3/annum (Table 7-2).

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 7-2).

The analysis of bed shear stress undertaken in Section 7.4 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 Gladstone Harbour which generally experience sufficiently high bed shear stresses during spring-tide current flows to mobilise deposited silt material and 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 GPCL and QGC.

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