Appendix I:

MetOcean Maintenance Dredging and Disposal Ground

Coastal Process Investigation Reports

EASTLAND PORT MAINTENANCE DREDGING AND DISPOSAL PROJECT

Report summarising findings

Report prepared for Eastland Port

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30 Salamanca Road, Kelburn, Wellington
T: 64-6-7585035 E: enquiries@metocean.co.nz
www.metocean.co.nz

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1. INTRODUCTION

Eastland Port Ltd are seeking to renew their maintenance dredging and disposal consents at the Port of Gisborne.

Currently, dredged sediment is disposed at an offshore disposal site situated in approximately 18 – 20 m water depth (**Error! Reference source not found.**), with an average annual rate of approximately 73,000 m^3 based on estimates obtained between 2002 and 2019 by Eastland Port.

Maintenance dredging is expected to occur using the Trailing Suction Hopper Dredge (TSHD) “Pukunui” although, if there are significant inflows of sediment due to large storm events, a higher productivity Trailing Suction Hopper Dredge (TSHD) may be required to ensure the required port and channel depths can be maintained. It is likely that some maintenance dredging may also be undertaken using a Backhoe Dredger (BHD) or Cutter Suction Dredger (CSD).

MetOcean Solutions (MOS) has been contracted to provide coastal oceanographic expertise to investigate both physical and morphological effects and associated sediment transport patterns resulting from the dredging and disposal of maintenance dredging material at the current disposal site. The following sections summarise the findings.

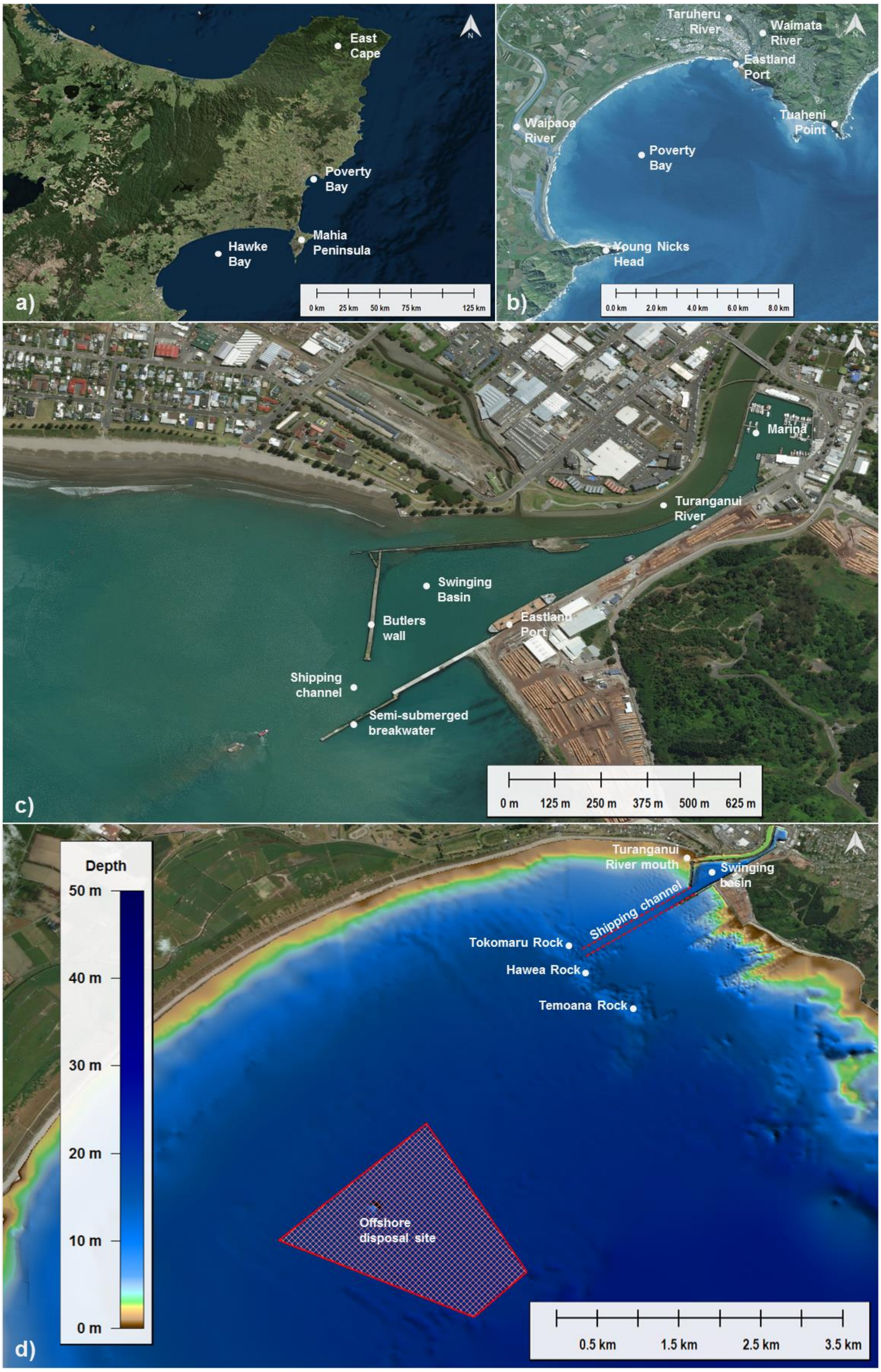

Figure 1.1 Maps showing the location of Poverty Bay (a and b), and Eastland Port (c) with the locations used in the present study. Both offshore disposal and shipping channel are indicated on top of the bathymetry in (d)

2. HYDRODYNAMIC HINDCAST VALIDATION

In this study (MetOcean Solutions, 2017a), ocean currents were simulated with two different models to investigate both regional and local scales. The open-source ROMS1 model was used to perform 3D hydrodynamic downscaling of the oceanic and tidal flows over the continental shelf adjacent to Poverty Bay.

The implementation of the unstructured FE[2] SCHISM[3] model nested within the Poverty Bay ROMS domain provided significant improvements in the nearshore predictive capability of the numerical models. Although some moderate flow events were not fully captured by the model, the overall statistical distribution of current velocities was satisfactory at the Waipaoa river mouth and near Eastland Port. In this context, the SCHISM model is considered suitable for forcing the subsequent morphological and plume models as part of the dredging and disposal impact assessments.

3. WAVE HINDCAST VALIDATION

In the present study (MetOcean Solutions, 2017b), the numerical wave transformation model SWAN[4] was used to hindcast the wave climate within Poverty Bay and at the entrance to Eastland Port over ten years. A four-level nesting approach was employed to simulate the spectral wave transformation to the coastal region.

The model was validated with measurements from two locations, and was shown to under-predict some of the extreme wave events partly due to limitations in the global model. In order to minimise some of this low-bias, a bias correction technique was successfully applied based on measured and modelled time series of significant wave height at one site located in Poverty Bay. Wave statistics based on the bias-corrected wave hindcast were provided. The bias-corrected SWAN model achieved good nearshore correlation at the port entrance making this tool appropriate to force the subsequent morphological and plume models.

4. LONG-PERIOD WAVES WITHIN EASTLAND PORT

This report (MetOcean Solutions, 2018a) establishes a set of 18 empirical equations to predict long period wave (LPW) climate along berth sites to optimise the maintenance dredging design. Outputs from 10 scenarios simulated with the Boussinesq wave model FUNWAVE5 has been examined to rescale the existing equation applied in the forecast system to taking into account the spatial variability of the LPW field within the harbour (5 at high tide and 5 at low tide).

Offshore nowcast data produced by MetOcean Solutions between 2012 and 2017 have been used as inputs for the new established empirical equations at berth sites to reproduce the LPW climate over this period. LPW statistics specific to each site have been calculated.

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1 ROMS - hydrodynamic model Regional Ocean Modeling System.
2 FE - triangular grid structure used by SCHISM.
3 SCHISM - Semi-implicit Cross-scale Hydroscience Integrated System Model
4 SWAN – wave model Spectral Wave Nearshore
5 FUNWAVE - Boussinesq model for ocean surface wave propagation in the nearshore.

The limited number of simulations has been considered, and this infers some caveats to the approach used.

5. MORPHOLOGICAL MODEL VALIDATION

In the present study (MetOcean Solutions, 2018b), the open-source Delft3D[6] system was used to run high-resolution process-based morphodynamic simulations over northern Poverty Bay and Eastland Port. The numerical modelling involved fully-coupled wave, current and seabed interactions.

It has been demonstrated that the numerical model replicated successfully the dominant physical and morphological processes in the bay. At Eastland Port, the predicted daily and annual infilling rates were close to the estimates provided by the Eastland Port from historical bathymetry surveys and dredging records. The morphological changes simulated over northern Poverty Bay were also broadly consistent with the patterns described in the previous studies. The present numerical modelling provides a well-founded method to assess the morphological evolution of proposed changes to the shipping channel and Swinging Basin and evaluate likely future Maintenance Dredging requirements, inclusive of associated channel infilling error-bounds.

6. DREDGING PLUME MODELLING

The present report (MetOcean Solutions, 2019a) focuses on the characterisation of the sediment plume patterns expected during the dredging operations. Dredging operations were simulated using particle-tracking modelling over two different 1-year periods within contrasting historical contexts, namely El Niño/La Niña episodes.

The general plume dispersion patterns vary along the shipping channel following ambient current regimes. Dispersion pattern are typically elliptical, with an elongation northwest-southeast, along the outer channel; this characteristic is conserved moving towards the Port entrance, but becomes combined with an increasing northeast-southwest dispersion characteristic associated with the “flushing” flows in and out Port swinging basin. Dispersion patterns further into the Port swinging basin become elongated in the northeast-southwest direction, following the general channel orientation.

7. MORPHOLOGICAL RESPONSE TO MAINTENANCE DREDGING

The present report is a technical reference document that investigates the likely morphological effects maintaining the current port configuration. Details of the modelling framework and assessment approach are provided in MetOcean Solutions (2018c).

The continuation of the Eastland Port maintenance dredging project is expected to have a limited impact on the environs existing morphodynamics. Subtle changes in the hydrodynamics and wave patterns to the north of the navigation channel may occur during the different phases of the ENSO and alter some of the sediment deposition patterns in the vicinity of the channel without fundamentally changing the overall coastal dynamics.

[6] Delft3D – morphodynamic model developed to simulate the dynamics of complex coastal regions.

The deposition of material at the entrance of Eastland Port is expected for both periods. This is attributed to a re-orientation of the wave refraction patterns in the vicinity of the port entrance, slight modifications to the location of the current eddy in the lee of Butlers Wall and sediment trapping processes over the outer dredged channel.

It is anticipated that, in the absence of ongoing maintenance dredging, the annual infilling rate in the channel and the inner basin will be 75,000 and 120,000 $m^3.yr^{-1}$. (for ‘La Niña’ and ‘El Niño’ phases of ENSO respectively).

During storm conditions, the daily volumetric infilling rate may increase from ~200-300 to 800 $m^3.day^{-1}$.

Infilling rate may temporarily increase after maintenance dredging is carried out attributed to the diffusion of sediments from the batters at the edge of the dredged areas into the channel itself; the gradual slope might contribute, however, to limit the influence of waves on the bed-load component of the sediment transport.

Within the outer channel, in the absence of ongoing maintenance dredging, the bathymetry is likely to quickly return to its equilibrium (pre-dredging) state due to large muddy discharges from the rivers.

Maintenance dredging is expected to be required to maintain design draft over time through the channel.

8. DISPOSAL PLUME MODELLING

The present report (MetOcean Solutions, 2018d) focuses on the characterisation of the sediment plume patterns expected during the dredging operations. Dredging operations were simulated using particle-tracking modelling over two different 1-year periods within contrasting historical contexts, namely El Niño/La Niña episodes.

The objective of the present report is to characterise the dispersion patterns of the sediment plumes and deposition footprints produced during the disposal of sediment dredged from the channel and port basins. Sediment plume dispersal and settling was simulated using particle-tracking simulations during two different 1-year periods with contrasting historical climatic contexts, namely El Niño/La Niña episodes.

The general *SSC* plume pattern consists of relatively contained *SSC* plume in the surface and mid-depth layers, becoming more dispersed (radius of order ~200 m) in the bottom layer due to the formation of a density current. Predicted deposition patterns are predominantly circular, with thinner northwest-directed features resulting from the deposition of the passive plumes. Predictions for the Pukunui vessel (hopper volume = 480 m^3) suggest *SSC* levels will generally fall below the 10 $mg.L^{-1}$ threshold within 0-50 m of the release in the surface and mid-depth levels and within 150 m of the release in the bottom levels. Predictions for the Albatros vessel (hopper volume = 1860 m^3) suggest *SSC* levels will generally fall below the 10 $mg.L^{-1}$ threshold within 50-200 of the release in the surface and mid-depth levels and within 250 m of the release in the bottom levels.

9. MORPHOLOGICAL RESPONSE OF THE CURRENT OFFSHORE DISPOSAL

The present report is a technical reference document that investigates the physical process affecting the proposed disposal site as well as the likely effects of the disposal on the existing environment. Details of the morphological modelling approach, including calibration and validation can be found in MetOcean Solutions (2019b).

The effect of the disposal mound on the nearshore wave climate is predicted to be negligible. The wave energy is expected to be redistributed along the beach areas adjacent to the Waipaoa River mouth. The resultant increase in significant wave height during energetic storm event is, however, not expected to exceed ~1 cm, or 0.2% of the incident wave height. Some very localised changes in wave direction occur which are not expected to modify the overall longshore sediment transport patterns along the beach. The relative scale of effects is not expected to alter either the nearshore morphodynamic or inshore surfing conditions.

Within the year period simulated, between 68% and 83% of the disposal mound associated with maintenance dredging activities is expected to be eroded due to the weakly-consolidated silt composition of the disposal. This corresponds to between 50,000 m3 and 100,000 m3 of sediment being advected from the disposal ground over a one-year period (for “La Niña” and “El Niño” respectively).

A notable segregation of silt, very fine sand and fine sand is anticipated.

The silt component of the disposal material (i.e. ~66%) is predicted to be transported northwest and northeast of the disposal ground. Small deposition of silt may occur to the west of the bay during relatively calm wave conditions.

The very fine sand particles of the disposal (i.e. ~19%) are expected to migrate south-south-westward by near-bed suspended transport, with sediment expected to move to depths of 16 – 24 m within the one-year period simulated.

The fine sand fraction of the disposal (i.e. ~15%) is expected to be weakly transported over the disposal area and its margins by bed-load transport.

10. MORPHOLOGICAL RESPONSE OF THE SHORELINE

This report (MetOcean Solutions, 2020) focuses on the potential effect of the Eastland Port Dredging Project on the shoreline, based on the morphological numerical modelling results provided in MetOcean Solutions (2018c; 2019b).

The effect of the existing shipping channel on the inshore incident wave climate and shoreline response will be consistent with what has been observed since the consented dredging began.

No changes in the alongshore transport is anticipated if existing maintenance dredging depths are maintained.

The immediate river delta region sedimentary budget is primarily dependent on fluvial regime.

The proposed one-year maintenance disposal mound is expected to have a negligible effect on the incident wave refraction patterns over and inshore of the disposal mound, with expected significant wave height modifications of the order ±0.2%, and some very localised changes in wave direction which are not expected to modify the overall sediment transport patterns and beach shoreline.

The relative changes to the incident wave climate are not expected to affect the shoreline sediment dynamics. Likewise, the morphological response of the disposal mound is not expected to result in any noticeable erosion/deposition of sediment over the inshore beach area.

The input of sediments from maintenance disposal activities is negligible in terms of beach morphodynamics compared to the fluvial sediment inputs provided by the Waipaoa River discharges.

11. SURFING WAVE DYNAMICS

The primary objective of this study is to assess the effects of the Eastland Port maintenance dredging and disposal on the existing nearshore wave processes in the Poverty Bay and specifically how it may affect the resulting surfable wave conditions (MetOcean Solutions, 2018e). The study includes an assessment of the general and surfing-related wave climates and numerical modelling of nearshore wave propagation within Poverty Bay.

Modelling suggests that under worst case conditions (i.e. maximum disposal mound height and neglecting any potential morphological response) the inshore wave heights expected to be modified by an order of ±0.2%, with the location dependent on the incident wave direction. This is expected to have a negligible effect on recreational surfing conditions at Big River (i.e. the increase/decrease in wave height not expected to exceed ~1 cm).

For these wave incidences, the nearshore phase-resolving wave propagation modelling illustrated that significant wave focusing develops over the offshore submerged reef system which redirects wave energy specifically towards the Midway Beach region. This is combined with wave crest “snapping” which is expected to further increase the surfability of the wave field reaching the beach.

The effect of the existing shipping channel on the inshore incident wave climate will be consistent with what has been observed since the consented dredging began. This can be attributed to the relatively small deepening of the outer channel and the approximate perpendicular angle of the channel relative to the incident wave direction. Further, the general channel footprint lies outside of the focused beam of wave energy developing during best, and most frequent, wave incidence for favourable surfing conditions at Midway Beach (150-160°T).

12. REFERENCES

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MetOcean Solutions, 2018c. Eastland Port Maintenance Dredging and Disposal Project. Morphological response to maintenance dredging (No. P0331- 04).

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