Port of Gladstone
Gatcombe and Golding Cutting
Channel Duplication Project

Environmental Impact Statement

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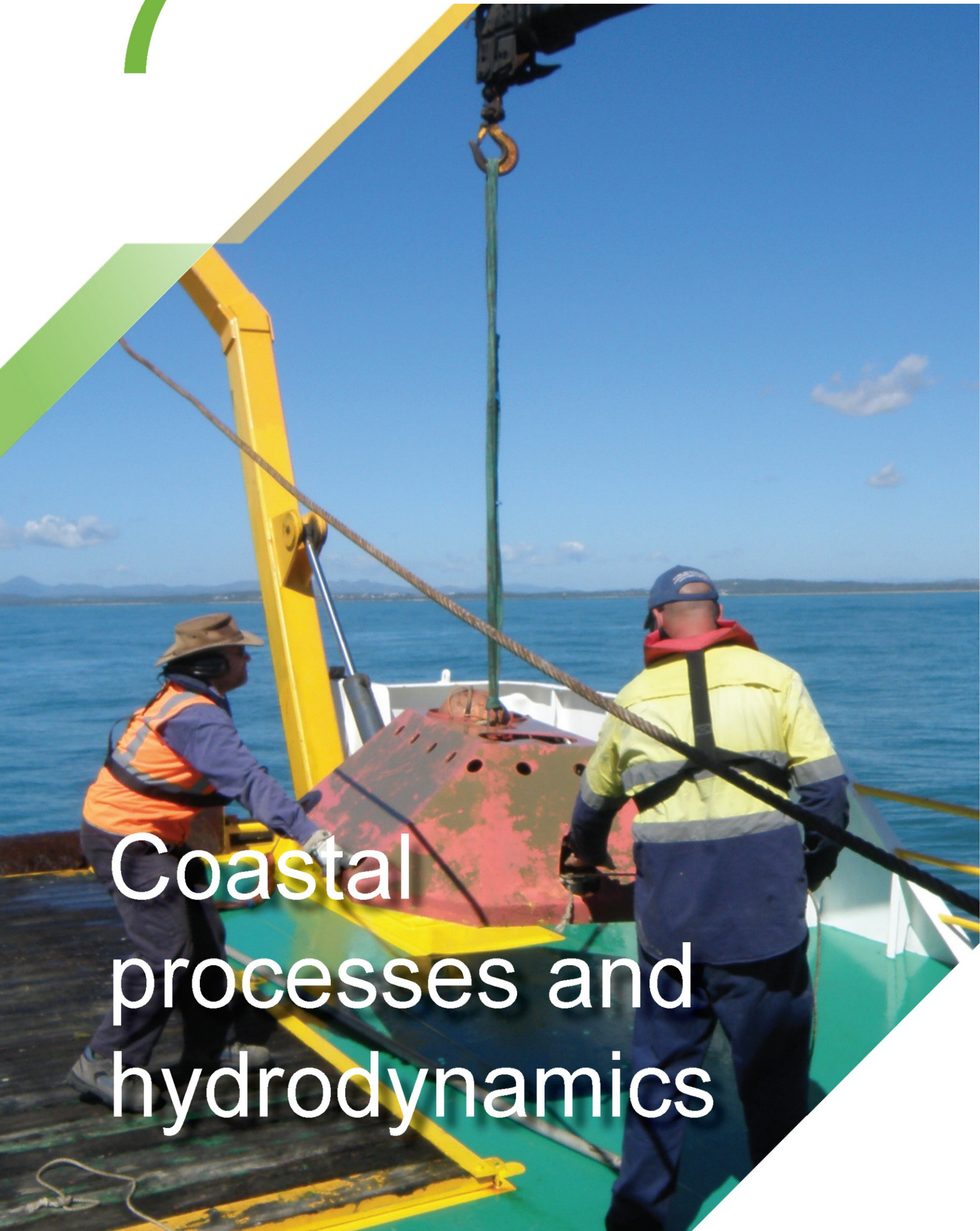


Coastal processes and hydrodynamics

Contents

7 Coastal processes and hydrodynamics

7.1 Chapter purpose

The purpose of this chapter is to assess the potential Project impacts to coastal processes and hydrodynamics of the Port of Gladstone. The existing environment is describe using Project-specific data collected and supplied by others as well as a suite of calibrated hydrodynamic, wave and sediment transport models. The data and models allow the Project potential coastal processes and hydrodynamics impacts and risks to be evaluated by simulating the changes that will be caused by the Project. These potential impacts and risks include changes to hydrodynamics, wave climate, shoreline sediment transport and siltation rates. This chapter includes the following:

- A summary of the methodology (refer Section 7.2)
- Description of existing coastal processes and hydrodynamic environment (refer Section 7.3)
- Assessment of potential impacts during the construction and maintenance phases of the Project (refer Section 7.4)
- Identification of mitigation measures to be implemented to minimise the potential coastal processes and hydrodynamics impacts from the Project (refer Section 7.5)
- Assessment of the coastal processes and hydrodynamic risks associated with the Project (refer Section 7.6).

The data collection and numerical modelling that informs the discussion in this chapter are described in more detail in Appendix G.

The coastal processes and hydrodynamics assessment also informs the Project description and other impact assessments chapters in the EIS, including:

- Water quality (Chapter 8)
- Nature conservation (Chapter 9)
- Cumulative impacts (Chapter 21).

7.2 Methodology

To characterise the existing coastal processes and hydrodynamics in the study area, an extensive data collection campaign was undertaken and a suite of numerical models were developed, calibrated and validated. The details of the data collection campaign and the model development are provided in Appendix G.

The data collected in the field was used to inform the qualitative descriptions of the existing environment provided in this chapter, and was also used to validate the numerical models to provide confidence that the models are able to accurately represent the key physical processes of the existing Port environment.

The modelling system was used to provide further information on the existing environmental conditions, and was also used to simulate Project activities and Project related changes to assess the risk of impacts to existing processes.

The numerical modelling was carried out in accordance with the GBRMPA Hydrodynamic Modelling Guidelines (GBRMPA 2012). For example, the modelling included:

- Fully 3D numerical modelling with baroclinic forcing terms
- The model was calibrated and validated against collected baseline information
- Baseline data was measured in close proximity to the dredging and placement sites, and included metocean parameters such as tidal range, wave height, water current, wind direction and intensity and sediment dynamics
- Sediment transport modelling considered a range of particle sizes
- The model mesh had appropriate level of resolution in areas of interest
- The numerical modelling used a spatially based scheme that provides for a clear and consistent way of presenting the extent, severity and duration of predicted impacts of dredging and dredged material placement and included likely 'best case' and likely 'worst case' scenarios
- The lethal and sublethal thresholds used for the ecological response modelling have been clearly indicated and supported by peer reviewed scientific published papers and compared against model outputs
- The output from the model has been overlaid upon maps of the sensitive habitats and ecological receptors in order to visualise and interpret what the impact of the sediment plumes might be.

7.3 Existing environment

7.3.1 Tidal hydrodynamics

An understanding of the tidal hydrodynamics is important because of its controlling influences on flushing and sediment transport processes. The Project involves dredging and reclamation works. As such, 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, sedimentation and associated ecological implications.

The extent of the tidal hydraulic system considered in the context of this assessment includes 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 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 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 Bay, while Graham's Creek and a number of smaller tributaries connect to The Narrows.

The Port area also contains a number of smaller islands and has extensive areas of intertidal flats, which become exposed at low water. For very low tides, some areas reduce to several narrow meandering channels. There are also extensive intertidal mangrove and saltpan areas in Port Curtis, which are inundated at higher tide levels. The large tidal range and extensive intertidal banks 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 the rate of water level rise and fall vary greatly depending on the extent of coverage of the saltpans and mangroves).

Tidal variations in Port Curtis and adjoining areas 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 planes for the Standard Port and other secondary locations within Port Curtis are presented in Table 7.1 as heights above the local LAT level.

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 within the Port; the range at Fisherman's Landing is approximately 6% greater than at Gladstone (Auckland Point) and the range at Gatcombe Head is 11% smaller than at Gladstone (Auckland Point).

Table 7.1 Gladstone region tidal planes (in metres relative to LAT)

Tidal Plane	Fisherman's Landing	Gladstone (Standard Port)	South Trees Wharf	Gatcombe Head
Latitude	-23° 47' S	-23° 50' S	-23° 51' S	-23° 53' S
Longitude	151° 11' E	151° 15' E	151° 19' E	151° 22' E
HAT	5.12	4.83	4.63	4.29
MHWS	4.20	3.96	3.80	3.45
MHWN	3.30	3.11	2.99	2.71
Mean Level (ML)	2.41	2.34	2.20	2.08
AHD	2.43	2.268	2.21	Not applicable
MLWN	1.66	1.57	1.51	1.37
MLWS	0.76	0.72	0.69	0.56
LAT	0.00	0.00	0.00	0.00

Source: Queensland Tide Tables 2015 (MSQ 2014)

Due to the large tidal storage areas and the amplification effect on water levels, good tidal flushing and high tidal velocities generally exist within the main channels of the Port. Typically observed spring tide velocities within dredged shipping channels are up to a maximum of approximately 2.0m/s in some local areas. Due to the strong spring tidal currents, the tidal flows in the estuary are usually well mixed and stratification is not significant except during periods of major flooding. Spatial plots of typical current fields in the vicinity of the proposed dredging works during spring flood and ebb tidal phases are shown in Figure 7.1. The highest velocities are typically found in the vicinity of the shipping channels, and can be especially high in the vicinity of Gatcombe and Golding Cutting Channels. Ebb tide velocity magnitudes tend to be slightly higher than flood tide velocity magnitudes for a given tidal range. Within the channels the current direction is generally parallel to the channel. The tidal velocities are highest at the southern end of the Gatcombe Channel, in the vicinity of Gatcombe Head. Further outside the Port, the flow fans out over East Banks and velocity magnitudes in the channel are lower.

Tidal velocities during neap tidal periods are much lower than during spring tidal periods.

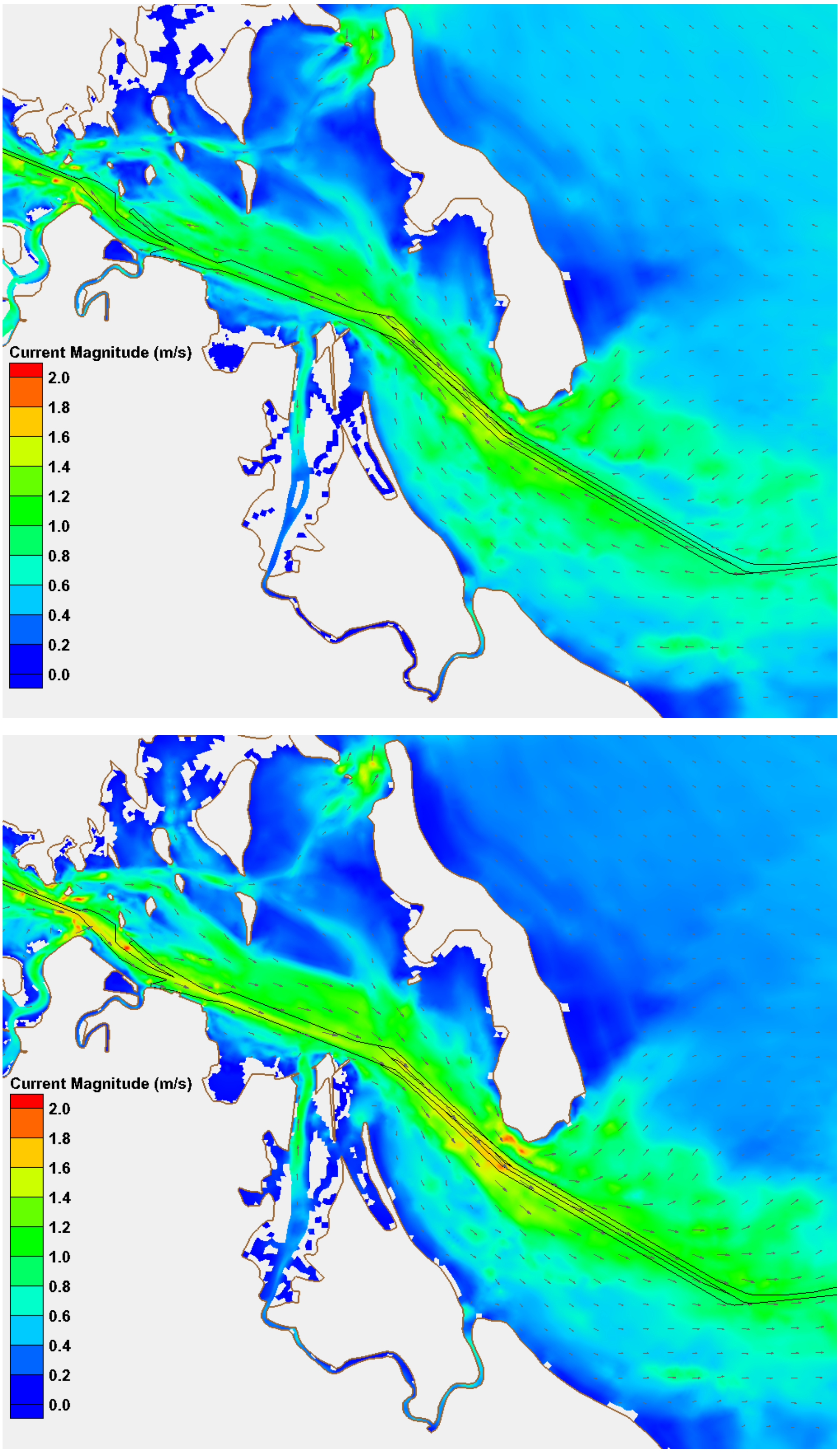


Figure 7.1 Example peak spring tidal currents; flood (top), and ebb (bottom)

7.3.2 Extreme 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 report commissioned by the Queensland Government (James Cook University (JCU) 2004) examined storm tide vulnerability and potential increases in sea level from climate change and more intense cyclonic effects on coastal communities. The predicted storm tide levels in the region are provided in Table 7.2 for various recurrence intervals excluding wave set-up and climate change effects.

Table 7.2 Peak storm tide levels (year 2003)

Location	Storm tide level (m AHD)		
	100 year ARI	500 year ARI	1,000 year ARI
Gladstone	2.82	3.51	3.80
Tannum Sands	2.50	3.05	3.31

The above storm tide levels do not contain provisions for sea level rise (SLR) due to climate change effects, other climate influences or wave set-up and run-up. Wave set-up and run-up only occur near or at the shoreline and therefore do not influence levels in the shipping channel.

The report also examined the potential implications for storm tide statistics of three specific climate change scenarios, including:

- Combined effect of an increase in Maximum Potential Intensity of 10% and a poleward shift in tracks of 1.3
- Increase in frequency/intensity of tropical cyclones of 10%
- Mean SLR of 0.3m.

The storm tide levels predicted with the combined climate change scenarios are presented in Table 7.3.

Table 7.3 Peak storm tide levels (combined climate change scenarios 50 year planning period)

Location	Storm tide level (m AHD)		
	100 year ARI[1]	500 year ARI	1,000 year ARI
Gladstone	3.33	4.18	4.51
Tannum Sands	2.95	3.64	3.94

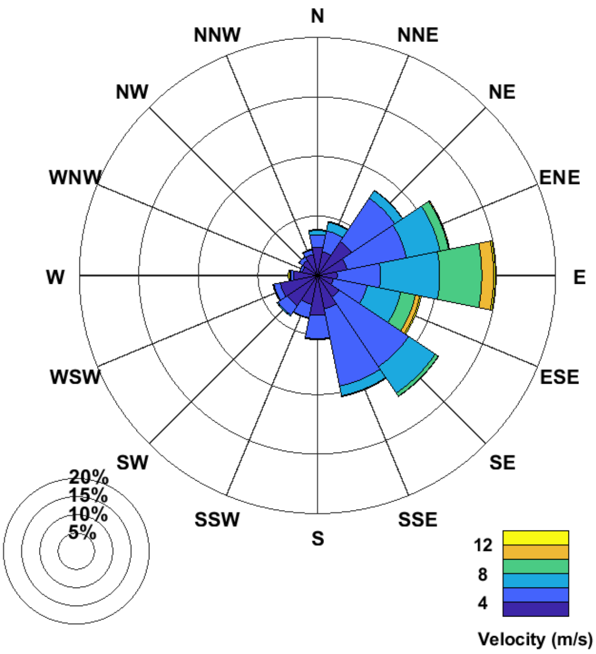
The report emphasised that the chosen values in the climate change scenarios are not necessarily endorsed, although care was taken to propose reasonable values. The intention was to demonstrate the sensitivity of the storm tide frequency curves to climate change scenarios. It should be further noted that the value of 0.3m mean SLR was derived for a 50 year planning period (the SLR allowance was based on recommendations in the now superseded Intergovernmental Panel on Climate Change (IPCC) third assessment report).

7.3.3 Wave climate

Waves are important drivers of sediment dynamics both within the estuary and in offshore areas. Wave-related bed shear stresses can resuspend sediment that has been deposited on the seabed, enabling subsequent transport of the sediment by tidal currents.

Facing and Curtis Islands effectively protect the inner Port areas from ocean-generated sea and swell waves. As such, the inner Port berths are within a sheltered estuarine environment and only exposed to locally generated waves within Port Curtis. The largest fetch lengths within the Port are aligned to the southeast to northwest axis. These fetch distances are all relatively short and confined to less than 10km.

The outer harbour and offshore areas are exposed to larger sea and swell waves. The dominant incident wave direction is from the northeast and east, and the wind direction is mainly northeasterly to southeasterly with the strongest winds coming from the east. The long term wind rose at the Gladstone Radar BoM station and the long term wave rose at the Gladstone Waverider Buoy are provided in Figure 7.2.



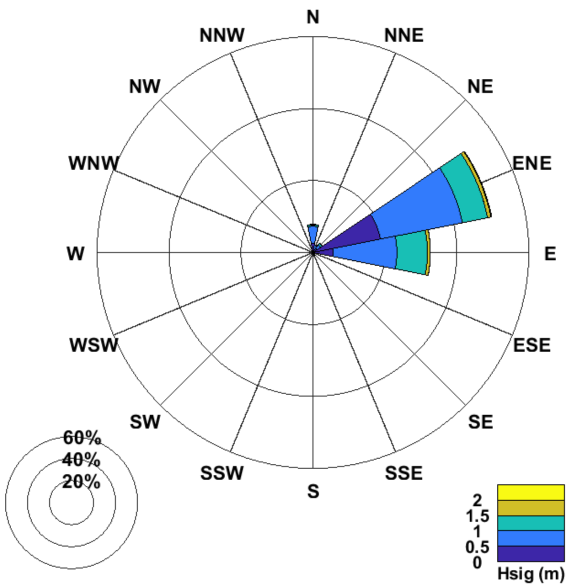


Figure 7.2 Long term wind rose (1994 to 2015) at Gladstone Radar (top) and wave rose (2010-2017) at the Gladstone Waverider Buoy (bottom)

Analysis of the year-by-year wave roses indicates that inter-annual variability is much smaller than the seasonal variation in the wave climate.

Numerical modelling has also been used to aid the understanding of the prevailing wave climate and assess the potential impact of the Project activities. Figure 7.3 shows an example of model output for a relatively energetic easterly incident wave condition, illustrating the effective protection that the Port is afforded by the presence of Facing Island and Curtis Island.

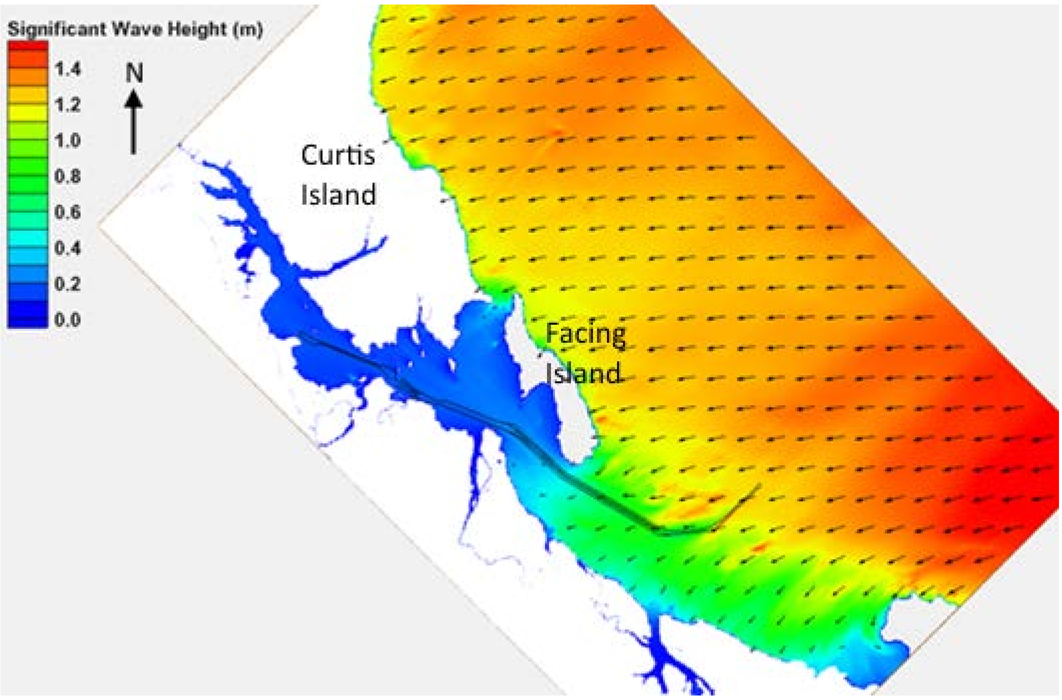


Figure 7.3 Example of energetic easterly wave conditions

7.3.4 Sediment dynamics

The energetic macro-tidal hydrodynamic conditions in Port Curtis play an important role in the context of natural bed remobilisation processes and associated patterns in TSS concentrations. Within the Port, the bed shear stress generated by the tidal currents is generally the dominant driver of sediment resuspension and wave-related bed shear stress is of secondary importance. In the outer reaches of the Port, and in offshore areas, wave energy is higher and tidal velocities are lower and therefore the wave-related bed shear stress is a much more significant driver of resuspension processes.

Measured turbidity within the Port shows substantial variation in turbidity levels over each tidal cycle as well as significant variation between neap tidal and spring tidal periods. The typical spring-neap variation in turbidity levels in the Port is shown in Figure 7.4. There is also substantial spatial variation in turbidity levels throughout the Port, particularly during spring tidal periods. Figure 7.5 shows an example of modelled total (depth-summed) sediment fluxes on an ebbing spring tide (top panel) and flooding spring tide (bottom panel). There is high sediment transport potential in the vicinity of the dredging operation during spring tides, particularly in the more northerly Gatcombe Channel.

The sediments in the vicinity of the existing passing channel to be dredged are a mixture of gravels, sands, silts and clays. The surface sediments in the main channels of the Port, where tidal velocities are high are typically dominated by coarser fractions with the finer particles having being naturally swept away. The shallower intertidal areas are a mixture of sands and silts with fine soft silts dominating in the lower current/wave energy areas.

The contribution of local catchments to the overall sediment budget of the Port is relatively minor. A quantitative sediment budget for Queensland ports estimated that the Calliope and Boyne Rivers contribute approximately 97,000 tonnes per year of sediment to the Port, while the natural resuspension of inner-shelf sediment deposits is approximately 15,400,000 tonnes per year. The net longshore transport of coastal sediment is to the north. The shipping channels within the Port act as a sediment sink because they are generally deeper than the surrounding seabed and are less exposed to wave and current energy. Approximately 250,000m^3 of material is removed from the shipping channels annually by maintenance dredging. The relocation of port maintenance dredging material to the placement area located within the active sedimentary system maintains ongoing transport of sediment along natural sediment pathways, with maintenance dredged material gradually re-assimilated into the ambient sedimentary system from which it originated.

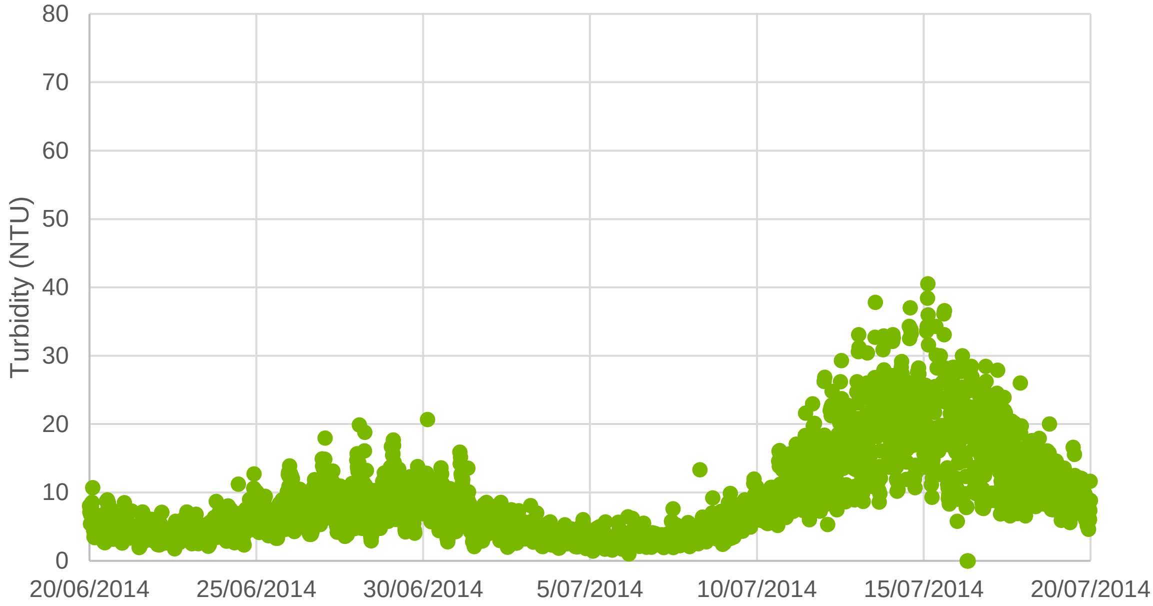
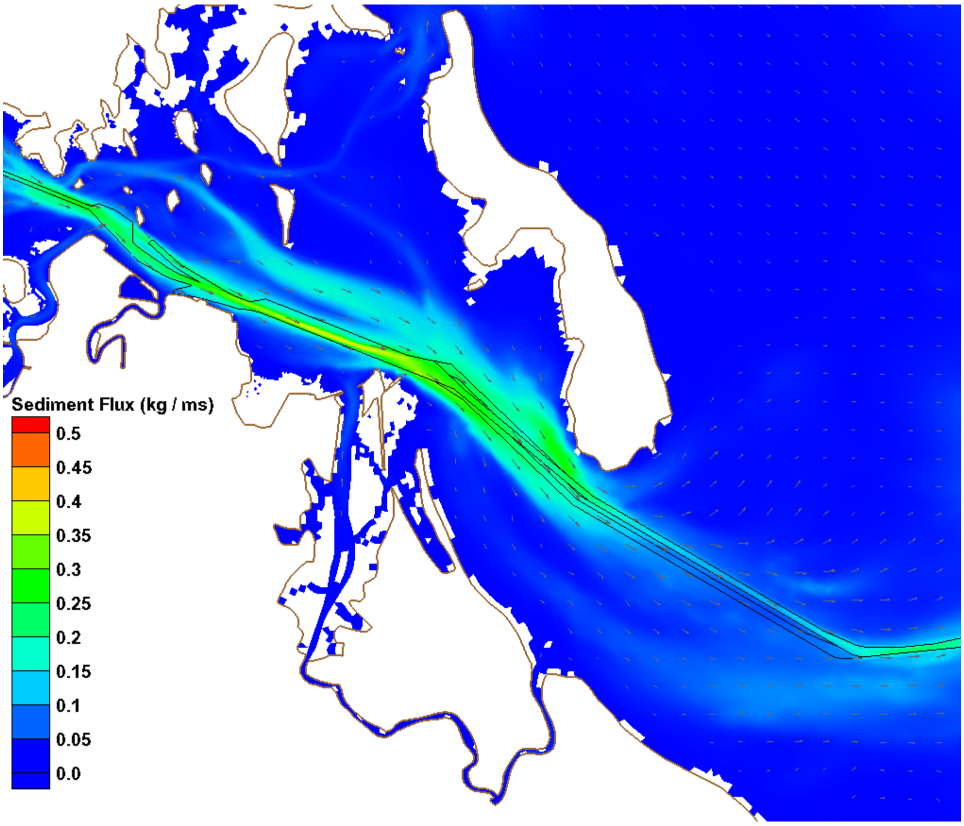


Figure 7.4 Example variation in turbidity within Port Curtis



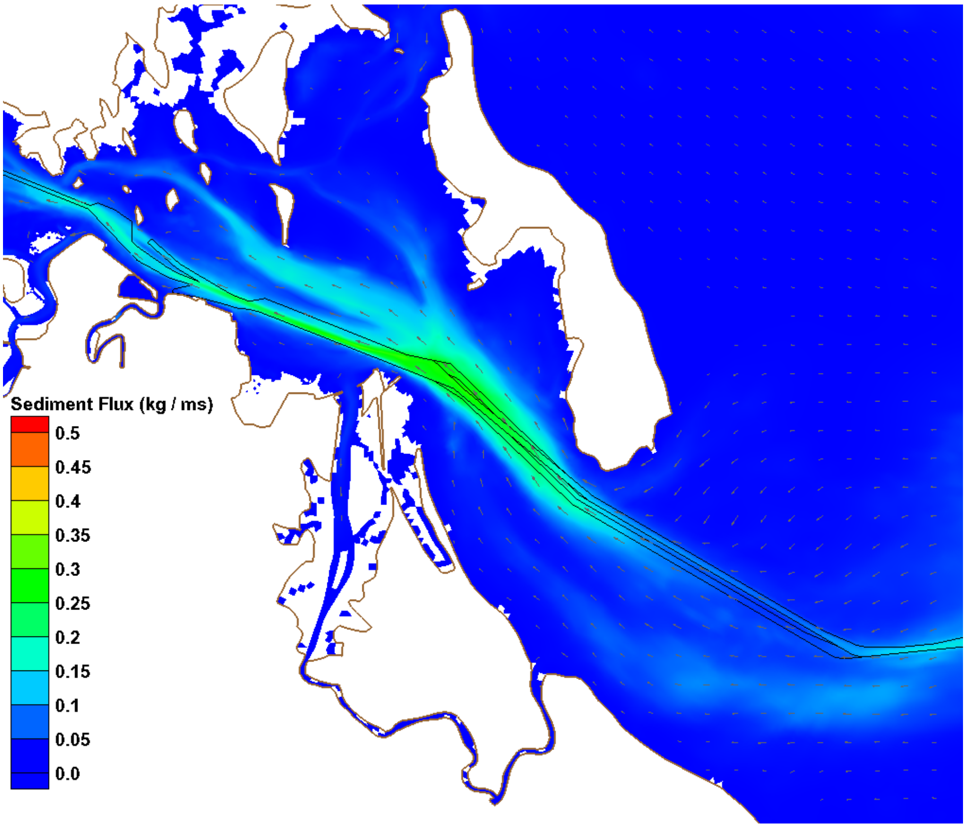


Figure 7.5 **Example sediment fluxes (kg/s per metre) for ebb spring tide (top) and flood spring tide (bottom)**

7.3.5 Coastal processes

Shoreline coastal processes within the study area are influenced by the local wave climate as well as the tidal hydrodynamics and sediment dynamics.

7.3.5.1 Western Basin Expansion reclamation area

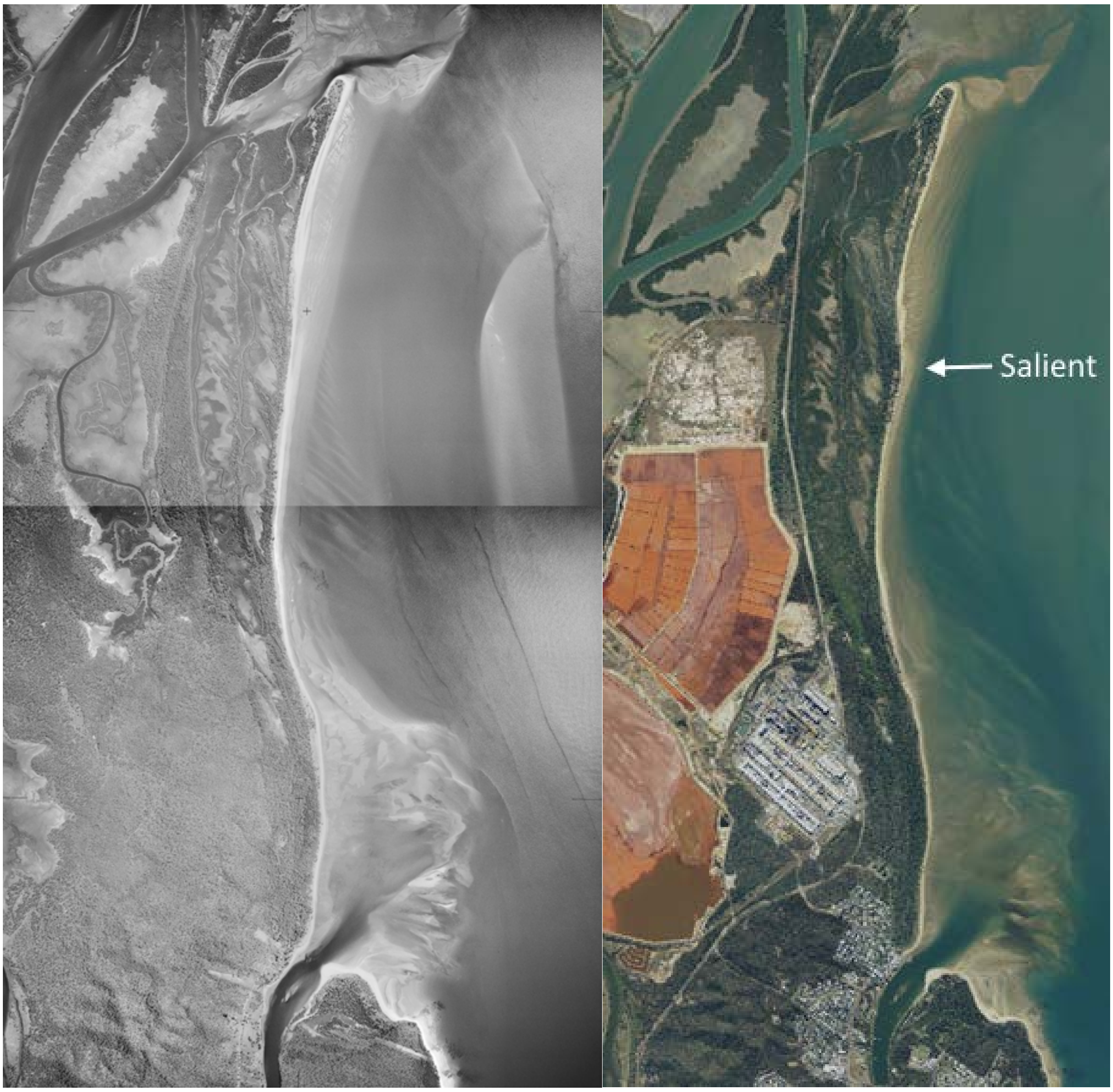
The wave climate in the vicinity of the existing Fisherman's Landing and Western Basin reclamation area is generally benign and the shoreline is characterised by fringing mangroves and a flat intertidal zone. Aerial photography does indicate some small sandy beach ridges which are likely composed of silty sand. Photograph 7.1 shows aerial photographs from 1959 (top panel) and 2015 (bottom panel). The major differences in the two photographs are associated with the WB reclamation works, including construction of the reclamation area and the LNG facilities on Curtis Island. Other changes include clearing and trenching activity associated with construction of the QCLNG pipeline. There are minor changes to the extent of mangrove cover but otherwise the shoreline alignment and character behind the existing WB reclamation area appears largely unchanged up to this point. The hydrodynamics, wave climate and sediment dynamics on the intertidal flat has been modified due to the construction of the reclamation area and over time this could be expected to cause changes in the bathymetric features and ecology of the intertidal area (e.g. may promote siltation and mangrove growth).

Photograph 7.1 Western Basin aerial photographs – July 1959 (top) and July 2015 (bottom)

Source: Queensland Government, GPC

7.3.5.2 Boyne Island shoreline

The Boyne Island shoreline is approximately 2km to 4km to the west of the Gatcombe Channel, with the shoreline exposed to higher energy wave conditions than the inner Port because it is open to the ocean to the east. The shoreline is a sandy beach with a relatively flat offshore profile. Aerial photographs taken in 1959 and 2015 are shown in Photograph 7.2. It is apparent that there have been some subtle shifts in the alignment of the beach but the overall character remains unchanged. The dominant easterly incident wave direction is likely to generate a net northerly longshore sediment transport along the beach. On close inspection of the 1959 and 2015 photographs it is apparent that the beach has prograded (built out) in a number of locations over the intervening years, including development of the small salient marked in Photograph 7.2. It is expected that the net longshore transport of sandy sediment along this section of coastline is to the north.



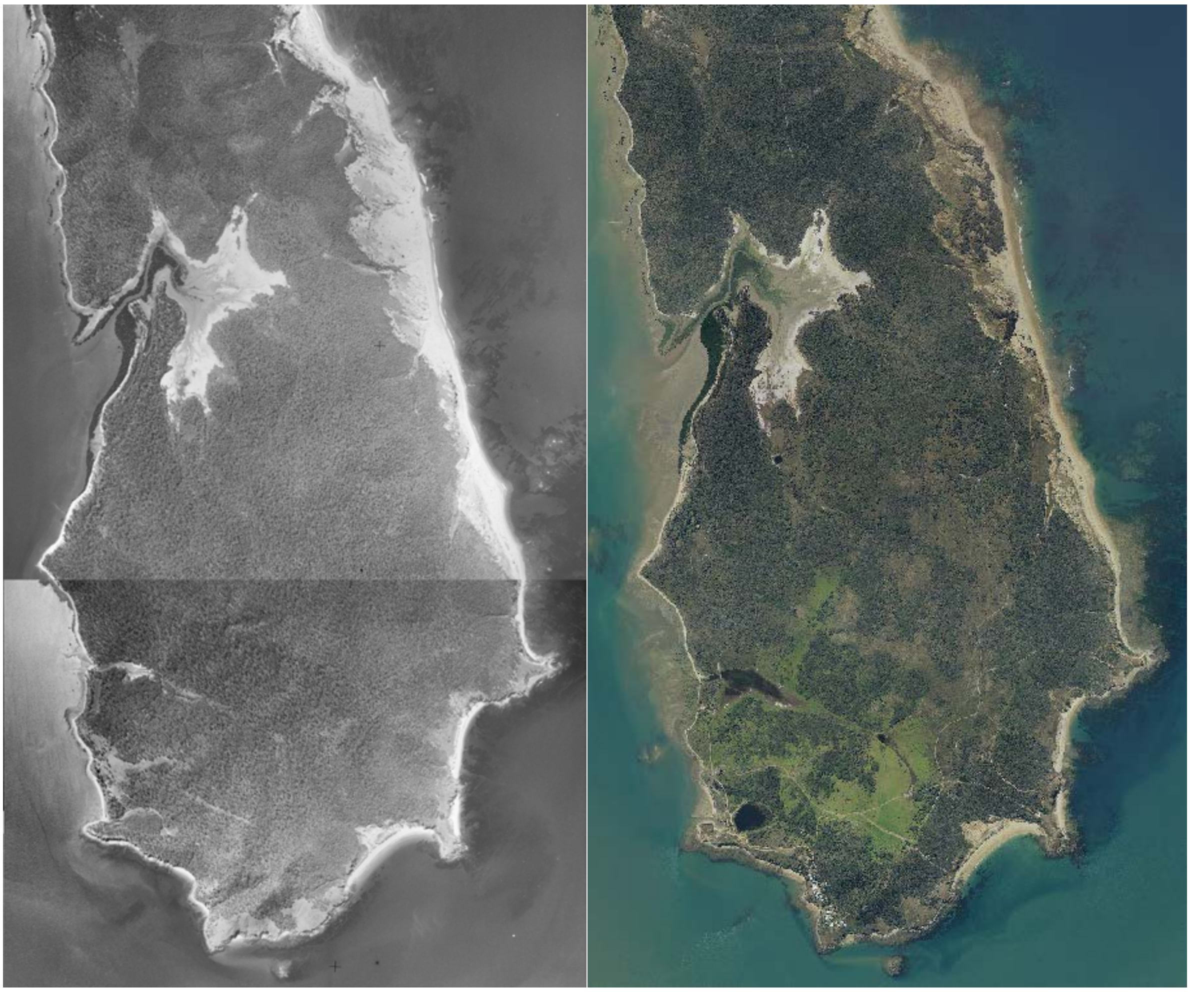
Photograph 7.2 Boyne Island aerial photograph – July 1958 (left) and July 2015 (right)

Source: Queensland Government, GPC

7.3.5.3 Facing Island

The shoreline of Facing Island is characterised by rocky headlands and sandy beaches, with some areas of intertidal mudflats and mangroves on the inner (harbour) side. The beaches on the ocean side of the island are wider than the beaches on the inner side, and are exposed to a much more energetic wave environment. It is therefore expected that the beaches on the ocean side have a larger typical grain diameter than those on the inner side. Aerial photographs from 1959 and 2015 are shown in Photograph 7.3. There is little visible change in the nature of the shoreline, except for the construction of a small boat harbour on the southwest corner of the island. There are significant increases in the extent of vegetation cover on dunes on the eastern side of the island.

It is acknowledged that the residents of Facing Island are concerned about ongoing siltation issues in the small boat harbour.



Photograph 7.3 Facing Island aerial photograph – July 1959 (left) and July 2015 (right)

Source: Queensland Government, GPC

7.4 Potential impact

7.4.1 Scenarios assessed

Potential impacts from Project activities to coastal processes and hydrodynamics were assessed based on the permanent changes associated with the construction of the:

- WBE reclamation area (northern and southern areas) – the full proposed WBE reclamation area (refer Figure 7.6), BUF and barge access channel to -7.0m LAT
- Bathymetric changes associated with the duplicated channel (design level of -16.1m LAT, refer to Figure 7.7).

This is referred to as the Project Channel Geometry Case.

7.4.2 Tidal hydrodynamics

7.4.2.1 Water levels

Model results indicate that the Project will have no effect on water levels at any point within the model domain. The modelled water levels for the Base Case and the Project Channel Geometry Case are identical throughout the model domain. As a result, the proposed Project land reclamation will not change the low water mark of the World Heritage Area boundary.

7.4.2.2 Water velocities

In the Western Basin area, construction of the WBE reclamation area and BUF will cause local changes in current patterns and velocity magnitudes. The model results indicate that there will be a reduction in velocity magnitudes immediately adjacent to the BUF and along the face of the northern part of the proposed WBE reclamation area. There would also be some increases in velocity magnitudes in the channels adjacent to the new WBE reclamation areas. The magnitude of the velocity changes on the ebb and flood tides is shown in Figure 7.8.

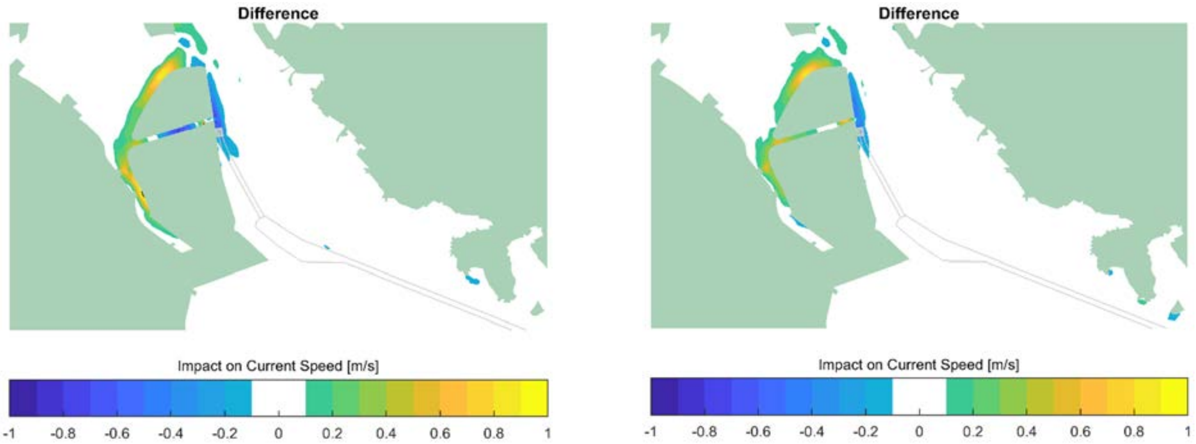


Figure 7.8 **Changes to the flood tide peak spring velocity (left) and ebb tide peak spring velocity (right) for the Project Channel Geometry Case**

In the area near the Gatcombe and Golding Cutting Channels, the model indicates there will be some slight reductions in velocity outside the channel in some areas, due to the reduction in volume of tidal storage (reduced tidal prism). Within the footprint of the newly deepened channel there will be some areas of increased velocity and some areas of decreased velocity, depending on the local change in the bed level. None of the changes in velocity impacts are significant in magnitude in the context of the existing velocity magnitudes. The pattern of the predicted changes to peak ebb and flood tidal magnitudes are shown in Figure 7.9.

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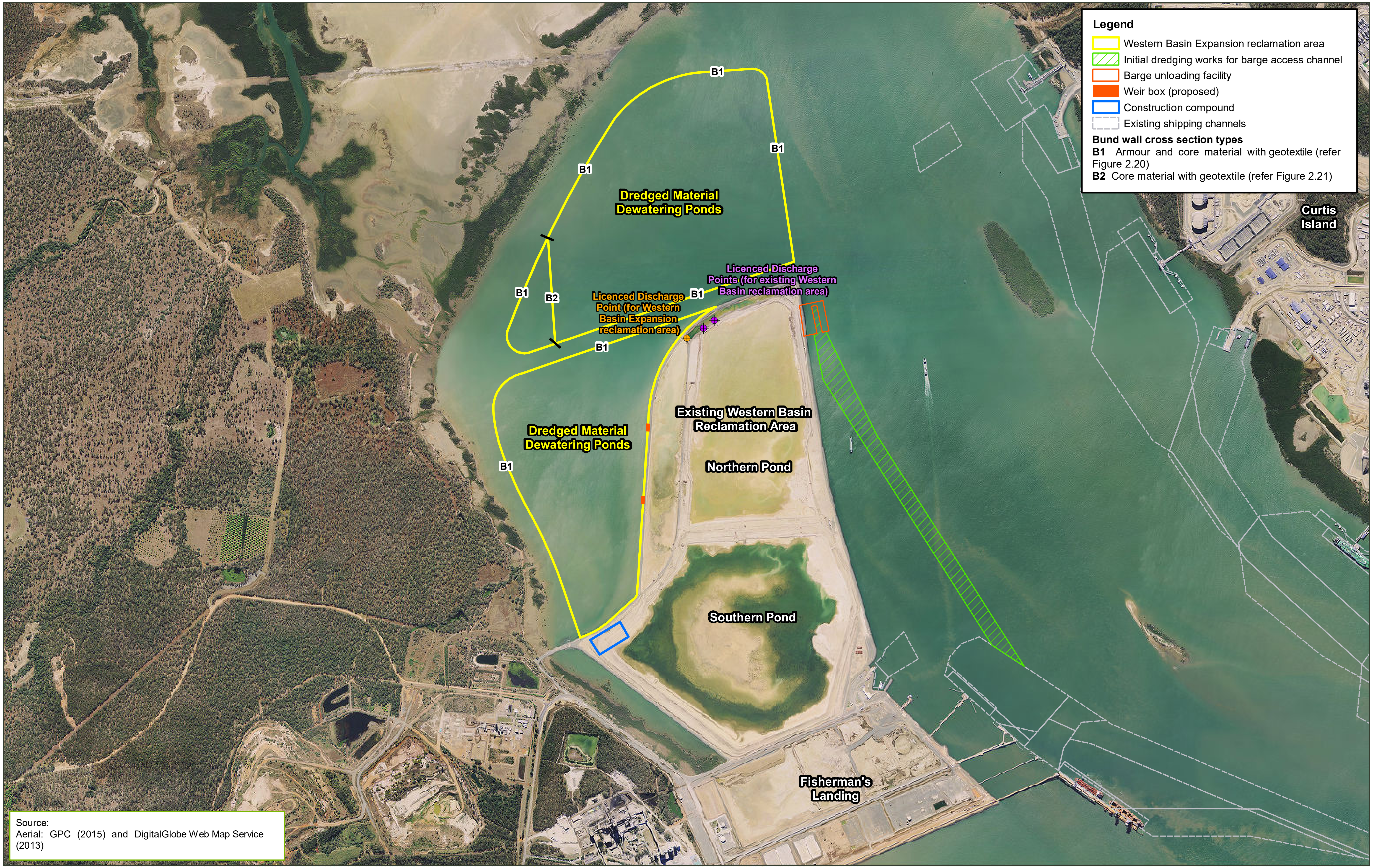

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Gatcombe and Golding Cutting Channel Duplication Project

Figure 7.6: Western Basin Expansion reclamation area

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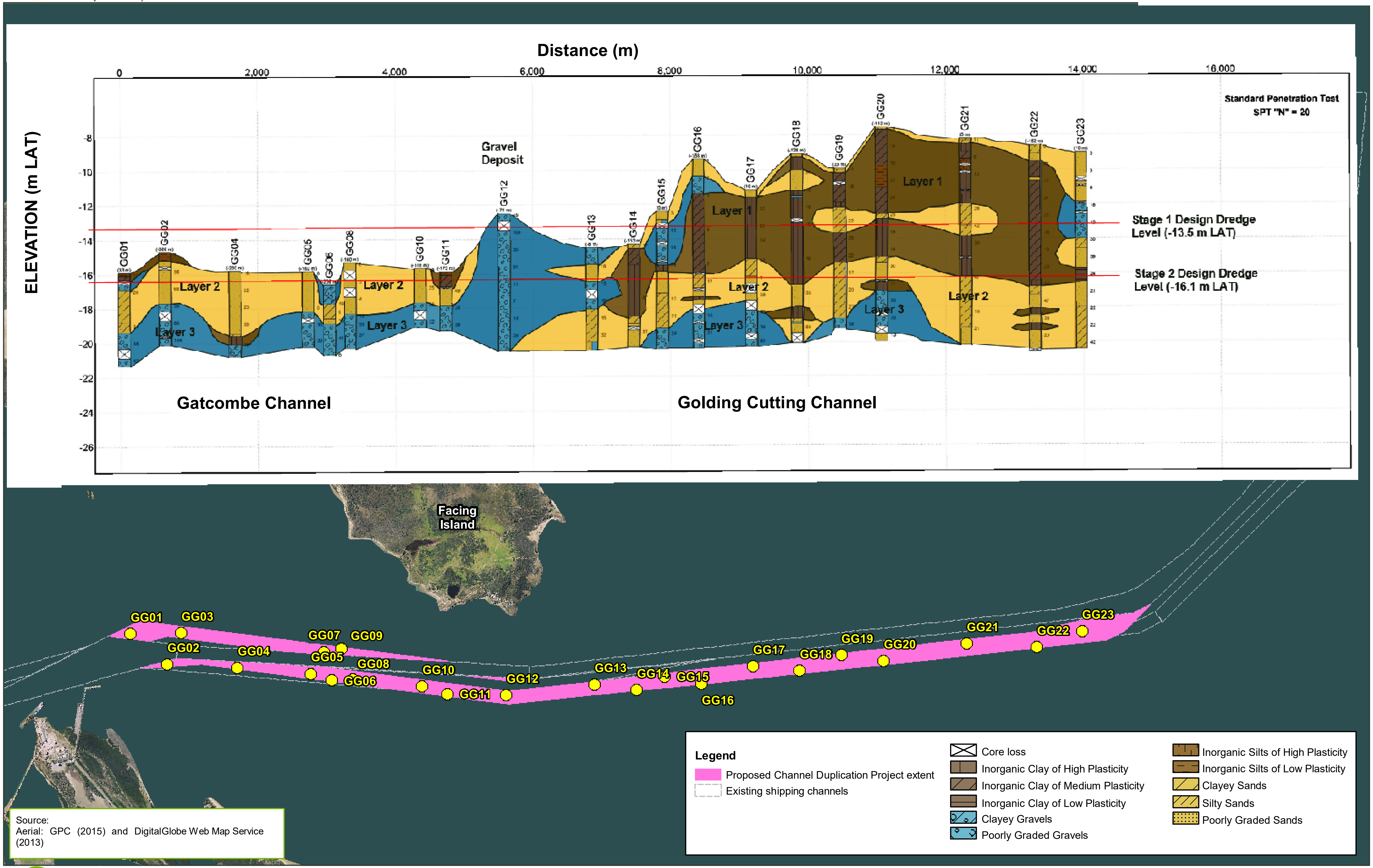

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Gatcombe and Golding Cutting Channel Duplication Project

Figure 7.7 Interpreted geological section for the combined Gatcombe and Golding Cutting Channels

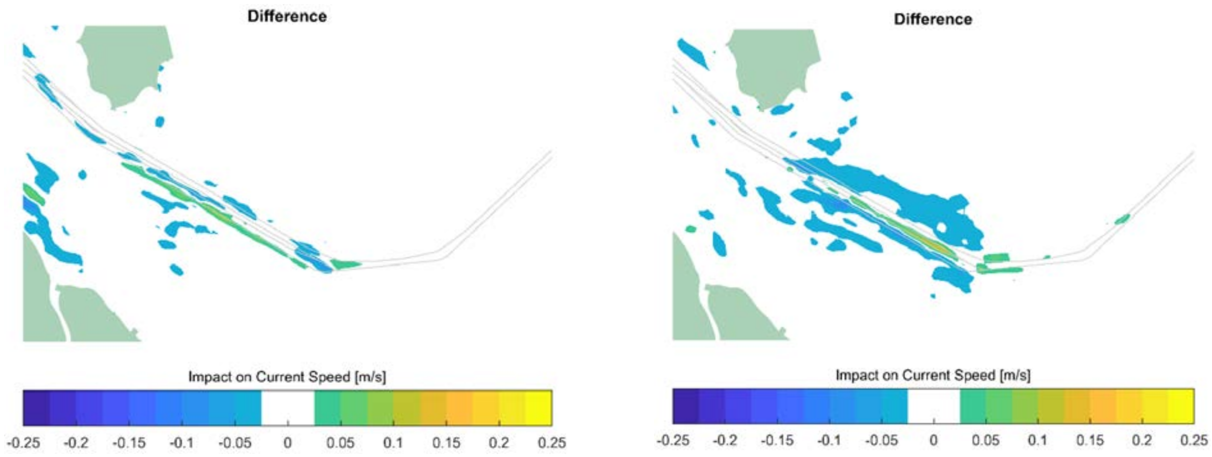


Figure 7.9 **Changes to the flood tide peak spring velocity (left) and ebb tide peak spring velocity (right) for the Project Channel Geometry Case**

7.4.3 Waves

The construction of the WBE reclamation area and BUF will reduce the wave activity that currently occurs on the shoreline adjacent to the reclamation (during high tide periods when the area is inundated), however this is a very sheltered area so the expected influence on the shoreline coastal processes is negligible.

The duplication of the Gatcombe and Golding Cutting Channels will cause some additional wave reflection for waves from the dominant incident direction (east) which has the effect of a slight modification in significant wave height in the immediate vicinity of the channels. The model indicates a very slight reduction in wave height to the southwest of the duplicated channel, and a corresponding slight increase in wave height within the new channel. These changes are not large in magnitude or extent, and the model results indicate that the wave characteristics at adjacent shorelines will not be altered by the Project (refer Figure 7.10).

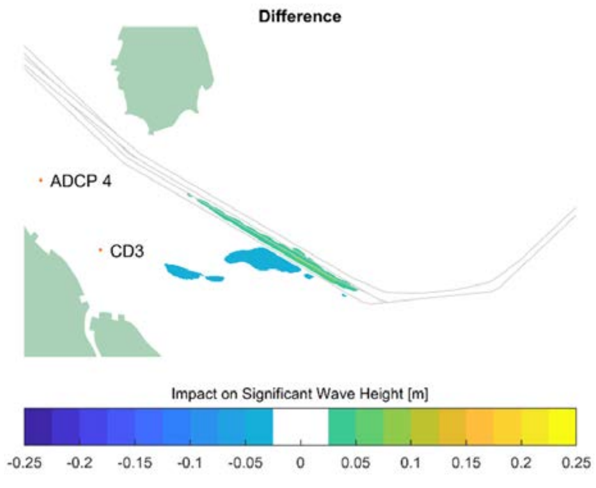
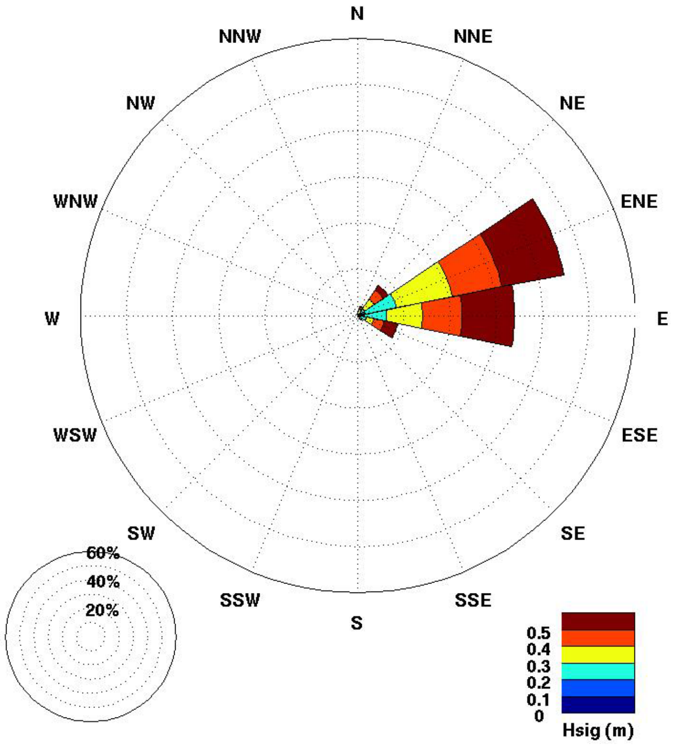


Figure 7.10 **Modelled change in the typical spatial wave height in areas near the Gatcombe and Golding channels for the Project Channel Geometry Case**

Figure 7.11 shows the wave roses for the Base Case and the Project Channel Geometry Case at site CD 3. The difference between them is negligible, indicating that there will be no change in wave climate at this location and therefore no consequential change in wave-driven sediment transport on the adjacent coastline. No Project-related impacts to wave-driven sediment transport are expected on either the Facing Island or Boyne Island shorelines.



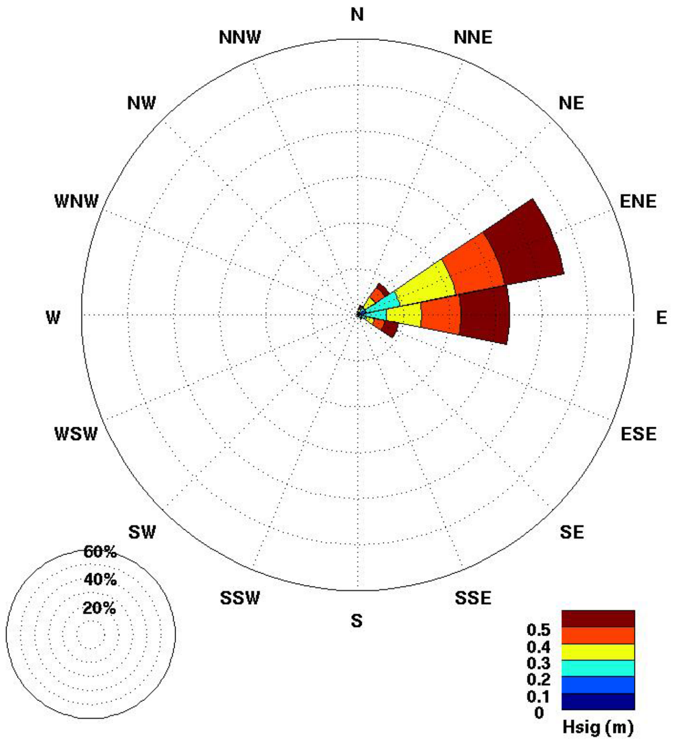


Figure 7.11 **Wave roses at Site CD3 for the Base Case (top) and Project Channel Geometry Case (bottom)**

7.4.4 Extreme water levels, sea level rise and climate change

The modelling results indicate that the duplication and deepening of shipping channels will have no impact on existing water levels in the Port. The wave climate on coastlines adjacent to the duplicated channels will not be impacted. The duplication and deepening of the shipping channels is therefore not likely to cause any change to the projected impacts of climate change and SLR in the Project area. Since SLR will have the effect of raising the level of LAT, and the design level of the channels is relative to the LAT tidal plane, the depth of the channels relative to the mean sea level is not expected to change over time.

7.4.5 Sediment dynamics

The influence of sediment plumes generated during dredging on water quality and ecological values are addressed in Chapter 8 (water quality) and Chapter 9 (nature conservation), respectively.

Potential long term changes in the sediment dynamics within the Port Curtis estuary caused by the duplication of the channels were assessed by modelling the ambient sediment dynamics for a 12 month period with the Base Case geometry and comparing the results with a simulation of the same 12 month period with the Project Channel Case Geometry.

In the vicinity of the WBE reclamation area and BUF, the model results indicate the potential for some erosion to occur in the channel surrounding the new reclamation areas. This erosion would continue (provided the bed material is erodible) until the channel reaches a new equilibrium depth. Note that this means that the predicted rates of erosion in the channels would not be sustained long term, since the bed morphology would adjust to the new regime and net erosion and accretion will trend towards zero as a new equilibrium profile is obtained. A monitoring program will be implemented to manage any observed impacts in the channels and along the shoreline adjacent to the new reclamation area.

The model results also indicate an increase in siltation rates in the Golding Cutting section of the new channel, due to a reduction in velocity caused by the increased water depth. Analysis of the modelling results indicates that the overall net annualised siltation rate within the shipping channels of the Port is likely to increase by approximately 7% following the completion of the Project.

The model indicates that the Project will have a negligible effect on siltation rates elsewhere in the Port, including at the small boat harbour at the southern end of Facing Island.

7.4.6 Coastal processes

The modelling results indicate that the Project related changes to water levels, flow velocities, wave climate and sediment dynamics within the Port will be very small, and there will be no impacts to physical processes on coastlines adjacent to the duplicated channels. There will be reductions in the wave activity on the coastline adjacent to the WBE reclamation area and BUF, but since this area is already very sheltered from waves this represents a minor impact.

7.4.7 Implications for changes in coastal processes and hydrodynamics

The potential impacts from the Project on coastal processes and hydrodynamics identified in this chapter and which are also discussed in detail in Appendix G (Coastal Processes and Hydrodynamics), have been used as the basis for the assessment of related impacts, most significantly Project impacts on water quality (Chapter 8) and nature conservation (Chapter 9).

Section 4 of Appendix G presents the long term changes to hydrodynamics and coastal processes due to the construction of the Project.

Section 5 of Appendix G presents the modelling results of the effects of dredging activities (initial dredging works, Stage 1, Stage 2 and dewatering activities) on suspended sediment in terms of changes in turbidity in the water column (i.e. expected dredge plumes). Impact predictions were modelled to assess potential impacts on both marine water quality and ecologically sensitive areas which are presented as zones of impact. The zones of impact were then used in the impact assessment for water quality (Chapter 8) and nature conservation (Chapter 9). A summary of the potential water quality and nature conservation impacts is provided below.

Water quality

- Water quality impacts associated with the establishment of the WBE reclamation area outer bund walls and the construction of the BUF (refer Section 8.6.4)
- Long term water quality impacts associated with the establishment of the duplicated shipping channels (refer Section 8.6.5)
- Short term water quality impacts (zones of impact) associated with dredging activities (refer Section 8.6.6).

Nature conservation

- Impacts on wetlands associated with increased marine water velocities and short term changes in water quality near the WBE reclamation area (refer Section 9.5.2.4, Section 9.5.2.6 and Section 9.5.3.2)
- Impacts on intertidal communities associated with hydrodynamic changes in the channel between the WBE reclamation area and the shoreline (refer Section 9.7.2.3)
- Impacts on seagrass including hydrodynamic impacts (refer Section 9.9.2.4), short term declines in water quality (refer Section 9.9.3.2) and short term increases in sediment deposition (refer Section 9.9.3.3)
- Impacts on reef communities associated with short term declines in water quality during establishment of the WBE reclamation area (refer Section 9.11.2.2) and during dredging activities (refer Section 9.11.3.2).
- The short term suspended sediment (turbidity) impacts associated with dredging activities on reef communities (refer Section 9.11.3.2), fish and other marine reptiles (refer Section 9.13.3.1) and soft sediment habitats and macroinvertebrates (refer Section 9.15.3.2)
- The hydrodynamic and water quality impacts on migratory bird habitat associated with the WBE reclamation area establishment (refer Section 9.17.2.4)
- Impacts on migratory birds during dredging activities as a result of short term declines in water quality (refer Section 9.17.3.3), and loss of food sources and impacts on migratory seabird prey (refer Section 9.17.3.4)
- The short term suspended sediment (turbidity) impacts associated with dredging activities impacting on marine turtles (refer Section 9.19.3.6) and marine mammals (refer Section 9.21.3.3).

Mitigation measures addressing these potential impacts are discussed in Section 8.7 (water quality) and Section 9.27 (nature conservation).

7.5 Mitigation measures

Due to the low consequence of predicted impacts to coastal processes and hydrodynamics associated with the Project, no mitigation measures are proposed. A monitoring program will be implemented to observe the changes in velocity and sediment dynamics in the channels adjacent to the WBE reclamation area and BUF, and trigger management actions implemented as required.

Mitigation measures in relation to minimising water quality and marine ecology impacts from Project activities are provided in Chapter 8 (water quality) and Chapter 9 (nature conservation), respectively.

7.6 Risk assessment

7.6.1 Methodology

To assess and appropriately manage the coastal processes and hydrodynamic risks as a result of Project activities, a risk assessment process has been implemented (herein referred to as 'risk assessment'). The risk assessment methodology adopted is based on principles outlined in the:

- AS/NZS ISO 31000:2009 Risk management – Principles and guidelines
- HB 203:2012 Handbook: Managing environment-related risk.

The risk assessment identifies and assesses the coastal processes and hydrodynamic risks for the establishment of the WBE reclamation area and BUF, dredging activities, installing navigational aids and maintenance activities on the WB and WBE reclamation areas.

The purpose of this risk assessment is to identify potential impacts to environmental values/receptors, prioritise environmental management actions and mitigation measures, and to inform the Project decision making process.

The risk management framework incorporates the Australian/New Zealand Standard for Risk Management (AS/NZS 4360:2004) and contains quantitative scales to define the **likelihood** of the potential impact occurrence and the **consequence** of the potential impact should it occur.

An overview of the interaction between Project activities (drivers/stressors), sensitive values/receptors and the risk impact assessment process is provided in Figure 7.12.

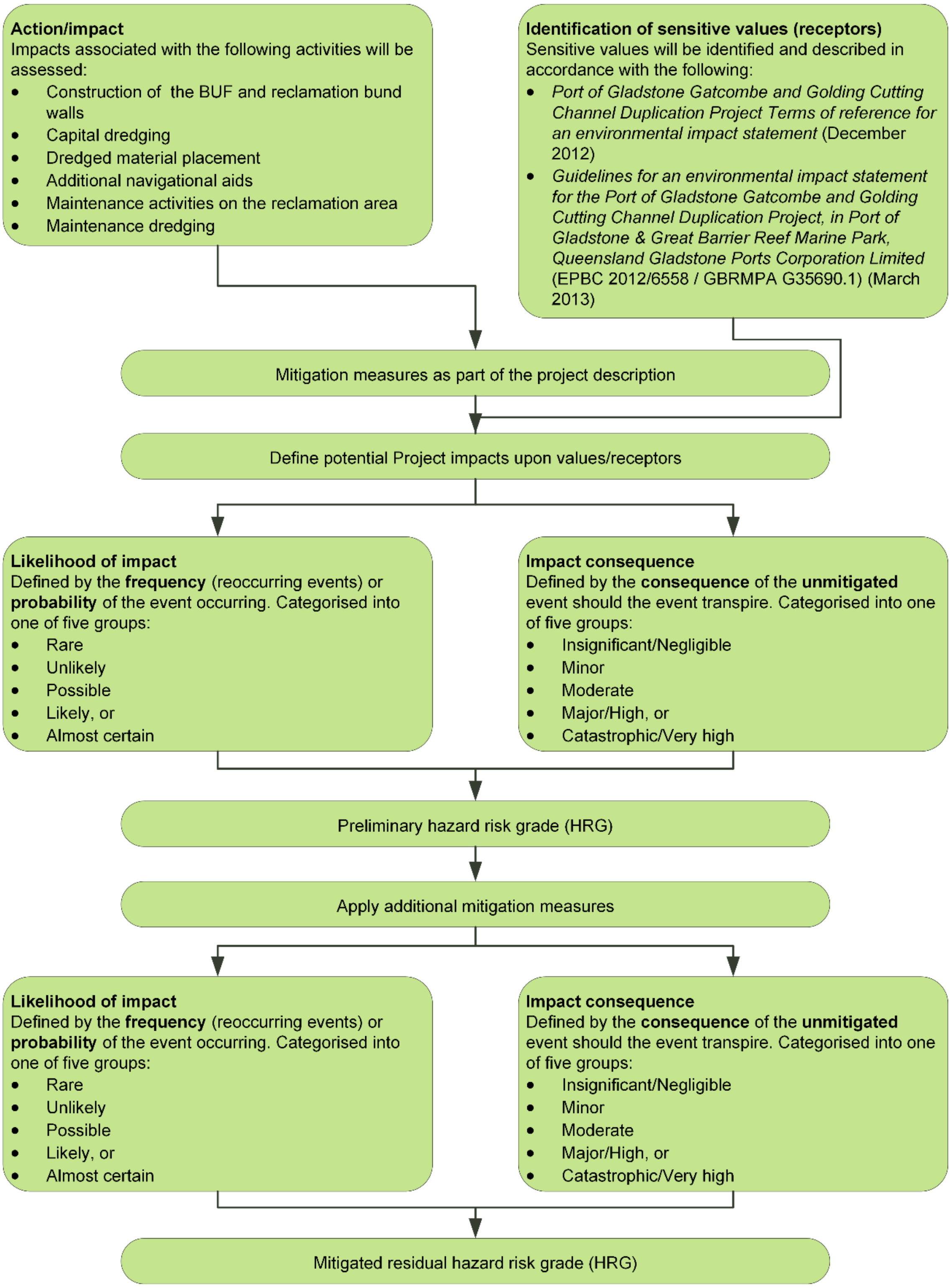


Figure 7.12 Risk assessment framework

Criteria used to rank the **likelihood** and **consequence** of potential impacts are provided in Table 7.4 and Table 7.5, respectively.

Table 7.4 Environmental (ecosystem), public perception and financial consequence category definitions (adapted from GBRMPA 2009)

Description	Definition/quantification[1]		
	Environmental*	Public perception	Financial
Negligible (Insignificant)	No impact or, if impact is present, then not to an extent that would draw concern from a reasonable person No impact on the overall condition of the ecosystem	No media attention	Financial losses up to $500,000
Low (Minor)	Impact is present but not to the extent that it would impair the overall condition of the ecosystem, sensitive population or community in the long term	Individual complaints	Financial loss from $500,001 to $5 million
Moderate	Impact is present at either a local or wider level Recovery periods of 5 to 10 years likely	Negative regional media attention and region group campaign	Financial loss from $6 million to $50 million
High (Major)	Impact is significant at either a local or wider level or to a sensitive population or community Recovery periods of 10 to 20 years are likely	Negative national media attention and national campaign	Financial loss from $51 million to $100 million
Very high (Catastrophic)	Impact is clearly affecting the nature of the ecosystem over a wide area **or** impact is catastrophic and possibly irreversible over a small area or to a sensitive population or community Recovery periods of greater than 21 years likely **or** condition of an affected part of the ecosystem irretrievably compromised	Negative and extensive national media attention and national campaigns	Financial loss in excess of $100 million

Table notes:

1 Quantification of impacts should use the impact with the greatest magnitude in order to determine the consequence category

* For Matters of National Environmental Significance (MNES) protected under the provisions of the EPBC Act the *Matters of National Environmental Significance – Significant Impact Guidelines 1.1 – Environmental Protection and Biodiversity Conservation Act 1999* (DoE 2013) are to be used to determine the consequence category

Table 7.5 Likelihood category definitions (adapted from GBRMPA 2009)

Description	Frequency	Probability
Rare	Expected to occur once or more over a timeframe greater than 101 years	0-5% chance of occurring
Unlikely	Expected to occur once or more in the period of 11 to 100 years	6-30% chance of occurring
Possible	Expected to occur once or more in the period of 1 to 10 years	31-70% chance of occurring
Likely	Expected to occur once or many times in a year (e.g. 1 to 250 days per year)	71-95% chance of occurring
Almost certain	Expected to occur more or less continuously throughout a year (e.g. more than 250 days per year)	96-100% chance of occurring

Once the likelihood and the consequence has been defined, determination of the HRG of the potential hazard will be determined through the use of a five by five matrix (refer Table 7.6).

Table 7.6 Hazard risk assessment matrix (adapted from GBRMPA 2009)

Likelihood	Consequence rating				
	Negligible (insignificant)	Low (minor)	Moderate	High (major)	Very high (catastrophic)
Rare	Low	Low	Medium	Medium	Medium
Unlikely	Low	Low	Medium	Medium	High
Possible	Low	Medium	High	High	Extreme
Likely	Medium	Medium	High	High	Extreme
Almost certain	Medium	Medium	High	Extreme	Extreme

Table note:

Hazard risk categories identified in Table 7.6 are defined in Table 7.7

Table 7.7 Risk definitions and actions associated with hazard risk categories (adapted from GBRMPA 2009)

Hazard risk category	Hazard risk grade definition
Low	These risks should be recorded, monitored and controlled. Activities with unmitigated environmental risks that are graded above this level should be avoided.
Medium	Mitigation actions to reduce the likelihood and consequences to be identified and appropriate actions (if possible) to be identified and implemented.
High	If uncontrolled, a risk event at this level may have a significant residual adverse impact on MNES, MSES, GBRWHA and/or social/cultural heritage values. Mitigating actions need to be very reliable and should be approved and monitored in an ongoing manner.
Extreme	Activities with unmitigated risks at this level should be avoided. Nature and scale of the significant residual adverse impact is wide spread across a number of MNES and GBRWHA values.

7.6.2 Summary of risk assessment.

The potential coastal processes and hydrodynamics impact risk assessment is summarised in Table 7.8.

Table 7.8 Potential coastal processes and hydrodynamics impacts and risk assessment ratings

Potential impact	Project phase					Preliminary HRG			Post mitigation HRG		
	Reclamation area and BUF establishment	Dredging	Navigational aids	Demobilisation	Maintenance	Likelihood	Consequence	HRG	Likelihood	Consequence	HRG
Changes to water levels											
Permanent changes to water levels	✓				✓	Rare	Negligible	Low	Rare	Negligible	Low
Changes to velocities											
Permanent changes to velocity magnitudes and/or patterns adjacent to the WBE reclamation area and BUF	✓				✓	Almost certain	Low (minor)	Medium	Almost certain	Low (minor)	Medium
Permanent changes to velocity magnitudes and/or patterns adjacent to the duplicated channel					✓	Almost certain	Negligible	Medium	Almost certain	Negligible	Medium
Changes to wave climate											
Permanent changes to wave climate adjacent to the WBE reclamation area and BUF	✓				✓	Almost certain	Low (minor)	Medium	Almost certain	Low (minor)	Medium
Permanent changes to wave climate adjacent to the duplicated channel					✓	Almost certain	Negligible	Medium	Almost certain	Negligible	Medium
Changes to extreme water levels											
Changes to extreme water levels	✓				✓	Rare	Negligible	Low	Rare	Negligible	Low
Changes to sediment dynamics											
Potential erosion of channels adjacent to the WBE reclamation area and BUF	✓				✓	Likely	Low (minor)	Medium	Likely	Low (minor)	Medium
Overall increase in siltation rates in the shipping channels and consequent increase in maintenance dredging requirements					✓	Likely	Low (minor)	Medium	Likely	Low (minor)	Medium

Potential impact	Project phase					Preliminary HRG			Post mitigation HRG		
	Reclamation area and BUF establishment	Dredging	Navigational aids	Demobilisation	Maintenance	Likelihood	Consequence	HRG	Likelihood	Consequence	HRG
Changes to coastal processes											
Changes to coastal processes along shorelines adjacent to the WBE reclamation area and BUF	✓				✓	Likely	Low (minor)	Medium	Likely	Low (minor)	Medium
Changes to coastal processes along other shorelines	✓				✓	Rare	Negligible	Low	Rare	Negligible	Low

7.7 Summary

Port Curtis has good tidal flushing characteristics and spring tidal velocities are generally high (up to 2m/s). Waves are important drivers of sediment dynamics both within the estuary and in offshore areas. Within the Port, the bed shear stress associated with the tidal currents is generally the dominant driver of sediment resuspension and wave-related bed shear stress is of secondary importance. In the outer reaches of the Port, and in offshore areas, wave energy is higher and tidal velocities are lower and therefore the wave-related bed shear stress is a much more significant driver of resuspension processes. Shoreline coastal processes within the Port are influenced by the local wave climate as well as the tidal hydrodynamics and sediment dynamics.

The modelling results indicate that water level impacts will be negligible. Velocity impacts will be significant in channels adjacent to the WBE reclamation area and BUF, but small in the vicinity of the deepened shipping channels. Wave climate impacts will be limited to the immediate vicinity of the WBE reclamation area. Sedimentation and temporary erosion impacts will be most significant adjacent to the WBE reclamation area, but there will also be a slight increase in overall Port-wide annual maintenance dredging requirements. The deepening of the shipping channels is not likely to cause any change to the projected impacts of climate change and SLR in the Project impact area.

The model was used to simulate the full dredging program and the expected impacts to the turbidity percentiles and deposition rates due to dredging were assessed. The model indicates that increases to the turbidity and deposition rate statistics are expected near the WBE reclamation area and in the vicinity of the TSHD operating in the Gatcombe and Golding Cutting Channels.

The most significant changes will occur in the immediate vicinity of the WBE reclamation area, and a monitoring program will be implemented to manage any observed impacts in the channels and along the shoreline adjacent to the new reclamation area.