APPENDIX 14B

MORPHODYNAMIC ASSESSMENT

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

New Zealand Government
Te Kāwanatanga o Aotearoa

Morphodynamic Modelling MBIE 2026 Update

Effects of Proposed Reclamation and Dredging Layout on the Morphodynamics

(Design July 2026)

Report prepared for MBIE

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MetOcean SOLUTIONS

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1.Introduction

Northport is a deep-water commercial port strategically situated at Marsden Point near Whangarei in Northland, New Zealand (Figure 1-1).

The Ministry of Business, Innovation and Employment (MBIE) proposes to seek approvals pursuant to the Fast-track Approvals Act 2024 for a shipyard and drydock facility (Northland Shipyard and Drydock Facility, NSDF) abutting the western side of the existing Northport facility at Marsden Point (Figure 1-2). The project includes a reclamation, vessel haul-out system, and associated wharf structures, dredging and supporting infrastructure.

Key components of the project include:

- Reclamation of approximately 9.5 hectares
- A 'cutout' to the reclamation where a vessel haul out system is to be located, being a floating drydock or potentially shiplift or other lifting mechanism
- Construction of a piled wharf structure to accommodate vessels either temporarily (before/after haul-out), or for extended periods where works not requiring haul out can be undertaken
- Capital and maintenance dredging associated with construction and ongoing operation of the marine maintenance operations facility, including a berth pocket and a vessel turning basin to provide for safe navigation
- Fixed plant and buildings to accommodate marine maintenance activities and materials
- Sufficient working and laydown areas for marine maintenance operations, including the ability to transfer vessels to hardstand
- Access to and around the marine maintenance operations facility, including a landside area for staff carparking
- Public access around the edge of the reclamation to a public fishing platform.

MetOcean Solutions (MOS, a division of the Meteorological Service of New Zealand) has already undertaken a number of numerical hydrodynamic and morphodynamic modelling and dredged plume dispersion simulations related to operations and expansion of Northport, with results presented in MOS reports P0367-01 to P0367-06 (MetOcean Solutions 2018f, 2018e, 2018d, 2018g, 2018a, 2018c), in 2021 reports P0519-01 to P0519-03 (MetOcean Solutions 2021b, 2021c, 2021a) and in 2022 reports P0519-10 to P0519-13 (MetOcean Solutions 2023, 2022a, 2022b).

This technical report provides the outcomes of morphodynamic modelling for three proposed scenarios:

1. The existing environment
2. The proposed shipyard and drydock facility (Design West, Figure 2-1); and
3. The proposed shipyard and drydock facility AND the recently consented Eastern Reclamation (Design East and West, Figure 2-2).

The morphodynamic modelling included the following tasks:

- Review and refine grid spacing in the area around the proposed reclamation and dredge footprints.
- Simulate and assess seabed morphological change associated with each design over a five-year simulation period. The results are compared against a baseline scenario representing existing bathymetry to evaluate the relative impacts of the proposed works.

The structure of this report is as follows:

- Section 2 presents the data used in the study, including the updated bathymetry and proposed designs.
- Section 3 describes the numerical model methodology and model setup.
- Results are presented in Section 4.
- Section 5 provides a summary of this report.
- A list of references is presented in Section 6.

Figure 1-1 Location of Northport within Whangarei Harbour.

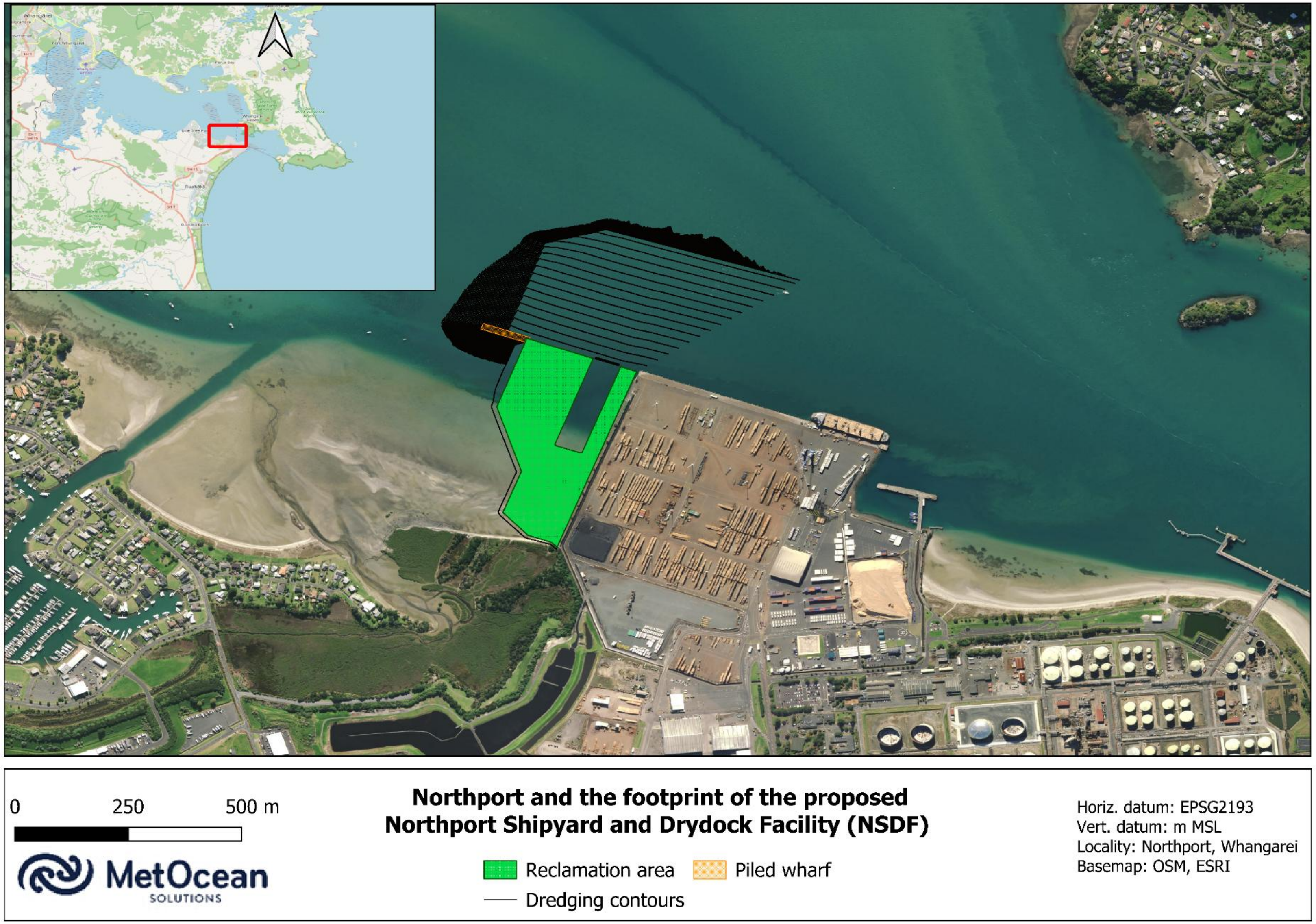

Figure 1-2 Proposed Northland Shipyard and Drydock Facility (NSDF) at Northport, Whangarei.

2. Data

2.1 Scenarios

Besides the existing harbour configuration, there are two proposed scenarios that have been modelled:

- **Design West** includes the Northland Drydock and Shipyard Facility (NDSF) proposed by MBIE (Figure 2-1), and
- **Design East and West** includes the Northland Drydock and Shipyard Facility proposed by MBIE and Northport's consented Eastern Development (reclamation and dredging) (Figure 2-2).

The three naming conventions of Existing, Design West, Design East and West are used within the simulations.

Figure 2-1 Concept drawing for the proposed area to be dredged and reclaimed for Design West.

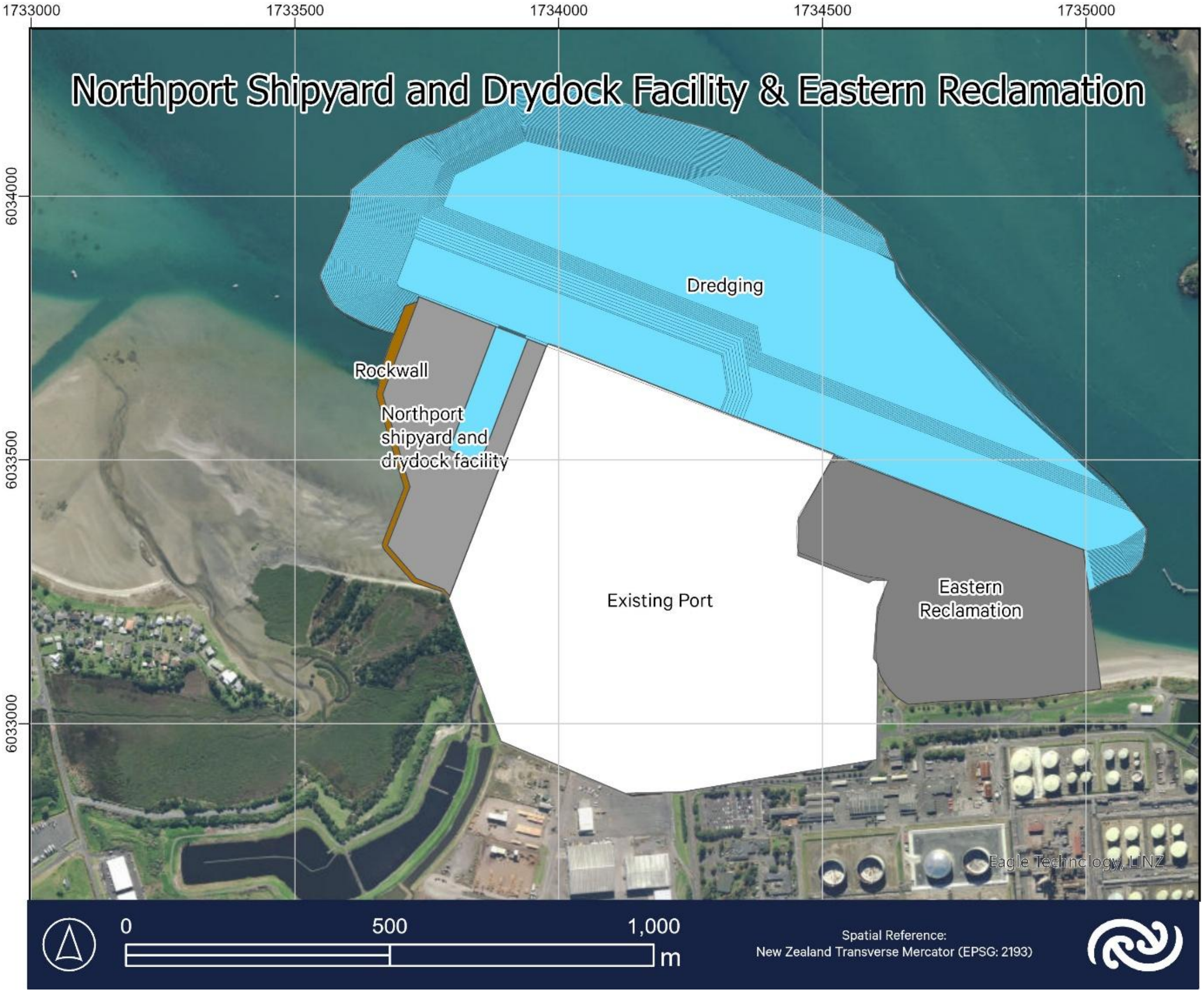

Figure 2-2 Concept drawing for the proposed area to be dredged and reclaimed for Design East and West.

2.2 Bathymetry datasets

In this study, provided, open-source, and archival bathymetric and topographic data encompassing the study area and its surroundings were identified and selected for inclusion in the bathymetry grid as summarised in Table 2-1.

The previous bathymetry dataset used in MetOcean Solutions (2022b) was updated with the latest bathymetry and topographic survey data from Table 2-1, as shown in Figure 2-3. The NDSF and eastern reclamation designs were provided by MBIE, with the designs incorporated into the existing bathymetry (Figure 2-5 to Figure 2-6).

Table 2-1 Summary of bathymetry and topographic data used for the model bathymetry.

Name	Coverage Area	Data Type	Data Acquisition Method(s)	Resolution	Vertical Datum	Source
2026 Port MBES Survey	Whangārei Harbour Channel, Marsden Bay Channel, Mair Bank Transects	Bathymetry	Multibeam Echosounder	50 cm	CD (Marsden Point)	DML Survey provided by Northport
2026 Port SBES Survey	Mair Bank and Marsden Point	Bathymetry	Singlebeam Echosounder	1 m point spacing	CD (Marsden Point)	DML Survey provided by Northport
2025 Snake Bank SBES Survey	Eastern Snake Bank	Bathymetry	Singlebeam Echosounder	20 m transects with 1 m point spacing	CD (Marsden Point)	DML Survey provided by Northport
2025 Marsden Bay SBES Survey	Nearshore areas of Marsden Bay	Bathymetry	Singlebeam Echosounder	40 m transects with 50 cm point spacing	CD (Marsden Point)	DML Survey provided by Northport
2025 Marsden Bay MBES Survey	Marsden Bay Channel and western area of Marsden Bay	Bathymetry	Multibeam Echosounder	50 cm	CD (Marsden Point)	DML Survey provided by Northport
2025 Northport MBES Survey	Northport dredging basin and proposed dredging/reclamation areas	Bathymetry	Multibeam Echosounder	50 cm	CD (Marsden Point)	DML Survey provided by Northport
2024 Ruakaka SBES Survey	Ruakaka transects	Bathymetry	Singlebeam Echosounder	20 m point spacing	NZVD	MetOcean Archive

2024 Bream Bay MBES Survey	17 km2 area in Bream Bay	Bathymetry	Multibeam Echosounder	1 m	NZVD	MetOcean Archive
2024 Portland Channel MBES Survey	Portland Channel	Bathymetry	Multibeam Echosounder	50 cm	CD (Marsden Point)	DML Survey provided by Northport
2024 Northland Lidar	Coastal areas to 0.3 m below MSL	Topography	Lidar	1 m	NZVD	LINZ Data Service
2023 Whangārei Harbour Channel MBES Survey	Whangārei Harbour Channel	Bathymetry	Multibeam Echosounder	1 m	CD (Marsden Point)	DML Survey provided by Northport
2022 MetOcean Northport Model Bathymetry	Whangarei Harbour, Northport, and Bream Bay	Bathymetry	Various	Various	MSL	MetOcean Archive
1999 Shipping Lane 1 MBES	Bream Bay shipping lane	Bathymetry	Multibeam sonar	20 m	LAT	LINZ Data Service
2026 Port MBES Survey	Whangārei Harbour Channel, Marsden Bay Channel, Mair Bank Transects	Bathymetry	Multibeam Echosounder	50 cm	CD (Marsden Point)	DML Survey provided by Northport
2026 Port SBES Survey	Mair Bank and Marsden Point	Bathymetry	Singlebeam Echosounder	1 m point spacing	CD (Marsden Point)	DML Survey provided by Northport
2025 Snake Bank SBES Survey	Eastern Snake Bank	Bathymetry	Singlebeam Echosounder	20 m transects with 1 m point spacing	CD (Marsden Point)	DML Survey provided by Northport

2025 Marsden Bay SBES Survey	Nearshore areas of Marsden Bay	Bathymetry	Singlebeam Echosounder	40 m transects with 50 cm point spacing	CD (Marsden Point)	DML Survey provided by Northport
2025 Marsden Bay MBES Survey	Marsden Bay Channel and western area of Marsden Bay	Bathymetry	Multibeam Echosounder	50 cm	CD (Marsden Point)	DML Survey provided by Northport
2025 Northport MBES Survey	Northport dredging basin and proposed dredging/reclamation areas	Bathymetry	Multibeam Echosounder	50 cm	CD (Marsden Point)	DML Survey provided by Northport
2024 Ruakaka SBES Survey	Ruakaka transects	Bathymetry	Singlebeam Echosounder	20 m point spacing	NZVD	MetOcean Archive

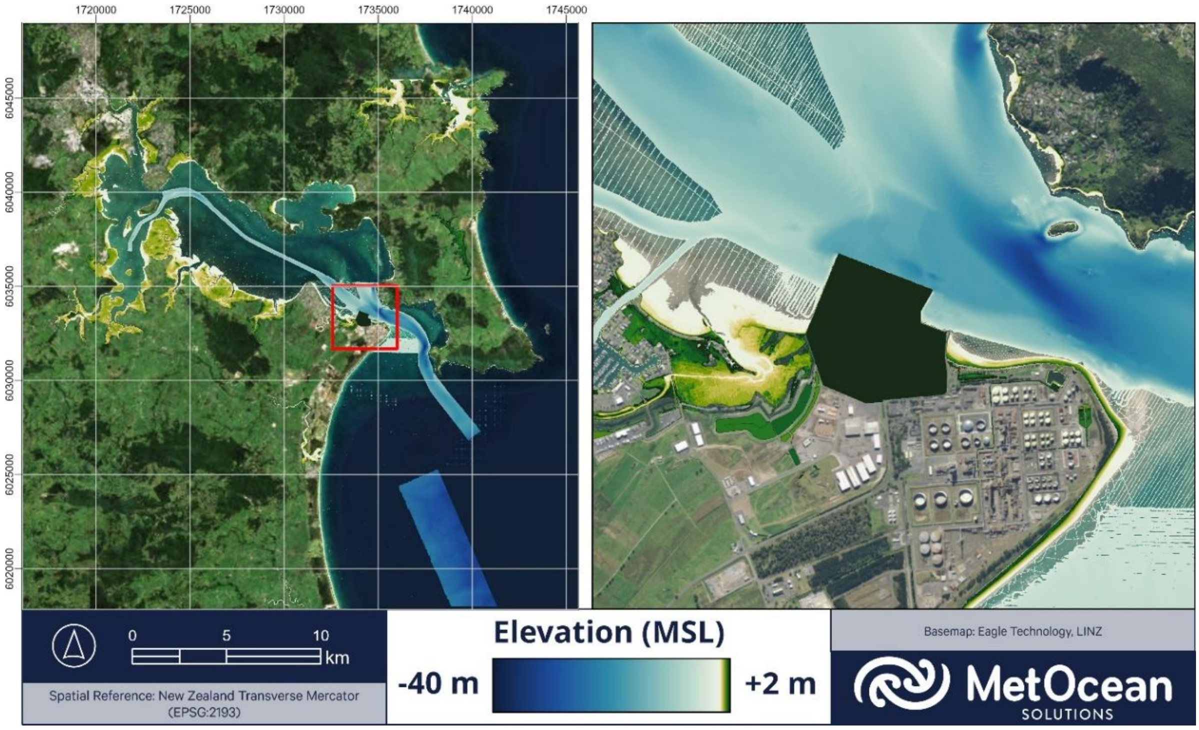

Figure 2-3 High resolution topography and bathymetry data used to update the previously constructed grid.

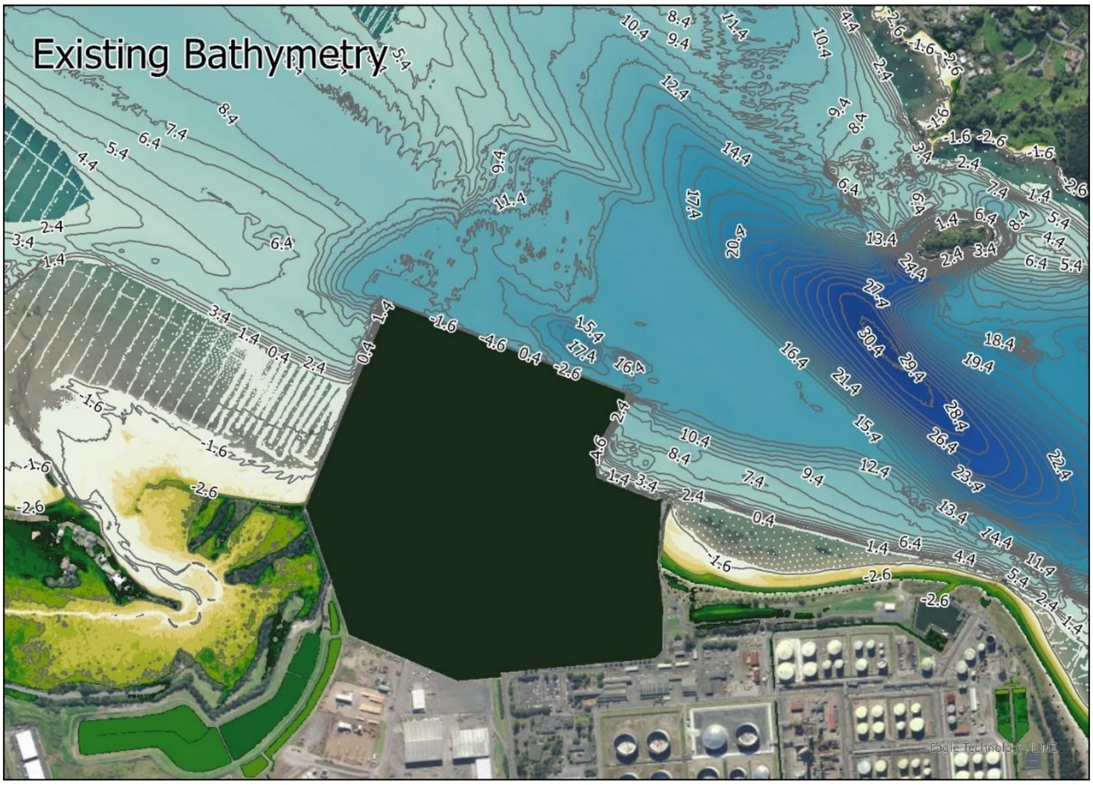

Figure 2-4 Existing bathymetry around Northport. Depths are in metres relative to CD.

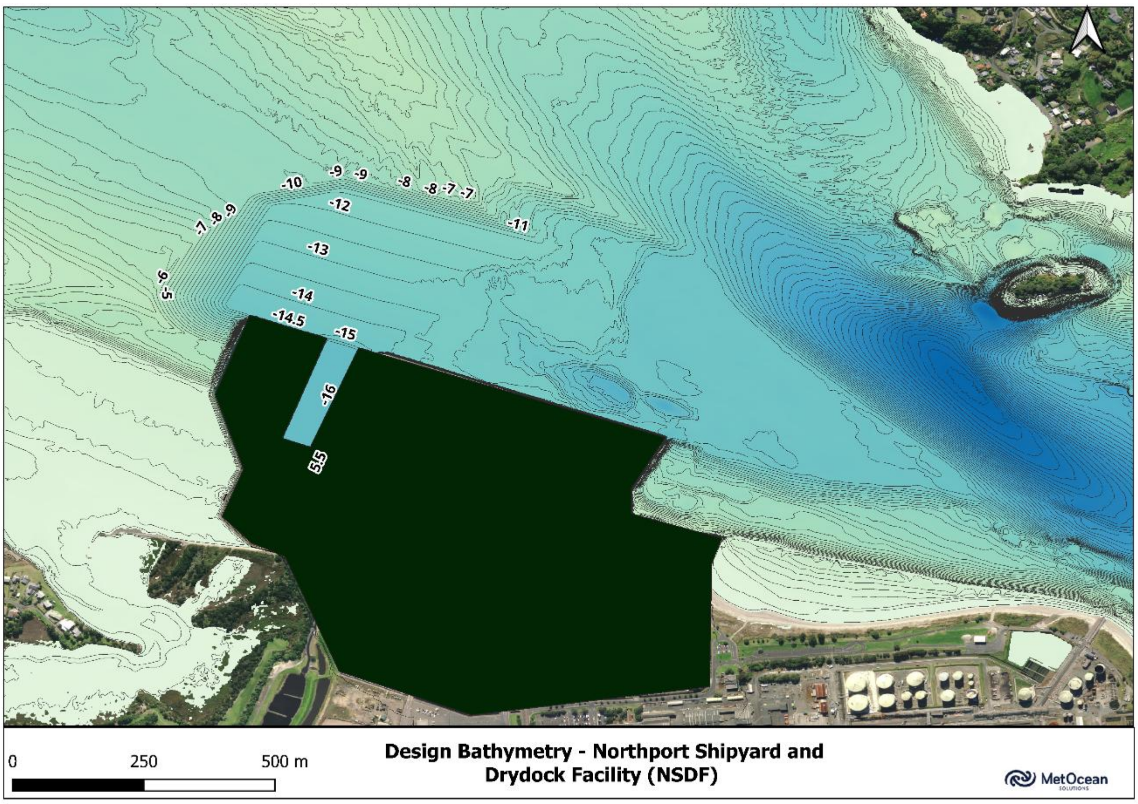

Figure 2-5 Bathymetry around Northport incorporating the Northland Shipyard and Drydock Facility design only. Depths are in metres relative to CD.

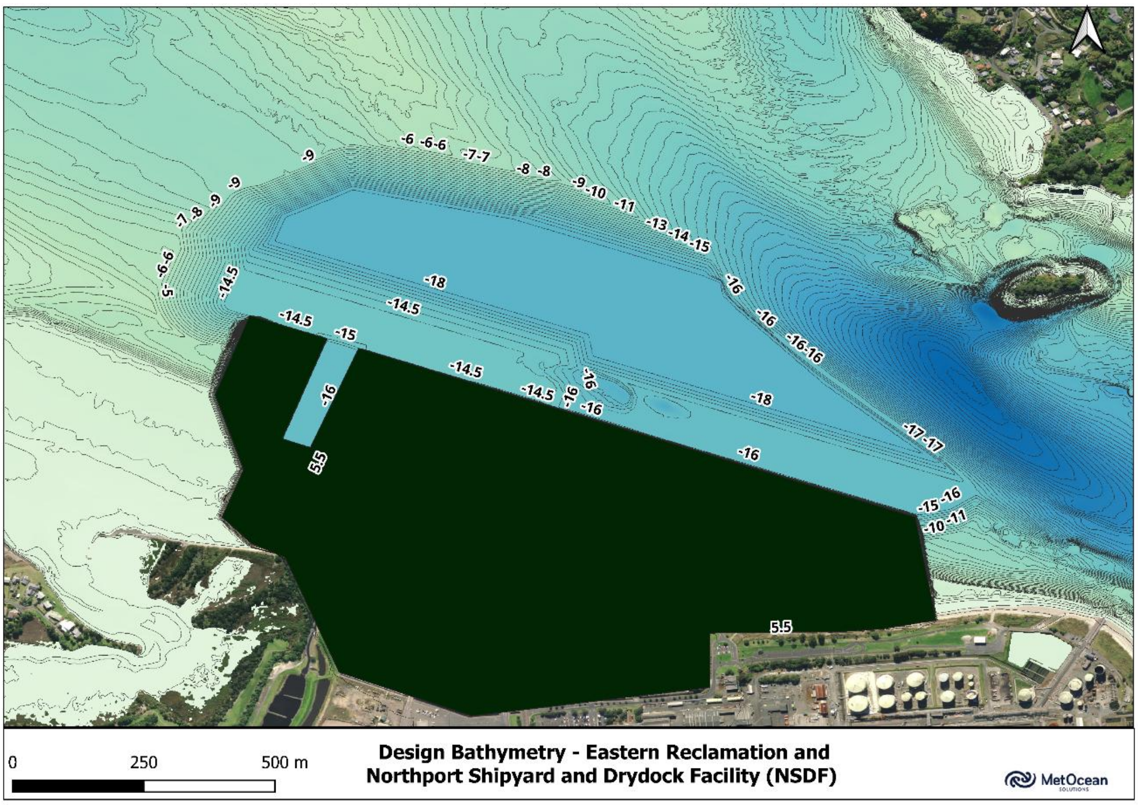

Figure 2-6 Bathymetry around Northport incorporating the Northland Shipyard and Drydock Facility and eastern reclamation designs. Depths are in metres relative to CD.

2.3 Vertical datum

Tide gauge data was used to determine the offset between Chart Datum (CD), Lowest Astronomical Tide (LAT), NZVD2016, and present day mean sea level (MSL), as shown in Figure 2-7. Tidal levels at Marsden Point were sourced from LINZ, which reports that LAT and MSL are 0.17 and 1.63 m above CD respectively. MSL (derived from data collected between 2001-2019) was calculated as 0.136 m below NZVD by Stephens & Paulik (2023). These offsets were used to convert the bathymetry and topographic datasets to a common MSL vertical datum for input to the model.

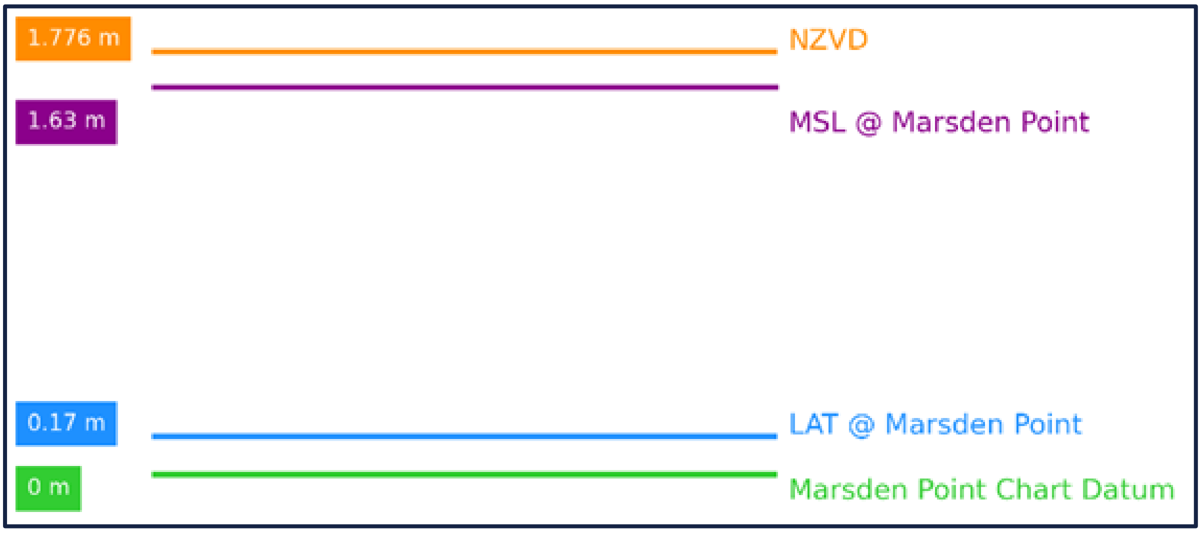

Figure 2-7 Vertical datum relationships at Marsden Point.

3.Methods

The present study applies the calibrated and validated Delft3D configuration model setup used in the previous morphodynamics studies of the environs (MetOcean Solutions 2018e). The modifications to the previous model configuration included in this study are the use of the updated bathymetry (see Section 2.2) and the grid refinement around the proposed layout (described in Section 3.2).

The modelling methodology applies an input reduction technique, which forces the model with representative wave and hydrodynamics conditions combined with morphological acceleration factors to examine sediment dynamics and morphological response within the port environs over a 5 year period.

The following sections describe the methodology used to undertake the morphodynamic modelling.

3.1 Model description

The modelling system Delft3D (Deltares 2018) is based on interlinking three separate components (Delft3D – WAVE, Delft3D – FLOW and Delft3D – MOR) that together simulate multi-dimensional hydrodynamic flows, waves and sediment transport. The three components are fully coupled.

Delft3D has been specifically developed to simulate the dynamics of complex coastal regions controlled by a wide range of physical and morphodynamic processes. Delft3D has been successfully applied worldwide to a wide range of coastal studies, including, within the New Zealand context, Port Otago (Weppe et al. 2015), Tauranga Harbour (Ramli et al. 2015), Rees River (Williams et al. 2016), Eastland Port (MetOcean Solutions 2019, 2020, 2018b), and Lyttelton Port (MetOcean Solutions 2026) .

The following subsections give a brief description of the different Delft3D modules used in this study.

Delft3D - WAVE

The third-generation SWAN model (Simulating WAves Nearshore) is used in the wave module (Booij et al. 1999; Ris et al. 1999). SWAN computes the evolution of random, short-crested waves in coastal regions with deep, intermediate and shallow water depths. Wave forces computed by the wave module on the basis of the radiation shear stress gradients can be used as a driving force to compute the wave-induced currents and set-up in the flow module.

Delft3D - FLOW

The hydrodynamic module is a 2D or 3D hydrodynamic model which calculates non-steady flows and transport processes. Delft3D – FLOW solves the Navier – Stokes equations on a staggered model grid for an incompressible fluid under the shallow water and Boussinesq assumptions. The system solves the horizontal equations of motion, the continuity equation, the transport equations for conservative constituents and a turbulence closure scheme.

Delft3D – MOR

The sediment transport module integrates the effects of waves and currents. At each computational time step the model computes both bedload and suspended-load sediment transport components within the model domain. The bed level is then updated as a result of sediment sink and sources terms and transport gradients. The model is able to simulate the sediment dynamics associated with both non-cohesive (sandy) and cohesive (silt/mud) sediments.

3.2 Model domain

The same model domain configuration from the calibration and validation modelling exercise is used in this study. The model was run using a nested approach as follows:

- The wave modelling consisted in a two-level nesting approach in Delft3D – WAVE allowing the retention of spatial variability in the incident wave field due to large scale regional refraction and sheltering effects. Open-boundary conditions were prescribed using constant wave parameters (significant wave height, peak period, direction and directional spreading) associated with each simulated input reduction scenario. The regional (coarse) wave grid extended approximately 120 km offshore Whangarei Head with resolutions ranging from 490 m to 3300 m (Figure 3-1, green grid) and higher resolution (11 m to 260 m) for the intermediate grid (Figure 3-2, dark blue grid).

- A model curvilinear grid was applied in the hydrodynamic and morphodynamic simulations and covered the tidal inlet entrance from northern Bream Bay to One Tree Point (Figure 3-2, light blue grid). The grid resolution varied from 10 m to 100 m focusing on Northport and the adjacent swinging basin (Figure 3-3). The updated grid consisted of 220 by 545 cells.

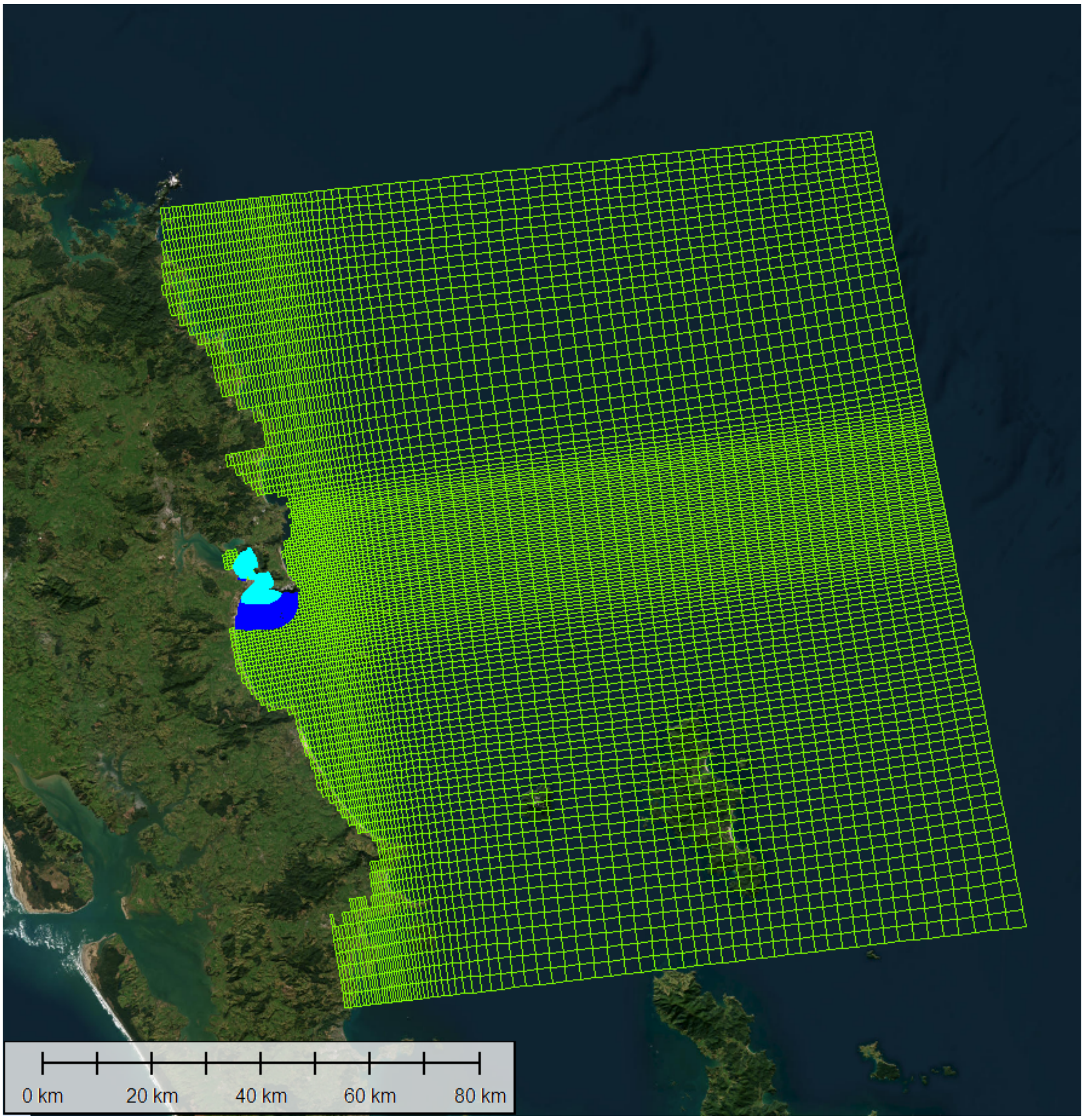

Figure 3-1 Map showing the two-level nesting strategy (green and dark blue grids) applied in SWAN (Delft3D – WAVE) to replicate the wave dynamics from northern Hauraki Gulf to Whangarei Harbour. The coarse grid resolution varies from 490 m to 3300 m and the intermediate grid ranges between 11 m and 260 m focusing on Northport and the adjacent swinging basin. Light blue grid is used in the hydrodynamic and morphodynamic simulations.

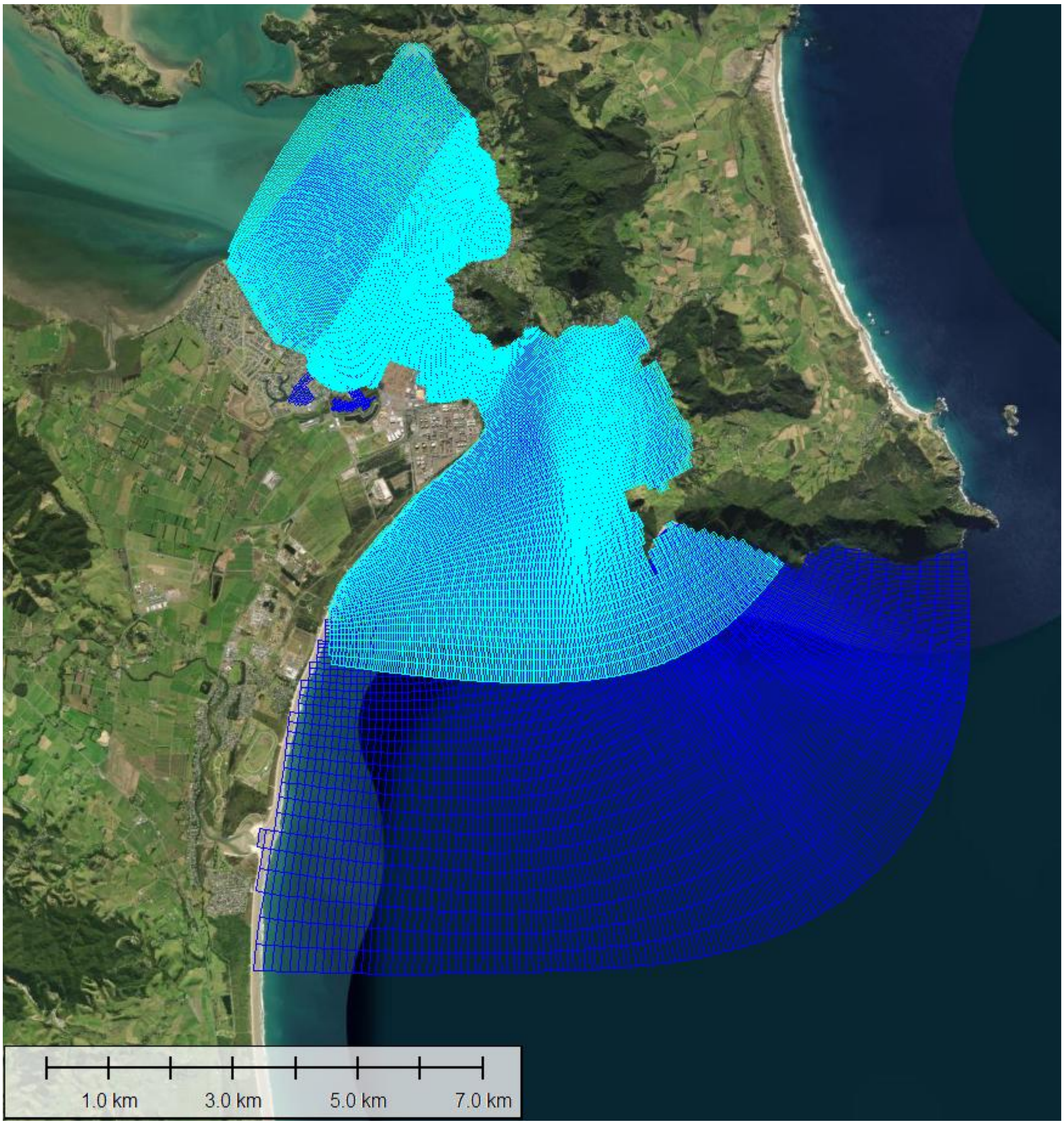

Figure 3-2 Map showing the intermediate wave grid (dark blue) and the Delft3D – FLOW and MOR grids used to replicate the hydro- and morphodynamics over the entrance to Whangarei Harbour. The resolution of the fine grid (light blue) varies from 10 m to 100 m.

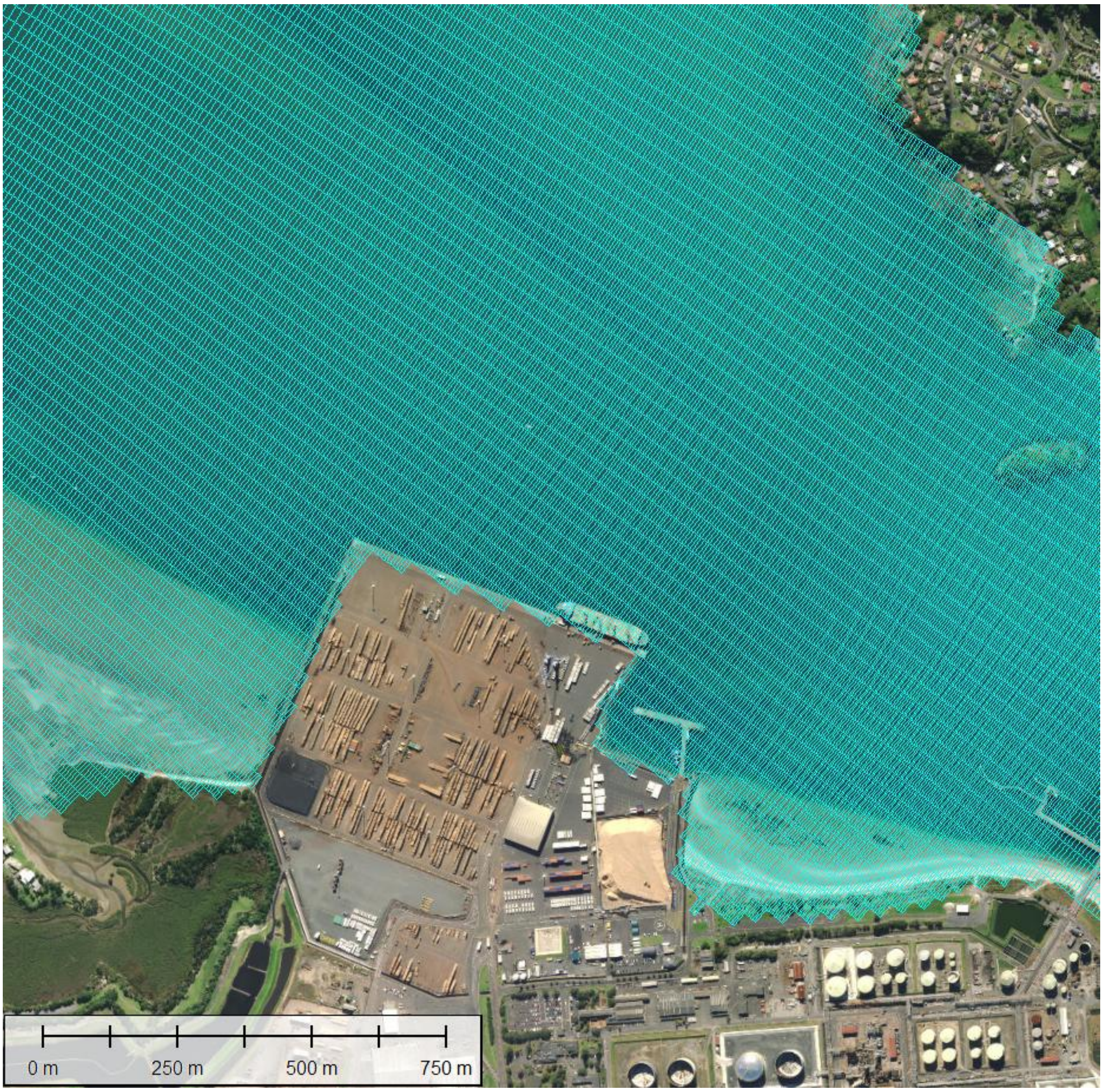

Figure 3-3 Detail of the Delft3D – FLOW and MOR grid showing the higher resolution at Northport and environs.

3.3 Model bathymetry

The updated existing bathymetry was used as the base for the Existing model layout presented in Figure 3-4. The bathymetry dataset constructed as described in Section 2.2, was interpolated onto the model grid with various resolutions. Similarly, the proposed 'Design West' and 'Design East and West', including reclamation and dredged areas, were interpolated onto the model grid, as shown in Figure 3-5 and Figure 3-6, respectively. Depths in Delft3D are relative to mean sea level (MSL).

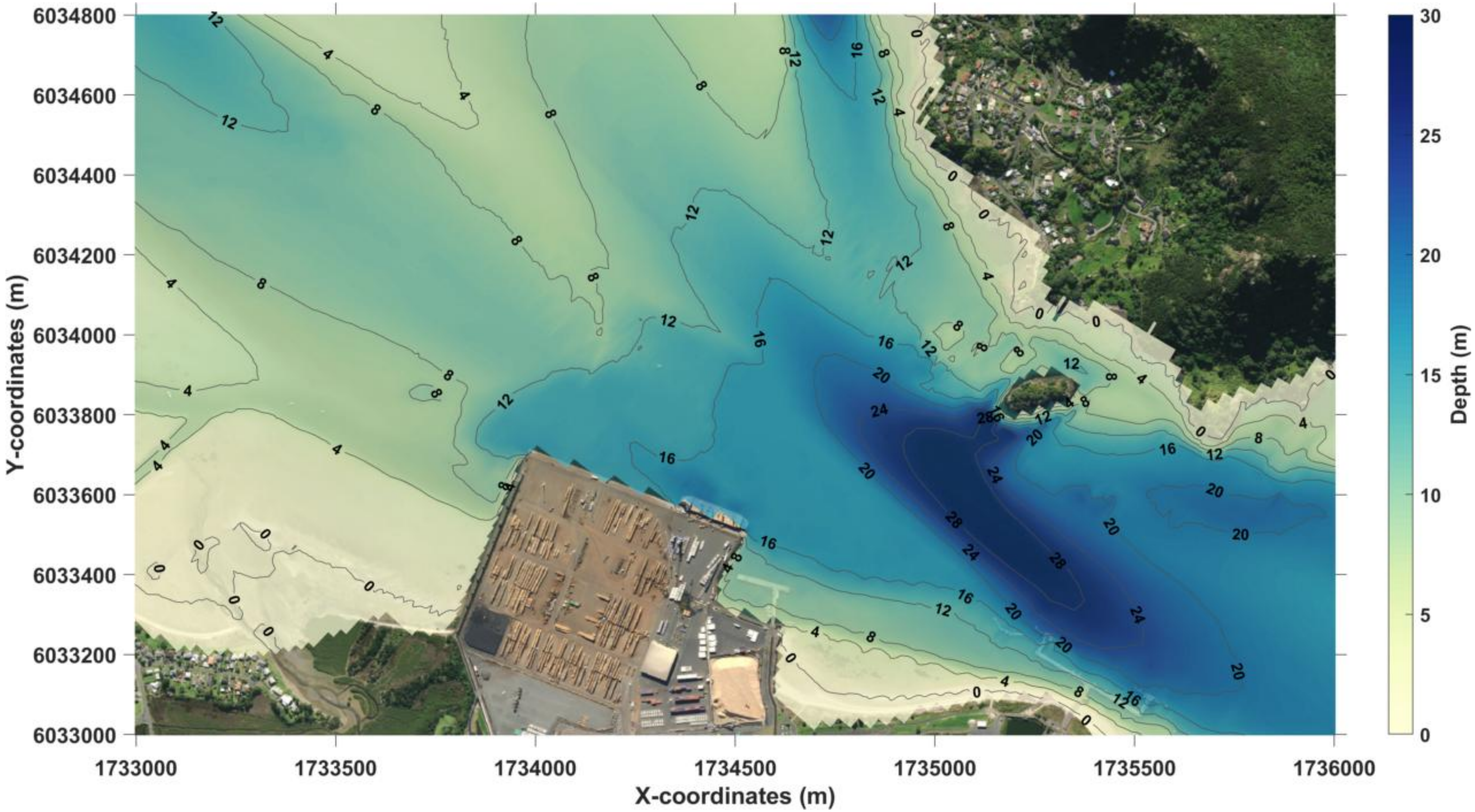

*Figure 3-4 Delft3D bathymetry for the **Existing** case. Depth relative to mean sea level.*

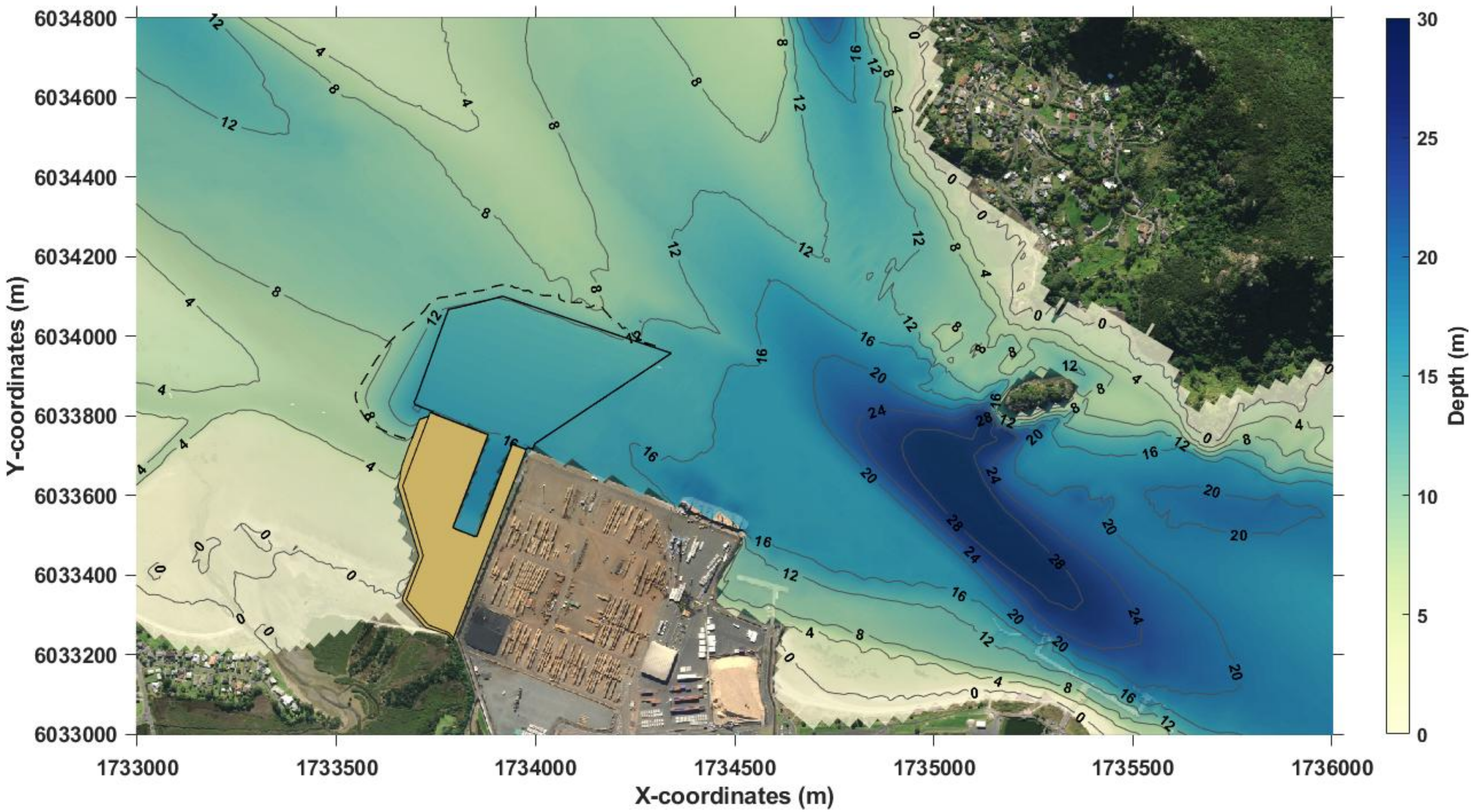

Figure 3-5 Delft3D bathymetry for the Northland Shipyard and Drydock Facility design case ***(Design West****). Depth relative to mean sea level. Filled polygons represent the reclamation and rockwall areas, solid black line polygon represents the dredge footprint and dashed black polygon represents the batter slope area.*

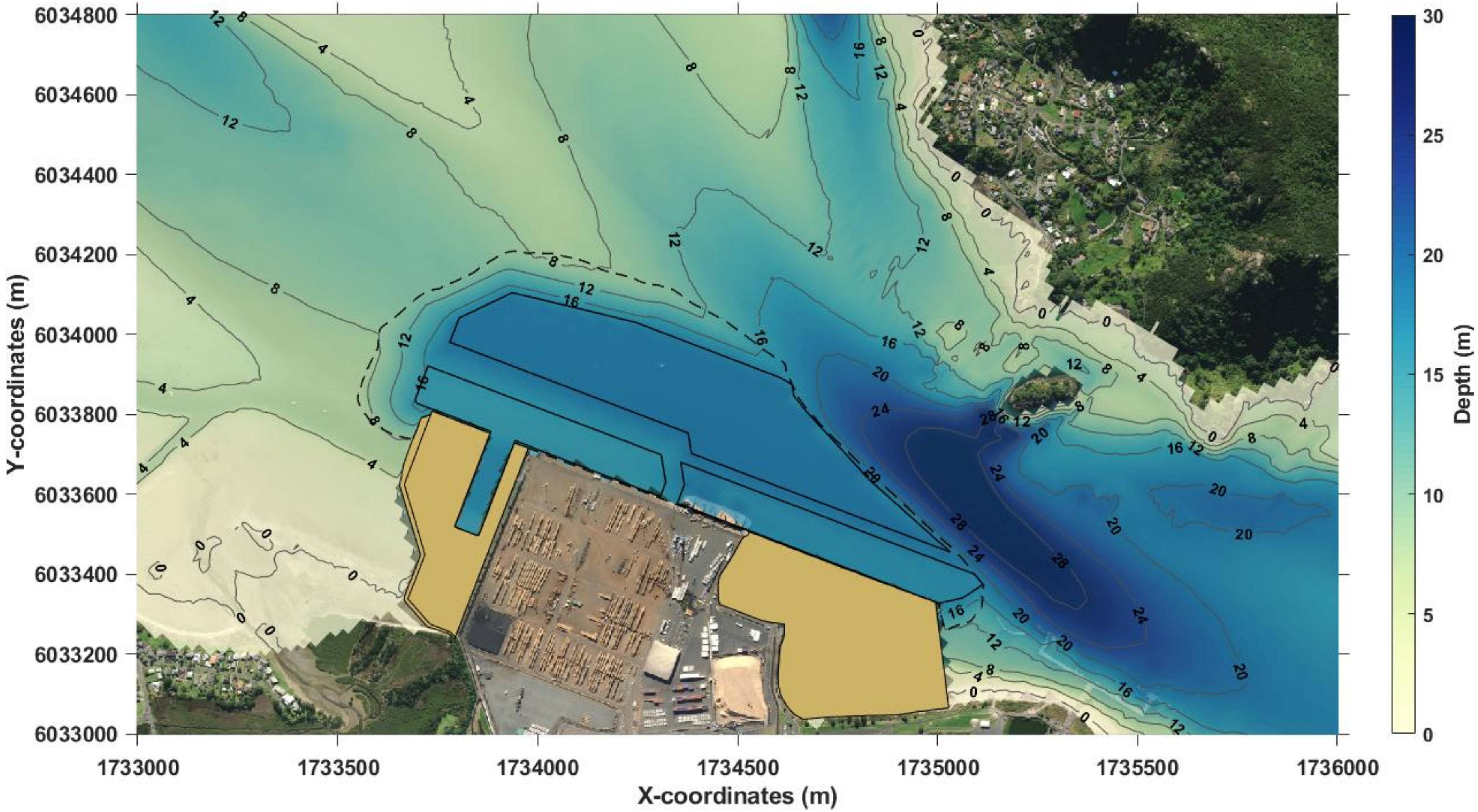

*Figure 3-6 Delft3D bathymetry for the Northland Shipyard and Drydock Facility and Eastern Reclamation design case (**Design East and West**). Depth relative to mean sea level. Filled polygons represent the reclamation areas, solid black line polygons represent the dredge footprint and dashed black polygons represent the batter slope areas.*

3.4 Initial bed composition

An accurate definition of the surficial sediment grain size distribution in the area of interest plays an important role in determining sediment dynamics and morphological response. As such, a sedimentological spin-up following a bed stratigraphy approach was carried out in MetOcean Solutions (2018e), whereby the spatial surficial sediment distribution was allowed to adjust to the *in-situ* bed shear-stresses associated with both hydrodynamics and wave forcing. The derived surficial sediment grain size distributions are then applied to the bathymetry being considered.

To ensure good model performances in replicating channel and sand bank dynamics, eight non-cohesive sediment classes were defined in Delft3D – MOR with grain sizes ranging from 100 µm to 2000 µm (Table 3-1).

Table 3-1 Sediment classes defined in Delft3D.

Sediment class	Grain size (µm)
Class 1	2000
Class 2	1200
Class 3	800
Class 4	500
Class 5	350
Class 6	250
Class 7	180
Class 8	100

3.5 Model forcing

The main challenge when applying process-based models to predict coastal and estuarine dynamics is that the morphology of these systems generally develops over time scales several orders of magnitude larger than the time scale of the hydrodynamic fluctuations driving the sediment transport (i.e. hours to days versus years to decades and more). This means that a model system that is able to predict the time series of instantaneous hydrodynamics and sediment transport will require a considerable computation runtime.

Several strategies are commonly used to simplify and accelerate the modelling of medium to long term morphological evolution (i.e. De Vriend et al. 1993; Roelvink 2006).

The approach employed in this study combines the reduction of the input forcing with the use of morphological acceleration factors, which is one of the most commonly applied methods and an industry standard technique.

The medium-term morphodynamic modelling was performed based on the reduction of waves and tides over 365 days using data from 2016 to 2017. Input reduction essentially means selecting a limited number of representative forcing conditions that will reproduce the medium-term residual sediment transport patterns and associated morphological evolution (De Vriend et al. 1993). The morphological factor is a technique to improve computational efficiency by accelerating computed morphological evolution.

Winds, waves and tidal currents are as defined in MetOcean Solutions (2018e). These are applied to the existing and both design cases to allow the comparison of the effect of the proposed dredging and land reclamation on the sediment dynamics and morphological response. Model derived tidal constituents are used to define the Delft3D–FLOW boundary tidal currents (MetOcean Solutions 2018e).

A summary of the wave classes used for the medium-term modelling from 2016 to 2017 is provided in Table 3-2. A total of 16 classes were used to represent the potential for sediment transport over a year. An overview of other model parameters and settings used within Delft3D are provided in MetOcean Solutions (2018e).

Bathymetry was updated at the conclusion of each simulation run and subsequently incorporated into following runs, thereby cumulatively capturing bathymetric changes over the five-year period presented in this report.

Table 3-2 Wave classification based on an average annual wave climate defined from hindcast data over 2016 (data from MetOcean Solutions 2018d). MORFAC = morphological factor.

Class	Representative H_s (m)	Representative T_p (s)	Representative D_p (deg.)	Probability of occurrence (%)	MORFAC
1	1.62	9.34	34.40	15.10%	106.50
2	2.40	10.57	35.33	4.75%	33.48
3	2.92	9.38	35.49	2.66%	18.79
4	4.12	10.57	31.18	1.37%	9.63
5	1.35	9.23	82.25	21.58%	152.20
6	1.99	9.23	83.42	7.92%	55.87
7	2.82	11.53	80.41	2.94%	20.71
8	4.31	11.88	91.19	1.40%	9.87
9	1.59	7.14	198.10	15.27%	107.70
10	2.50	8.19	185.10	4.85%	34.20
11	3.68	9.10	143.70	1.71%	12.04
12	6.64	12.09	119.90	0.48%	3.37
13	1.70	8.45	333.10	13.15%	92.72
14	2.70	8.48	328.40	3.72%	26.25
15	3.42	8.69	323.40	2.02%	14.21
16	4.50	9.40	319.40	1.06%	7.47

4. Results

4.1 Sediment Transport

Sediment transport is driven by hydrodynamic processes, primarily waves and currents, which generate bed shears stresses capable of mobilising and transport sediments.

In this section, we present examples of model predicted sediment transport for the Existing, Design West, and Design East and West cases in Figure 4-1 for Year 5. The figures show the modelled potential for sediment movement averaged over a tidal cycle (i.e. the set sediment transport over a tidal cycle) under three contrasting wave conditions (namely Class 5, 12 and 15 as per Table 3-2). Areas shown in purple indicate the highest potential for transport, while lower transport potential is represented by cooler blue colours.

The examples illustrate that, in general, higher wave energy and faster current velocities increase the potential for sediment movement which is illustrated by the relatively higher transport rates predicted under wave class 12 (Figure 4-1, middle panel) and within the narrower sections of the channel. Changes in bathymetry, such as resulting from dredging, can result in changes to local hydrodynamic conditions and therefore influence the potential for sediment transport relative to the existing conditions.

These maps of potential sediment transport show the model capacity to respond to changes in wave and tidal conditions. They do not directly indicate areas of sediment deposition or erosion, as these depend on the cumulative balance of sediment deposition and erosion over time and across all hydrodynamic conditions. Therefore, sediment transport patterns reflect the underlying hydrodynamic conditions and indicate where sediment is likely to be mobilised, rather than where it will ultimately accumulate or erode.

A total of 16 wave classes were simulated (see Table 3-2). The results from all wave classes were used to determine the net sediment movement and resulting patterns of erosion and deposition presented in Section 4.2.

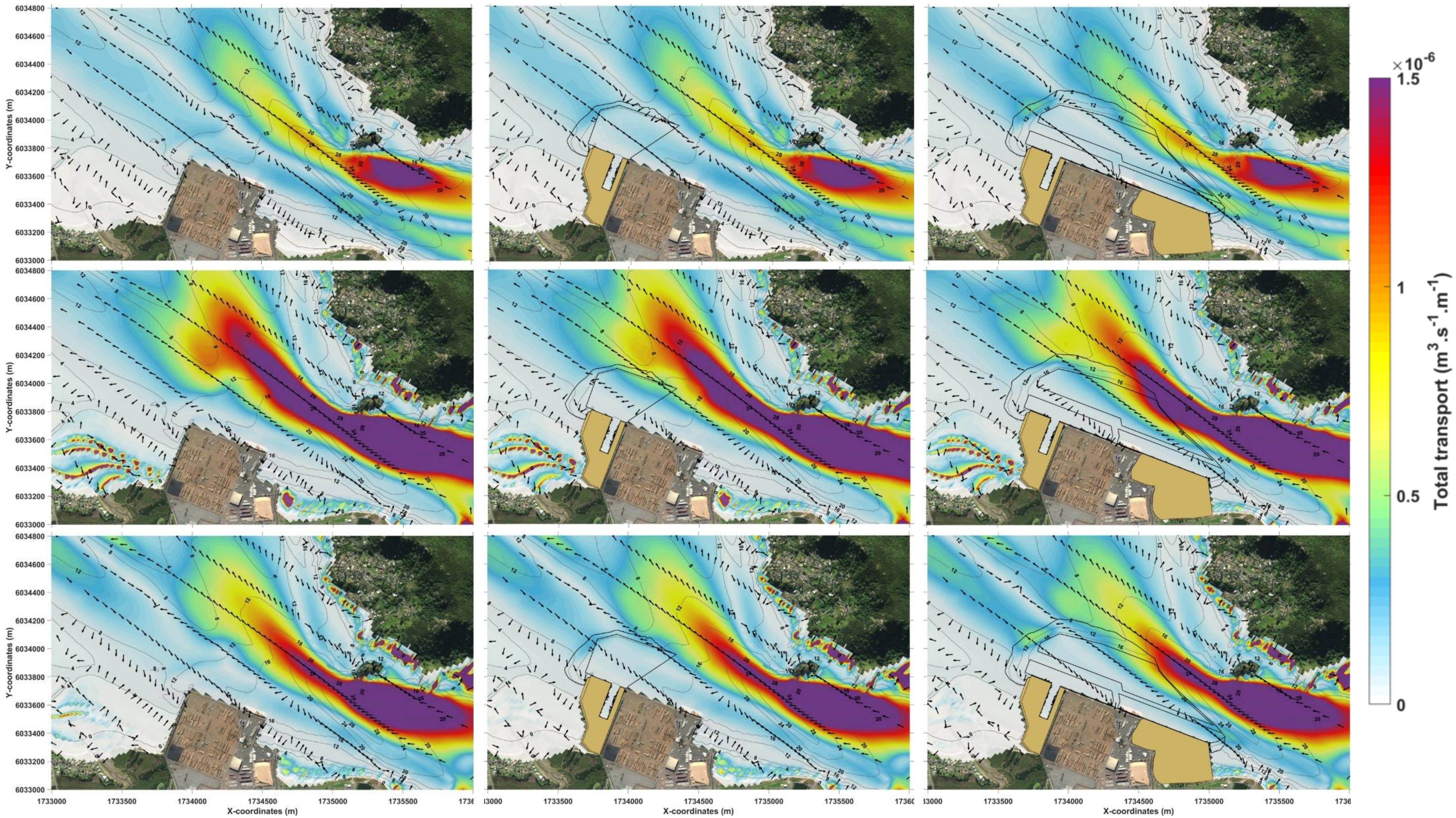

Figure 4-1 Example of potential for sediment transport at Northport averaged over one tidal cycle (~12.25 hours) for the ***Existing*** *(left column), the* ***Design West*** *(middle column) and the* ***Design East and West*** *(right column) cases for the* ***5[st] year*** *simulation for boundaries forced with* ***wave class 5*** *(top row),* ***wave class 12*** *(middle row), and* ***wave class 15*** *(bottom row). Solid black line polygons represent the design footprint.*

4.2 Morphological Changes

This section presents the predicted morphological response to the proposed design scenarios. Depth change maps are provided to illustrate the distribution of sedimentation and erosion at the end of the simulation period. The results from all wave classes were used to determine the resulting patterns of erosion and deposition.

Depth changes for the existing case are presented in both Figure 4-2 and Figure 4-3 in the left panels. Depth change for the Design West case is presented in Figure 4-2 (middle panels) and for the Design East and West case in Figure 4-3 (middle panels).

To isolate the morphological response of the proposed designs, and illustrate seabed changes outside the proposed dredging footprints, the proposed cases are compared against the existing configuration, following the equation:

$$Response = (Design_{end} - Design_{start}) - (Existing_{end} - Existing_{start}) \tag{4.1}$$

where $\boldsymbol{Design_{end}}$ and $\boldsymbol{Design_{start}}$ are the bathymetry at the end and start of the model simulation using the design configurations, and $\boldsymbol{Existing_{end}}$ and $\boldsymbol{Existing_{start}}$ are the existing bathymetry at the start and end of model simulation, respectively. The results from this equation are presented as difference maps in Figure 4-2 and Figure 4-3 (right panels).

In general, depth changes associated with the design configurations are expected to be predominantly limited to the immediate port environs, with only subtle modifications to overall sediment dynamics within the broader region (Figure 4-2 and Figure 4-3, right panel). Depth differences within the dredging areas are a combination of the different initial bathymetries (existing vs. dredging) adopted for the existing and proposed scenarios and the morphodynamic changes.

The largest morphological changes are predicted to occur within the dredging footprints of the proposed designs and immediate environs. Greater changes occur along the batter slopes, predominantly northwest of the dredged areas for both designs (Figure 4-2 and Figure 4-3, middle panels). Predicted deposition within the batter slope to the west of the proposed designs reaches a localised maximum of approximately 0.4 m (Design West) and 0.5 m (Design East and West) at the end of the 1st year simulation and 1.5 m (Design West) and 1.8 m (Design East and West) at the end of the 5th year. These maximum values occur over limited areas and decrease progressively away from the areas of peak deposition.

These changes are attributed to increased transport resulting in erosion of the upper batter slopes and deposition further down the slopes, indicating a gradual adjustment towards a more stable equilibrium profile. Therefore, most predicted change represents the redistribution of sediment within the batter slope areas. Cumulative seabed changes are more pronounced after 5 years of simulation (Figure 4-2 and Figure 4-3, bottom middle panels). Other areas within the design footprints may also experience localised erosion and deposition.

A reduction in transport rates associated with changes in current velocities due to reclamation sheltering effects resulted in small, localised increases in sediment deposition. For the Design West case, a localised increase in sediment deposition is observed immediately west of the reclamation area, particularly along the 0-m contour Figure 4-2, right panel). The maximum deposition is in the order of 0.4 m at the end of the 5th year.

Similarly, for the Design East and West case, small, localised increases in sediment deposition are observed immediately west of the NDSF area in the same order of magnitude. Reduced transport rates associated with lower current velocities east of the eastern reclamation area also results in localised sediment deposition, with maximum deposition in the order of 0.7 m at the end of the 5th year (Figure 4-3, right panel).

The key differences between the existing and design cases are mainly attributed to a combination of dredging (deepening) and slope changes, affecting sediment transport rates and the redistribution of sand wave features previously present in the area (MetOcean Solutions 2018e).

Within Marsden Bay, localised changes in sediment transport rates are not expected to alter the overall morphology of the bay, resulting in minor to less than minor, localised adjustments in seabed morphology.

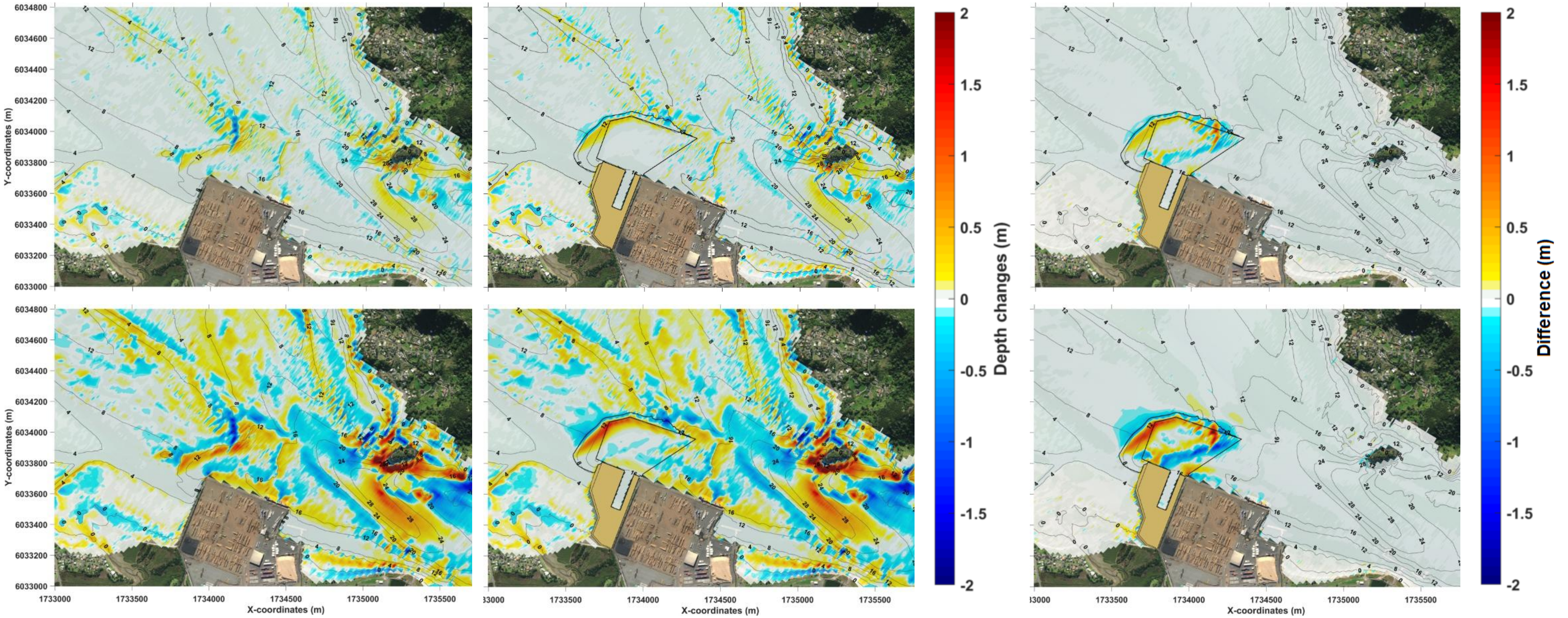

Figure 4-2 *Predicted depth change at Northport for the* ***Existing*** *(left column) and the* ***Design West*** *(middle column) cases for the* ***1st year*** *(top) and* ***5th year*** *(bottom) simulations. The difference between the design and existing cases is shown in the right column. Solid black line polygons represent the design footprint.*

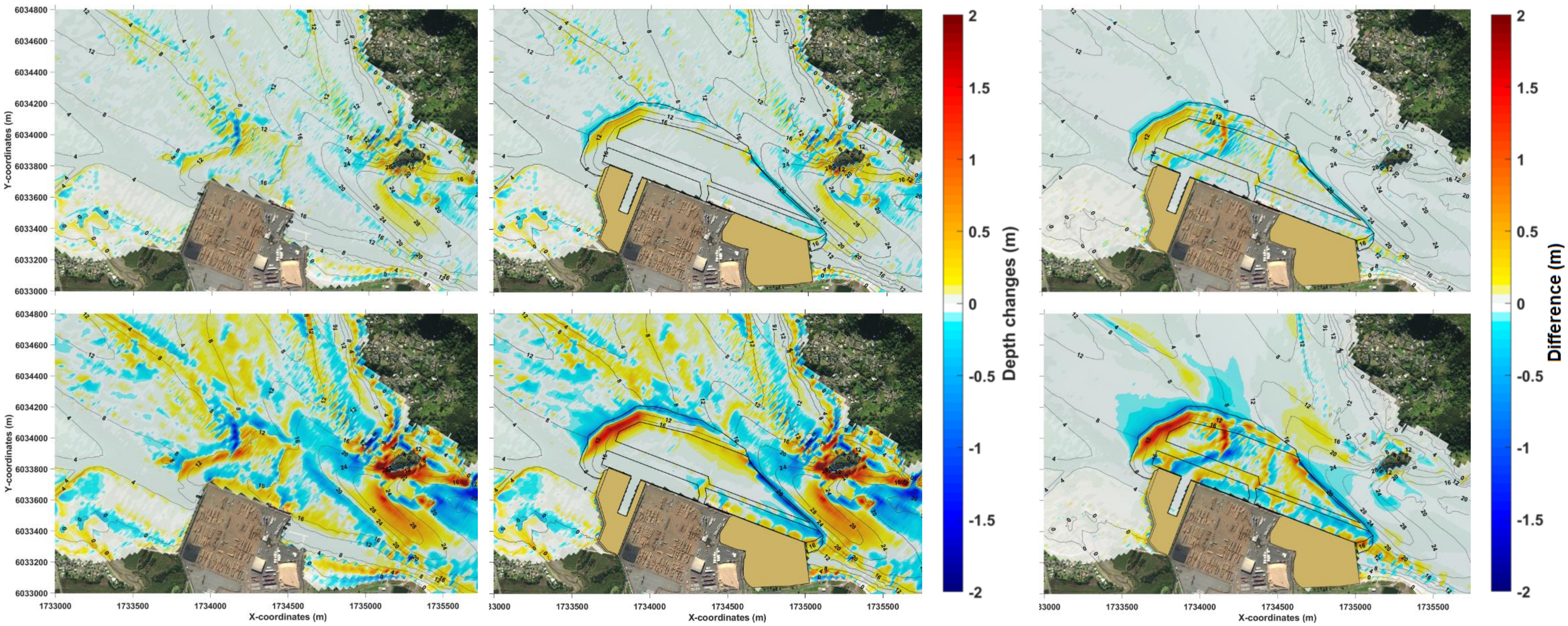

Figure 4-3 Predicted depth change at Northport for the ***Existing*** *(left column) and the* ***Design East and West*** *(middle column) cases for the* ***1st year*** *(top) and* ***5th year*** *(bottom) simulations. The difference between the design and existing cases is shown in the right column. Solid black line polygons represent the design footprint.*

4.3 Infilling Rates

Infilling and erosion volumes within the proposed dredging areas (Figure 4-4), are provided in Table 4-1 for the Design West footprint and Table 4-2 for the Design East and West footprint. Calculations were undertaken separately for the two design cases.

The infill volume after 1 year for the Design West case is estimated at 8,290 m^3 within the total footprint combined (Table 4-1). Most of the infilling occurs within the batter slope area, with 4,480 m^3 and the northwest region within A1, adjacent to the batter. Some erosion is also predicted within the footprint (-3,953 m^3). The net sediment volume change within the entire Design West dredging footprint, calculated as total deposition minus total erosion, is 4,337 m^3.

The infill volume after 5 years for the Design West case is approximately 19,598 m^3 across the batter slope and dredged areas combined. Approximately 8,291 m^3 of this volume is deposited within the batter slope area alone (Table 4-1) and the north and northwest region within A1 adjacent to the batter (Figure 4-2), indicating that deposition remains concentrated within the northwest area of the dredge footprint.

Infill volumes are higher for the Design East and West case, as expected, as a result of the larger area considered in the calculations (Figure 4-4). After 1 year, the total infill volume within the batter slope and dredged areas combined is 18,706 m^3 (Table 4-2). Total erosion volume is -11,767 m^3. Deposition and erosion volumes are greater within batter slopes (12,656 m^3 and -6,632 m^3, respectively) compared to the areas A1, A2 and A3 (Table 4-2). The net volume change for the entire Design East and West footprint, calculated as total deposition minus total erosion, is 6,939 m^3.

After 5 years, the total infill volume calculated for the Design East and West case is 76,220 m^3 (Table 4-2). The greatest deposition occurs within batter slopes (48,558 m^3). Total eroded volume is -45,527 m^3, with the greatest erosion also occurring within the batter slope areas. The net sediment volume change for the entire Design East and West dredging footprint, calculated as total deposition minus total erosion, is 30,693 m^3.

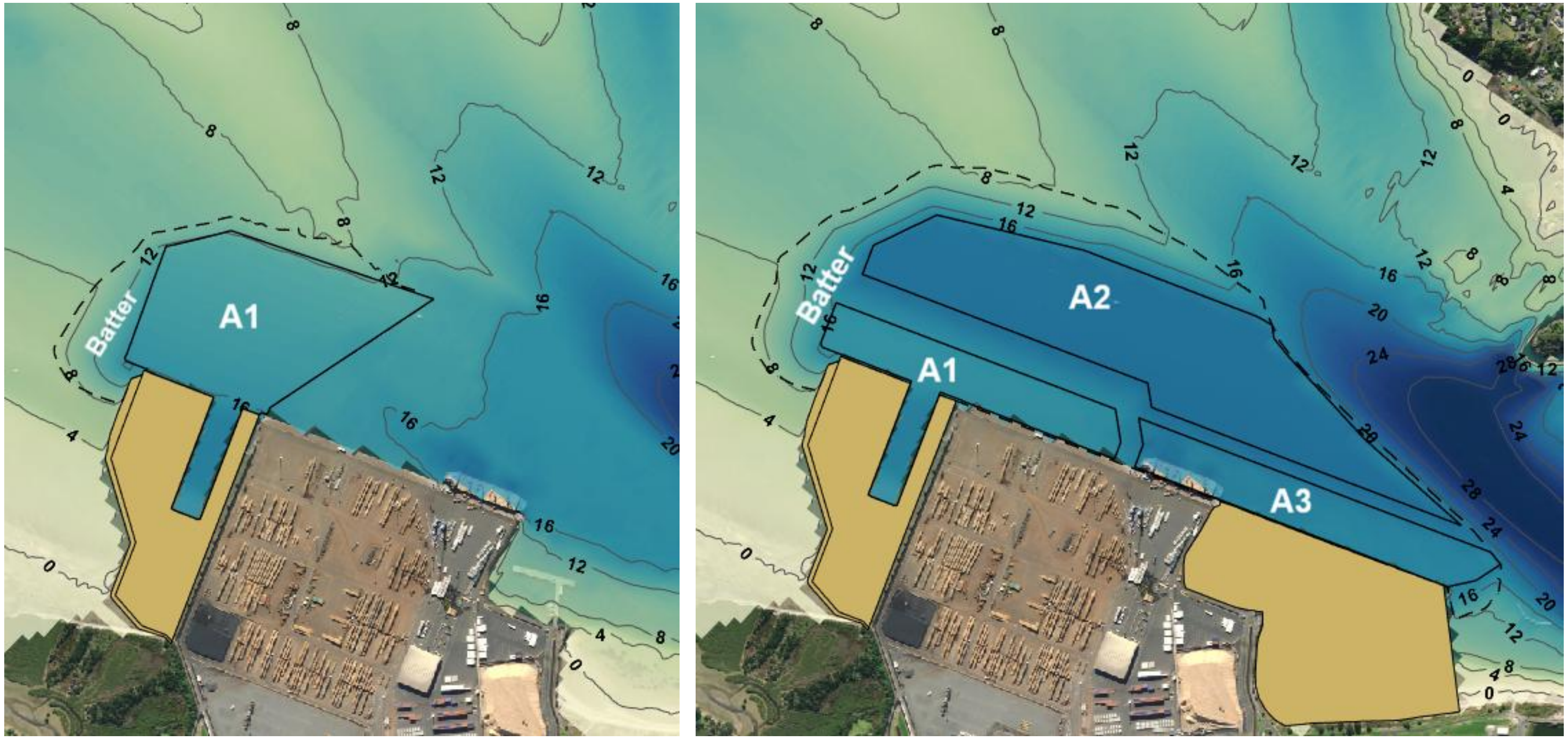

Figure 4-4 Areas used for the calculation of the infilling rates. Total areas are within the dashed polygons and include batters plus area A1 (Design West) and batters plus areas A1, A2, and A3 (Design East and West)

Table 4-1 Predicted infill volumes (m^3) after 1 year and 5 years simulation of the Design West case.

		Total Area	Area A1	Batter only (Total Area – A1)
1 year	Infilling	8,290	3,810	4,480
	Erosion	-3,953	-1,542	-2,411
	Net	**4,337**	**2,268**	**2,069**
5 years	Infilling	31,114	16,522	14,592
	Erosion	-11,516	-5,215	--6,301
	Net	**19,598**	**11,307**	**8,291**

Table 4-2 Predicted infill volumes (m^3) after 1 year and 5 years simulation of the Design East and West case.

		Total Area	Area A1	Area A2	Area A3	Batters only Total Area – (A1+A2+A3)
1 year	Infilling	18,706	331	4,144	1,575	12,656
	Erosion	-11,767	-87	-2599	-2448	-6,632
	Net	**6,939**	**244**	**-2,599**	**-2,448**	**-6,632**
5 years	Infilling	76,220	1,402	19,451	6,809	48,558
	Erosion	-45,527	-391	-10,218	-11,044	-23,875
	Net	**30,693**	**1,011**	**9,233**	**-4,235**	**24,683**

4.4 Profiles

The morphological response (depth changes) of the batter slopes to the two designs after 1 and 5 years are presented along two transects for Design West and three transects for Design East and West cases, as shown in Figure 4-5.

In general, the main morphological changes are similar across the analysed profiles, characterised by erosion along the crest of the batter and deposition on the slope and at the toe. This pattern is consistent with the adjustment of the batter slopes towards a more stable equilibrium profile shape, as the system responds to the modified bathymetry over time.

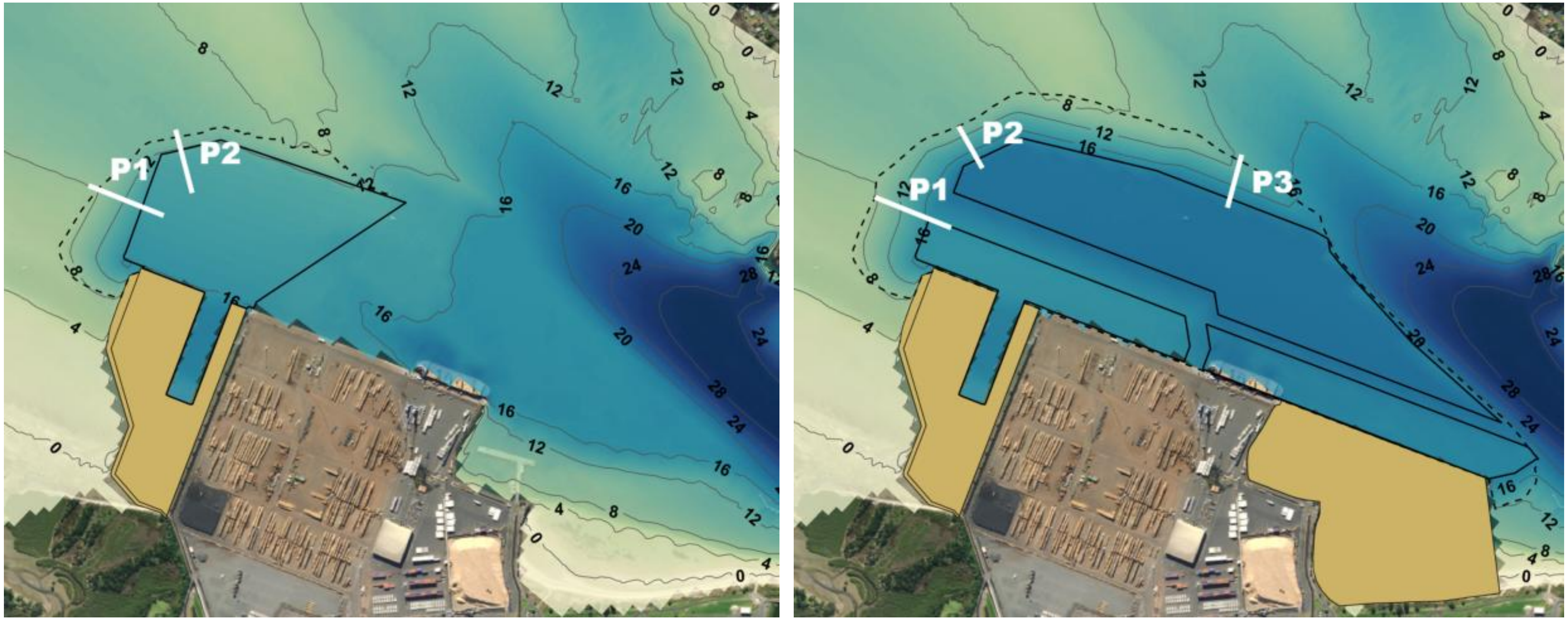

Figure 4-5 Profiles (white lines) across batter slopes of the Design West case (left) and Design East and West case (right).

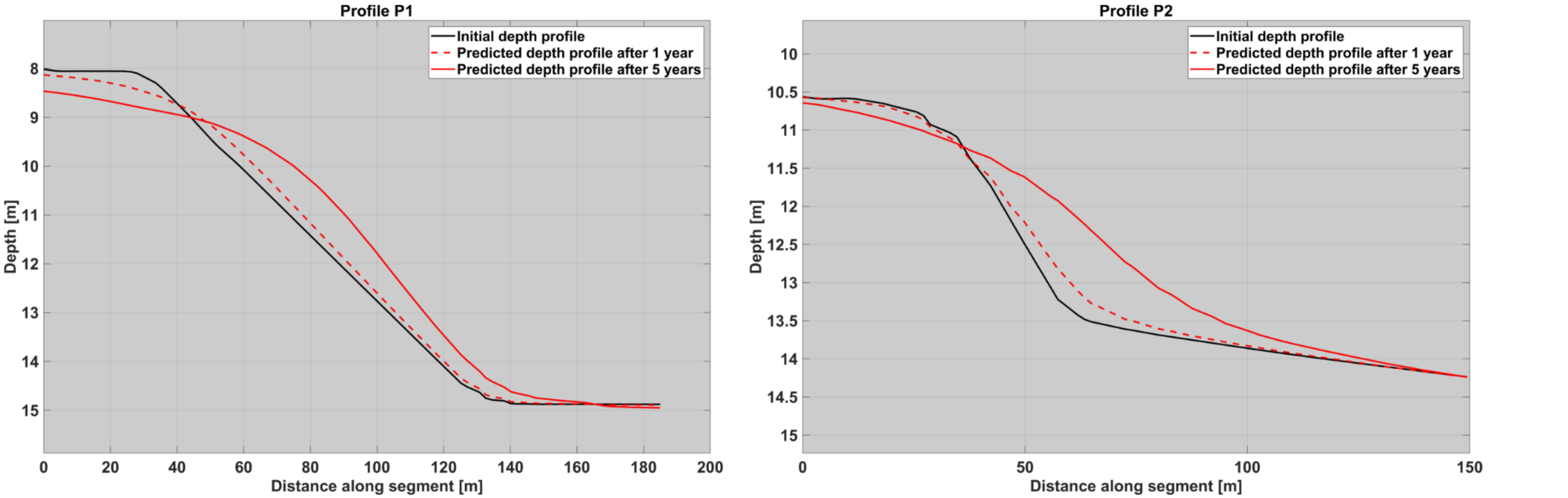

Figure 4-6 Depth profiles of the initial (black) and the predicted bathymetries at the end of 1 year (dashed red) and 5 years of simulation (solid red) for the Design West scenario.

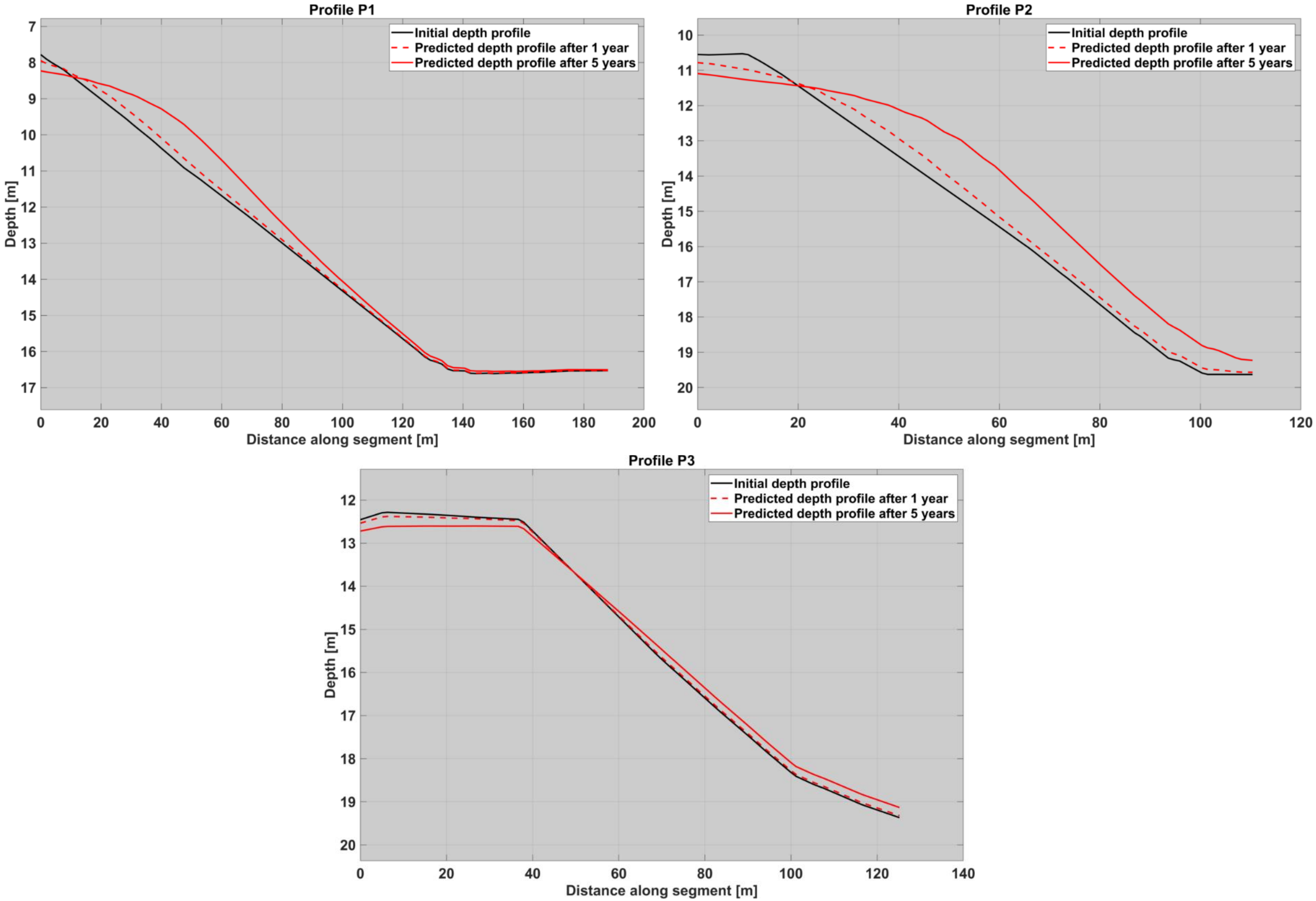

Figure 4-7 Depth profiles of the initial (black) and the predicted bathymetries at the end of 1 year (dashed red) and 5 years of simulation (solid red) for the Design East and West scenario.

5. Summary

The calibrated and validated Delft3D model (MetOcean Solutions 2018e) was used to run high-resolution, process-based morphodynamic simulations of Whangarei Harbour in the vicinity of Northport, to assess the likely morphological response of the existing environment to the proposed design cases. The numerical modelling included fully coupled wave, current and seabed interactions.

The modelling approach consisted in simulating the sediment dynamics over a 5-year period using representative wave and hydrodynamic conditions combined with morphological acceleration factors to reproduce the medium-term residual sediment transport patterns and associated morphological evolution.

A summary of the results is provided below:

- The morphological response associated with the combination of land reclamation and dredging is modelled to be limited to the immediate port environs.
- The largest differences between the existing and design cases are mainly attributed to hydrodynamic and sediment transport changes resulting from batter slope modifications, dredging (deepening) and redistribution of sand wave features previously present in the area.
- The largest depth changes are expected to occur along the western batter slopes. Sediment deposition is expected within these areas.
- Predicted deposition within the western batter slopes for the Design West and Design East and West reach a localised maximum of, approximately, 0.4 to 0.5 m, respectively at the end of the 1st year and 1.5 to 1.8 m, respectively at the end of the 5th year. Some erosion and deposition also occur within the dredged areas.
- Reclamation sheltering effects reduced current velocities and sediment transport rates, resulting in localised sediment deposition west of the NDSF for the Design West case, and west of the NDSF and east of the eastern reclamation area for the Design East and West case, with maximum deposition of approximately 0.4 m and 0.7 m after 5 years, respectively.
- Infilling volumes (i.e. only considering sediment deposition) within the dredged and batter slope areas combined are predicted to be 8,290 m^3 (1st year) and 31,114 m^3 (5th year) for the Design West case and 18,706 m^3 (1st year) and 76,220 m^3 (5th year) for the Design East and West case.
- While some limited changes in sediment transport and bathymetry are predicted within Marsden Bay, morphodynamic modelling suggests these will not alter the overall bay morphology.

6.References

Booij, NRRC, R. C. Ris, and Leo H. Holthuijsen. 1999. “A Third-Generation Wave Model for Coastal Regions: 1. Model Description and Validation.” *Journal of Geophysical Research: Oceans* 104 (C4): 7649–66.

De Vriend, H. J., M. Capobianco, T. Chesher, H. J. de Swart, B. Latteux, and M. J. F. Stive. 1993. “Approaches to Long-Term Modelling of Coastal Morphology: A Review.” *Coastal Engineering* 21: 225–26.

Deltares. 2018. *User Manual Delft3D-FLOW*. Version: 3.15. Deltares.

MetOcean Solutions. 2018a. *Dredging Plumes for NorthPort Environment*. Report Prepared for Northport Report P0367-04.

MetOcean Solutions. 2018b. *Eastland Port Maintenance Dredging and Disposal Project. Morphological Response to Maintenance Dredging*. Nos. P0331-04.

MetOcean Solutions. 2018c. *Hydrodynamic Modelling - Methodology, Validation and Simulations*. Report Prepared for Northport Report P0367-02.

MetOcean Solutions. 2018d. *Morphodynamic Evolution Modelling for the Northport Environment - Five Year Morphological Prediction of the Swinging Basin Morphological Response*. Report Prepared for Northport Report P0367–05.

MetOcean Solutions. 2018e. *Morphodynamic Evolution Modelling for the Northport Environment - Morphological Model Calibration*. Report Prepared for Northport Report P0367–01 Rev B.

MetOcean Solutions. 2018f. *Morphodynamic Evolution Modelling for the Northport Environment - Predicted Morphological Response to Proposed Capital Dredging and Land Reclamation*. Report Prepared for Northport Report P0367–03.

MetOcean Solutions. 2018g. *Northport Dredging Project - Dredging Plume Modelling*. Report Prepared for Northport Report P0367–01.

MetOcean Solutions. 2019. *Eastland Port Maintenance Dredging and Disposal Project. Morphological Response of the Offshore Disposal Ground to Maintenance Dredging*. Nos. P0331-10.

MetOcean Solutions. 2020. *Eastland Port Maintenance Dredging and Disposal Project. Morphological Response of the Shoreline to Maintenance Dredging and Disposal of Sediments*. Nos. P0331-11.

MetOcean Solutions. 2021a. *Dredge Plume Modelling . Dredging Sediment Plume Dispersion over Existing and Proposed Port Configurations*. Report Prepared for Northport Report P0519-03.

MetOcean Solutions. 2021b. *Hydrodynamic Modelling - Effect of Proposed Reclamation Layouts on Hydrodynamics*. Report Prepared for Northport Report P0519-01.

MetOcean Solutions. 2021c. *Morphodynamic Modelling for the Northport Environment. Modelling Update . Predicted Morphological Response to Proposed Capital Dredging and Land Reclamation*. Report Prepared for Northport Report P0519-02.

MetOcean Solutions. 2022a. *Hydrodynamic Modelling Update - Effects of Proposed Reclamation and Dredging Layout on Hydrodynamics*. Report Prepared for Northport Report P0519-10.

MetOcean Solutions. 2022b. *Morphodynamic Modelling for the Northport Environment. Modelling Update . Predicted Morphological Response to Proposed Eastern Land Reclamation*. Report Prepared for Northport Report P0519-11.

MetOcean Solutions. 2023. *Hydrodynamic Modelling Additional Output Locations - Effects of Proposed Reclamation and Dredging Layout on Hydrodynamics*. Report Prepared for Northport Report P0519-13.

MetOcean Solutions. 2024. *Tauranga Harbour Historical Configurations Modelling*. Report Prepared for Port of Tauranga Nos. P0621-05.

MetOcean Solutions. 2026. *Dredged Sediment Disposal at the Maintenance and Capital Spoil Grounds. Assessment of Sediment Dynamics.* No. P0655. Report prepared for Lyttelton Port Company Limited.

Paulik, R., and S. Stephens. 2023. *Mapping New Zealand's Exposure to Coastal Flooding and Sea-Level Rise*. NIWA Internal Report NIWA internal report. https://niwa.co.nz/sites/default/files/Coastal%20flood%20mapping%20methodology%20report%20FINAL_0.pdf.

Ramli, A. Y., W. de Lange, K. Bryan, and J. Mullarney. 2015. "Coupled Flow-Wave Numerical Model in Assessing the Impact of Dredging on the Morphology of Matakana Banks." 758.

Ris, R. C., L. H. Holthuijsen, and N. Booij. 1999. "A Third-Generation Wave Model for Coastal Regions: 2. Verification." *Journal of Geophysical Research: Oceans*, no. 104: 7667–81.

Roelvink, J. A. 2006. "Coastal Morphodynamic Evolution Techniques." *Coastal Engineering*, no. 53: 277–87.

Weppe, S., P. McComb, and L. Coe. 2015. "Numerical Model Studies to Support the Sustainable Management of Dredge Spoil Deposition in a Complex Nearshore Environment." In *Coastal Sediments 2015*, 0 vol. World Scientific. http://www.worldscientific.com/doi/abs/10.1142/9789814689977_0113.

Williams, R. D., R. Measures, D. M. Hicks, and J. Brasington. 2016. "Assessment of a Numerical Model to Reproduce Event-scale Erosion and Deposition Distributions in a Braided River." *Water Resources Research* 52: 6621–42.