TOONDAH HARBOUR

CHAPTER 8

COASTAL PROCESSES
AND DREDGE PLUMES

8. Coastal Processes and Dredge Plumes

8.1. Introduction

The Coastal Processes and Dredge Plume technical studies were completed by BMT. Details of the key personnel involved in the study are provided in Appendix 1-F. The full technical report is provided in Appendix 2-E. The technical report has been independently peer reviewed by Dr Andrew Symonds of Ports and Coastal Solutions. The peer review summary is provided in Appendix 2-F.

8.1.1 Scope of Study

The Project incorporates dredging, excavation and reclamation works along the foreshore and across adjacent intertidal and subtidal areas at Toondah Harbour. Such works have the potential to impact the prevailing hydrodynamic and coastal processes which in turn also influence the design of the works. This chapter describes those physical processes and assesses the potential impacts of the Project on them, as well as providing consideration of potential management measures.

The components included in the assessment are:

- Tidal hydraulics (water levels and currents);
- Wave climate;
- Marine sediment dynamics (erosion and siltation);
- Shoreline processes;
- Extreme events and storm tides;
- Dredge plume dispersion;
- Coastal hazards and risks;
- Climate change considerations.

Specific requirements for the coastal processes and dredge plume modelling assessment to address the EPBC Act Guidelines for the preparation of a Draft EIS and other legislative requirements include:

1. Assess the change in flow from all phases of the development, including potential stream diversions, scouring and erosion;
2. Consider changes to tidal inundation levels and frequencies associated with the development, under both the current range of environmental conditions and under a climate change scenario resulting in sea level 1.5 m above the current highest astronomical tide (HAT) with a storm surge;
3. Predictive, fully three-dimensional modelling of indirect impacts of dredge-generated sediments must include a number of technical requirements as detailed in the EIS guidelines;
4. Other requirements associated with the modelling of dredging activities.

Full details of the methodology and model calibration are included in the technical report (Appendix 2-E).

8.1.2 Activities that May Result in Impacts

Changes in coastal processes and turbidity levels from dredge plumes could occur as a result of a number of Project activities. These include:

- Changes to coastal processes (currents, waves, etc) due to the physical barrier created by the reclamation and increased harbour navigation channel and turning basin;
- Suspension of any contaminants and nutrients including ASS into the water column from the sediment being dredged;
- Creation of temporary suspended sediment (turbidity) plumes in the water column during dredging and loading of barges with sediment;
- Impacts from plumes generated from ongoing maintenance dredging of the Fison Channel, turning basin, internal waterways and marina—note, maintenance dredging is currently carried out regularly for the Fison Channel and turning basin.

8.2. Assessment Methodology

There are no specific legislative, planning or guideline documents relative to coastal processes and dredge plume modelling. The coastal processes and dredge plume modelling assessment has been conducted using best practice methods such as the Great Barrier Reef Marine Park Authority's *The use of Hydrodynamic Numerical Modelling for Dredging Projects in the Great Barrier Reef Marine Park*.

Numerical modelling techniques form the basis of the assessment of the coastal processes and dredge plume dispersion. The processes themselves are integrated and similarly the numerical models are typically either integrated dynamically, or outputs from one model feed into others as inputs as part of the overall system.

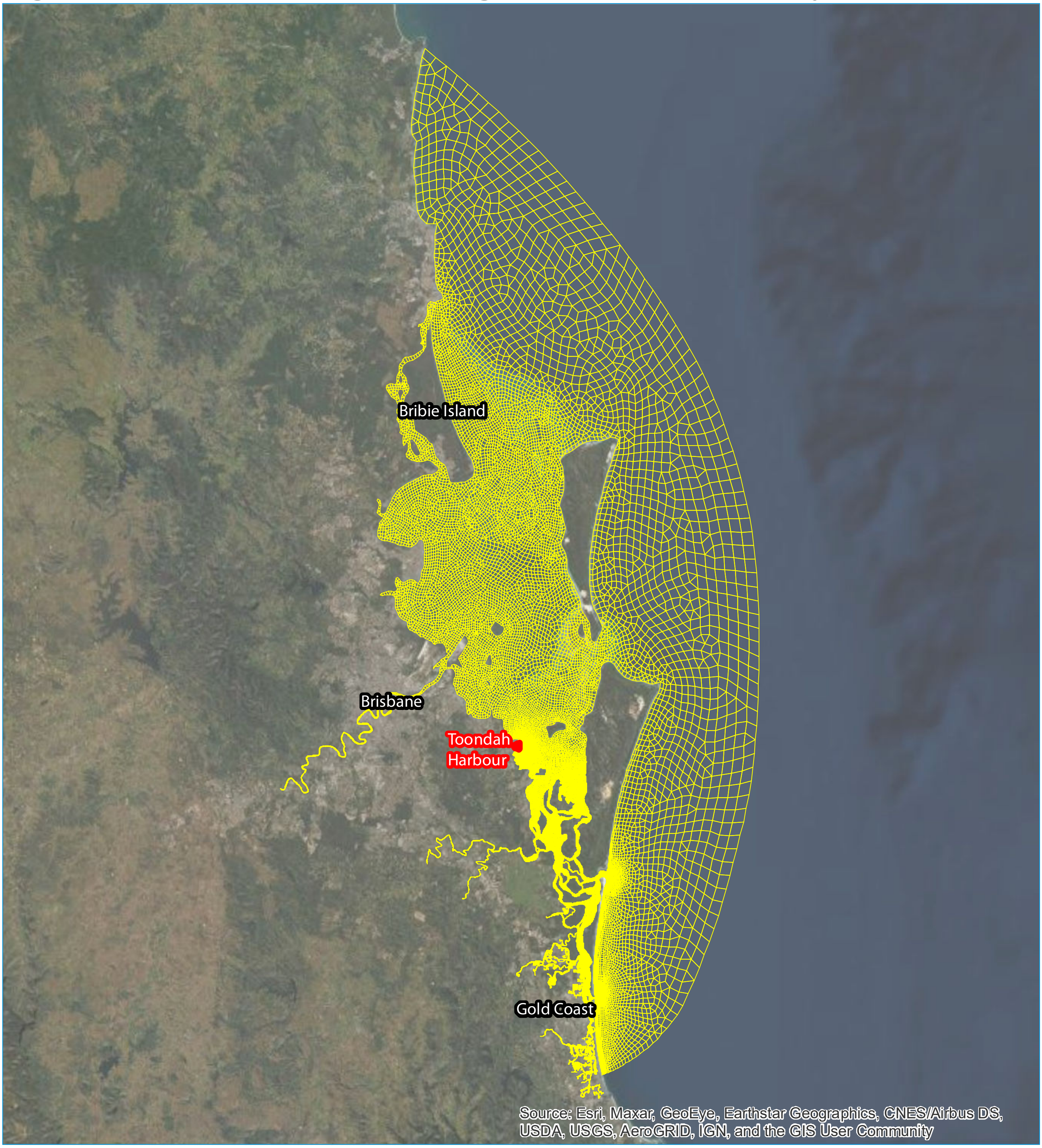
The models used are primarily based on regional numerical models that have been established as part of other studies and updated and refined for the purposes of this study. The general approach included collection of local site-specific data to firstly calibrate the models and validate that they are reproducing the existing local processes. The models have then been used to simulate typical existing conditions and proposed design scenarios under those same conditions to assess potential impacts and mitigation measures. Specific stages of the Project have been included as part of the assessments.

8.2.1 Model Component Descriptions and Calibration

The integrated numerical modelling system used for the assessments incorporated the following main components:

- TUFLOW FV – The central three dimensional hydrodynamic and transport model with modules used to simulate and assess tidal hydraulics (water levels and currents), marine sediment dynamics (suspended sediments and erosion and siltation potential) and dredge plume dispersion. This model was also used for receiving environment water quality modelling (salinity, temperature, suspended sediments and passive tracers representing stormwater-generated constituents). The model covers the whole of Moreton Bay including connected waterways and extends out into the ocean from the Sunshine Coast in the north, to the Gold Coast in the south (Figure 8-1). It has a flexible mesh which allows incorporation of very high resolution in the Project footprint (Figure 8-2).
- SWAN – The base wave model which simulates day-to-day and extreme waves and is dynamically linked to the TUFLOW FV model to provide combined shear stresses for sediment mobilisation and modification of currents. It incorporates a nested modelling approach which encompasses a decreasing grid size, thus increasing resolution, from a regional scale model to a local scale model which represents the study area and resolves the key elements influencing the local wave field (Figure 8-3).

Figure 8-1: Coastal Processes Regional Model Boundary and Mesh



Toondah Harbour EIS

Legend

Toondah Harbour PDA

Model Mesh

TOONDAH HARBOUR

walker

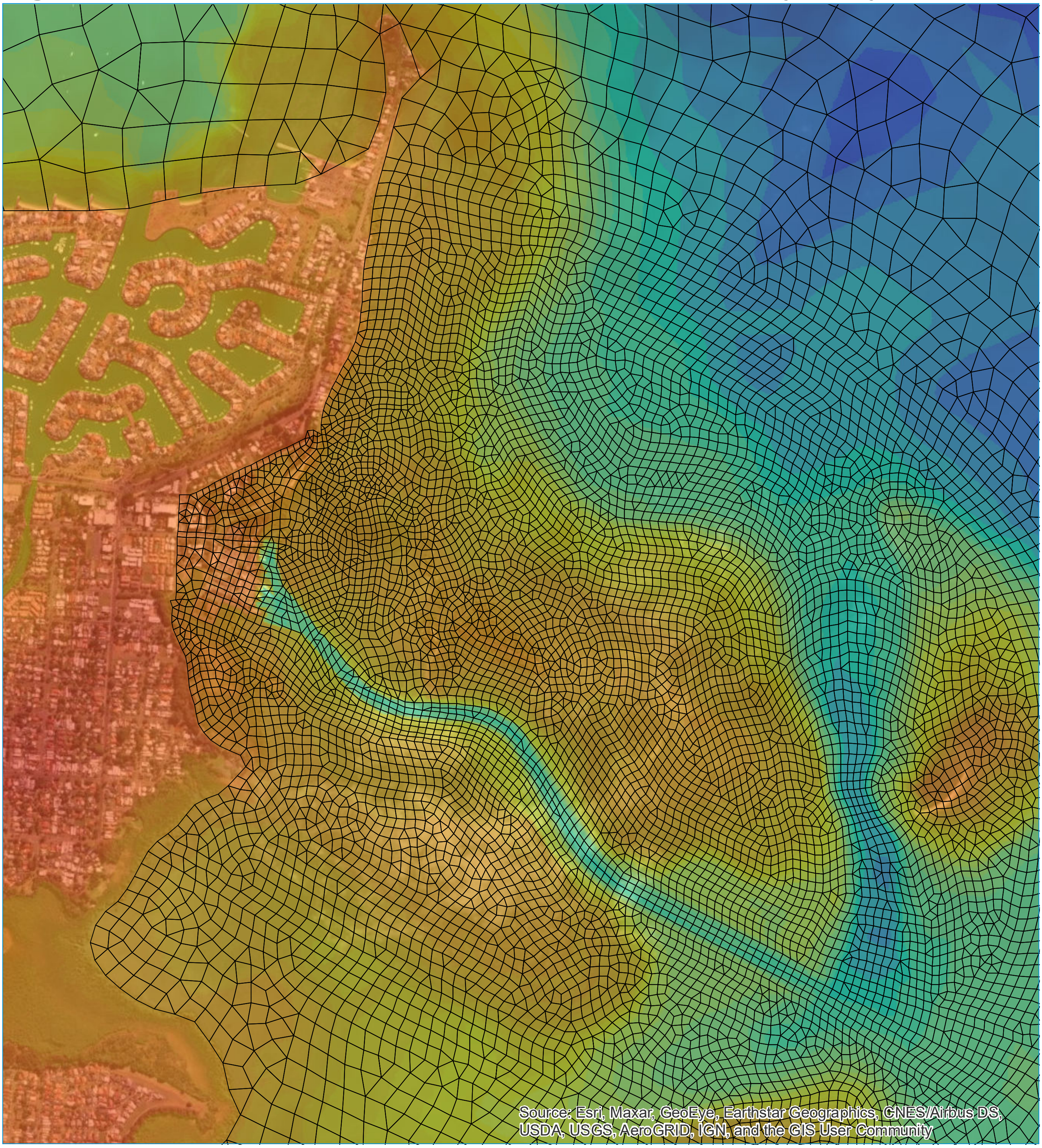
N

0 10 20 30 40 Kilometers

GDA 1994 MGA zone 56

Scale (A4):1:970,000

Figure 8-2: Toondah Harbour Model Mesh and Bathymetry



Toondah Harbour EIS

Legend

Model Mesh

Elevation (m AHD)

+25

-2

-15

TOONDAH HARBOUR

walker

N

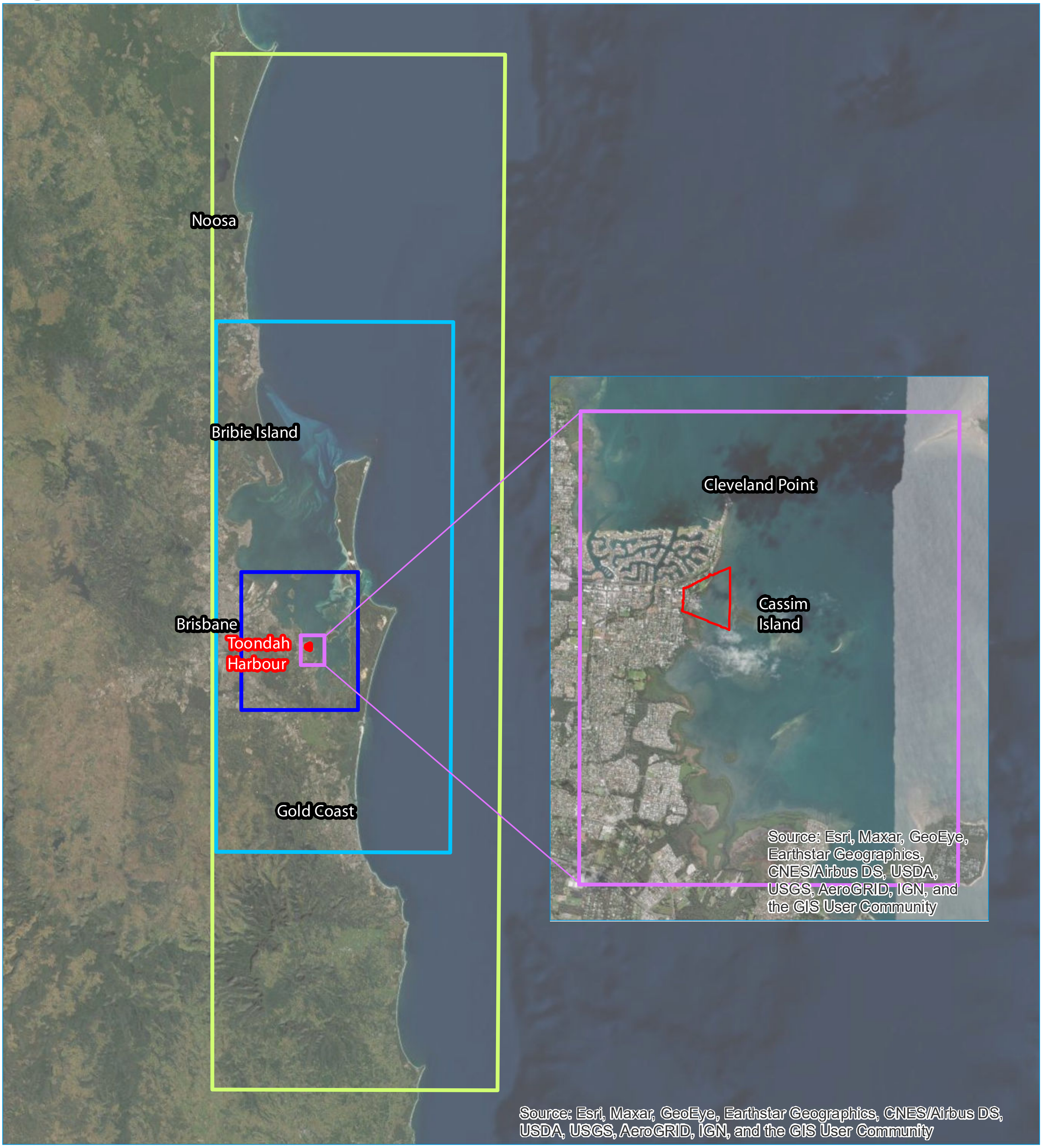
0 100 200 300 400 m

GDA 1994 MGA zone 56

Scale (A4): 1:20,000

Layer Source: © State of Queensland Datasets (Department of Resources 2022), Aerial (Nearmap 2020) DATE 12/04/2022 FILE REF. 9858 E Figure 8 2 Model Mesh and Bathymetry B

Figure 8-3: SWAN Model Grids



Toondah Harbour EIS

Legend

- Toondah Harbour PDA (Project Area)
- 25m SWAN
- 100m SWAN
- 400m SWAN
- 1600m SWAN

TOONDAH HARBOUR

walker

N

0 10 20 30 40 Kilometers

GDA 1994 MGA zone 56

Scale (A4)1:1,583,375

The modelling system was supplied with appropriate boundary condition data (external forcing) from global atmospheric and ocean models (see Appendix 2-E for details).

The modelling system was calibrated and validated using a comprehensive set of data collected specifically for the Project. These datasets included measurements of water levels, current velocity, wave parameters, turbidity at multiple locations for extended periods of time spanning all seasonal conditions. In addition, current velocities were measured across several transects and compared to the modelled velocities. The modelling system was also validated using data from external agencies where available.

Wave-induced mud fluidisation has not been explicitly included in model parameters as it is not a significant driver of sediment dynamics in the area due to the relatively low energy wave climate. It is implicitly included in the modelled suspended sediment dynamics through the calibration of the erosion rate and the critical bed shear stress threshold.

The validation process established that the numerical modelling system is fit for purpose and is able to accurately reproduce the key physical processes in the Project footprint. For the full details of the model calibration and validation results, refer to Appendix 2-E.

8.2.2 Scenarios Assessed

The Project is proposed to be constructed in several development stages, with ultimate completion scheduled approximately 18 years from the start of construction. Within the staged construction approach, five development phases were adopted for the potential impact modelling assessment, including the hydrodynamic and wave models. The modelled interim and completed stage scenarios are detailed in the following sub-sections, with the schematised footprint configurations each presented in Figure 8-4.

The raised development footprints are defined with completed elevations of +3.0 m AHD, with exception of the southern port car park, where an elevation of +2.5 m AHD is defined. Both the marina and internal waterways are defined by completed levels of -4.25 m AHD.

8.2.2.1 *Base Case Scenario*

The existing conditions were simulated to provide a base case against which development-related impacts were assessed. Details included:

- Existing bathymetry and coastline, present-day Toondah Harbour configuration;
- Various periods have been modelled for model calibration and validation purposes between 2015 and 2020. For the purposes of the base case for impact assessment, two periods were used to represent typical seasonal conditions:
  - Wet, warmer period: 01 October 2016 to 01 February 2017;
  - Dry, cooler period: 01 April to 01 August 2020;
- These periods also aligned with data collection activities at Toondah Harbour;
- Models included 3D hydrodynamics (including salinity and temperature), waves and sediment transport.

8.2.2.2 *Stage 1 Phase 1 Scenario*

The Stage 1 Phase 1 scenario is proposed for year one of construction and involves the installation of sheet pile walling to form the containment perimeter of the northern reclamation bund, as well as the construction of the southern port car park and hardstand. Hydrodynamic assessments were undertaken for each seasonal period for this configuration.

8.2.2.3 *Stage 1 Phase 3 Scenario*

Stage 1 Phase 3 is proposed to be completed in year two to four and included the completion of Dredging Campaign 1 and the northern reclamation landform. This scenario included the enclosed northern marina cove with a non-navigable

15 m wide culvert that connects s to Moreton Bay on the north-east of the development. This phase also includes further construction to the Toondah Harbour port facility and Middle Street and assumes completion of the port turning basin and internal waterway (end of Dredging Campaign 1). Water quality flushing assessments were undertaken for this scenario and this configuration was the base for the Stage 1 dredging assessment (but prior to any dredging works).

8.2.2.4 *Stage 1 Complete Scenario*

Stage 1 Complete will be completed circa year five and includes the marina basin and internal waterways within the northern reclamation. This scenario included the interim northern reclamation footprint and internal waterways shown in Figure 8-4 and the completed dredging of the Dredging Campaign 1 footprint. The marina was connected to Moreton Bay via the previously established north-eastern culvert and an additional south-western culvert (also 15 m wide and anticipated to be implemented through use of a culvert) connecting the marina and turning basin. A full range of assessments of Stage 1 Complete relative to the base case was undertaken on the basis that this completed scenario may be in place for some time prior to commencement of the southern peninsula envisaged for Stage 2. Sensitivity testing was also carried out with respect to the need and benefits of the internal and south-west connections.

8.2.2.5 *Stage 2 Phase 7 Scenario*

The Stage 2 Phase 7 scenario is proposed for year 7 of the construction campaign and includes the addition of the Stage 2 reclamation area and the completed dredging of the entrance channel. The internal channels are assumed to be completed to their full design depth, but the main marina entrance channel is closed while construction of the Stage 2 landform is underway. Hydrodynamic assessments were undertaken for each seasonal period for this configuration. This configuration was also the base for the Stage 2 dredging assessment (but prior to any dredging works).

8.2.2.6 *Stage 2 Complete Scenario*

Stage 2 Complete included the fully developed Project with all landform, marina, and internal waterways and channels completed. This scenario included the final reclamation and marina footprint, and the completed dredging of the Fison Channel and turning basin. The internal waterways are complete, and connections exist between the turning basin and marina and between the marina and the northern channel. A full range of assessments of Stage 2 Complete relative to the base case was undertaken for the hydrodynamic, water quality and coastal process assessments.

8.2.3 Assessment Processes

Potential hydrodynamic and wave climate impacts have been modelled using the TUFLOW FV and SWAN models.

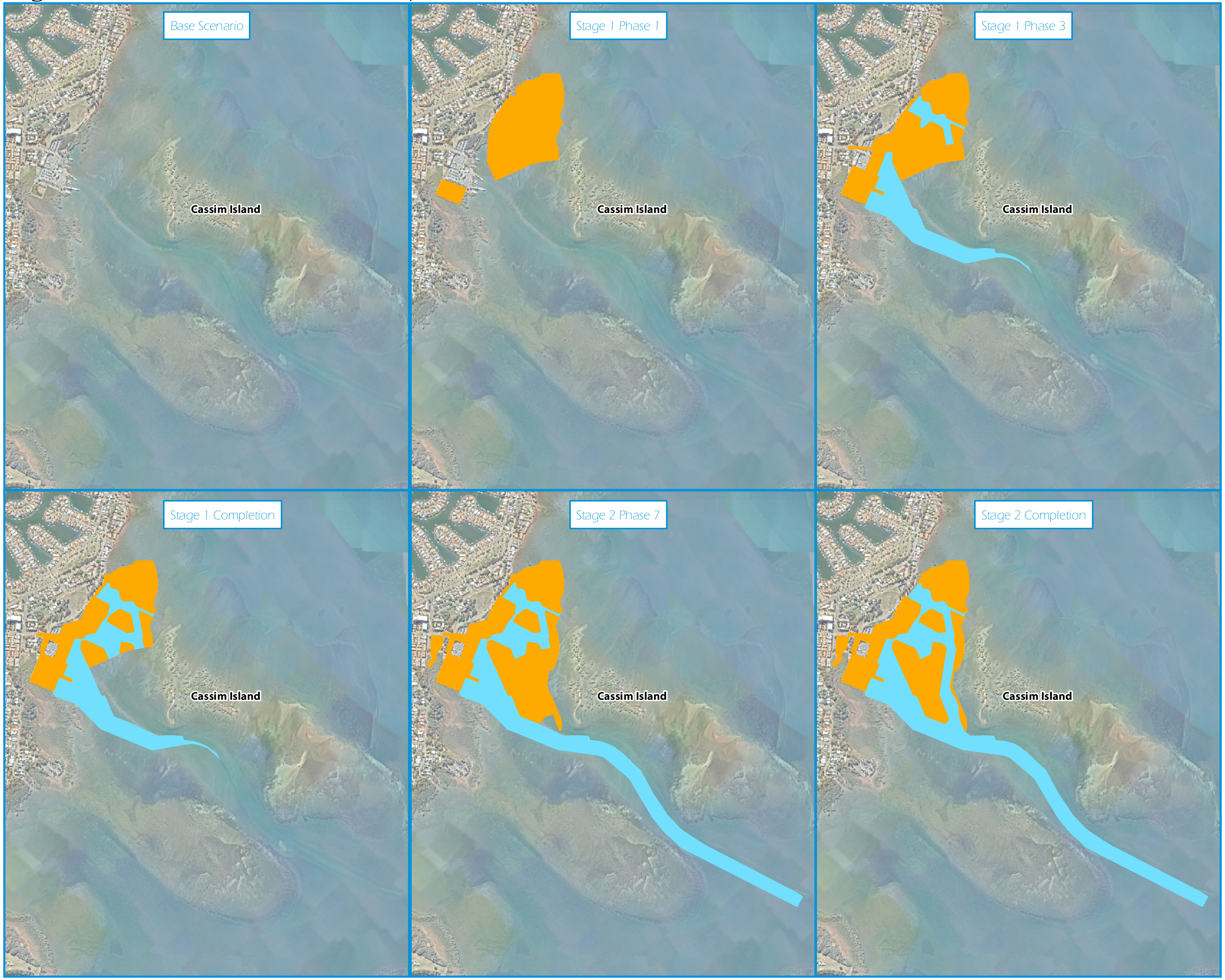
The potential impacts of the Project landform on wave processes and tidal hydrodynamics have been assessed using two different presentation techniques:

- Spatial impact plots; and
- Time series at key points of interest.

Spatial impact plots are shown as the spatial change in magnitude and direction of a variable at a particular moment in time, or alternatively as the change in the 50th and 95th percentiles of a given variable (calculated over a representative 30-day period).

Complementing the spatial impact plots, time series of model outputs are also presented to illustrate temporal variations. The locations of these output points were chosen based on areas of interest identified from the spatial analysis. The location of output points for water level, velocity and wave time series are presented in Figure 8-5.

Figure 8-4: Modeled Development Scenarios



Legend

- Development Footprint
- Proposed Navigaton Channel

TOONDAH HARBOUR

walker

0 200 400 600 800 1,000 Meters

N

GDA 1994 MGA zone 56

Scale (A3): 1:23,000

Layer Source: © State of Queensland Datasets (Department of Resources 2022), Aerial Imagery (Nearmap.com 2020)

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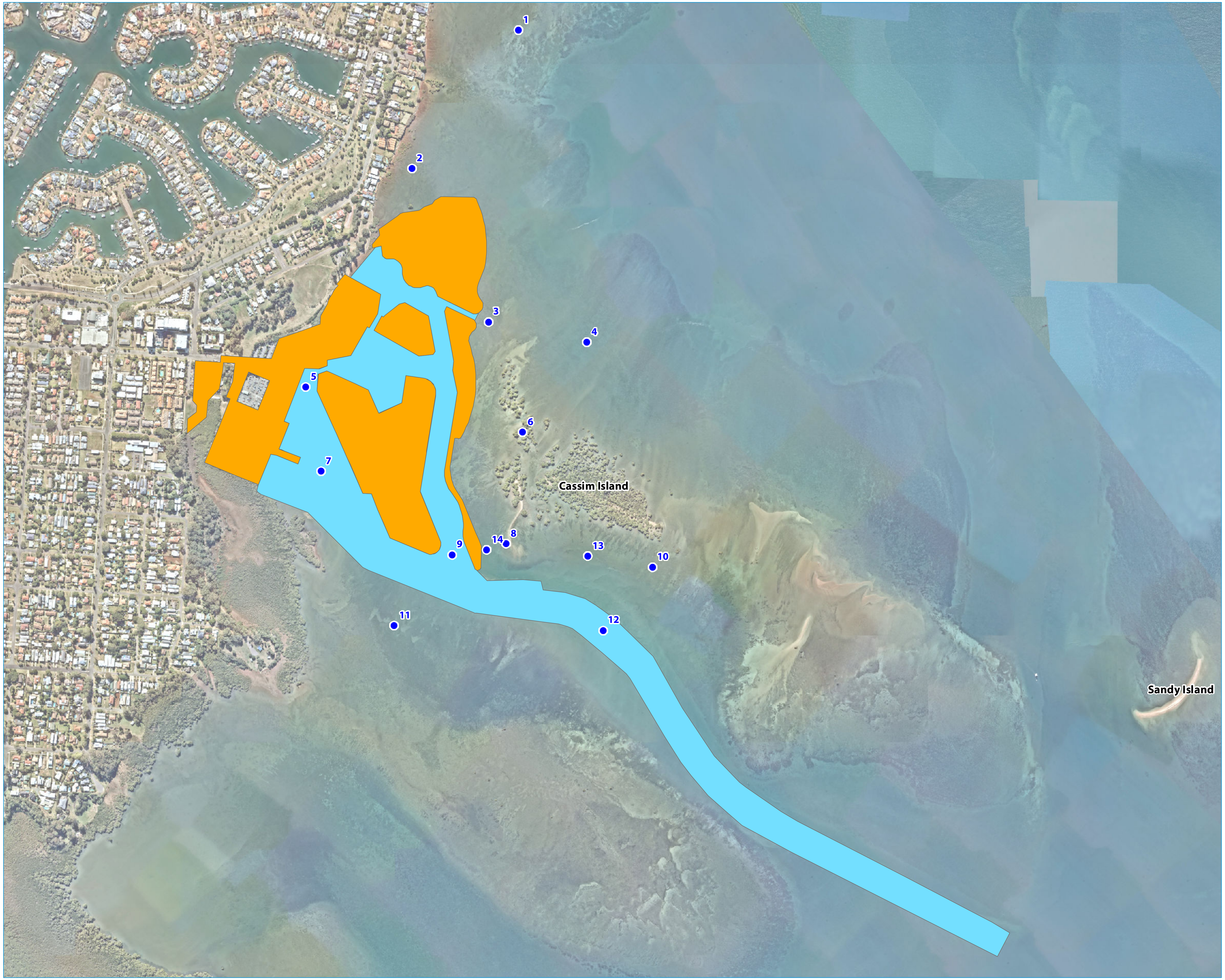
Figure 8-5: Hydrodynamic and Wave Reporting Locations



Legend
- Development Footprint
- Proposed Navigaton Channel
- Sampling Locations

TOONDAH HARBOUR

walker

0 100 200 300 400 m

GDA 1994 MGA zone 56

Scale (A3): 1:10,500

N

Layer Source: © State of Queensland Datasets (Department of Resources 2022), Aerial Imagery (Nearmap.com 2020)

DATE: 12/04/2022

FILE REF. 9858 E Figure 8 5 Hydrodynamic Sampling Locations B

8.3. Existing Values

8.3.1 Tidal Currents and Circulation

Throughout most of Moreton Bay, the tide flows in a southerly direction during a flood tide and a northerly direction during the ebb tide (Newell 1971). The typical spring flood tide and spring ebb tide velocity patterns reproduced in the hydrodynamic model for Toondah Harbour are provided in Figure 8-6 and Figure 8-7. The current patterns here are complex and influenced by the presence of Cassim Island and surrounding intertidal shoals to the north and south of Fison Channel.

At the beginning of the flood tide, the shoals are dry with strong flood tide currents flowing to the south between sand shoals and the outer edge of the intertidal areas. The flood tide currents also flow in a north westerly direction up the Fison Channel towards the shore, with the intertidal areas inundating from both sides. As the tide rises, currents increase and shoals become submerged, a clockwise eddy forms to the north of Cassim Island, with the currents close to shore moving in a northward direction towards Cleveland Point. The flood tide currents also then flow southwards across the shoals east and west of Cassim Island, with another clockwise eddy forming at the end of the Fison Channel. Towards the top of the flood tide, the currents reverse in the channel and flow in an offshore direction towards the south east.

At the start of the ebb tide, the currents typically flow from south to north parallel to the shore across the shoals and channel. As the tide falls and shoals to the north of the channel begin to dry, the currents begin to flow towards the south east with strong currents again flowing to the north between the shoals and the outer edge of the intertidal areas.

Cassim Island itself provides a local shadowing effect on the general southwards and northwards flood and ebb tide currents respectively. During large spring tides, current speeds through the shallow intertidal area of the Toondah Harbour PDA between Cassim Island and the mainland can be up to 0.5 m/s.

A hydrodynamic study of circulation patterns in Moreton Bay (Dennison and Abal, 1999) showed that the pattern of flood tide flows into the bay does not quite match the ebb flows out of the bay, resulting in a northward residual flow on the western side of the bay and a southward flow on the eastern side. This results in a general clockwise circulation pattern throughout all seasons (Quigg *et al*. 2010).

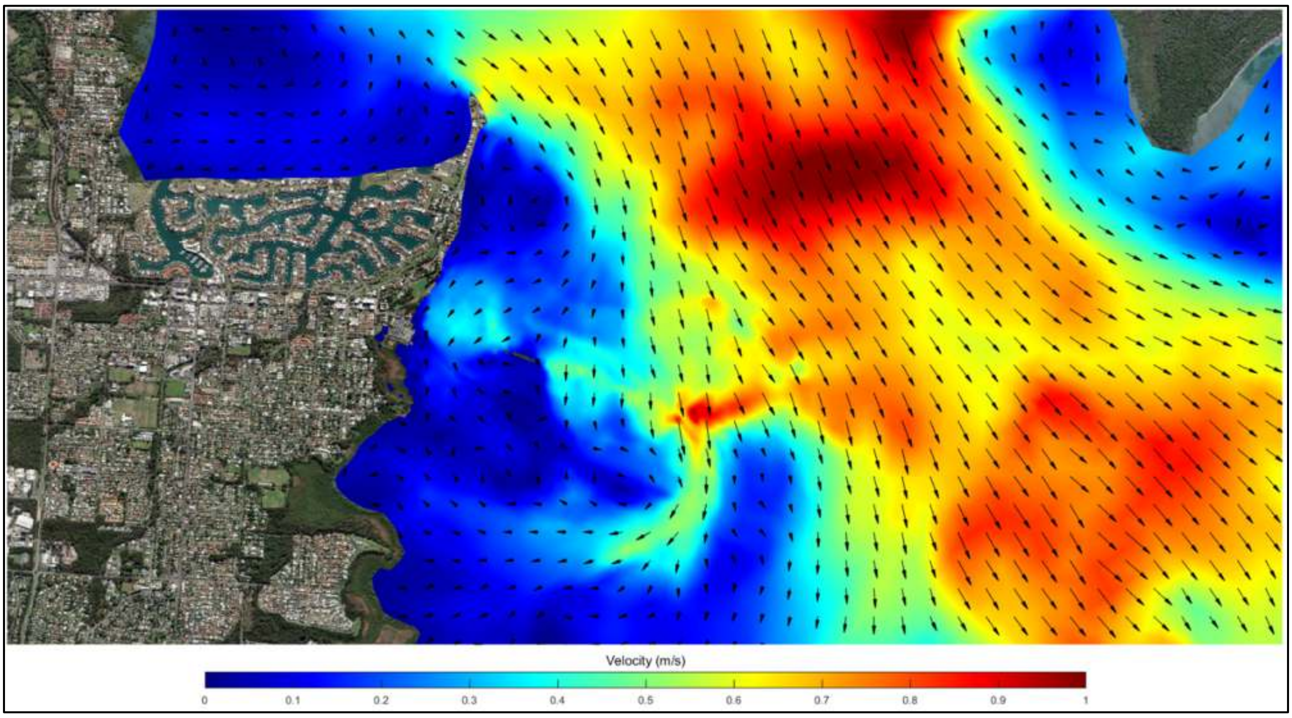


Figure 8-6: Toondah Harbour Locality Peak Flood Tide Current Patterns.

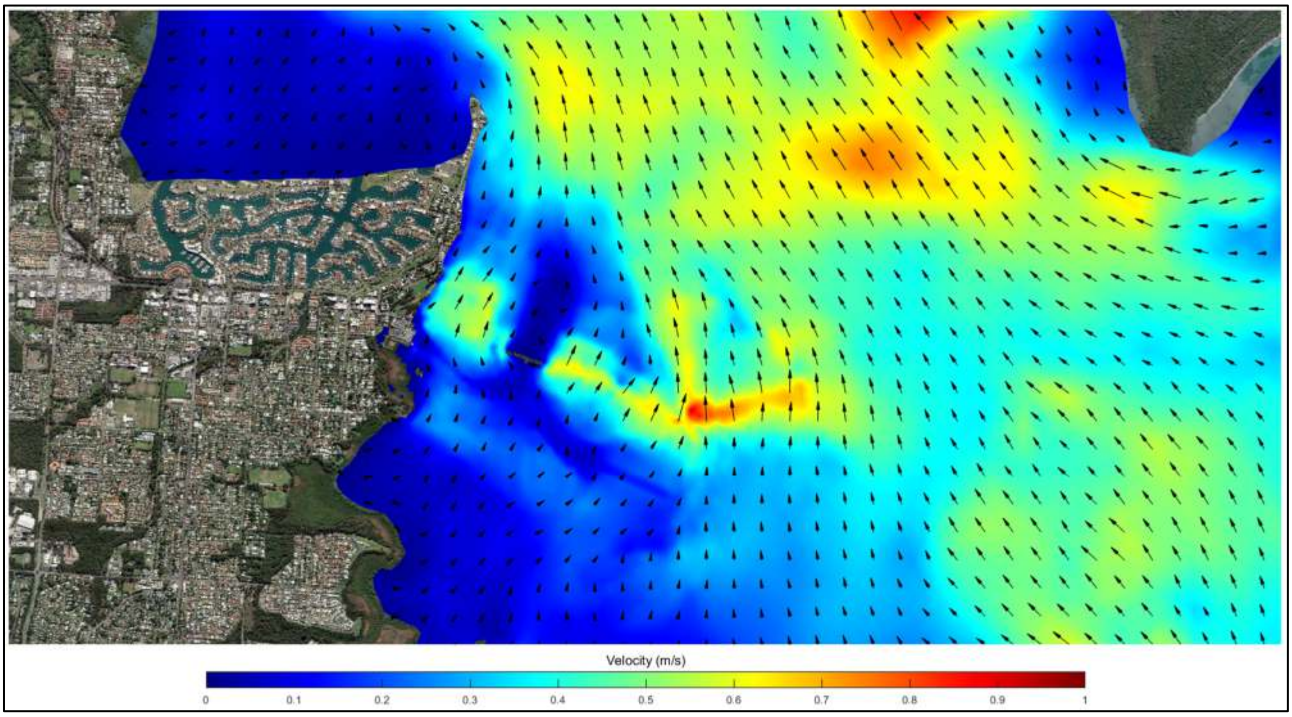


Figure 8-7: Toondah Harbour Locality Peak Ebb Tide Current Patterns.

8.3.2 Waves

Toondah Harbour is sheltered from "swell" waves by Minjerribah (North Stradbroke Island) and Mulgumpin (Moreton Island). The ocean swell energy that enters Moreton Bay and reaches the bay shorelines is substantially attenuated by the processes of refraction, diffraction, bed friction and breaking across the shallow shoals at the bay entrance.

The wave climate at Toondah Harbour, and in Moreton Bay more generally, is dominated by waves generated by winds from within the bay itself. The available fetch lengths and depths are limited and restrict wave development substantially compared to the ocean. The height and direction of Moreton Bay waves are determined directly by the prevailing winds and are highly seasonal in nature. These small "sea" waves can develop quickly with the onset of stronger local winds, and, at certain times of the year (particularly in summer), substantial daily variability may be observed.

The wave conditions captured approximately 1 km north of Cassim Island (ADCP North) at a deployed depth of -4.1 m AHD from March to June 2020 are summarised in Figure 8-8. The wave-roses show that the wave height is mostly governed by the largest wind-fetch direction in the north, despite the predominating south to south-easterly winds measured over the respective deployment period.

Modelled SWAN results demonstrate that during northerly wind conditions, waves show some degree of shielding from Cleveland Point and the shallow mudflats on approach to Toondah Harbour (Figure 8-9). With the shallower bathymetry between Cassim Island and Toondah Harbour, the wave patterns show refraction of the wave direction toward the existing harbour, however wave heights reduce markedly before reaching the shoreline at Toondah Harbour.

Under south-easterly wind conditions there is significant attenuation and refraction of the wave height and direction from the shallow mudflats south of the Fison Channel and along Cassim Island, as shown by the SWAN model output presented in Figure 8-10. The measured wave data at the ADCP North site shows the influence of the wave refraction, since the dominant wave direction is from the east rather than the south-east (Figure 8-8). Less wave shielding and energy dissipation on approach to the shoreline at Toondah Harbour is generally observed under south to south-easterly conditions, compared to northerly conditions.

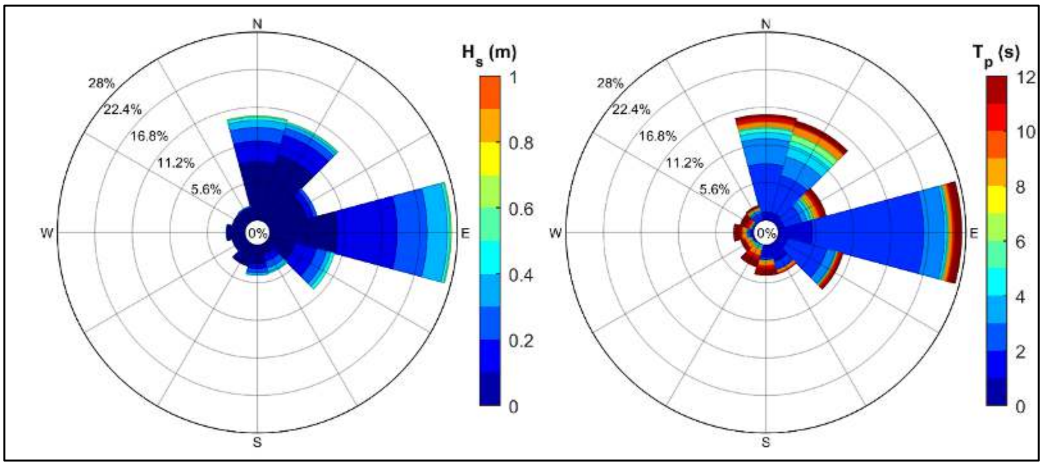


Figure 8-8: Wave Roses Showing Recorded Significant Wave Height (Left) and Peak Wave Period (Right) at ADCP North (06/03/2020 – 04/06/2020).

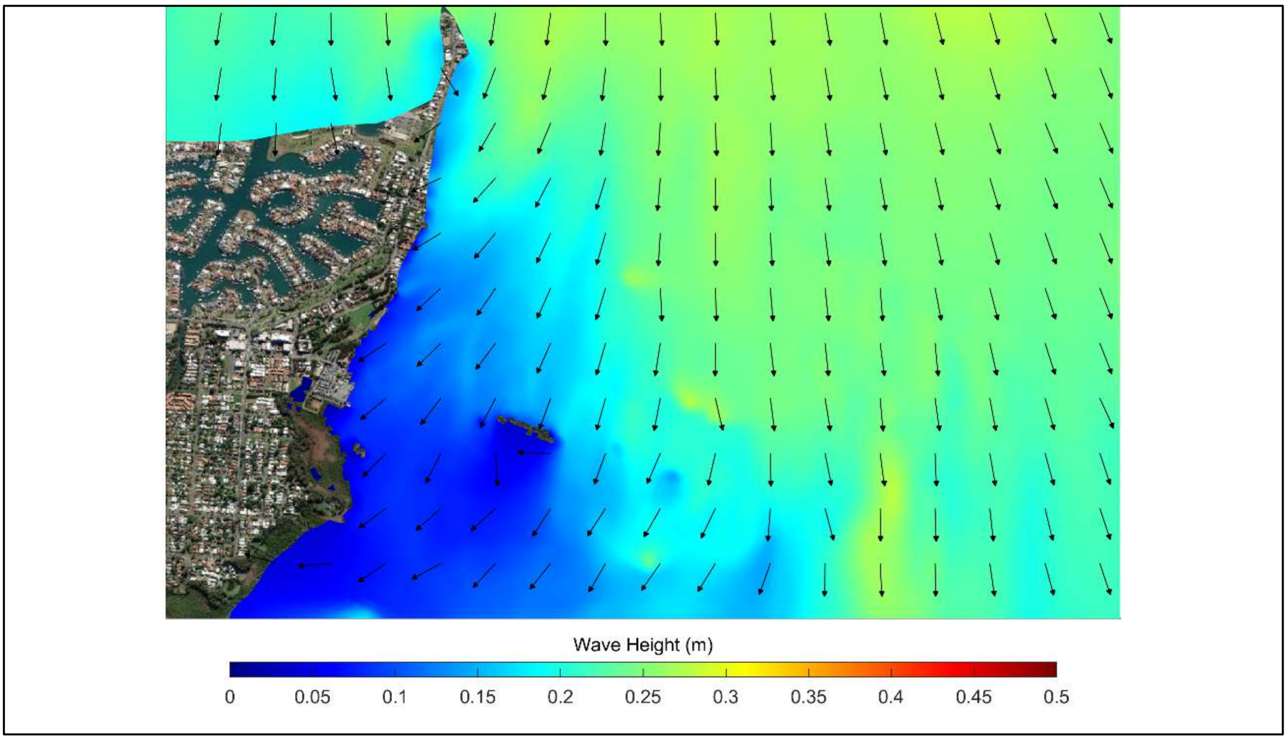


Figure 8-9: Modelled Wave Height in Toondah Harbour Locality. Example Northerly Wind Conditions.

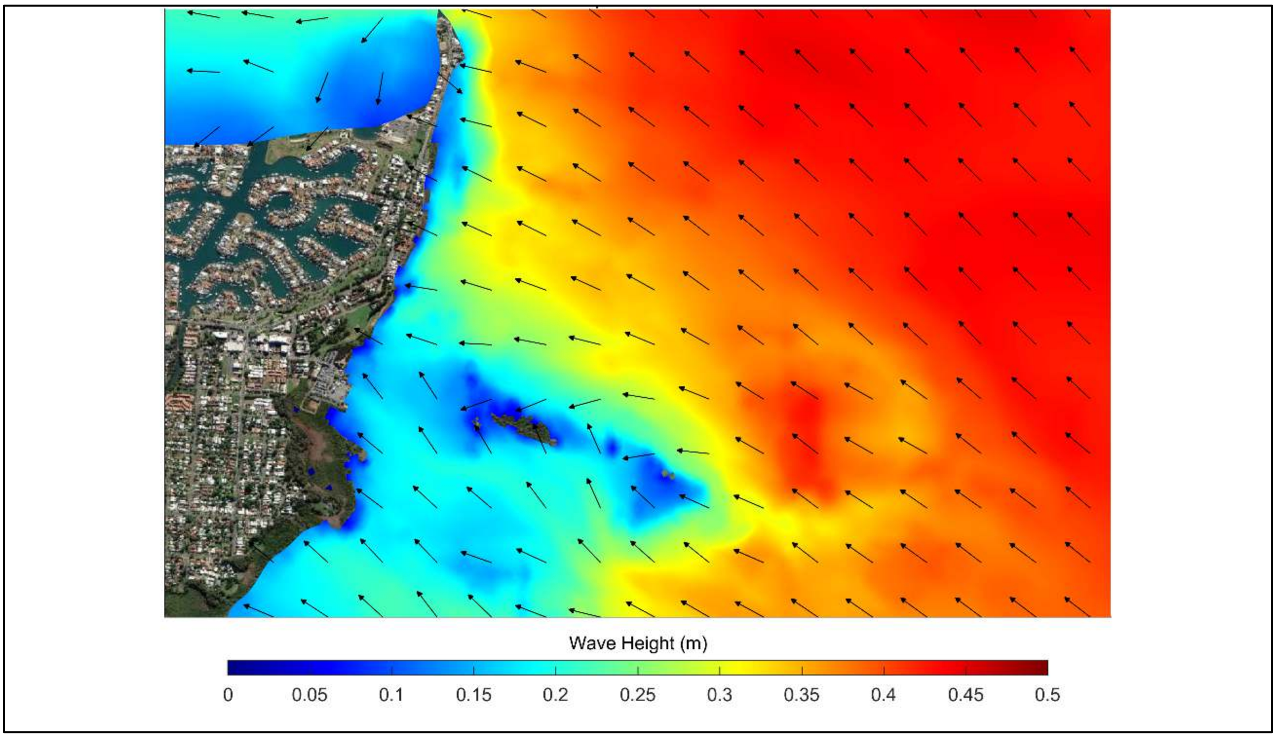


Figure 8-10: Modelled Wave Height in Toondah Harbour Locality. Example South-Easterly Wind Conditions.

8.3.3 Shoreline Processes

The movement of sediment along the shorelines to the north and the south of the Project is driven by the wave climate and current patterns immediately adjacent to the shoreline.

Aerial photography of the area to the north of the Project shows that the shoreline has been modified over time by the construction of various types and lengths of rock walls, groynes and revetments. Where groynes have been built at right-angles to the shoreline, there is evidence that the net transport of sand at the shoreface is to the south, since sand has built up on the north side of the groynes (see Figure 8-11).

Aerial photography of the area to the south of the Project (Figure 8-12) shows that the shoreline is fringed by mangrove forests. The wave climate in this area is less energetic than the area north of the Project, since it is more sheltered, and extensive shallow mudflats also contribute to the dampening of incident wave energy.

Figure 8-11: 2017 Aerial Photo of the Shoreline to the North of the Project Site (Google Earth).

Figure 8-12: 2017 Aerial Photo of the Shoreline to the South of the Project Site (Google Earth).

8.4. Potential Impacts

8.4.1 Tidal Hydrodynamics

The situation of the Project within the shallow intertidal zone of southern Moreton Bay means tidal currents are the dominant hydrodynamic driver. Potential project-related impacts to the tidal hydrodynamics are considered in this section.

Project scenarios considered for the tidal hydrodynamic impact assessments include (refer to Section 8.2.2):

- Stage 1 Phase 1;
- Stage 1 Complete;
- Stage 2 Phase 7; and
- Stage 2 Complete.

The technical report (Appendix 2-E) presents results for the above four scenarios. Only Stage 1 Complete and Stage 2 Complete are presented in the EIS chapter as the outcomes are very similar to the preceding phases of those stages. In addition, only the results from the January 2017 modelled assessment period are presented here as the assessment of the May 2020 period yielded similar conclusions.

Potential hydrodynamic impacts induced by the Project are presented as both spatial plots (changes to current patterns and magnitudes) as well as time series of key variables at point locations. Spatial impacts are presented as instantaneous snapshots of depth-averaged velocity at the peak flooding and ebbing tides during a spring tide period with a large tidal range. The times corresponding to the peak velocity magnitudes through the Project footprint that were chosen for the velocity impact analysis are shown in Figure 8-13.

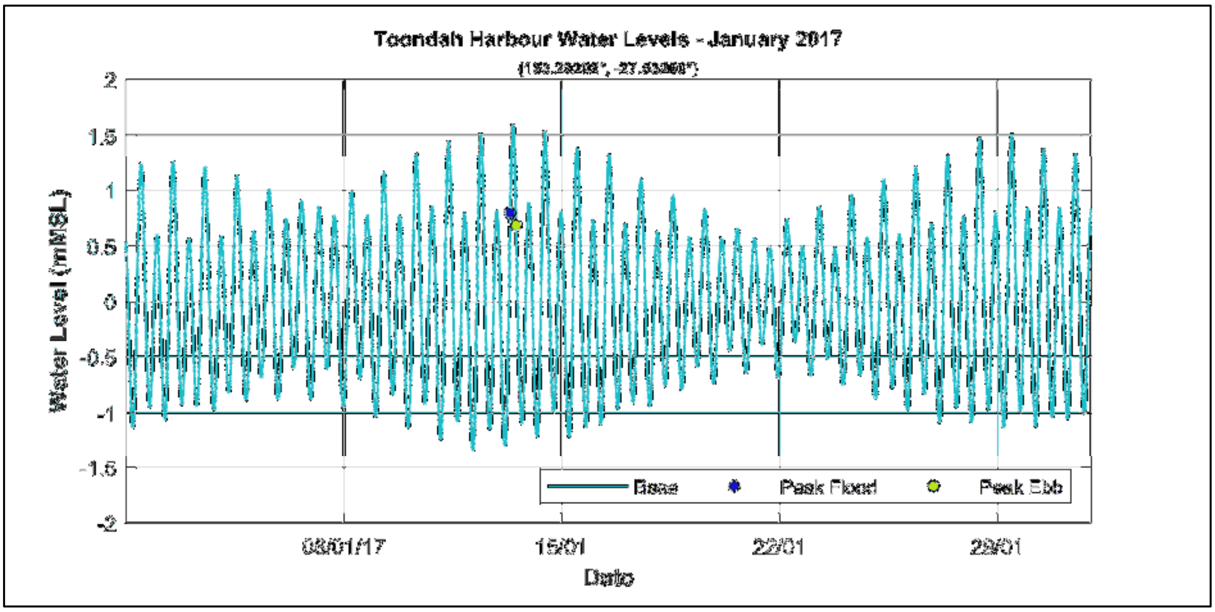


Figure 8-13: Water Level at the Peak Flood and Peak Ebb Instantaneous Velocity Impact Analysis Times.

Time series plots are presented for representative sites selected from the sampling locations shown in Figure 8-5. The full set of hydrodynamic timeseries including water levels, velocity magnitude and current direction over a spring-neap cycle are presented in the main technical report (Appendix 2-E).

The modelling shows that the Project does not cause any changes to tidal water levels during all stages and phases of construction outside of the reclamation footprint and internal waterways.

8.4.1.1 *Stage 1 Complete Velocities*

Velocity impact plots showing the instantaneous depth-averaged current magnitude and direction are presented in Figure 8-14 and Figure 8-15 for the peak flooding and ebbing tides, respectively. The modelling results demonstrate how the flow patterns between the mainland and Cassim Island adjust following construction of the initial Stage 1 Project footprint.

During the flooding tide (Figure 8-14), in the existing case, the tidal dynamics in the vicinity of the Project are characterised by south-flowing currents between Cassim Island and the mainland. Construction of the Stage 1 Project footprint causes increase in velocity (green shading) immediately west of Cassim Island with increases of up to 0.1 m/s. Velocity increases are also noted in the shallows east of Cassim Island and near the harbour entrance (Fison) channel, with increases in the order of 0.05 to 0.1 m/s. Peak flood tide velocity magnitude reductions (blue shading) occur within the internal waterways of the Project and to the immediate east, north and south of the Project footprint, with reductions in velocity magnitude in the order of 0 – 0.25 m/s.

During the ebbing tide (Figure 8-15), the north-flowing currents are diverted by the constructed reclamation in a north-easterly direction over the mangrove islets between the south-eastern side of the Project and Cassim Island and extending out to the north of Cassim Island. Peak ebb tide velocities in this region show increases of up to 0.3 m/s. Smaller increases in peak velocity in the shallows to the southeast of Cassim Island are also observed, with a magnitude of up to 0.15 m/s. The diversion of the currents to the east results in a reduction of velocity magnitude during ebbing tides to the east and north of the Project footprint and along the mainland shoreline up to Cleveland Point. Decreases in peak ebb tide velocity magnitude are also observed in the area of the internal waterways of the Project.

Time series of the modelled water level, depth-average velocity magnitude and velocity direction are provided for Points 4, 6 and 8 in Figure 8-16, Figure 8-17 and Figure 8-18 respectively. At Points 4 and 6 the increase in the velocity magnitude in the developed case is most clearly visible on the ebb tide (typically from around 0.2m/s to 0.45m/s at Point 4, and from around 0.4m/s to 0.55m/s at Point 6). This only occurs during large spring tides when there is substantial flow over the intertidal banks. At other times, the impacts are only small. At Point 8 the change in modelled velocity magnitude is smaller, with only a slight reduction in magnitude on the ebb tide in the developed case.

The implications of increased tidal velocity on sediment transport and morphology are assessed in Section 8.4.4.

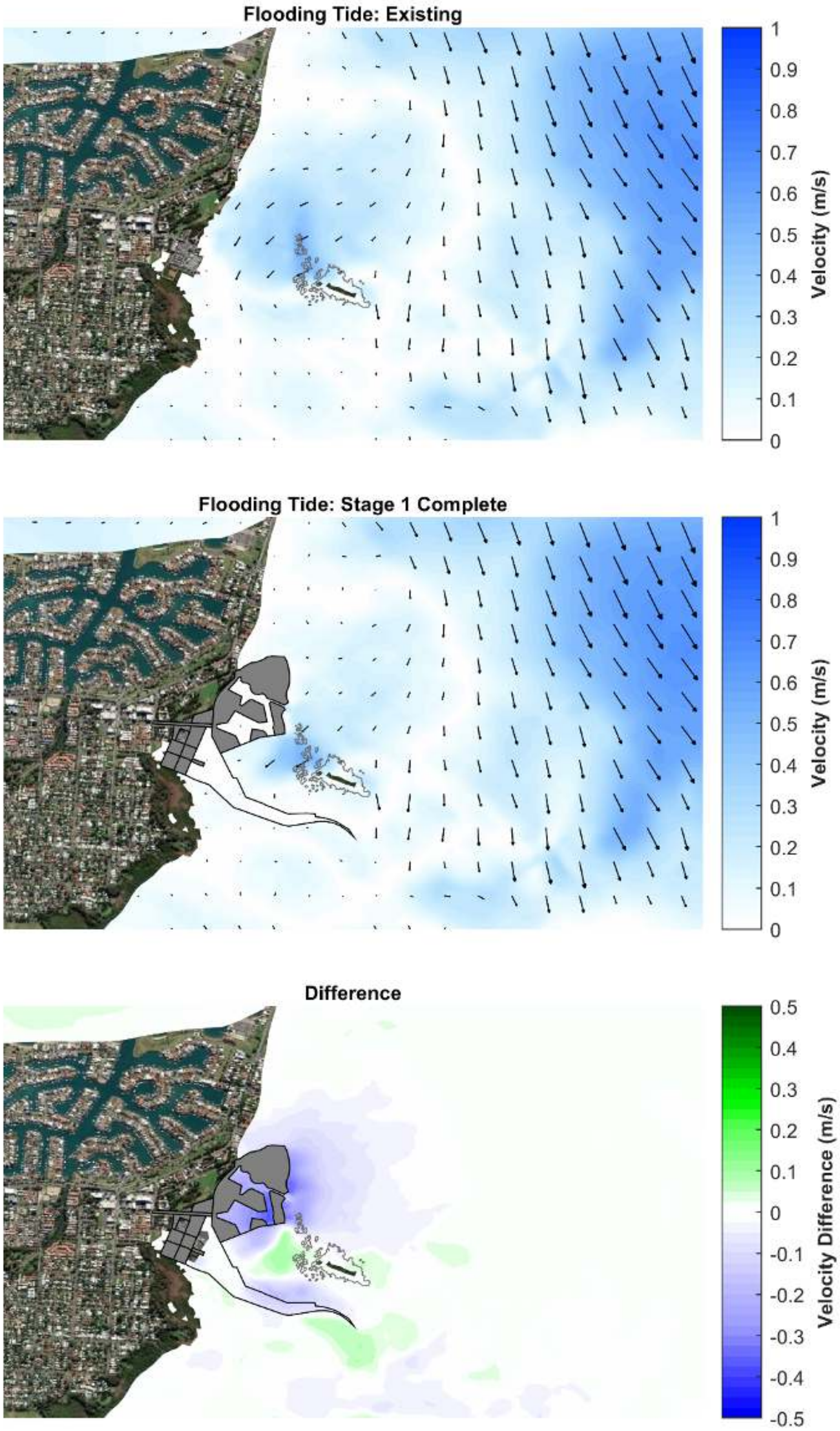


Figure 8-14: Stage 1 Complete Peak Flooding Tide Instantaneous Velocity impacts.

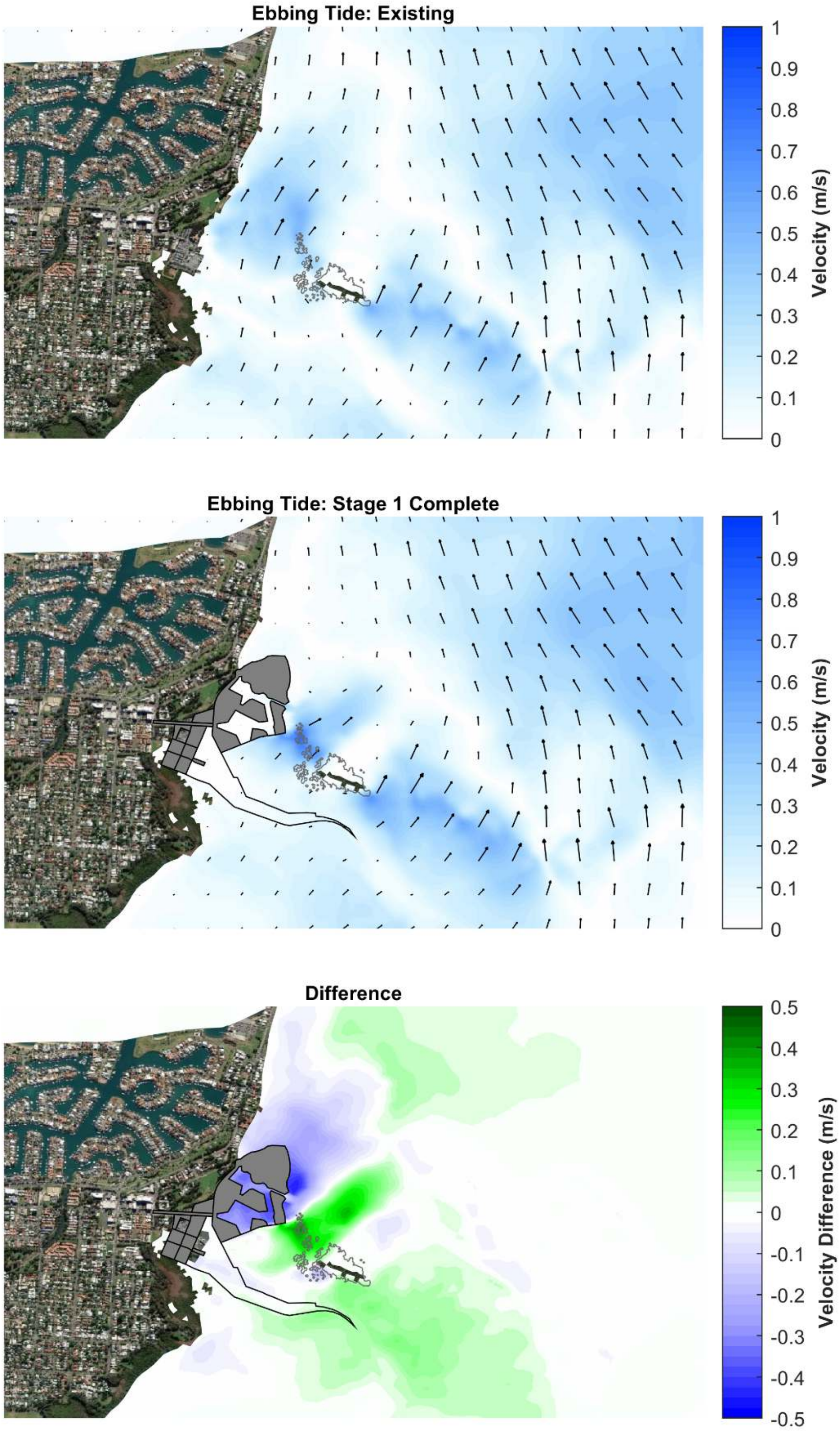


Figure 8-15: Stage 1 Complete Peak Ebbing Tide Instantaneous Velocity Impacts.

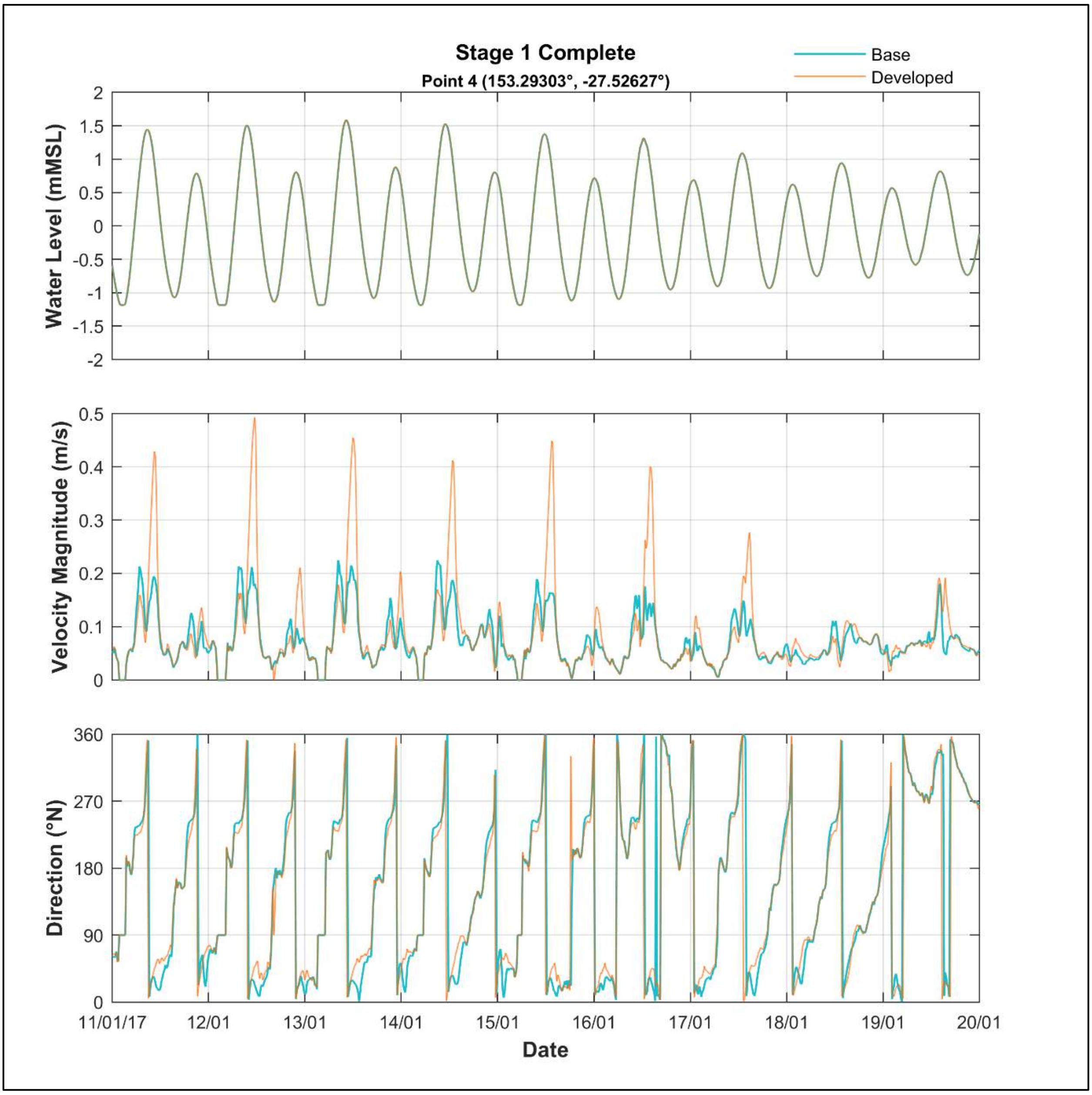


Figure 8-16: Stage 1 Complete Water Level (top), Depth Averaged Velocity (middle) and Current Direction (bottom) for Point 4 (North of Cassim Island).

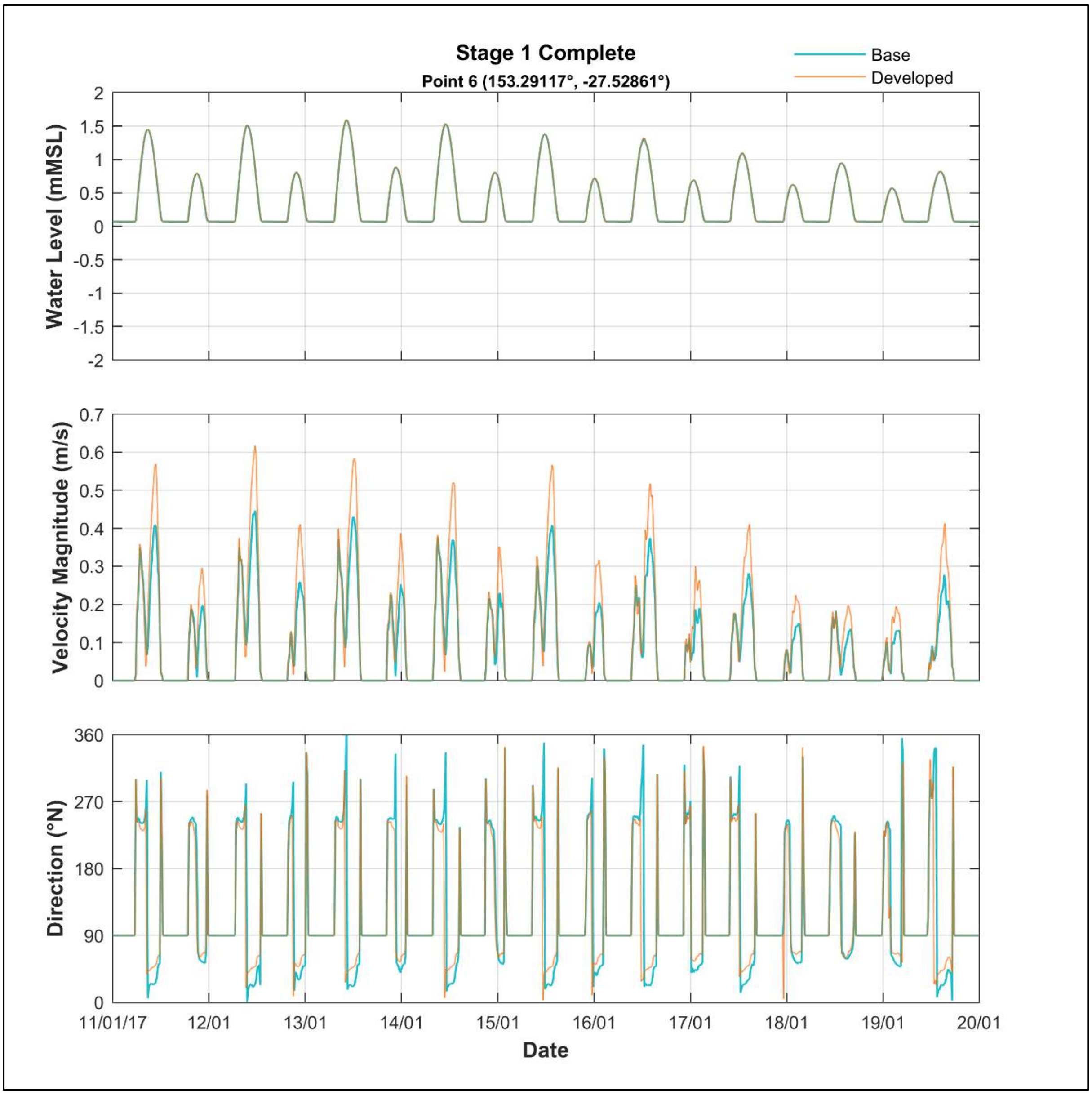


Figure 8-17: Stage 1 Complete Water Level (top), Depth Averaged Velocity (middle) and Current Direction (bottom) for Point 6 (Mangrove Islets East of the Development).

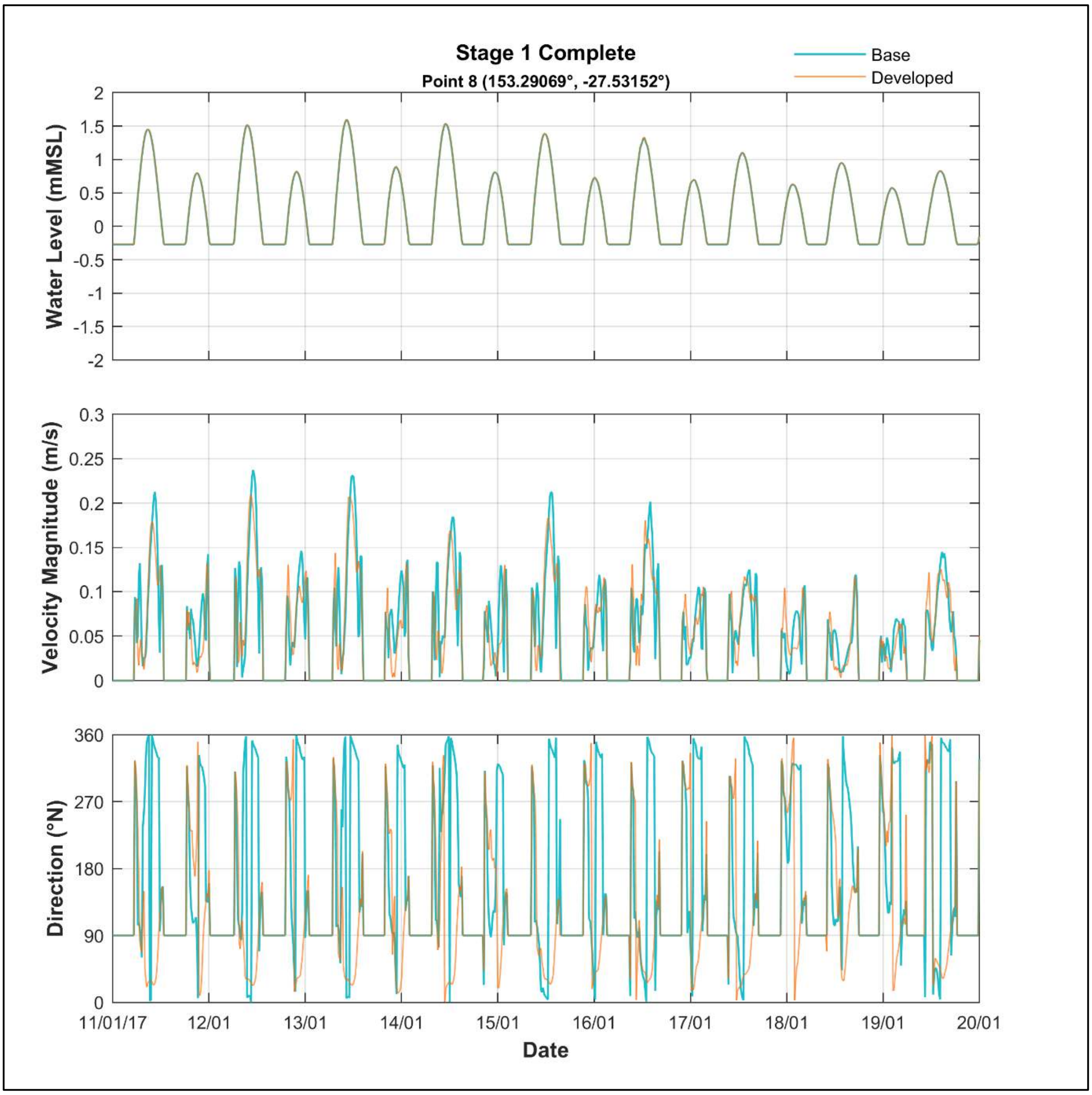


Figure 8-18: Stage 1 Complete Water Level (top), Depth Averaged Velocity (middle) and Current Direction (bottom) for Point 8 (South of Mangrove Islets Located East of the Development).

8.4.1.2 *Stage 2 Complete Velocities*

Spatial velocity impacts for the Stage 2 Complete scenario are presented in Figure 8-19 and Figure 8-20 and time series at key locations are shown in Figure 8-21 to Figure 8-23. The velocity impacts are similar to those for the Stage 2 Phase 7 development, indicating that the addition of the internal waterway in the Stage 2 Complete scenario does not have a major effect on current flows.

Velocity impact plots showing the instantaneous depth-averaged current magnitude and direction are presented in Figure 8-19 and Figure 8-20 for the peak flooding and ebbing tides, respectively. The modelling results demonstrate how the flow pattern between the mainland and Cassim Island adjusts following construction of the final Project footprint.

During the flooding tide (Figure 8-19), the final Project footprint causes increases in velocity (green shading) in a small area immediately to the west of Cassim Island with increases of up to 0.1 m/s. Smaller velocity increases are also noted to the east of Cassim Island and at points along Fison Channel, in the order of 0.05 to 0.1 m/s. Velocity reductions (blue shading) are noted in other areas to the east of the Project and within the internal waterways, with reductions in velocity magnitude in the order of 0 – 0.25 m/s.

During the ebbing tide (Figure 8-20), peak velocities to the west, south and east of Cassim Island show increases of up to 0.2 m/s. The previous higher increases observed for Stage 1 between the Project footprint and Cassim Island and extending to the northeast during large spring tides are no longer present. The diversion of the currents to the east results in a reduction of velocity magnitude during ebbing tides to the northeast of the Project and along the mainland shoreline up to Cleveland Point.

Time series of the modelled water level, depth-average velocity magnitude and velocity direction are provided for Points 4, 6 and 8 in Figure 8-21, Figure 8-22 and Figure 8-23 respectively. At Points 4 and 6 there is a decrease in the velocity magnitude in the developed case on the flooding tide (typically from around 0.2m/s to 0.15m/s at Point 4, and form around 0.35m/s to 0.25m/s at Point 6). The previous increases in ebb tide velocities at these points during large spring tides are no longer evident. At Point 8 there is an increase in both the peak flooding and ebbing tide in the developed case, to around 0.3 m/s.

The implications of increased tidal velocity on sediment transport and morphology are assessed in Section 8.4.4.

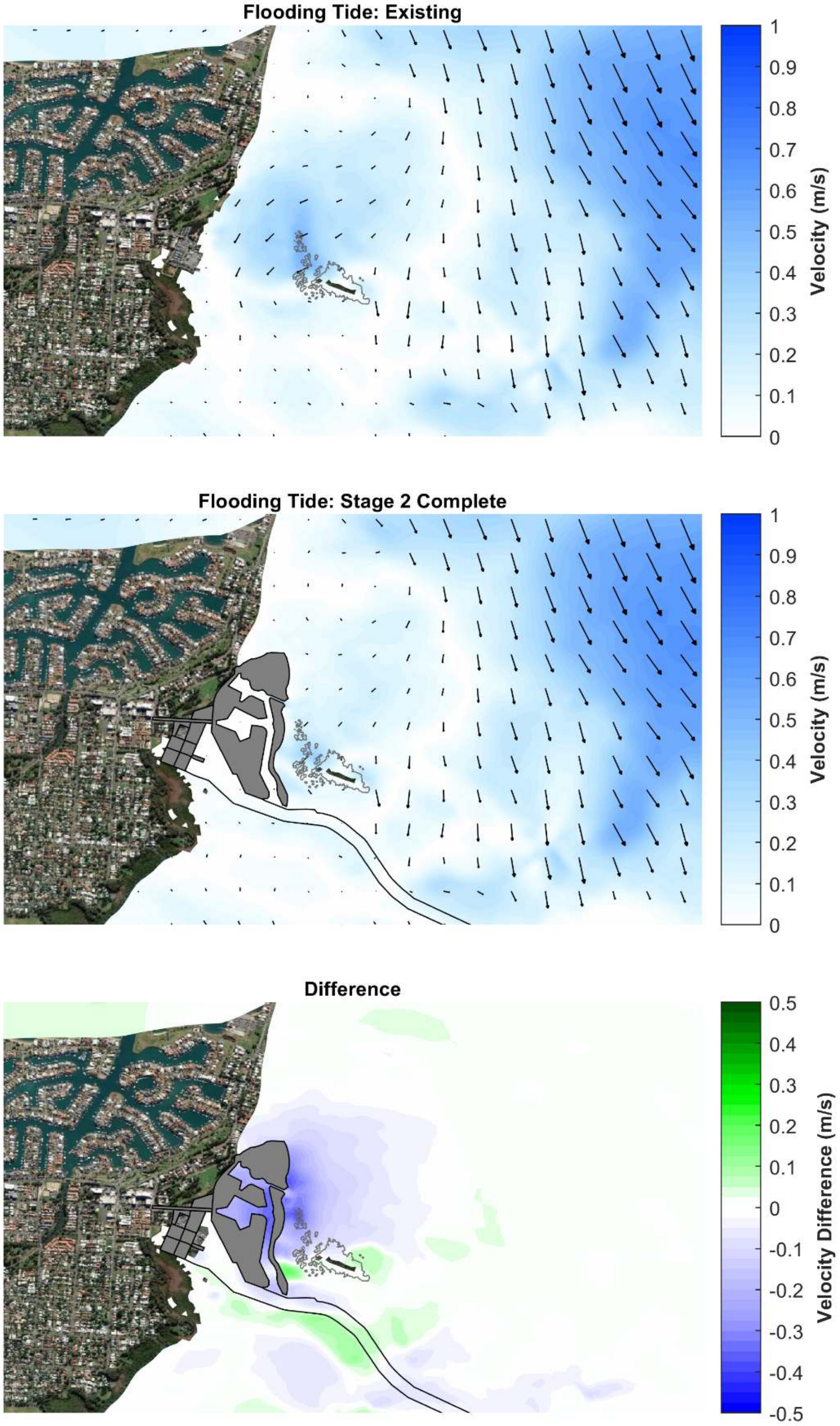


Figure 8-19: Stage 2 Complete Peak Flooding Tide Instantaneous Velocity Impacts.

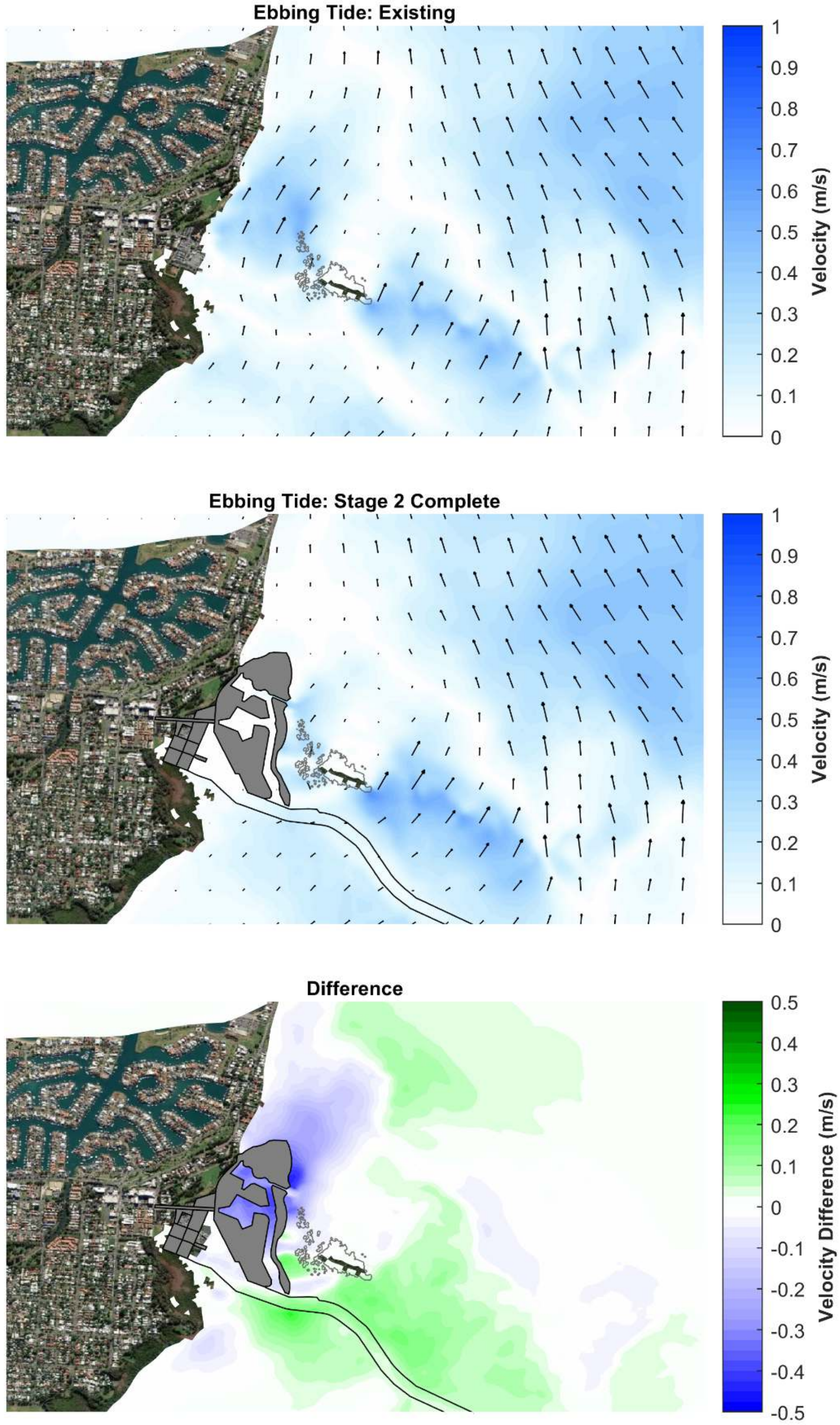


Figure 8-20: Stage 2 Complete Peak Ebbing Tide Instantaneous Velocity Impacts.

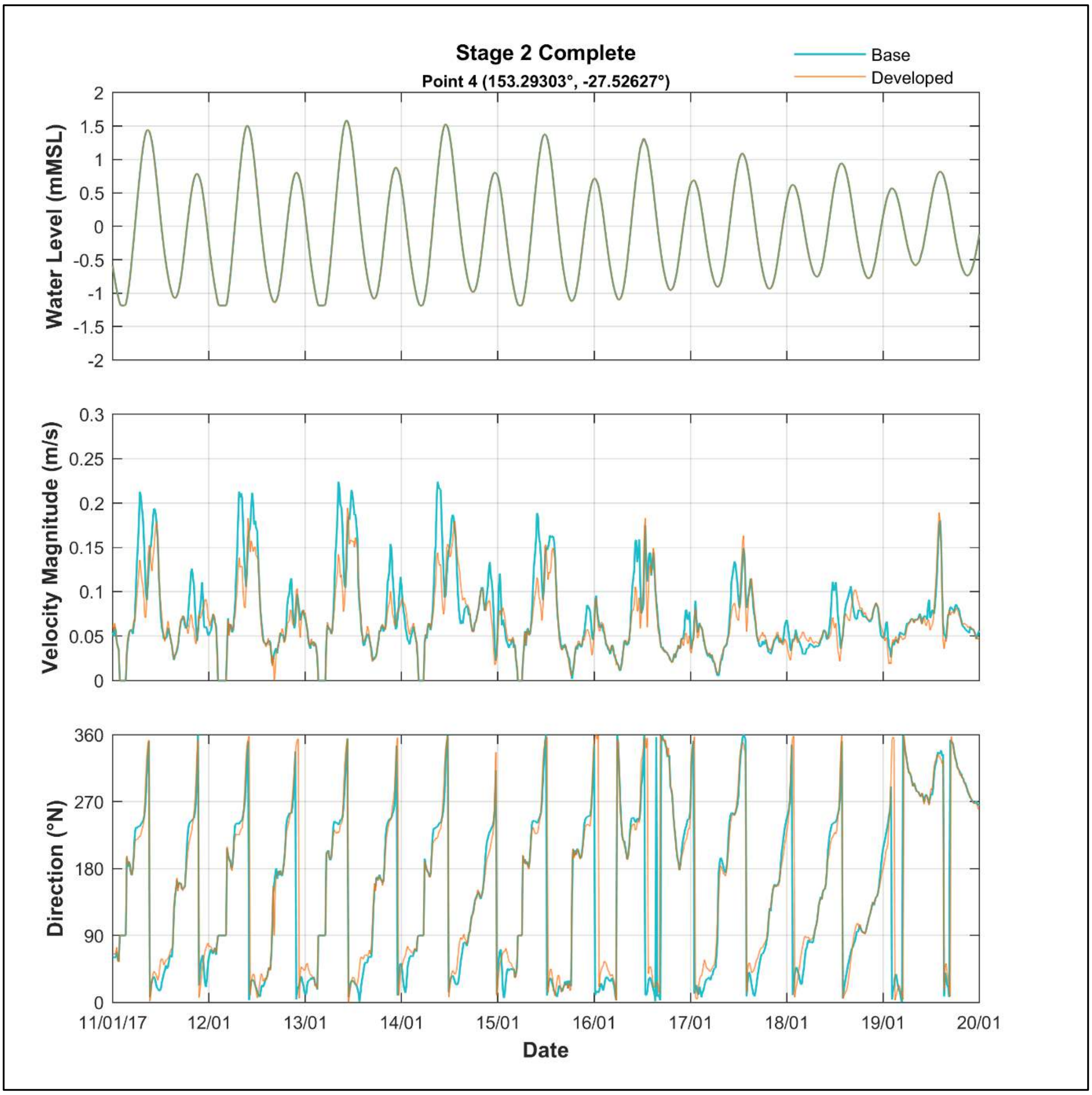


Figure 8-21: Stage 2 Complete Water Level (top), Depth Averaged Velocity (middle) and Current Direction (bottom) for Point 4 (North of Cassim Island).

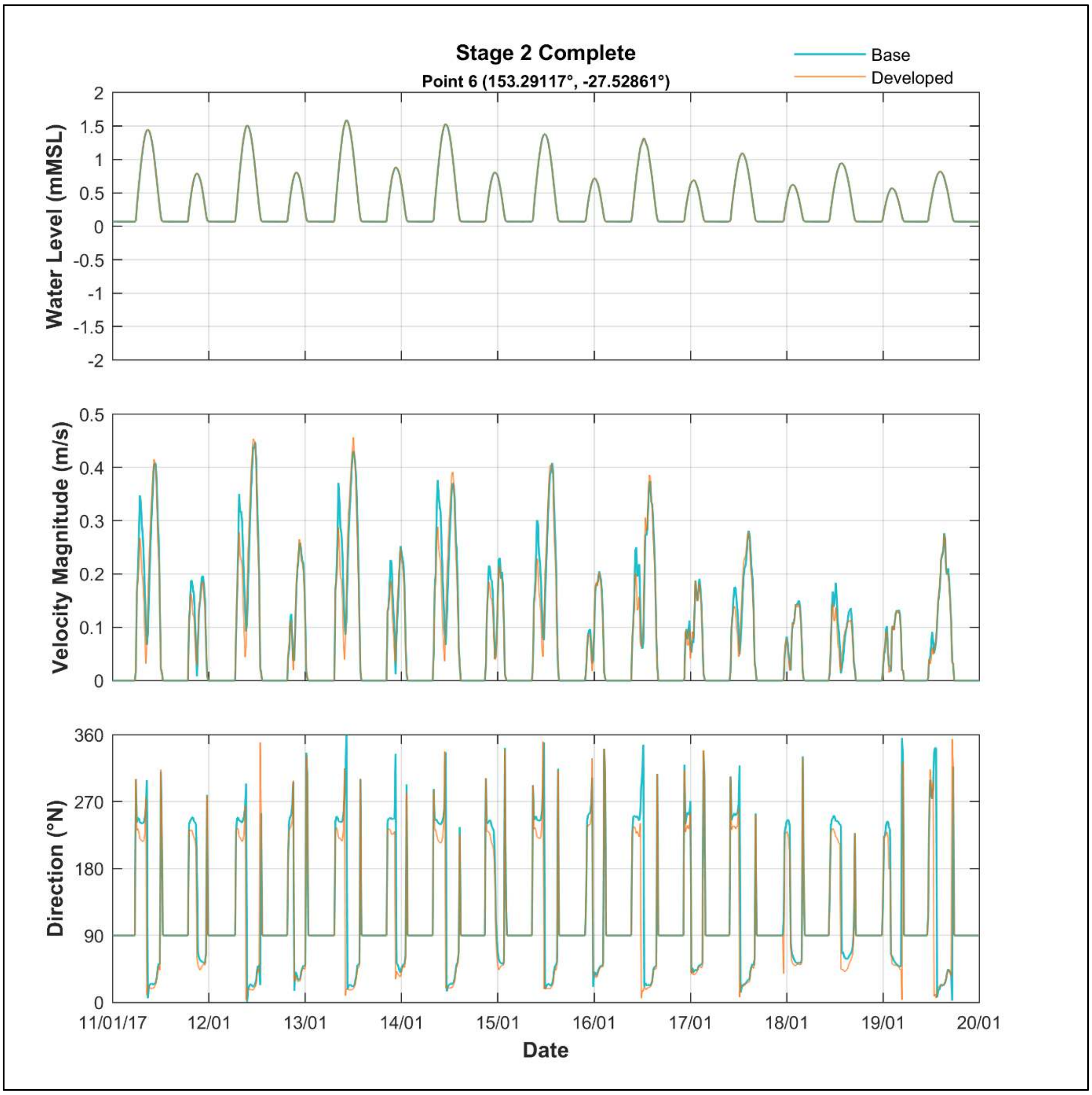


Figure 8-22: Stage 2 Complete Water Level (top), Depth Averaged Velocity (middle) and Current Direction (bottom) for Point 6 (Mangrove Islets East of the Development).

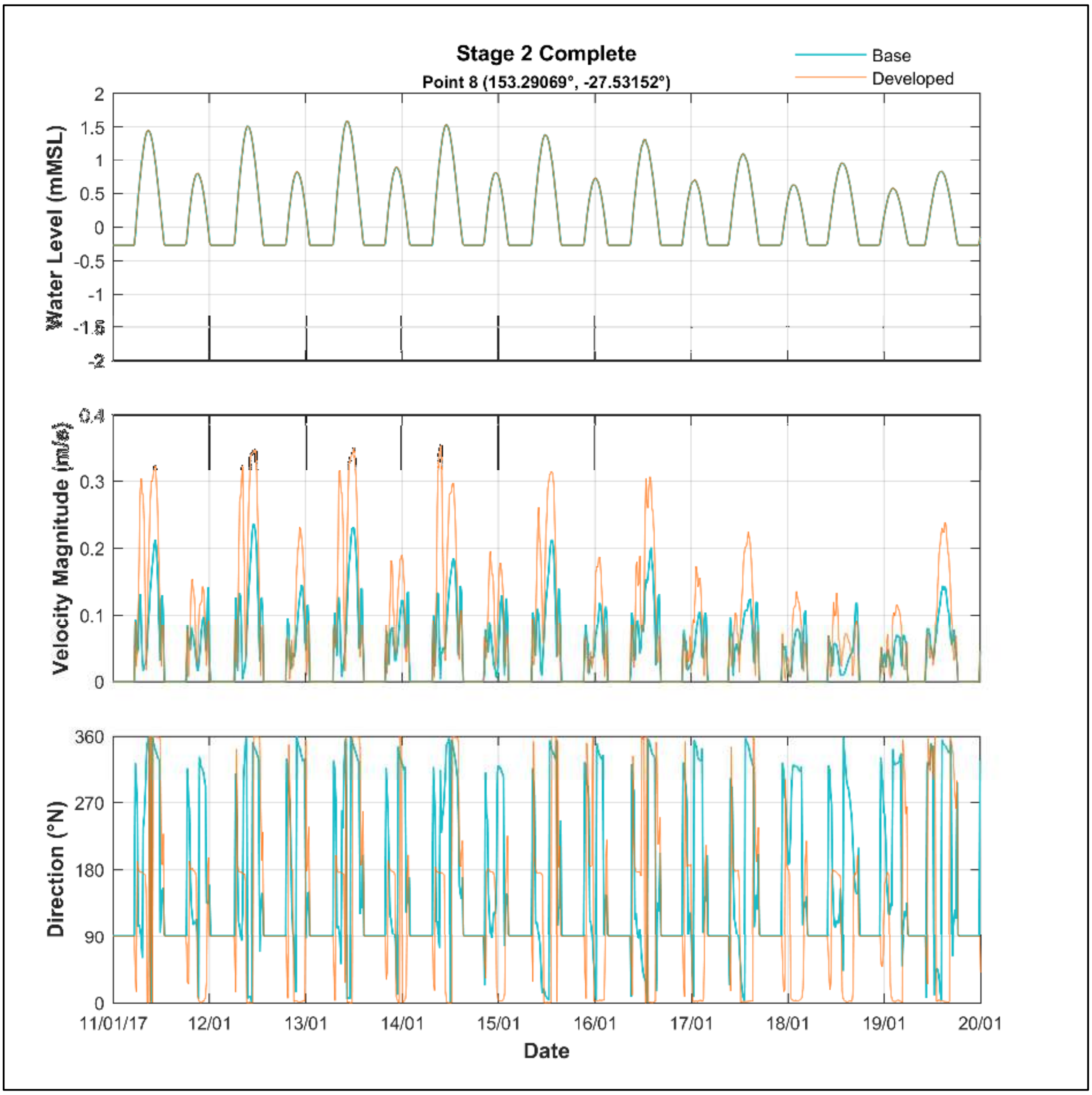


Figure 8-23: Stage 2 Complete Water Level (top), Depth Averaged Velocity (middle) and Current Direction (bottom) for Point 8 (South of Mangrove Islets Located East of the Development).

8.4.2 Wave Climate

Development scenarios for which the SWAN wave model was run for wave climate impact assessments include:

- Stage 1 Complete; and
- Stage 2 Complete.

The spatial impact plots consider the change in the 50th and 95th percentile significant wave height to capture impacts across the model domain under typical conditions and event conditions.

Since the results of analysis of both assessment periods are similar, only the results from the January 2017 modelled assessment period are presented in this chapter. Other results are included in the technical report (Appendix 2-E).

8.4.2.1 *Stage 1 Complete*

The influence of the Stage 1 Complete configuration of the Project on the 50th percentile of the significant wave height magnitude is presented in Figure 8-24. This plot represents the change in the 'typical' waves in the vicinity of the Project. The incident wave direction at the Project footprint generally ranges from northeast to southeast (see discussion on directional impacts below). The 50th percentile impact plot shows that there will be some minor reductions in the typical wave heights to the north and south of the northern reclamation, however the existing typical wave conditions are already relatively mild, so this is not expected to represent a major change.

The influence of the Stage 1 Complete configuration of the Project on the 95th percentile of the significant wave height magnitude is presented in Figure 8-25. This plot represents the change during high-energy wave conditions in the vicinity of the Project (incident directions varying from northeast to southeast). It shows that there will be some minor reductions (up to 0.1 m) in the wave height during significant wave events to the north and south of the northern reclamation. However, wave energy is already dissipated significantly by the shallow areas to the north and east of the Project footprint, so the additional sheltering effect of the new landform is not considered to be a major change. There is a small area of increased wave height to the northwest of Cassim Island, however the magnitude of the increase is very small (around 0.01 m). The implications of the increased wave height and tidal velocity in that area on sediment transport and morphology are assessed in Section 8.4.4.

8.4.2.2 *Stage 2 Complete*

The influence of the Stage 2 Complete configuration of the Project on the 50th percentile of the significant wave height magnitude is presented in Figure 8-26. This plot represents the change in the 'typical' waves in the vicinity of Toondah Harbour. It shows that there will be some minor reductions in the typical significant wave heights to the north and south of the reclamation area, and a slight increase in wave height to the immediate east. At the location of the wave height increase, the modelling results indicate that current speed is reduced, so the effect on sediment transport is likely to be small. The existing typical wave conditions are already relatively mild, so this is not expected to represent a major change.

The influence of the Stage 2 Complete configuration of the Project on the 95th percentile of the significant wave height magnitude is presented in Figure 8-27. This plot represents the change during high-energy wave conditions in the vicinity of Toondah Harbour. It shows that there will be some minor reductions (up to 0.1 m) in the wave height during significant wave events to the north and south of the reclamation area, and a very minor area of wave height increase to the east. However, wave energy is already dissipated significantly by the shallow areas to the north and east of the Project footprint, so the additional sheltering effect of the new landform is not considered to be a major change.

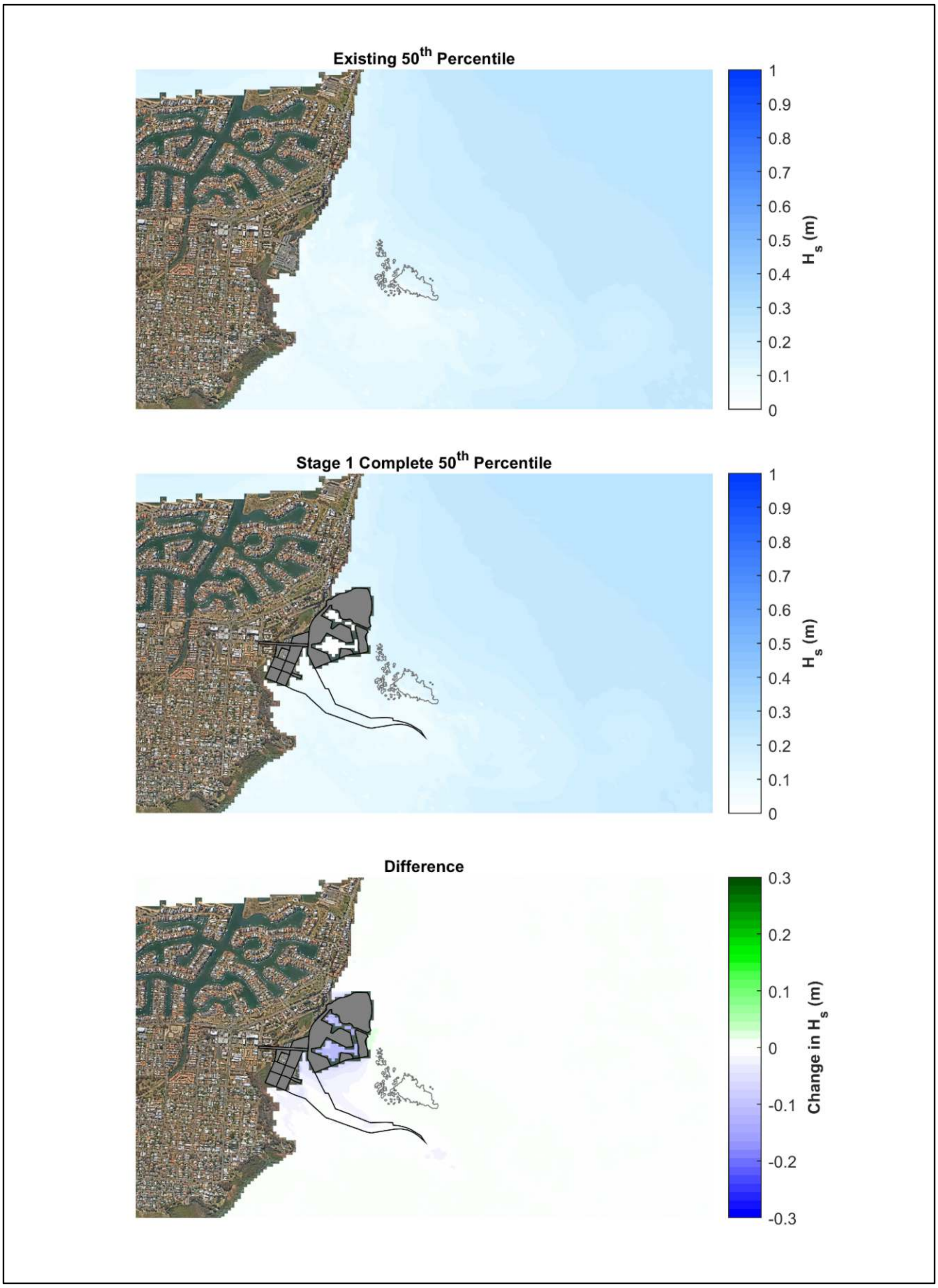


Figure 8-24: 50th Percentile Significant Wave Height. Existing Condition (top), Developed Scenario (middle) and Impact (bottom) Stage 1 Complete.

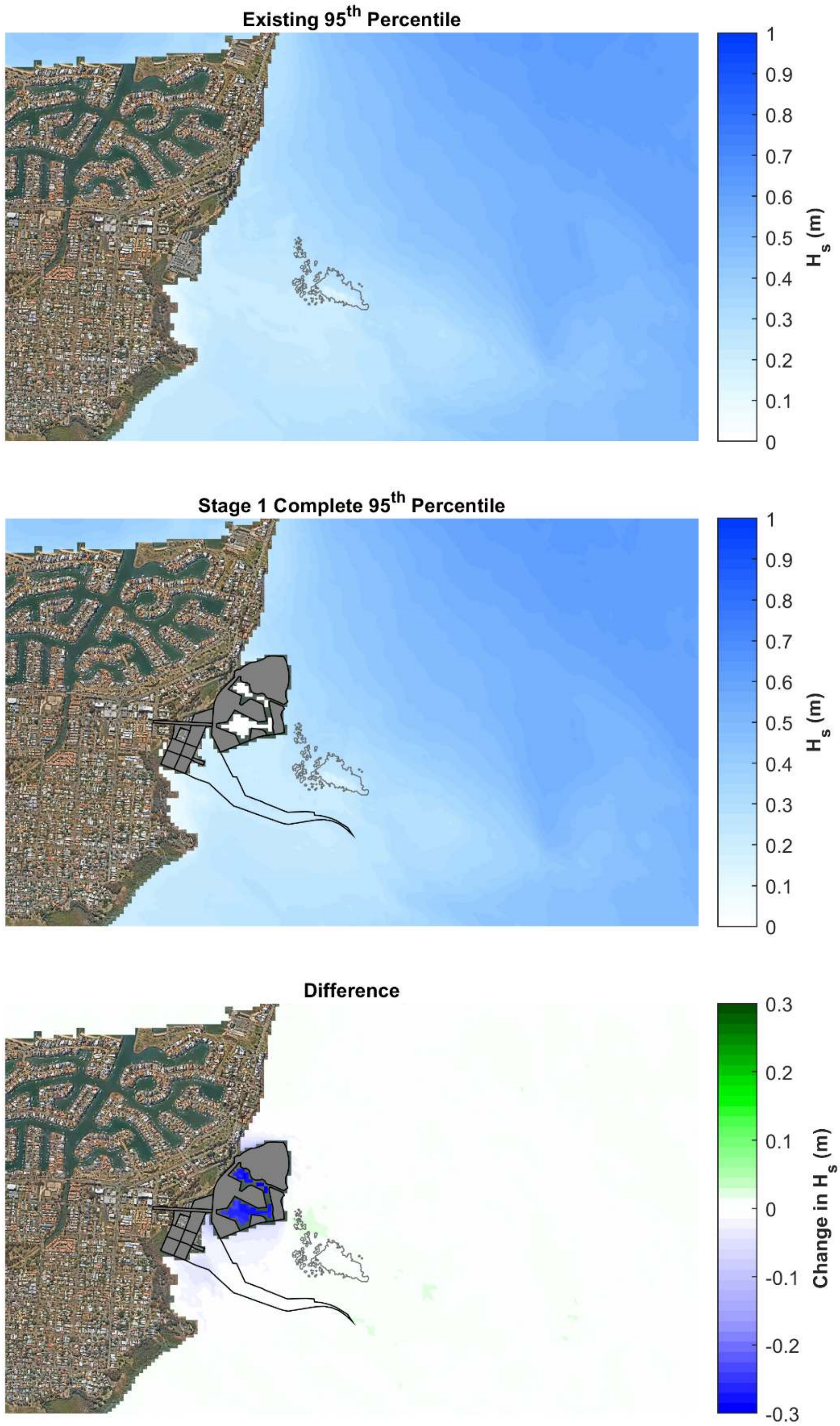


Figure 8-25: 95th Percentile Significant Wave Height. Existing Condition (top), Developed Scenario (middle) and Impact (bottom) Stage 1 Complete.

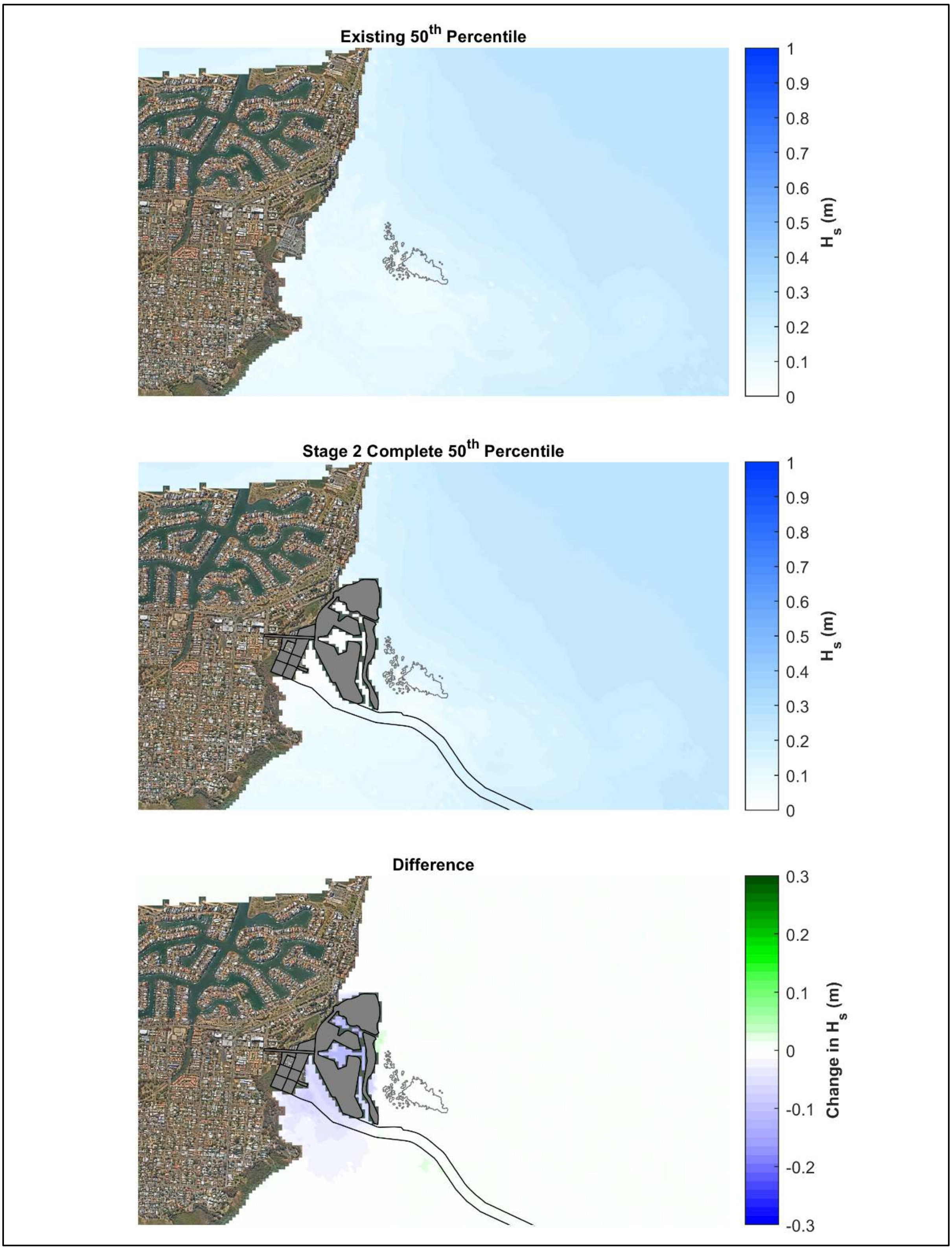


Figure 8-26: 50th Percentile Significant Wave Height. Existing Condition (top), Developed Scenario (middle) and Impact (bottom) Stage 2 Complete.

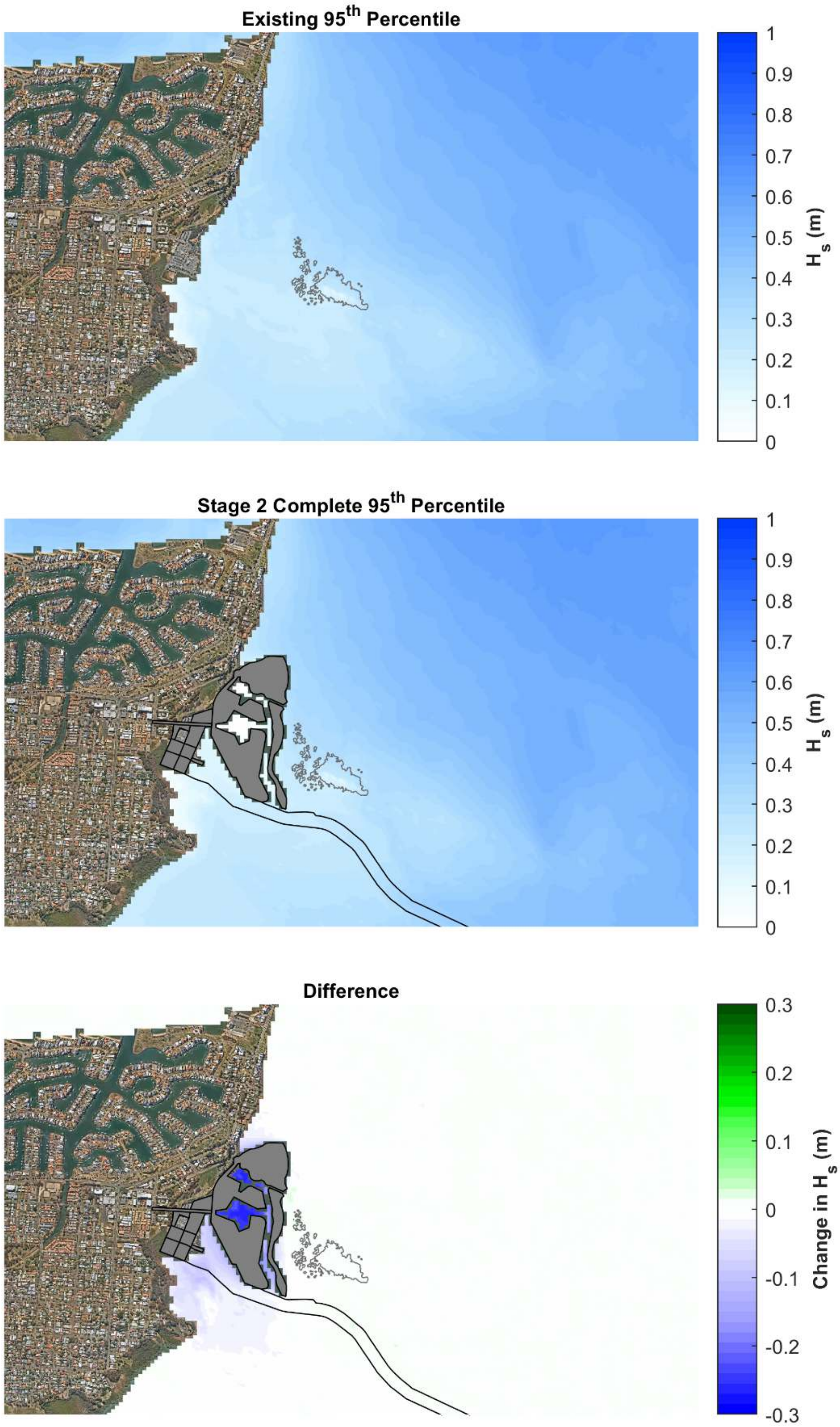


Figure 8-27: 95th Percentile Significant Wave Height. Existing Condition (top), Developed Scenario (middle) and Impact (bottom) Stage 2 Complete.

8.4.3 Shoreline Processes

Sediment transport processes at the shoreline to the north and south of Toondah Harbour will be influenced by changes to the wave climate and current patterns caused by the Project. The wave climate changes identified in the preceding section indicate that the shoreline to the north of the reclamation area will be shielded from some of the incident wave energy which currently reaches the shoreline from the south-east. It is therefore likely that the existing southerly net sediment transport on the beach to the north of the reclamation area will be locally increased. However, it is unlikely that there is any significant ongoing sand supply from the north, given the presence of Cleveland Point and the narrow width of the existing beaches. It is therefore unlikely that the Project will cause significant impacts to the beach face on the shoreline to the north, apart from local accretion immediately to the north.

There is some likelihood that the changes to the current patterns and incident wave energy in the area immediately to the north of the reclamation area will also cause accumulation of sediment and potentially progradation of the shoreline in the sheltered area over a long period of time. However, the beach in that area will still be exposed to incident wave energy from the north and therefore the accumulation of very fine sediment (silt/clay particles) on the beach face is unlikely. It is more likely that fine sand may accumulate, limited by the amount of supply available from the north.

To the south of Toondah Harbour, the shoreline has been very stable in the past due to the lower energy wave climate and substantial fringing mangrove forests. The additional sheltering effect that the new landform will have on the wave climate and velocity magnitude will further contribute to shoreline stability, and no adverse impacts are expected as a result of the Project.

The shoreline in the vicinity of the Project will be affected by sea level rise associated with climate change in future. The modelling demonstrates that the Project will not have any influence on the response of adjacent shorelines to those effects.

In order to further assess the likelihood of any changes to shoreline processes and beach alignment caused by the Project, historical aerial imagery was analysed for both Toondah Harbour and an analogous development on the Moreton Bay shoreline – the Manly Boat Harbour.

Aerial photos of Toondah Harbour in 1955 and 2017 are shown in Figure 8-28. While a number of changes are apparent (including the construction of Toondah Harbour, entailing significant capital dredging and reclamation, and the Raby Bay canal estate development), the shoreline alignment is not substantially different in the two photos. The sandy beach to the north of Toondah Harbour is a little less evident in the 2017 photo, and to the south of Toondah Harbour the extent of mangrove forest has increased. There are very few noticeable changes in the Cassim Island area between the two photos.

Aerial photos of Manly Boat Harbour in 1945 and 2017 are shown in Figure 8-29. The boat harbour is about 12 km to the northwest of Toondah Harbour, and the physical setting and coastal processes at the two sites are broadly similar. The Manly Boat Harbour was constructed in the 1960s and the adjacent shoreline had already been modified by engineering structures. There is very little evidence of any changes to shoreline position or alignment in Figure 8-29 that could be attributed to the construction of the boat harbour. While there are some fringing mangroves to the south of the boat harbour in the 2017 photo which are not present in the 1945 photo, any naturally occurring mangroves may have been removed prior to 1945.

Figure 8-28: Shoreline in the Toondah Harbour Area, 1955 (Left) and 2017 (Right).

Left Photo: Qimagery (Qld Government), Right Photo: Google Earth

Figure 8-29: Shoreline at the Manly Boat Harbour Area, 1945 (Top) and 2017 (Bottom).

Left Photo: Qimagery (Qld Government), Right Photo: Google Earth

8.4.4 Sediment Dynamics and Siltation

8.4.4.1 *Scour Potential and Siltation*

In order to assess the potential impacts of the Project on seabed elevation the model was run for the six-month period March – August 2017 (inclusive) and the bed mass in each cell at the end of the simulation was compared to the bed mass at the start of the simulation. The change in bed mass over the six-month simulation period was then converted into an annualised rate of bed level change using an assumed bulk dry density of 1,000 kg/m^3. While this method does not incorporate simulation of ongoing bed level changes in the form of full morphological modelling, it provides an indication of the likely areas and potential rates of scour and siltation.

Figure 8-30 and Figure 8-31 show the modelled annualised bed level change for the existing configuration, and the Stage 1 Phase 1 configuration and Stage 2 Complete configuration respectively, as well as the difference for each configuration. In interpreting these figures, it is important to note that in the difference plots, a negative change (blue shades) can reflect either an increase in the rate of erosion or a decrease in the rate of deposition. Conversely, a positive change (green shading) can reflect either an increase in the rate of deposition or a decrease in the rate of erosion.

In the existing case, the siltation that occurs in the existing channel and surrounds is apparent (green shading). The Stage 1 Phase 1 case (Figure 8-30) also shows significant siltation in the Fison Channel (no additional dredging has been completed in this scenario). In the difference plot, there are areas showing an increased rate of siltation (green) as well as some areas of reduced siltation (blue) within the channel and immediate surrounds. There are also some light blue areas to the northwest of Cassim Island near the southeast corner of the northern bunded area which may represent areas of increased bed erosion. These correspond to the areas of increased velocities identified in Section 8.4.1. Whether erosion actually occurs in the developed case will depend on whether those areas have available soft material to erode, noting some areas of the seabed are armoured with rubble. If erosion does occur, the bathymetry will gradually adjust to a new equilibrium depth, so the erosion rate will be reduced over time. For example, in the area with the largest velocity increase (near the southeast corner of the Project footprint), the increase is from approximately 0.4 m/s to 0.55 m/s on spring ebb tides. The water depth at the time of the increase is approximately 0.75 m. If the bed was lowered by approximately 0.2 m, the conveyance would increase so that the original peak ebb tide velocity would be restored (0.4 x 0.95 ~= 0.55 x 0.75). Therefore, up to approximately 20 cm of bed erosion may be expected in this area. In areas where the velocity increase is smaller, the expected long-term bed erosion would also be smaller.

The model results indicate that accretion is likely in the wedge adjacent to the existing shoreline on the north-west side of the Project. Since this area is still exposed to wave energy from the north, it is more likely that fine sand would accumulate on the beach face rather than silt/clay particles.

The Stage 2 Complete case (Figure 8-31) also shows significant siltation in the expanded Fison Channel. In the difference plot, there are areas showing an increased rate of siltation (green areas), particularly along the southern edge adjacent to the shallow inter-tidal flats as well as some areas of reduced siltation (blue) within the channel. Areas of potential reduced erosion (green) are evident to the east of southern reclamation. There are some areas of light blue on the southern part of Cassim Island, indicating a potential for slightly increased erosion rates. This is unlikely to cause any change to the low water mark of the Ramsar wetland, since these areas are on the island itself rather than the surrounding mudflat. The light blue area near the Stage 1 connection entrance indicates the potential for bed erosion in this area. Again, whether erosion actually occurs in the developed case will depend on whether those areas have available soft material to erode, noting some areas of the seabed are armoured with rubble. If erosion does occur, the bathymetry will gradually adjust to a new equilibrium depth, so the erosion rate will be reduced over time.

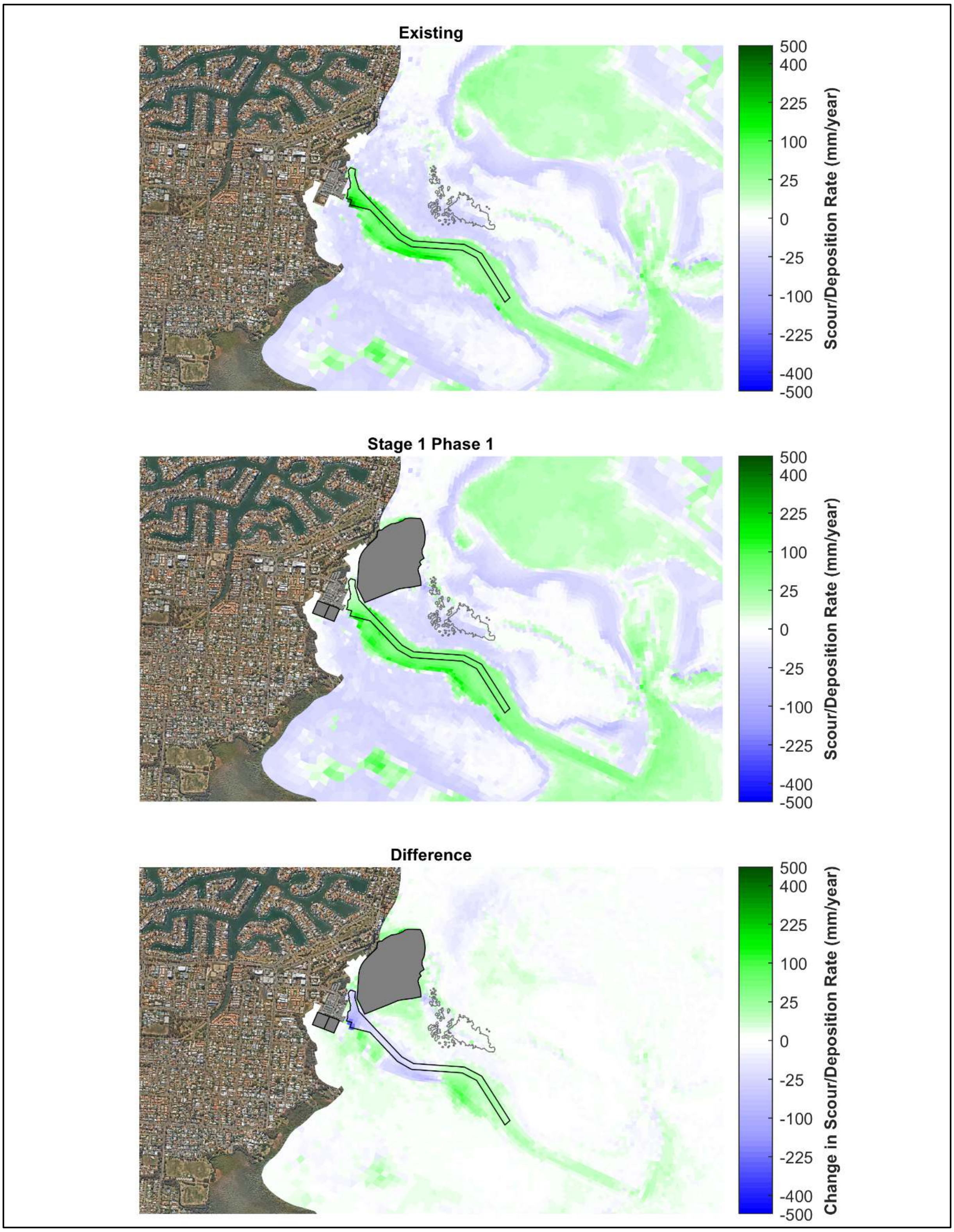


Figure 8-30: Stage 1 Phase 1 Annualised Scour /Sedimentation Rate.

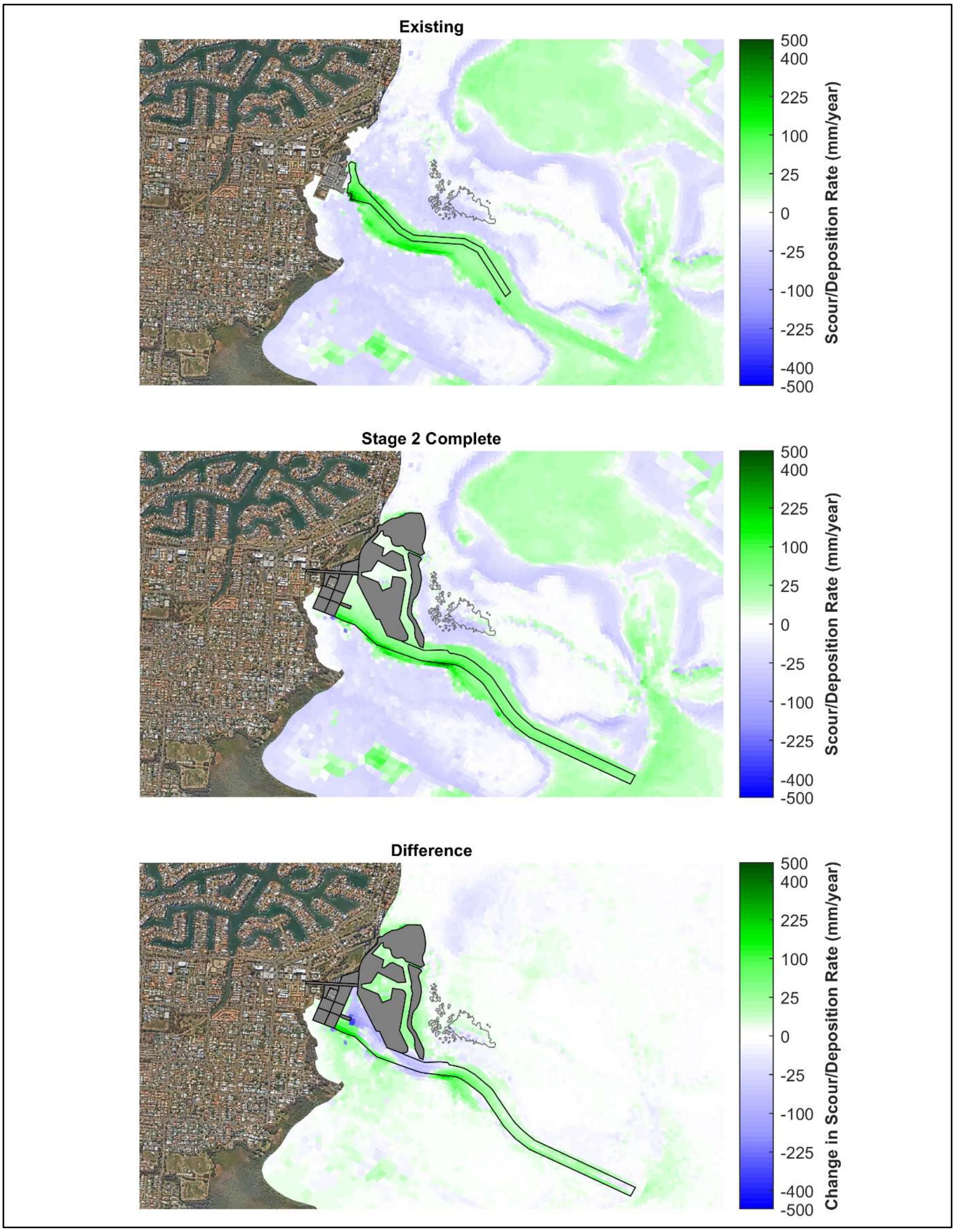


Figure 8-31: Stage 2 Complete Annualised Scour /Sedimentation Rate.

The reduction in current speeds together with wave-driven alongshore transport to the south is likely to result in continued net accretion in the wedge adjacent to the existing shoreline on the north-west side of the Project, as indicated by the model results. Since this area is still exposed to wave energy from the north, it is more likely that fine sand would accumulate rather than silt/clay particles.

While the Project will result in some changes to local currents and waves (refer Section 8.4.1 and Section 8.4.2), those changes are generally only small or occur in areas where the currents and waves themselves are small. In areas where larger impacts are predicted, they occur for limited periods of time only during large spring tides and/or are in areas where the water depths are greater. As such, while some local changes to seabed morphology can be expected, the model indicates that the magnitude of those changes beyond the Project footprint will be small. Sea level rise associated with climate change will also cause changes to the coastal and seabed morphology with or without the Project.

It is important to note that there are many variables and complexities in the system which influence sediment dynamics and introduce uncertainties around the calculation of scour and deposition rates. Therefore, the quantitative values provided in the plots are only approximate estimates of the potential rates. Nevertheless, the difference plots are indicative of areas of potential change.

8.4.5 Extreme Event Simulation with Climate Change

Toondah Harbour is periodically subject to the influence of storm and cyclone activity. A summary of the results of previous storm tide assessments is provided in Section 8.3.1.

Potential wave and water level impacts of the completed Stage 2 of the Project were modelled under extreme event conditions using the SWAN and TUFLOW-FV models. From analysis of Brisbane Airport (weather station ID: 040842) wind-speed records 01/04/1994 – 30/03/2017, ex-Tropical Cyclone Oswald was the most significant event identified at the site. This event generated considerable sustained wind speeds with an east to north-easterly wind direction, which - with the available fetch - generated significant waves at the Toondah Harbour locality. Although larger events could potentially occur within the Project's design life, the influence of the Project on water levels and wave characteristics would be consistent.

Two different levels of sea level rise (SLR) were superimposed to the modelled water level boundary conditions in order to represent possible future climate change scenarios:

- 0.4 m sea level rise (likely change over the next 50 years); and
- 1.5 m sea level rise (required by the EIS guidelines – worst case, far-future scenario).

Present-day bathymetry was used for the simulations. It is important to note that the bathymetry will adjust over time in unknown ways, and therefore the results presented here are not completely representative of future conditions but give an indication of relative impacts with and without the Project in place.

Timeseries plots describing the wind, water level and wave conditions at Toondah Harbour are presented in Figure 8-32 and Figure 8-33 for the 0.4 m and 1.5 m sea level rise cases, respectively.

The wave height response to the wind-event demonstrates a high degree of correlation with the elevated wind speeds of the event. Diurnal wave height signatures remain evident at the reported timeseries location under the 0.4 m sea level rise condition; however this tidally induced depth-influence is reduced in the 1.5 m sea level rise condition and the wave height is slightly larger due to reduced dissipation (in the order of 0.11 m higher at the presented location).

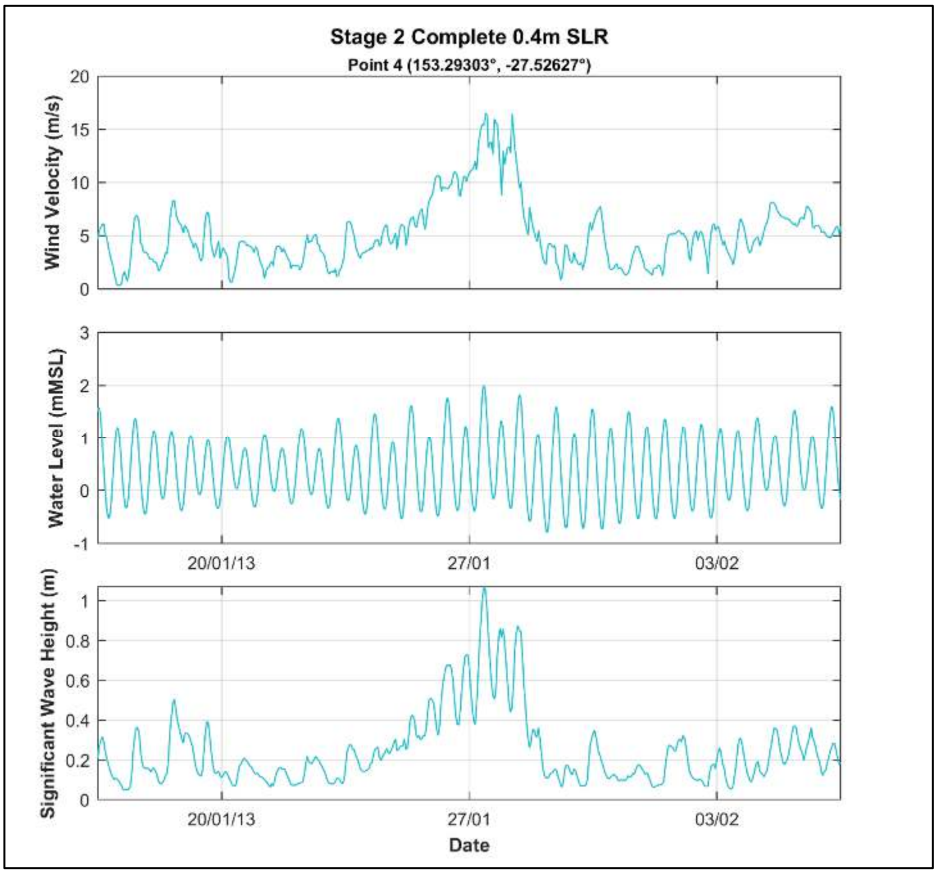


Figure 8-32: Wind, Water Level and Significant Wave Height Conditions Stage 2 Complete 0.4 m Sea Level Rise.

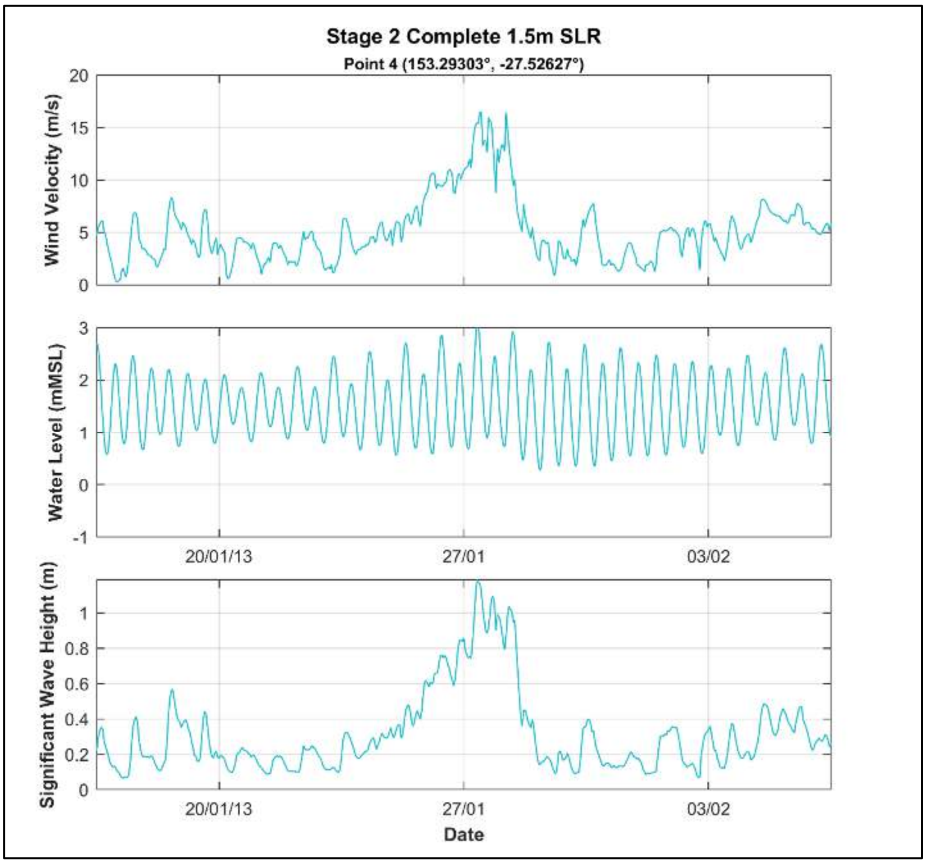


Figure 8-33: Wind, Water Level and Significant Wave Height Conditions Stage 2 Complete 1.5 m Sea Level Rise.

8.4.5.1 *Extreme Event with 0.4 m Sea Level Rise*

Impacts to the maximum water level and significant wave height for the 0.4 m sea level rise condition are presented in Figure 8-34 and Figure 8-35, respectively.

Modelled maximum water levels during the storm event with 0.4 m sea level rise show some minor increases in the water level within and around the Project footprint (less than 0.01 m), but no impacts to adjacent shorelines. This difference in water level impacts with and without the Project in place is very minor, since they are localised and do not represent increased risk of inundation to areas adjacent to the Project.

The wave modelling results indicate that the Project effectively provides additional shielding from Toondah Harbour to south of Oyster Point. This shielding produces a marked reduction in modelled wave height within and around the Project footprint. Overall, the model results indicate that the Project provides additional protection for the adjacent shorelines in this extreme event scenario. Furthermore, the Project would have no effect on the magnitude of any saltwater intrusion into freshwater aquifers caused by sea level rise, since the water levels are not higher with the Project in place.

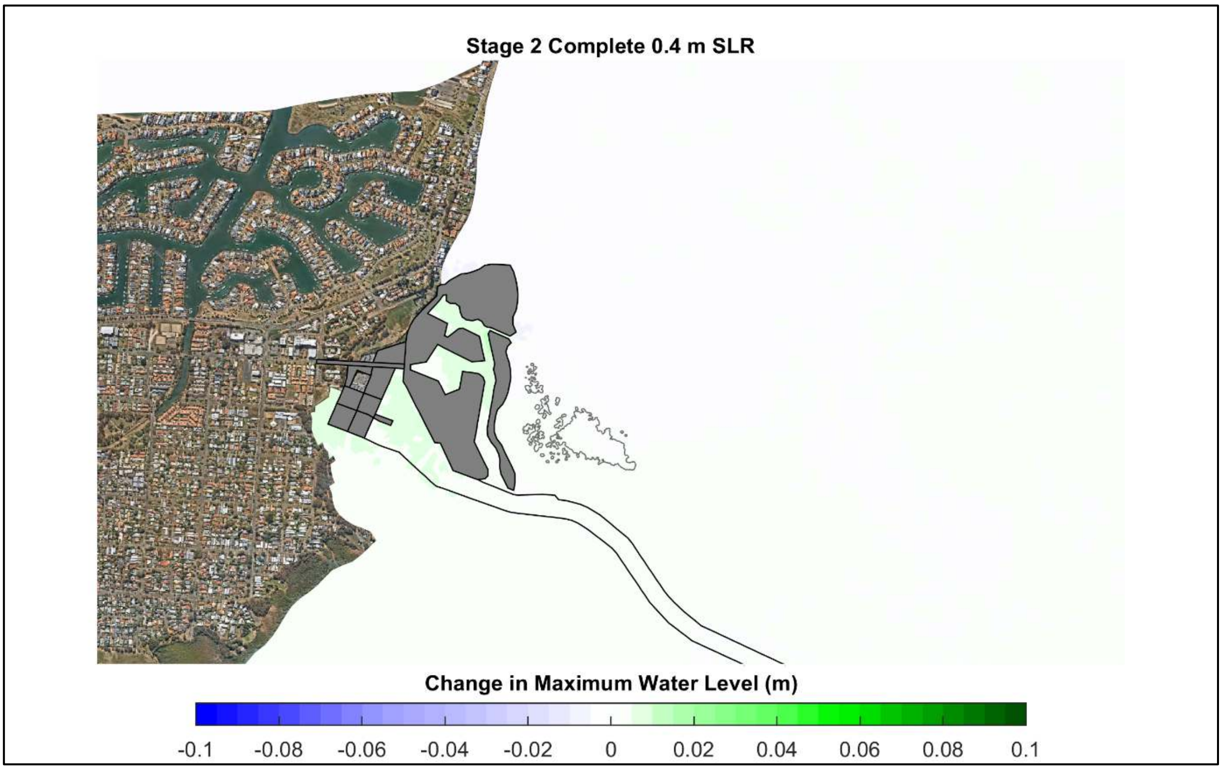


Figure 8-34: Water Level Impacts Stage 2 Complete Ex-Tropical Cyclone Oswald Simulation 0.4 m Sea Level Rise.

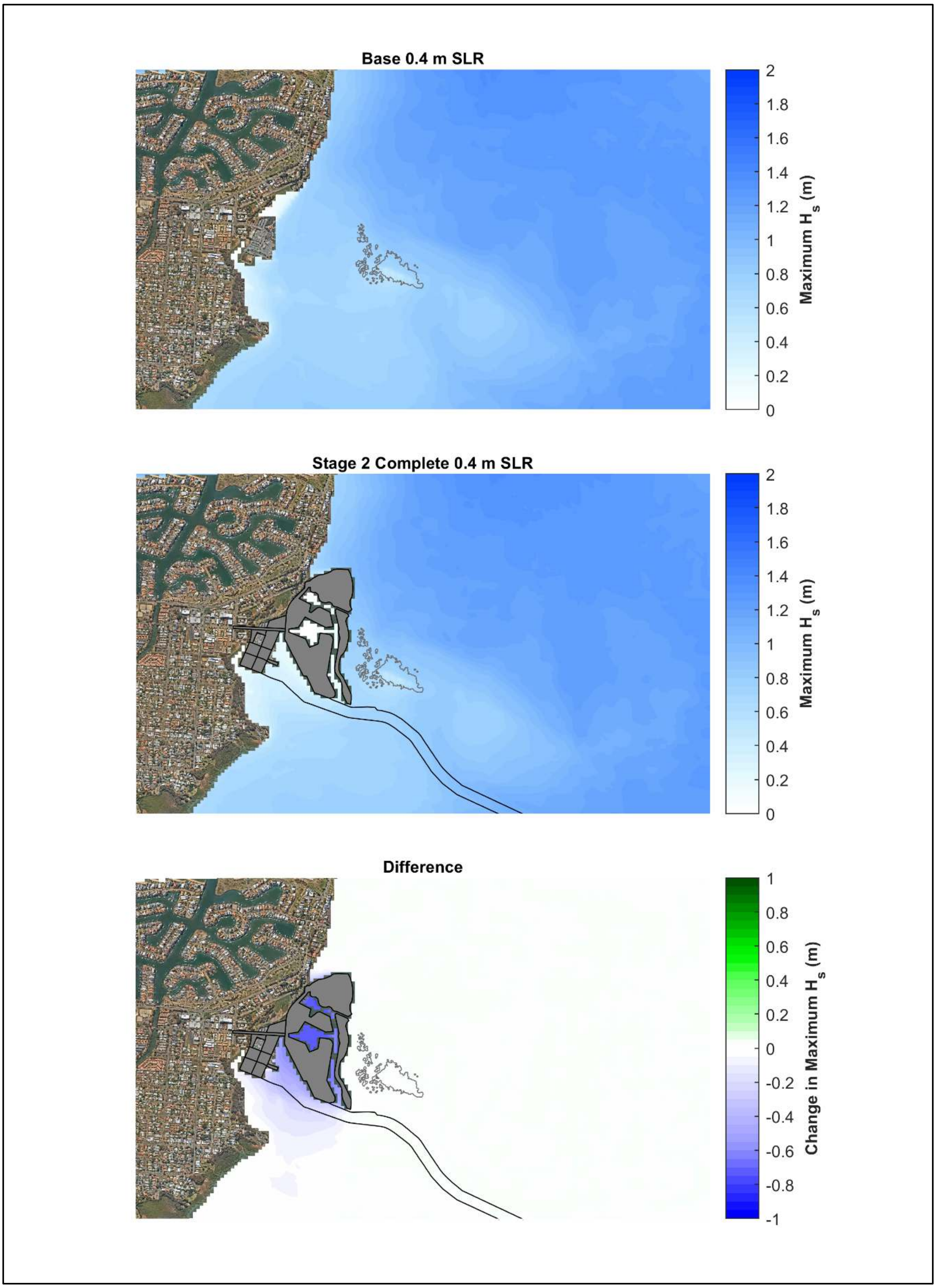


Figure 8-35: Maximum Significant Wave Height Impacts Stage 2 Complete Ex-Tropical Cyclone Oswald Simulation 0.4 m Sea Level Rise.

8.4.5.2 *Extreme Event with 1.5 m Sea Level Rise*

Impacts to the maximum water level and significant wave height for the 1.5 m sea level rise condition are presented in Figure 8-36 and Figure 8-37. Note that the modelled water level extends further onto land areas in these plots due to the elevated water levels with the sea level rise applied.

Modelled maximum water levels during the storm event with 1.5 m sea level rise correspond to 3.08 m AHD and briefly exceed the 3.0 m AHD design level of the development. This level would only occur during the peak of a large storm event and would still be unlikely to impact on any infrastructure or dwellings. There is little difference between modelled water levels with the Project in place and the equivalent base case design event.

Similar to the wave impacts previously described for the 0.4 m sea level rise condition, the Project effectively provides a shielding mechanism from Toondah Harbour to south of Oyster Point. This shielding produces a marked reduction in modelled wave height within and around the Project. Some increases in maximum significant wave height (approximately 0.1 m) are observed along the Fison Channel, however these effects are highly localised and do not represent an adverse impact. Overall, the model results indicate that the Project provides additional protection for the adjacent shorelines in this extreme event scenario. Furthermore, the Project would have no effect on the magnitude of any saltwater intrusion into freshwater aquifers caused by sea level rise, since the water levels are not higher with the Project in place.

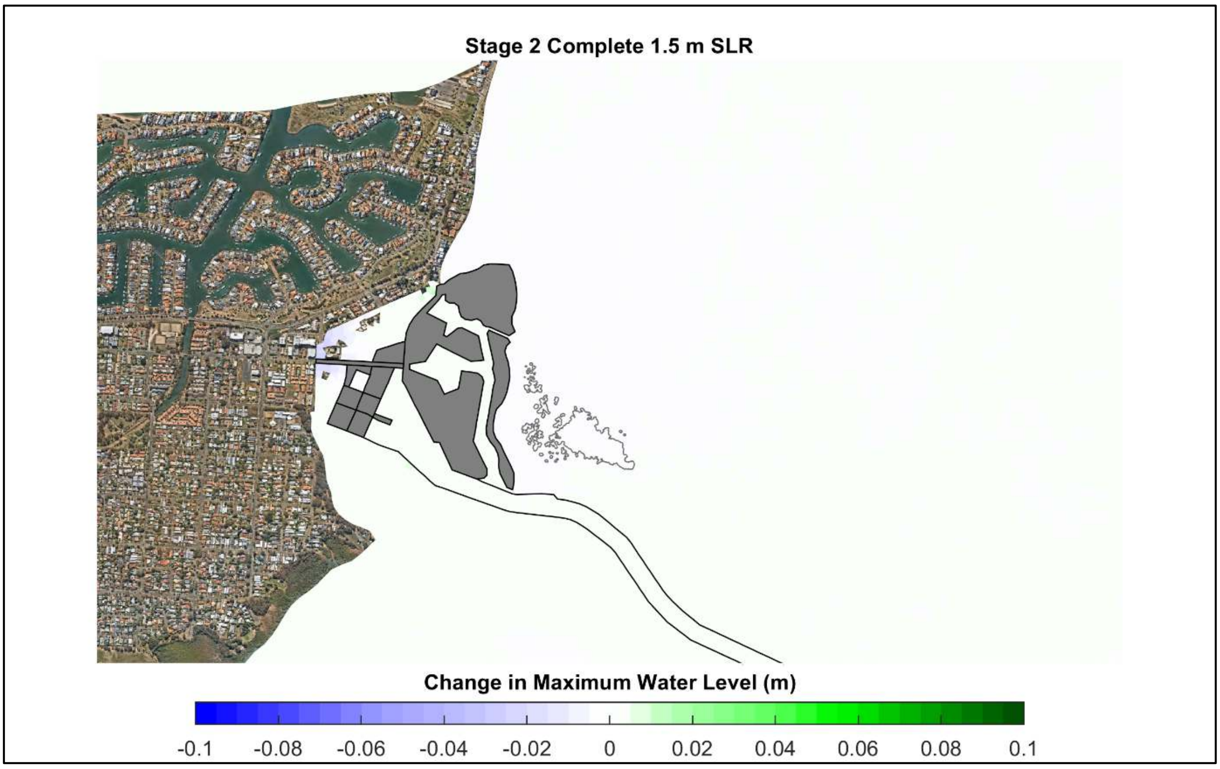


Figure 8-36: Water Level Impacts Stage 2 Complete Ex-Tropical Cyclone Oswald Hindcast Simulation 1.5 m Sea Level Rise.

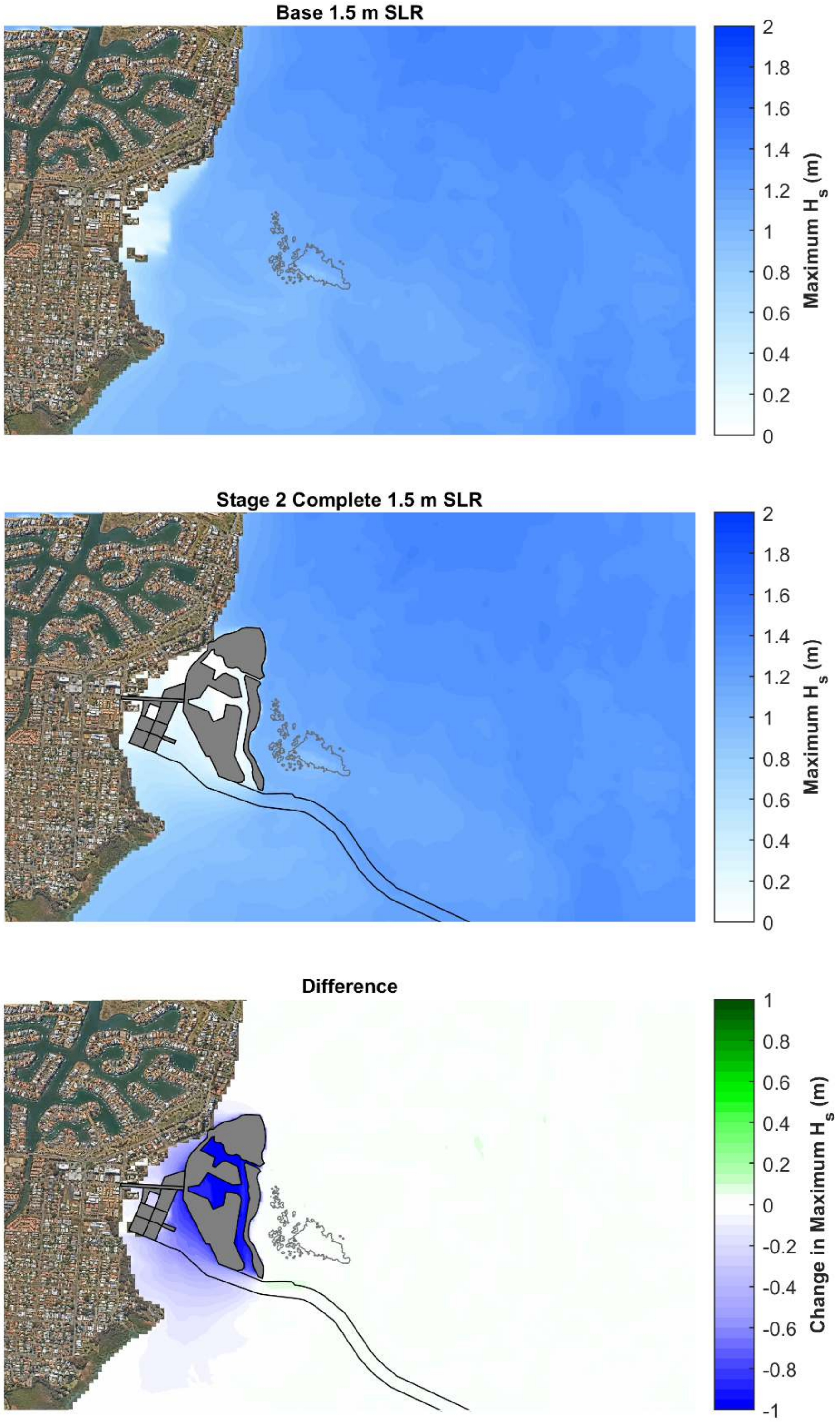


Figure 8-37: Maximum Significant Wave Height Impacts Stage 2 Complete Ex-Tropical Cyclone Oswald Hindcast Simulation 1.5 m Sea Level Rise.

8.4.6 Modelling of Dredging Activities

8.4.6.1 *Dredging Program*

To determine potential water quality impacts of turbid plumes associated with dredging of the Fison Channel, the numerical model was used to simulate the dredging activities. Natural resuspension of both ambient and dredged sediments was included, allowing the impacts of dredging on the overall turbidity and deposition rate to be determined. The dredging is proposed to take place in two stages, and both campaigns were modelled in their entirety.

This section reports the outcomes of dredge modelling. Potential impacts on water quality and marine flora and fauna as a result of dredge plumes are addressed in Chapters 9 and 16, respectively.

Stage 1

The potential impacts of turbid dredging plumes were modelled from the existing ferry terminals heading east to Chainage 1200 m for Dredging Campaign 1 (the inner channel and turning basin). The Stage 1 Phase 1 northern landform was in place for this dredging stage, along with the existing bathymetry.

Stage 2

The potential impacts of turbid dredging plumes were modelled for Dredging Campaign 2 (outer channel from Chainage 1200 m to the seaward end of the dredge area). The Stage 2 Phase 5 southern landform was in place for this series of simulations. The bathymetry assumed the final dredged bathymetry for the first dredging campaign, while the existing bathymetry was otherwise adopted for the second dredging campaign.

The dredging footprints for Stages 1 and 2 are schematised in Figure 8-38.

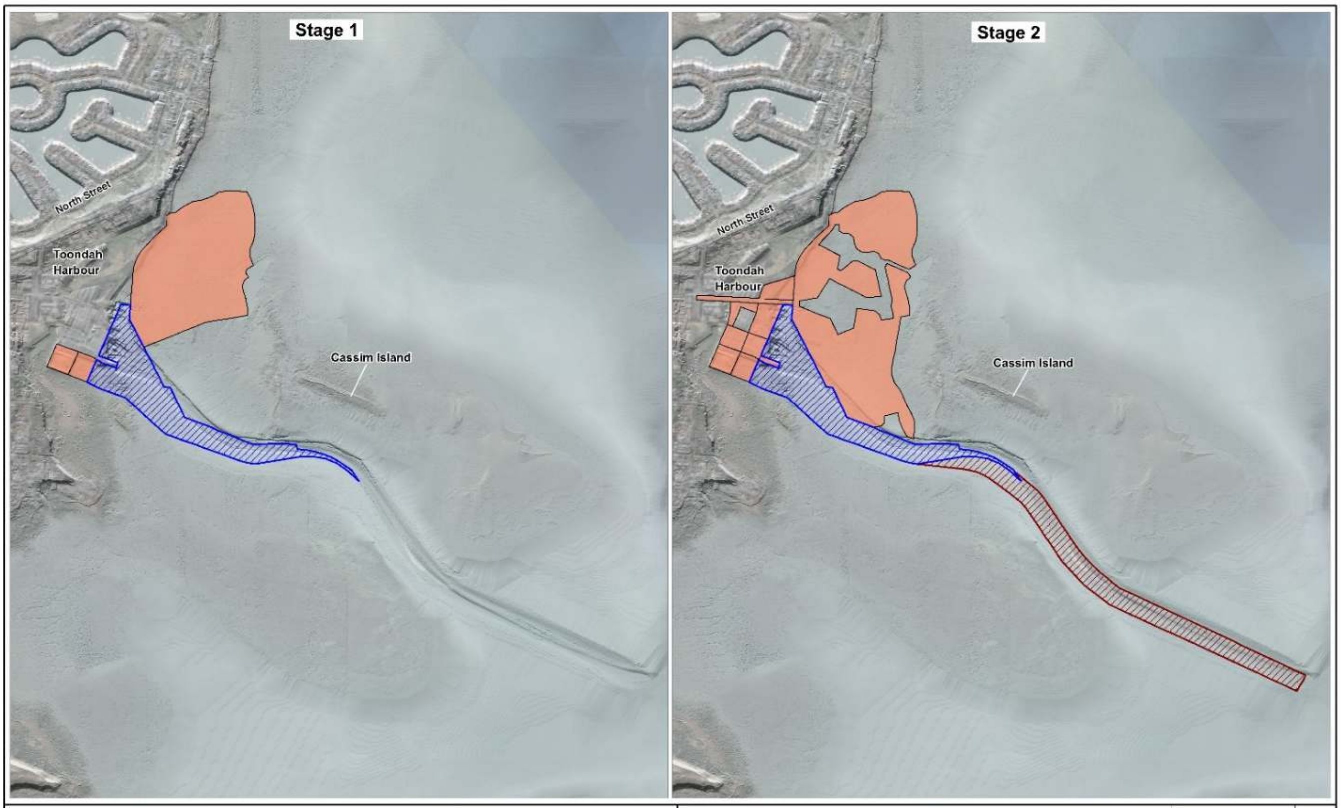


Figure 8-38: Toondah Harbour Development Fison Channel Dredge Stage Scenarios.

8.4.6.2 *Model Parameters*

The hydrodynamic and sediment transport model was run for the base case (no dredging) and dredging scenarios for each dredging campaign. In accordance with 2014 and 2020 sediment analyses, dredging and disposal sediment fluxes were assumed to have the following sediment composition:

- Clays (<4 micron) – 65%;
- Silts (4 – 75 micron) – 15%;
- Sand/Gravel (> 75 micron) – 20%.

To facilitate both ambient sediment suspension and effects of potential dredge sediment resuspension post-dredging, dredge modelling simulations included a one-month period both before and after the respective dredging periods. A nominal dredging simulation window was selected to represent typical conditions for dredging activities at the time of year that dredging is expected to occur and includes a wave event following completion of dredging to simulate the potential resuspension of dredged sediment (based on a wave event in August 2017).

Modelling inputs used to define the dredging campaigns are summarised in Table 8-1.

Table 8-1: Dredging Model Input Summary (BHD).

Property	Dredging Stage 1	Dredging Stage 2
Dredge Type	Backhoe Dredge (BHD)	
Cut Volumes (m^3)	361,990 m^3	168,020 m^3
Date Dredging Start	28/03/2017	03/06/2017
Date Dredging End	01/08/2017	01/08/2017
Date Simulation Period Start	01/03/2017	01/05/2017
Date Simulation Period End	01/09/2017	01/09/2017
Dredging Productivity	200 m^3 in-situ/effective hour	
Dredge Activity	144 hours/week	
Dredge Downtime	30%	
Barge Frequency	4 barges/24 hrs	
Dredge Plume Source Rate	3.0 kg/s	

The dredging sediment fluxes are input into the model as intermittent source terms. Dredging activity is based around a 24-hr daily dredging schedule with no dredging activity on Sundays to make up a 144 hour/week dredging schedule. The dredging intermittence further accounts for downtime (barge changeover/maintenance), allocated at regular intervals during the dredging campaign. The offshore rate of movement of the dredge was calculated according to the expected dredging productivity rate and the cut volumes. Dredge spoil from the backhoe dredging was assumed to be placed entirely within the reclamation areas, with no tailwater discharge. Modelling assumes silt curtains are not used during the dredging process even though it is proposed to utilise them wherever possible. As a result, modelled plumes would be considered worst case scenario.

8.4.6.3 *Turbidity Plume Extents*

The potential effects of dredging were assessed based on the modelled increases in the turbidity and deposition rate above natural or ambient levels. The water column turbidity associated with dredging-related suspended sediment was derived by converting the modelled TSS levels into an equivalent turbidity value using an established relationship (refer to Appendix 2-E for details).

Depth-averaged turbidity values are presented here since they are most relevant to assessing potential ecological impacts due to the reduction in seabed photosynthetically active radiation (PAR) (i.e., light intensity on the seabed). Deposition rate impacts were derived from the daily rate of change in bed sediment mass. The adopted sedimentation rate units are $mg/cm^2/day$.

Snapshots of the Dredge Plumes

To illustrate the potential extent of the dredging-related plume, snapshots of modelled depth-averaged turbidity are presented at discrete points in time in Figure 8-39 to Figure 8-42. These figures provide an indication of the spatial distribution of dredging impacts at particular points in time, with comparisons against the modelled total turbidity (all sources of suspended sediment including both ambient and dredged sediment). The location of the dredge within the dredged envelope at the snapshot in time is indicated by the yellow circle marker.

Due to the cohesive sediment composition that predominates in the region and the intertidal setting within regional vicinity of the Project, both the measured field data (addressed in detail in Chapter 9 of the EIS) and the modelling demonstrates that the ambient (background turbidity) is relatively high throughout Toondah Harbour and the surrounding area and prone to turbid “spikes” in response to wave activity.

A combination of regional forcing and intertidal dynamics (see Section 8.3.1) results in the net northward transport of the dredge sediment plume, particularly over the ebbing tide phase. With the dredge positioning in the Fison Channel in both dredging stages, the localised tidal exchange results in advection of the plume to the east before sweeping northward due to tidal exchange near Sandy Island. The snapshots of plume dispersion were selected to illustrate these mechanisms.

Figure 8-39 presents the typical eastern extent of the advected dredge sediment plume as the Fison Channel drains eastward in the ebbing tide phase during the first dredging campaign. The eastern extent of the dredge plume reduces to very low levels before reaching Sandy Island. The northern transport of the dredge plume (Figure 8-40) then begins with the northward flowing currents on the ebbing tide, before being cut off from the plume source in the navigation channel as the water level drops to expose the intertidal mudflats surrounding Cassim Island. The advected dredge plume extends to Cleveland Point, but levels are very low (less than 10 nephelometric turbidity units (NTU) above ambient).

During the second dredging campaign, the more exposed dredging location results in increased advection and subsequent mixing of the dredge plume. Eastward advection of the plume (Figure 8-41) again occurs along Fison Channel, particularly at the end of the ebbing tide after water levels have dropped and exposed the Cassim Island mudflats. The northward transport of the plume over the ebbing tide for the second campaign (Figure 8-42) occurs further offshore than the first campaign as the plume is advected by the northward ebb tide currents to the east of Cassim Island. In both presented snapshots, the dredge turbidity impacts are very low (less than 10 NTU above ambient) and are constrained to the local area around the Project footprint.

The snapshots presented here are during normal dredging operations after several days of continuous dredging. The plume advection is relatively consistent and continuously present during normal operations. When the dredge is inactive for 24 hours during the regular weekly maintenance window, the model indicates that the dredging-related turbidity drops to less than 5 NTU outside the dredging envelope within approximately 12 hours after dredging operations cease.

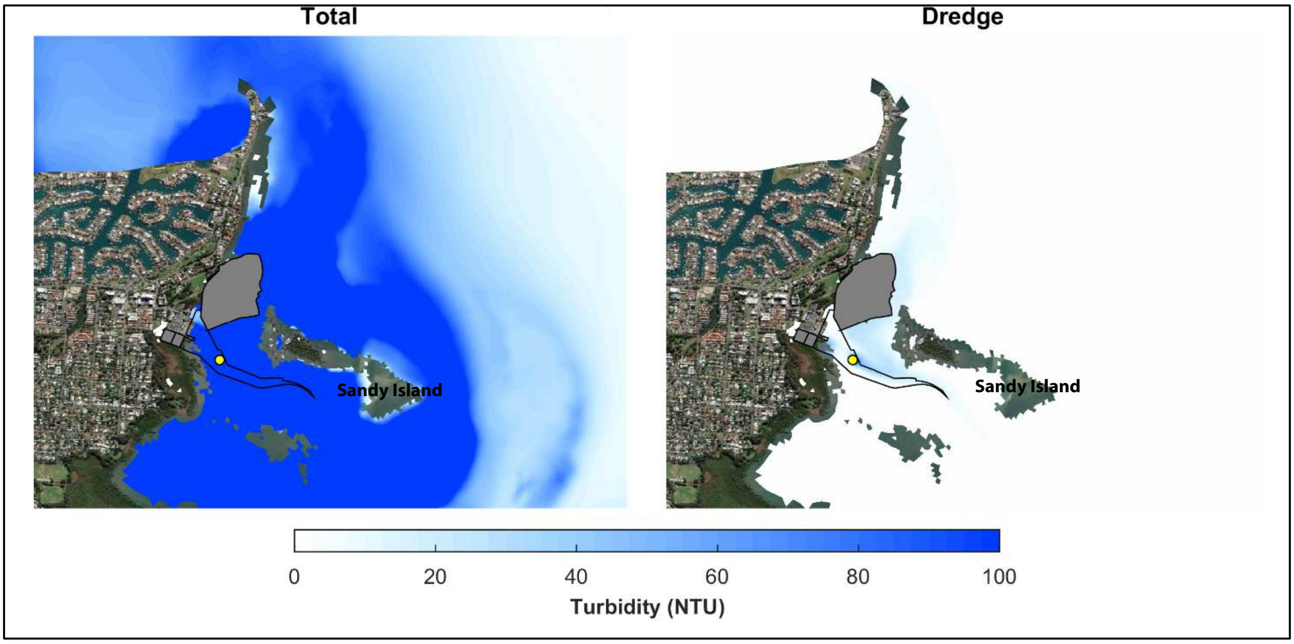


Figure 8-39: Snapshot of Stage 1 Dredging Depth-Averaged Turbidity – Depicting Eastward Advection of Dredge Plume.

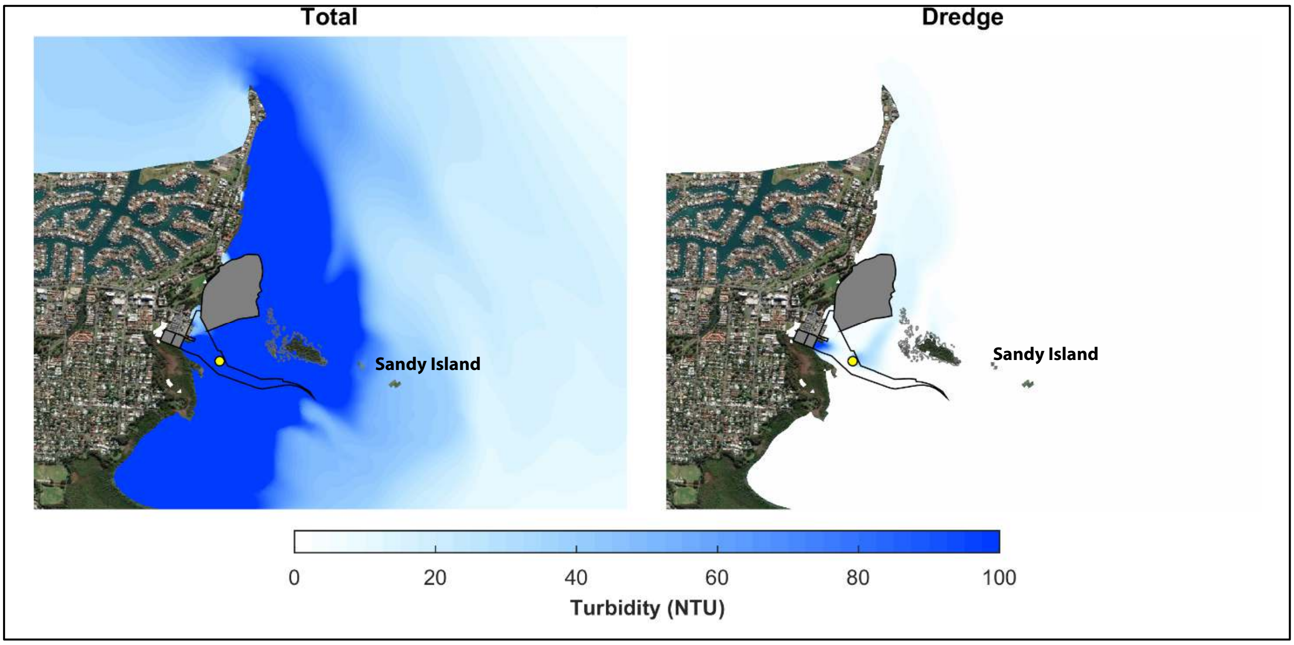


Figure 8-40: Snapshot of Stage 1 Dredging Depth-Averaged Turbidity – Depicting Northward Advection of Dredge Plume.

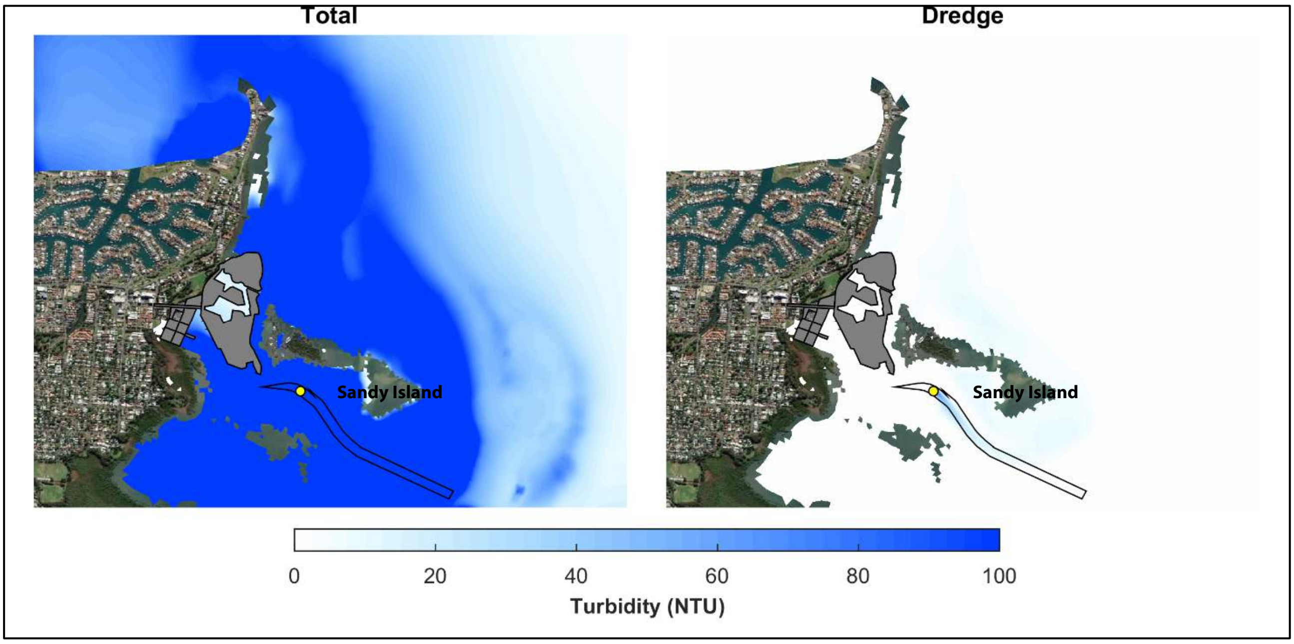


Figure 8-41: Snapshot of Stage 2 Dredging Depth-Averaged Turbidity – Depicting Eastward Advection of Dredge Plume.

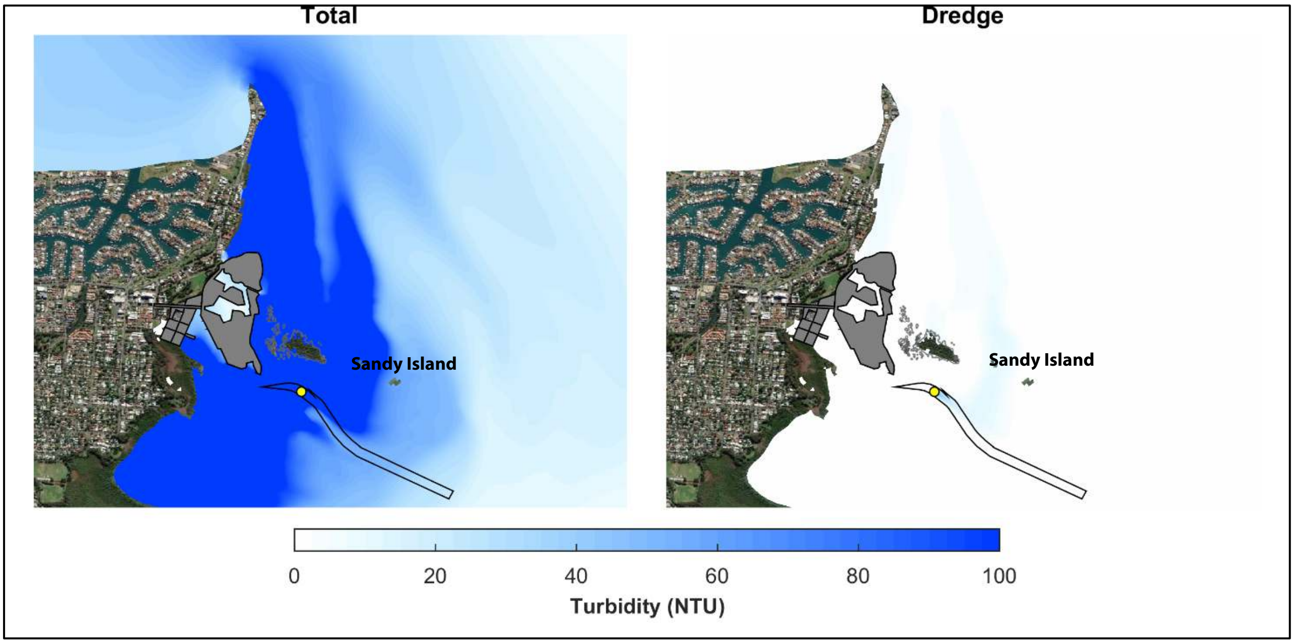


Figure 8-42: Snapshot of Stage 2 Dredging Depth-Averaged Turbidity – Depicting Northward Advection of Dredge Plume.

Percentiles of the Dredge Plumes

The modelled effects of the dredging program on the percentiles of the depth-averaged turbidity are presented in Figure 8-43 to Figure 8-46. These figures give an overall indication of the spatial distribution of dredging impacts characteristic of the dredging program in its entirety, including all sources of suspended sediment.

It is important to note that the colours used to demonstrate the changes in the turbidity for the 50th and 95th percentile plots use different scales, therefore the specific colour used in the figures does not represent the same level of turbidity for every modelled scenario (i.e., each figure needs to be interpreted with respect to the specific NTU scale colours given at the bottom of each figure).

The modelled Dredging Campaign 1 (Figure 8-43 and Figure 8-44) indicates the following:

- The change in the 50th percentile turbidity shows that dredging impacts are mostly localised within the vicinity of the dredge area of the first campaign. Tidal processes (notably the ebb tide phases) are attributed to some dredge plume advection to the north and along the navigation channel, however corresponding increases in the median turbidity are generally considered low (below 2 NTU).
- The change in the 95th percentile turbidity presents similar distribution patterns to the 50th percentile impacts (northward longshore transport and offshore plume advection via the Fison Channel). The magnitude of the modelled change in the 95th percentile outside the channel is generally less than 10 NTU.
- The "sheltering" of the dredged sediment plume resulting from both Cassim Island and the Project footprint itself, along with the relatively low release rate of the BHD source term, help contain a significant proportion of the overall plume sediment transport within the dredge area.

The modelled Dredging Campaign 2 (Figure 8-45 and Figure 8-46) indicates the following:

- A combination of the location of the dredge area of the second campaign further offshore and the altered hydrodynamics resulting from the Stage 2 development configuration limiting longshore ebb-tide transport between the mainland and Cassim Island is seen to result in a slightly larger spatial impact on the 50th percentile of the turbidity.
- The 50th percentile central median estimate of the turbidity increases due to dredging by approximately 3 to 4 NTU east of Cassim Island, beyond the bounds of the Stage 2 dredge area. Due to the increased "sheltering" south of the Project and effect of flood-tide transport, the 50th percentile turbidity increases by up to 5 NTU to the west of the Stage 2 dredged envelope (indicating the expected impact to the turbidity for 15 days out of every 30 days during dredging), however these changes are highly localised.
- The modelled increase to the 95th percentile turbidity demonstrates that acute impacts are mostly contained within the dredge area of the second campaign. A combination of the reduced dredge cutting volumes as the dredge progresses offshore and the increased tidal hydrodynamic activity along the dredged envelope results in relatively low 95th percentile dredging turbidity impacts at the offshore limits of the dredged envelope of the second campaign. The modelled increase to the 95th percentile turbidity is less than 10 NTU outside the dredging envelope.

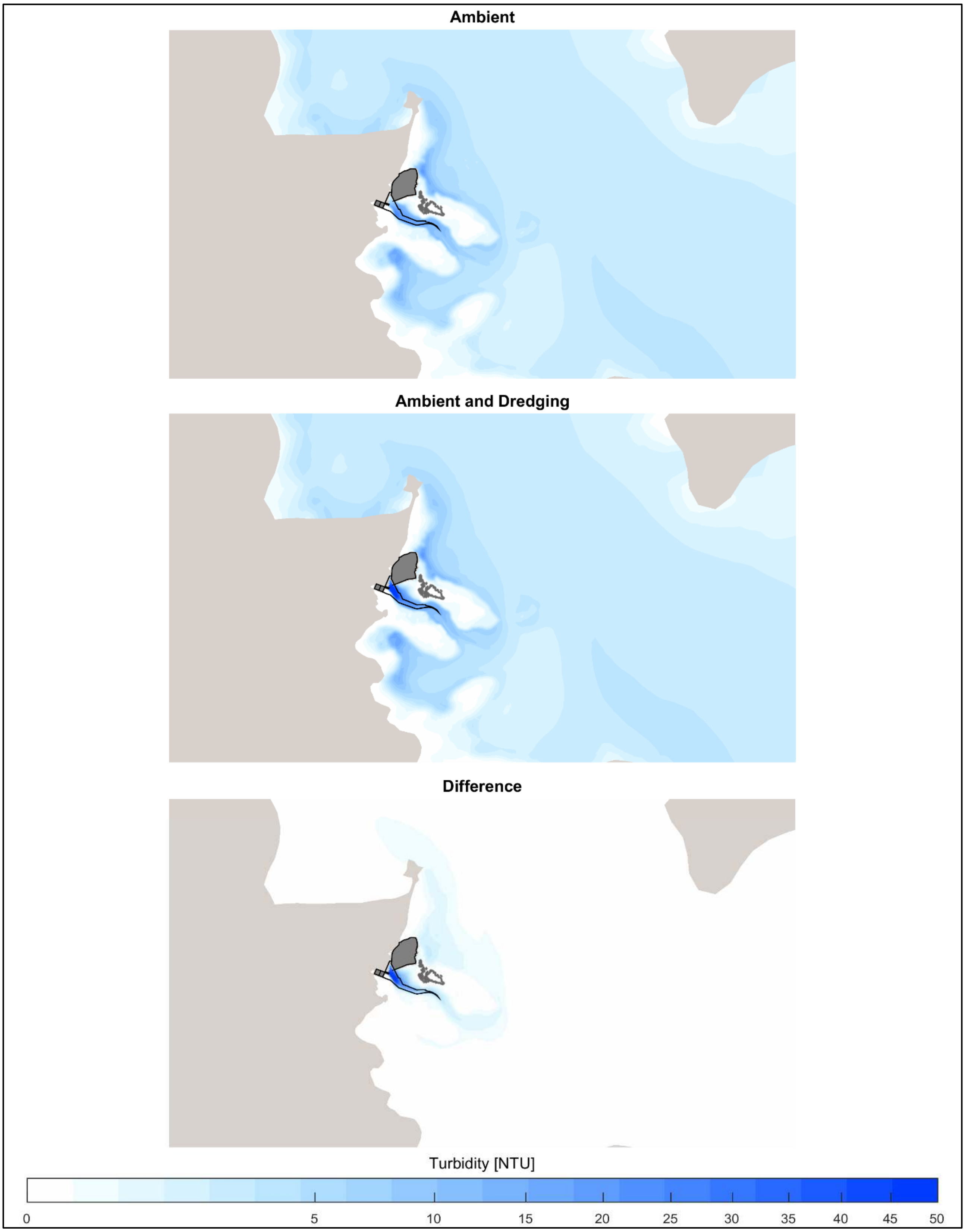


Figure 8-43: 50th Percentile of the Depth-Averaged Turbidity Dredging Campaign 1.

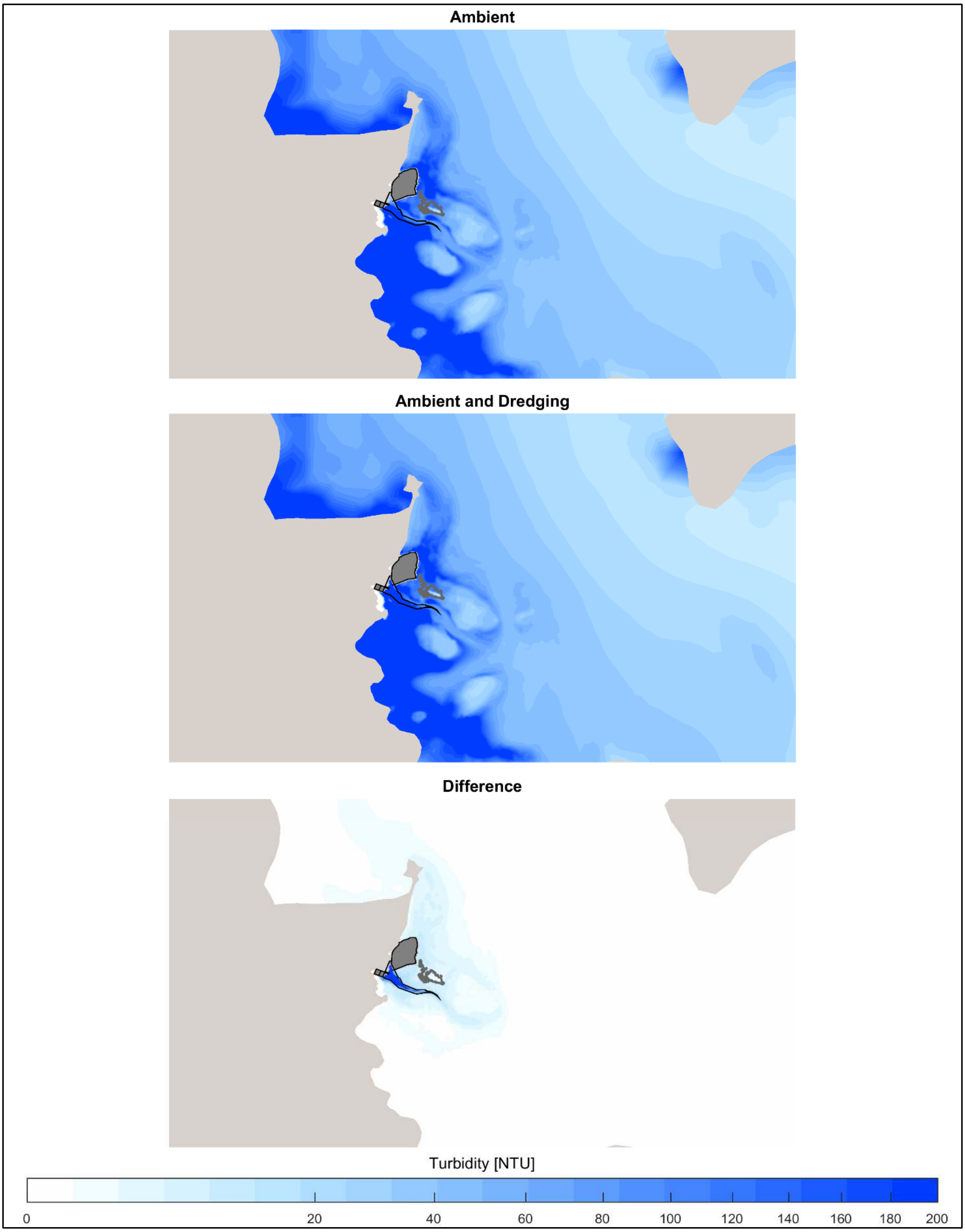


Figure 8-44: 95th Percentile of the Depth-Averaged Turbidity Dredging Campaign 1.

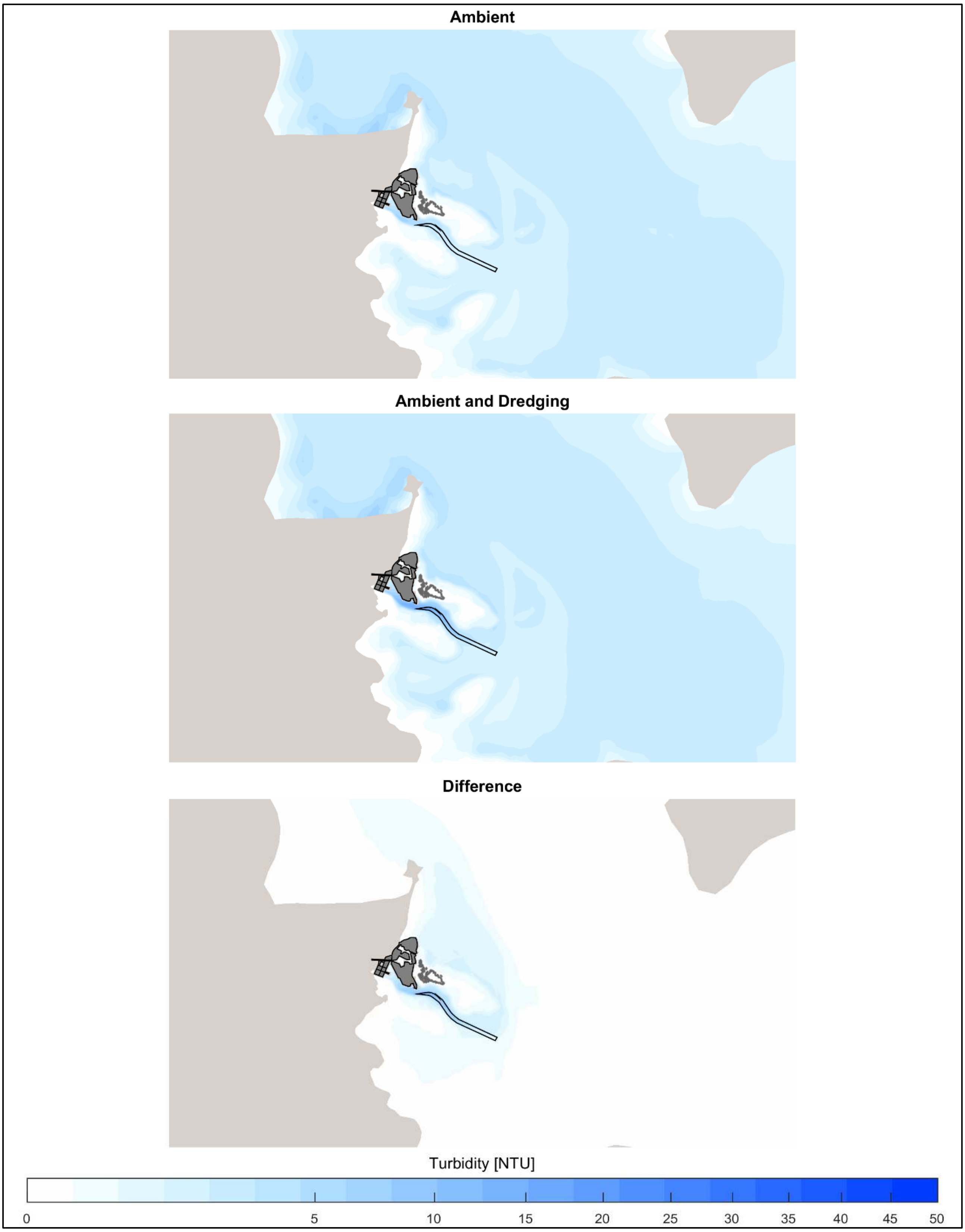


Figure 8-45: 50th Percentile of the Depth-Averaged Turbidity. Dredging Campaign 2.

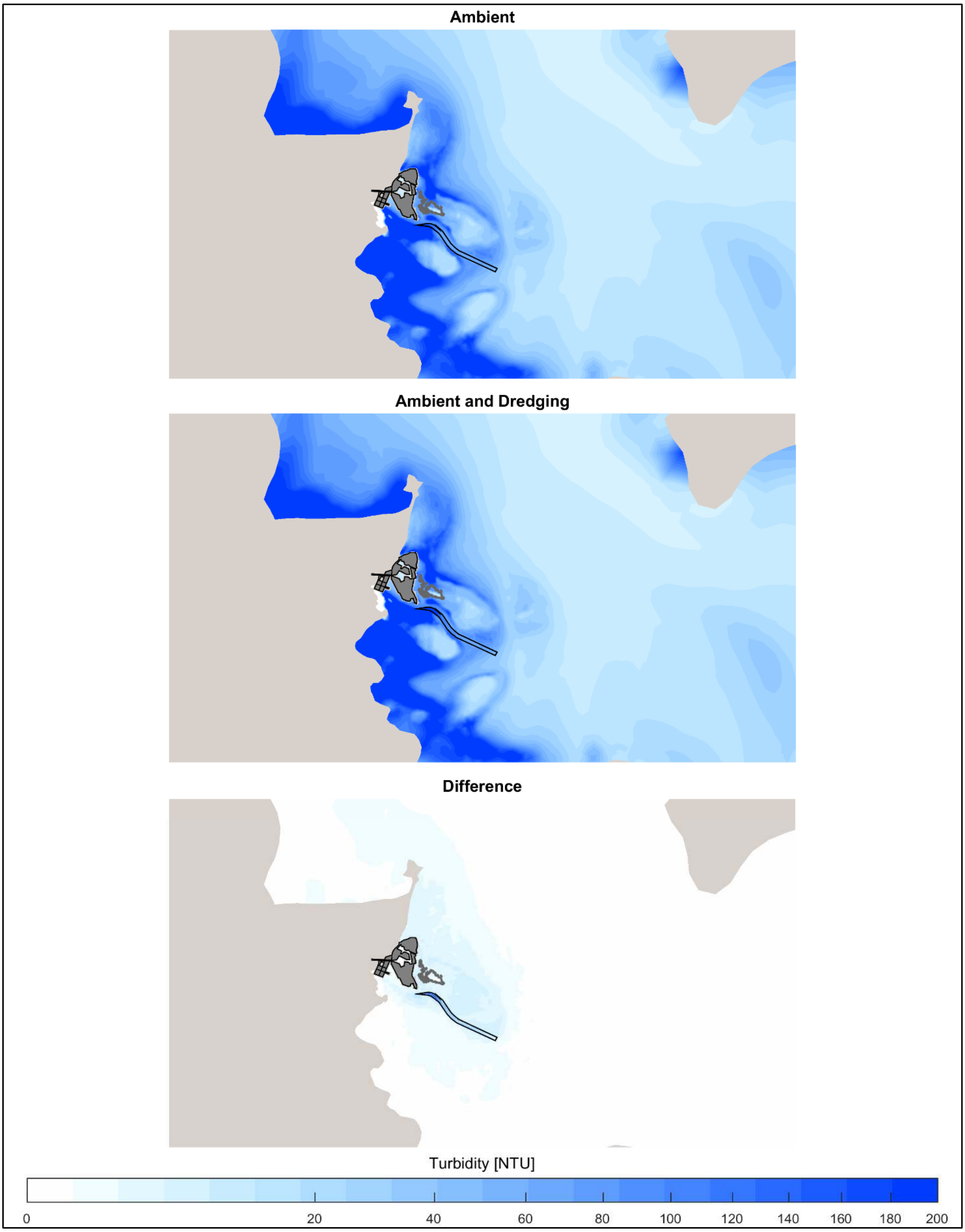


Figure 8-46: 95th Percentile of the Depth-Averaged Turbidity Dredging Campaign 2.

8.4.6.4 *Sediment Deposition*

The modelled effects of the dredging program on the percentiles of the sediment bed deposition rate are presented in Figure 8-47 to Figure 8-50. These figures give an overall indication of the spatial distribution of benthic dredging impacts characteristic of the dredging program in its entirety, including all sources of deposited sediment.

As for the turbidity percentile plots previously presented in Section 8.4.6.3, it is important to note that the colours used to demonstrate the changes in the bed deposition rate use different colour scales for the 50th and 95th percentile plots. The deposition rate is reported in mg/cm^2/day, and if a bulk dry density of 1000 kg/m^3 is assumed then 100 mg/cm^2/day is equivalent to 1 mm/day.

Note that the upper deposition rate percentiles include some small, localised areas with high sediment deposition rate impacts, which may not represent real impacts (for example, an area where dredged sediment has accumulated and the sediment is then briefly resuspended by a wave event).

The model (refer to top panel in Figure 8-47 to Figure 8-50) demonstrates that ambient deposition rates within the vicinity of Toondah Harbour are highest in the Fison Channel and the deeper waters north-northeast of Cassim Island.

The modelled Dredging Campaign 1 (Figure 8-47 and Figure 8-48) results indicate that increases to the deposition rate are largely confined to the dredge area and the bounds of the existing channel incorporated in the model bathymetry for the Stage 1 Case. Modelling results indicate some slight increases to the 50th percentile of the deposition rate south of the Stage 1 reclamation.

Results from the modelled Dredging Campaign 2 (Figure 8-49 and Figure 8-50) indicate increases in the deposition rate westward along the dredged inner channel as a result of tidal flood-tide dynamics. Short-term (95th percentile) increases are generally limited to the Fison Channel, while some small increases to the 50th percentile deposition rate (generally less than 4 mg/cm^2/day) are noted northeast of Cassim Island.

The net total deposition of dredged sediment at the completion of both dredging campaigns is shown in Figure 8-51 and Figure 8-52.

The first dredging campaign (Figure 8-51) results indicate 2 to 3 mm dredge sediment deposition depth to the northeast of the Project, while dredged sediment is otherwise deposited largely within the Fison Channel.

The second dredging campaign results (Figure 8-52) similarly show sediment deposition northeast of the Project, but less than that reported for the Stage 1 scenario, with a deposition depth of 1 to 2 mm. Dredge sediment deposition is also noted to occur along the southern edge of the Fison Channel and within 300 m either side of the dredged channel at the offshore end of the dredging envelope for the second campaign, with generally less than 3 mm dredged sediment deposition depth.

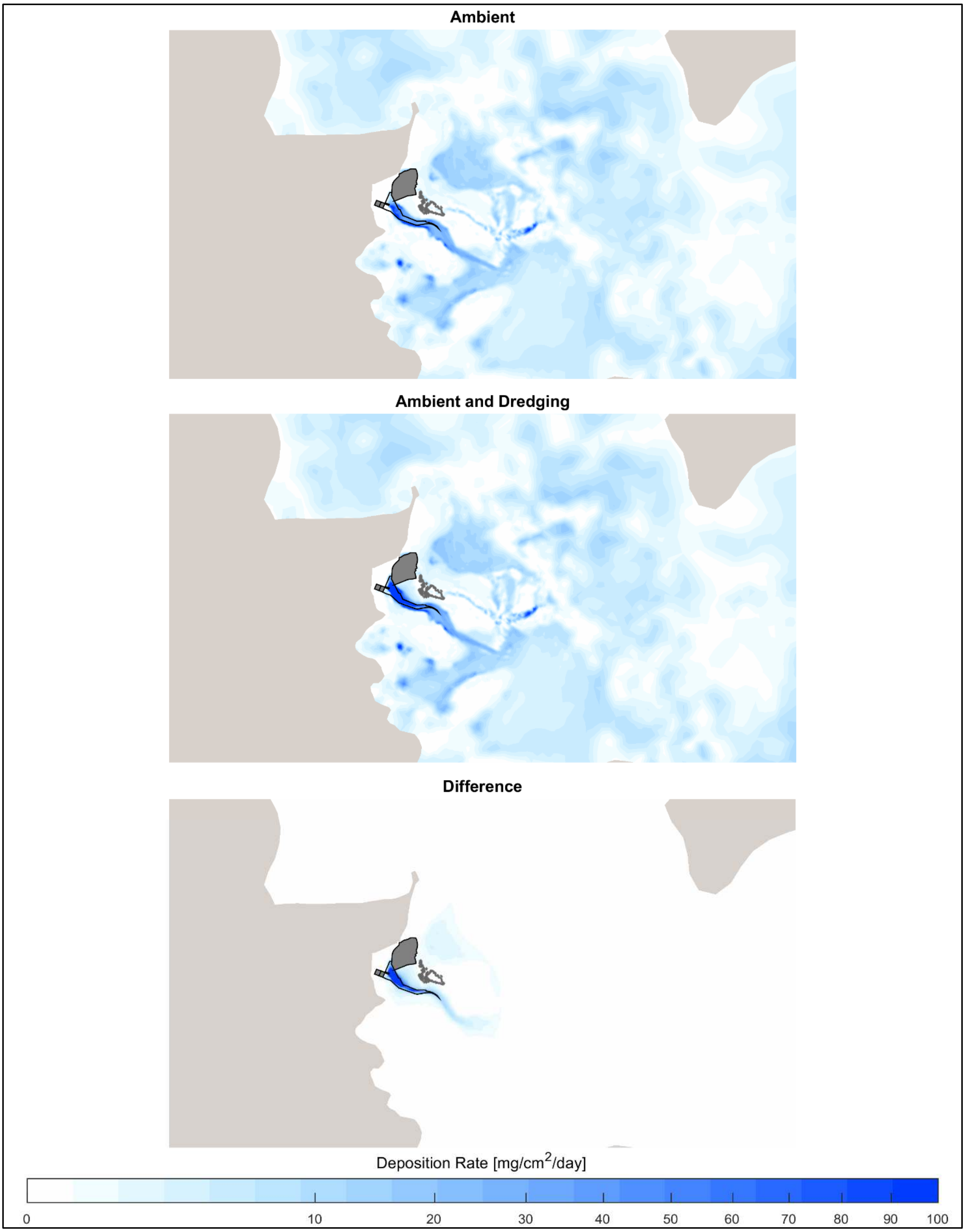


Figure 8-47: 50th Percentile Deposition Rate Dredging Campaign 1.

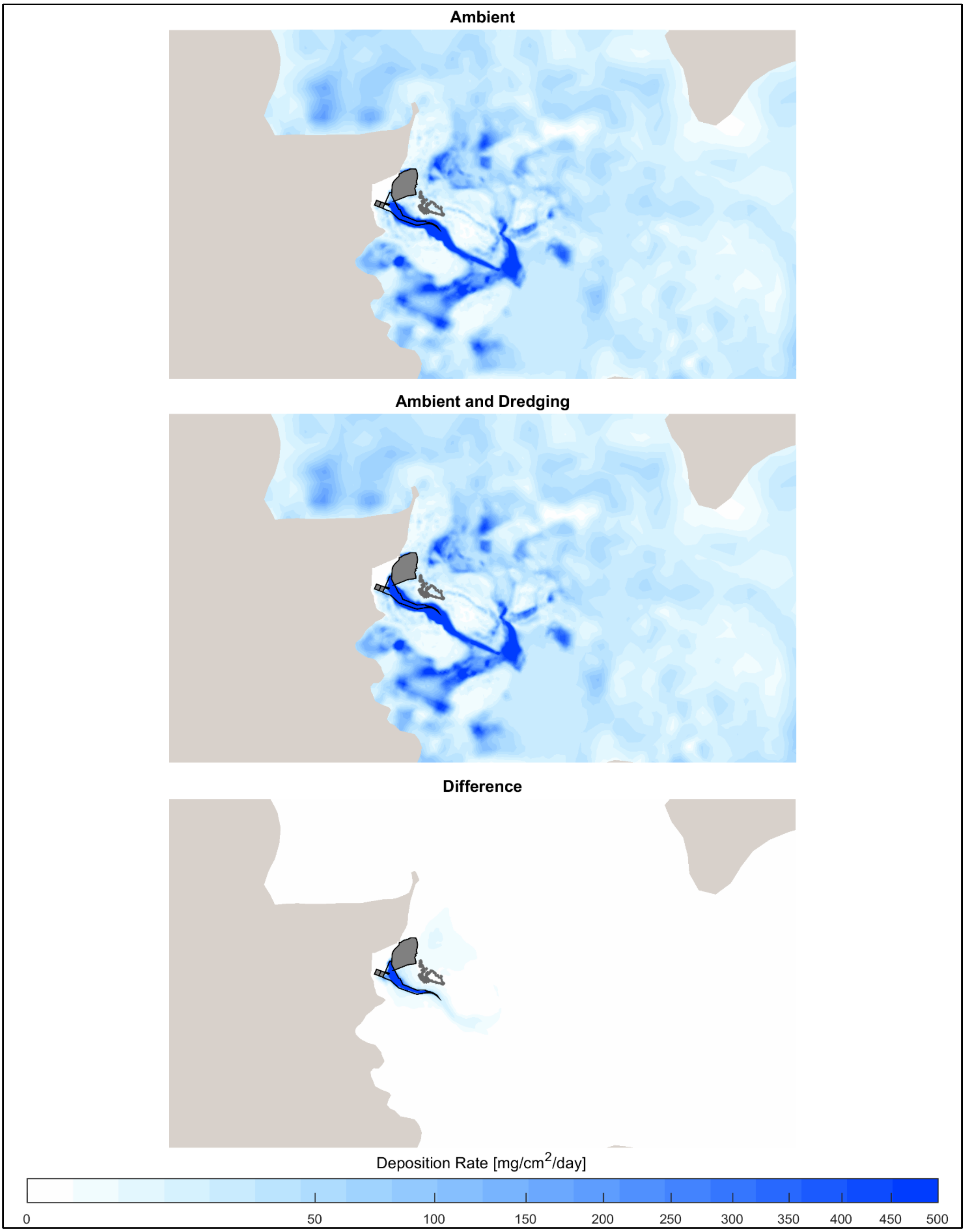


Figure 8-48: 95th Percentile Deposition Rate. Dredging Campaign 1.

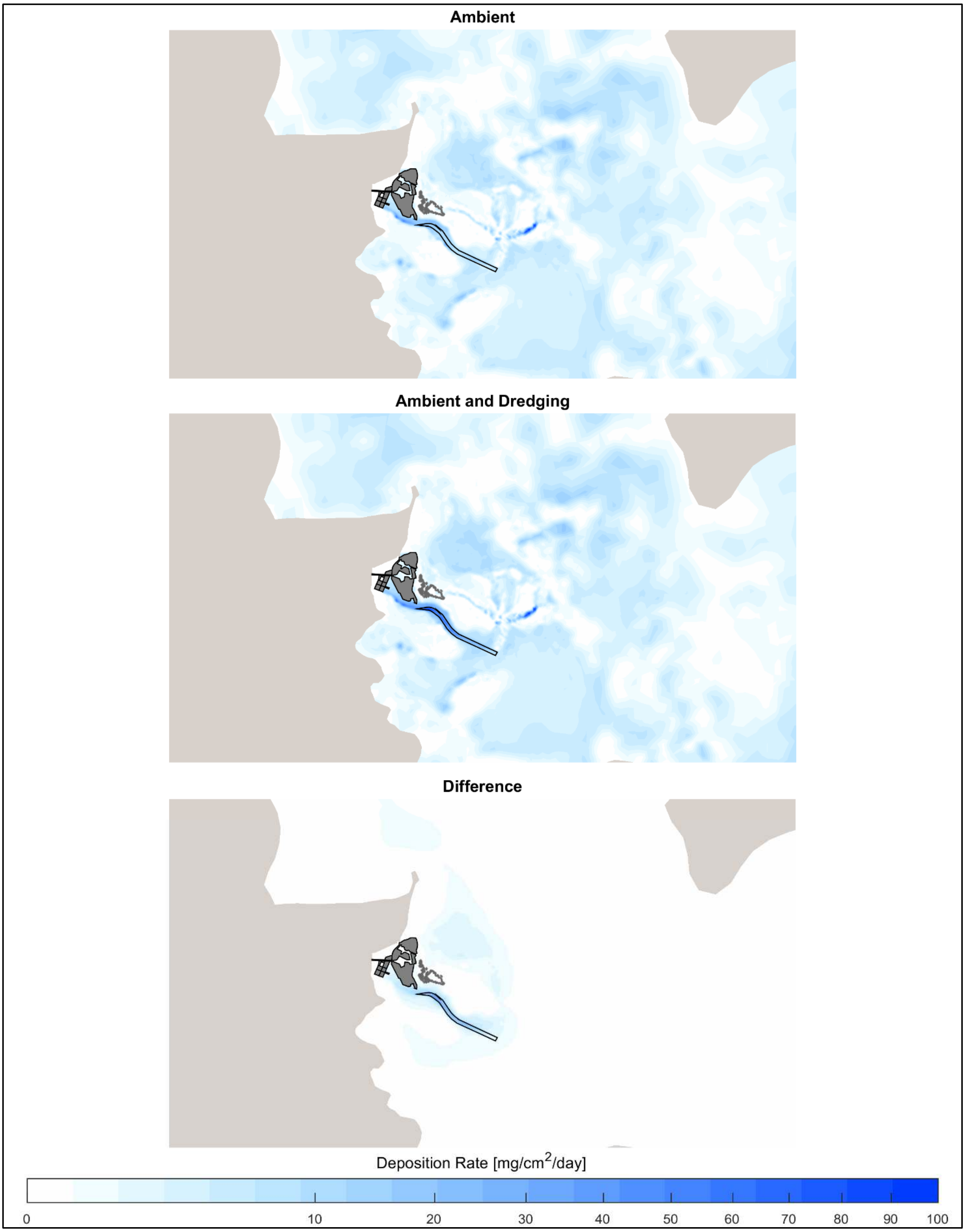


Figure 8-49: 50th Percentile Deposition Rate. Dredging Campaign 2.

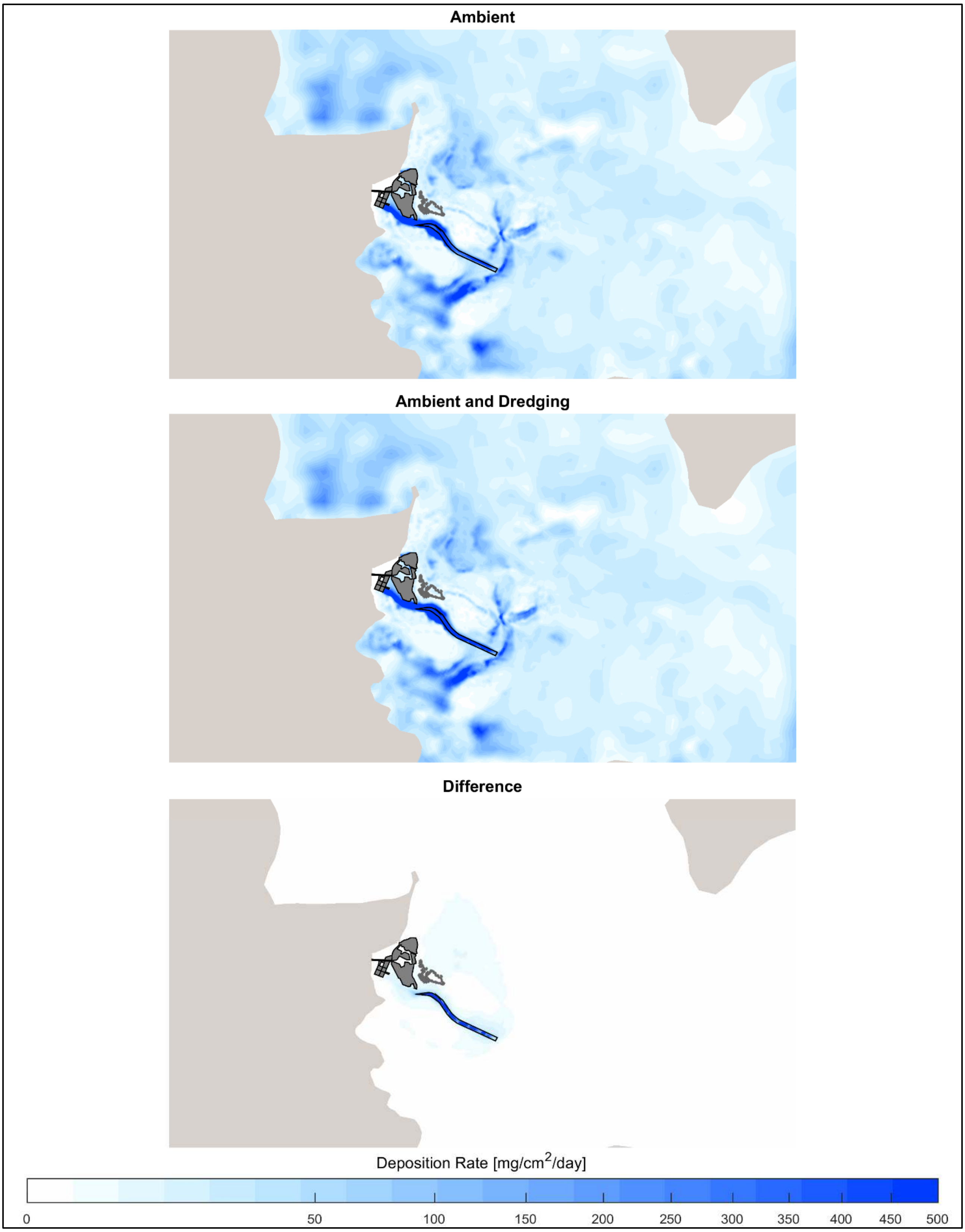


Figure 8-50: 95th Percentile Deposition Rate Dredging Campaign 2.

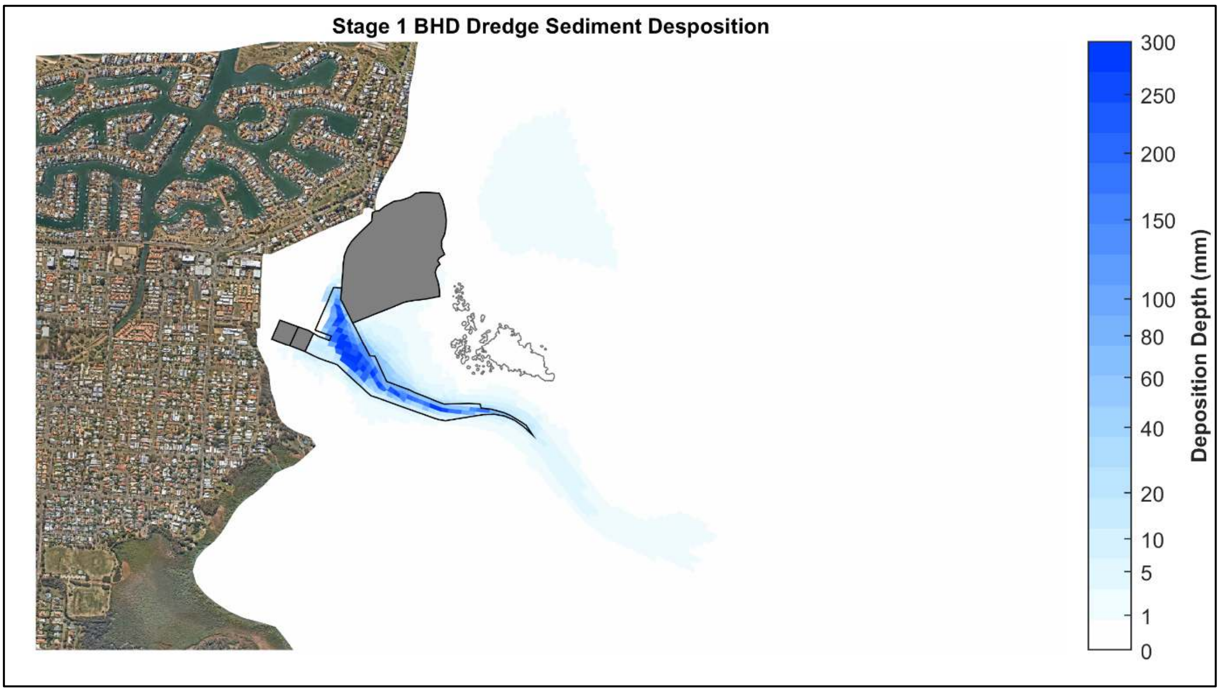


Figure 8-51: Modelled Ultimate Dredged Sediment Deposition Thickness. Dredging Campaign 1.

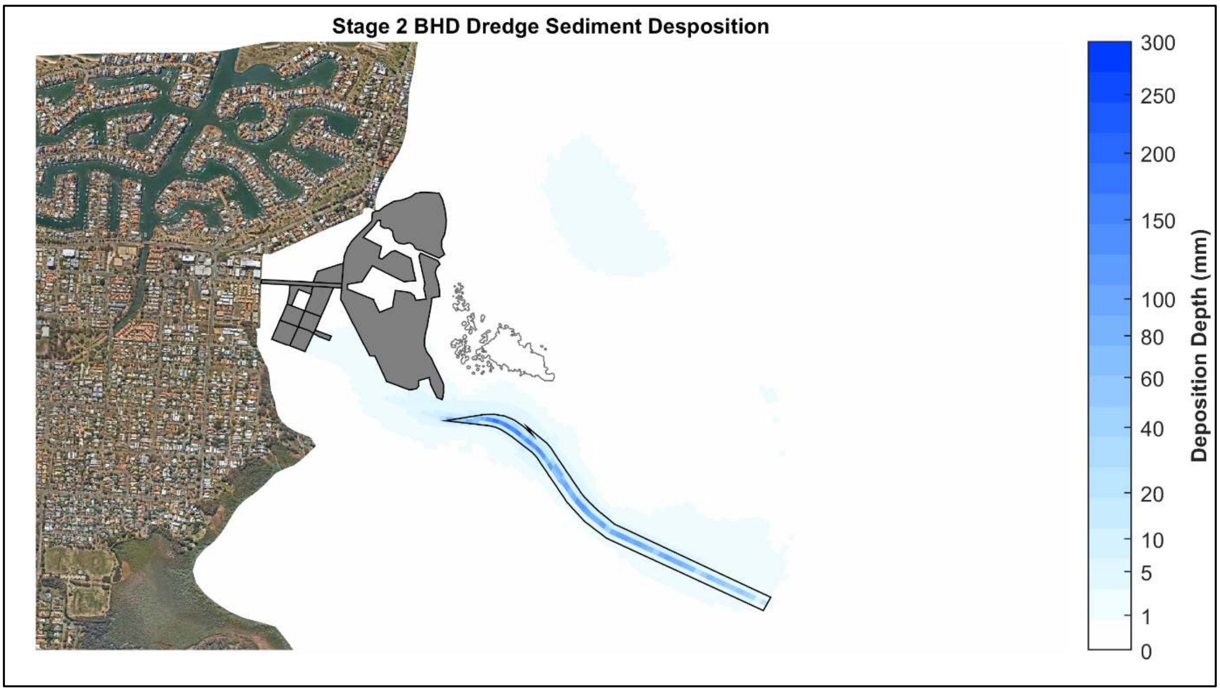


Figure 8-52: Modelled Ultimate Dredged Sediment Deposition Thickness. Dredging Campaign 2.

8.5. Adaptive Management and Monitoring Measures

This section addresses management and monitoring of impacts directly related to potential changes in coastal processes as a result of the Project. Potential impacts on water quality and marine ecology and proposed management and monitoring are addressed in Chapters 9 and 16 respectively.

As the impacts to hydrodynamics and coastal processes outlined in the previous section are expected to result in only minor changes to the physical environment surrounding the Project footprint, intensive management measures are not required. However, ongoing monitoring of the coastal environment in the vicinity of the Project will be undertaken and any changes will be addressed through active management. Examples of possible intervention measures that could be implemented include:

- If excessive sediment builds up on the sheltered beach to the north of the Project, measures can be put in place to reduce sediment build up;
- If the area to the northwest of Cassim Island begins to erode after completion of the Stage 1 footprint due to higher flow velocities during spring tides, construction of the rockwall breakwater could be brought forward (velocity and erosion impacts in that area are smaller for the Stage 2 configuration); and
- If wave reflection at the eastern boundary of the Project generates local erosion or amplification of wave heights, additional wave absorption treatments can be applied to the revetment structure.

Where an activity is anticipated to have an impact on environmental values, mitigation measures are proposed in Table 8-2. Management measures will be reviewed at least annually to ensure they are achieving the best environmental outcomes. Where trigger criteria are exceeded or if management outcomes are not achieved, management measures will be reviewed more frequently.

Table 8-2: Coastal Processes Management Measures.

Potential impacts	Management and monitoring measures	Desired outcomes and effectiveness
Changes to coastal erosion and accretion in areas outside of the Project footprint	▪ Monitor changes in coastal morphology in areas adjacent to the Project. Key areas include potential for sediment build up at the sheltered beach area north of the reclamation and erosion to the northwest of Cassim Island. If significant erosion around Cassim Island occurs, construction of the rockwall breakwater could be brought forward in the development cycle. Measures such as removal or placement of sand would be considered in the unlikely event of significant changes.	▪ Changes in coastal morphology will not impact on ecological values surrounding the Project footprint, such as shorebird use of the Cassim Island roost site. ▪ Modelling predicts only minor changes to coastal processes as a result of the Project. Given the low risk of impact, the monitoring and management measures are expected to be highly effective.

8.6. Residual Risk of Impact

The risk of significant impacts to environmental values from coastal processes have been assessed following the methodology outlined in Section 6.1 of the EIS and are presented in Table 8-3.

Potential environmental impacts from turbidity plumes and the settlement of suspended sediments from dredging on water quality and marine ecology are addressed in Chapters 9 and 16 respectively).

Table 8-3: Coastal Processes Risk Assessment of Key Activities.

Activity	Initial risk assessment					Mitigated risk assessment				
	Scale	**Duration**	**Impact**	**Likelihood**	**Risk**	**Scale**	**Duration**	**Impact**	**Likelihood**	**Residual risk**
Changes to coastal erosion and accretion in areas outside of the Project footprint	Local	Medium	Medium	Possible	**Medium**	Local	Medium	Medium	Not Likely	**Low**