3.2.6 Point Franklin Groyne

Annual rates of littoral drift transport along the Portsea foreshore resulting from the Point Franklin groyne are presented in Figure 3-13 and compared with those as existing.

The change in beach alignment that the groyne would induce would result in a reduction in the rates of alongshore transport of littoral drift. However, given the small degree to which the coastal alignment could be changed in the eroded area by the groyne, there would still be a deficit in the sediment budget and erosion at Portsea Pier would continue, albeit at a lesser rate of 16,000 m³/a (compared with 30,000 m³/a).
3.2.7 Portsea Front Beach Groyne

Annual rates of littoral drift transport along the Portsea foreshore resulting from a groyne situated on Portsea Front Beach some 250 m east of the Pier are presented in Figure 3-14 and compared with those as existing.

![Littoral Drift Budget](image)

**Figure 3-14. Calculated annual rates of littoral drift transport from 350 m west of Police Point to 400m east of Point Franklin for the Portsea Front Beach groyne option**

The significant change in beach alignment that the groyne would induce would result in a significant reduction in the rates of alongshore transport of littoral drift. However, there still would be a small deficit in the sediment budget and erosion at Portsea Pier would continue, albeit at a lesser rate of 8,000 m$^3$/a, compared with 30,000 m$^3$/a for the existing condition. Maintenance sand nourishment would be required periodically to service this erosion.

3.2.8 Beach Nourishment

Annual rates of littoral drift transport along the Portsea foreshore for the beach nourishment option are presented in Figure 3-15, which are the same as those existing.

Figure 3-15 indicates the continuation of severe erosion from some 200 m west of Portsea Pier up to some 150 m east of the Pier. The potential erosion rate over this stretch would be some 30,000 m$^3$/a, which would require regular maintenance.
3.2.9 Removal of Foreshore Revetment

Annual rates of littoral drift transport along the Portsea foreshore for the option of removing the revetment are presented in Figure 3-15, which are the same as those existing. Figure 3-15 indicates the continuation of severe erosion from some 200 m west of Portsea Pier up to some 150 m east of the Pier. The potential erosion rate over this stretch would be some 30,000 m$^3$/a, which would require regular maintenance.

3.3 Shoreline Change Estimates

Estimates of shoreline change potential were calculated using UNIBEST-CL+. The model uses wave climates obtained at the toe of each beach profile, and calculates the littoral drift as a function of the local wave climate and the beach profile angle at regular intervals along the shore. The model uses a curvilinear coordinate system that is fitted to the shape of the shoreline. Wave climates are smoothly interpolated at beach profiles between locations where the inshore wave climate has been determined. In this way the two-dimensional structure of the coast (and incident wave climate) is preserved as much as possible, within the limitations of 1-line numerical models.

The change in calculated coastline position should be thought of as potential and represents the amount that could happen under idealised assumptions of a coastline composed of unconsolidated sand with no rock substrate. Where rocky headlands exist (either naturally as cliffs, or artificially as sea walls or revetments), these have been imposed as ‘revetment’ layers that prevent the coastline from eroding beyond a predetermined distance from the existing shoreline.

The shape of the coastline imposed in the model was digitised from Google Earth imagery (image date 2009), and closely follows the −1 m AHD contour derived from LiDAR topography (survey date 2012) supplied by the Department. In the following analysis this is assumed as the ‘2016 coastline’ position.

Figure 3-15. Calculated annual rates of littoral drift transport from 350 m west of Police Point to 400 m east of Point Franklin for the beach nourishment option.
3.3.1 Existing (‘Baseline’) Conditions

Figure 3-16 shows the predicted evolution of the shoreline under ‘baseline’ conditions. It assumes that the wave climate is adequately described by statistics derived from analysis of the wave record between 2003 to 2013. That is, the wave climate is an annual average derived from a 10 year record. The method neglects inter-annual changes in wave height due to incident swell at Point Nepean, or any changes in wave height, period and obliquity that may occur due to movement of Quarantine Bank and associated sand shoals.

Assuming that the geotextile revetment is maintained over the 50 year simulation period, the beach is expected to continue eroding in front of the revetment. In reality this would occur via beach lowering and scouring of the revetment toe rather than the suggested beach retreat. However the modelling serves to illustrate how the beach is tending towards an equilibrium orientation such that it becomes ‘normal’ to the wave angle incident between Portsea Pier and Point Franklin. This equilibrium orientation determines where beach erosion and beach accretion is expected along Weeroona Bay. That is, the model strongly suggests beach erosion at Portsea is primarily caused by gradients in longshore transport and changes in littoral drift magnitude over time, rather than cross-shore processes.
3.3.2 Offshore Dredged Configuration

The expected evolution of the shoreline due to configuration dredging of the sea floor at Quarantine Bank is shown in Figure 3-17. The Option successfully maintains the shoreline position at Portsea Pier and along the location of the geotextile revetment, but shoreline erosion is predicted along western Weeroona Bay. This is due to increase in wave energy predicted for this section of the shoreline (Figure 2-5). Beach material removed from here is deposited between Portsea Pier and Point Franklin, advancing the beach east of the geotextile revetment.
Assuming that the position and geometry of the offshore trench can be maintained by periodic dredging, the beach would be expected to continually evolve over the 50 year design life of the scheme. Beach recycling is recommended for portion of Weeroona Bay west of Portsea Pier, using material accumulated between Portsea Pier and Point Franklin.

Should this scheme be undertaken in conjunction with beach nourishment, the predicted shoreline change would remain as predicted in Figure 3-17, but with the position of the shoreline advanced seaward by the design nourishment profile.

![Predicted shoreline change: Trench11](image1)

![Movement of 0m AHD contour relative to 2016 position: Trench11](image2)

Figure 3-17: Predicted change in shoreline position during 50 year design life of offshore configuration dredging conceptual option.
### 3.3.3 Nearshore Dredged Configuration

The expected evolution of the shoreline due to configuration dredging of the nearshore sea floor is shown in Figure 3-18. The shoreline is predicted to remain broadly stable over the 50 year design lifespan. In this respect it is the most successful of all the conceptual Options considered, as it affects the least shoreline change.

Should this option be considered with beach nourishment, the predicted shoreline change would remain the same as in Figure 3-18, but with the position of the shoreline advance seaward some 30 m.

![Predicted shoreline change: Trench13](image1)

![Movement of 0m AHD contour relative to 2016 position: Trench13](image2)

Figure 3-18: Predicted change in shoreline position during 50 year design life of nearshore configuration dredging conceptual option.
3.3.4 Detached Breakwater

The expected shoreline evolution for this conceptual Option is shown in Figure 3-19. The simulation shows that a salient is expected to form, of some 50 m distance from the present shoreline position.

If no beach nourishment were to occur with this conceptual Option, the model predicts that the shoreline would evolve to the new equilibrium shape within 5 years of breakwater construction. Erosion would be expected at the shoreline parallel with the western and eastern edges of the breakwater. The worst erosion would occur immediately west of Portsea Pier, as the incident wave angle is rotated via diffraction past the breakwater, locally increasing eastward transport. It is therefore recommended that any beach nourishment occurring with this option includes advancing the beach seaward some 20 m for the beach west of Portsea Pier.

Figure 3-19: Predicted change in shoreline position during 50 year design life of shore detached breakwater conceptual option.
3.3.5 Point Franklin Groyne

This option considers the construction of a rock groyne some 130m long, extending north-west from Point Franklin. The position and length of the groyne has been selected to provide sufficient beach volume to advance the shoreline some 20 m in front of the geotextile revetment, and hold it in place for the duration of the 50 year lifespan of the conceptual design.

Figure 3-20 shows the predicted change in shoreline position over the 50 year design life. Assuming that no beach nourishment takes place, an equilibrium shoreline is achieved after approximately 20 years after construction. Sediment bypassing to the east of Point Franklin would be expected to return to present levels approximately 20 years after construction.

If no beach nourishment were to occur as part of the construction, beach erosion would be expected to occur at the present location of the geotextile revetment for a period of 10 years after construction of the groyne.

If the groyne is constructed with beach nourishment to the suggested equilibrium beach plan shape, the position of the shoreline would be expected to remain stable over the 50 year design life, assuming that incident wave obliquity and height along Weeroona Bay remains constant and does not evolve over time, for example due to changes in wave focussing patterns due to movement of Quarantine Bank, and bypassing of the groyne that will occur at rates in excess of supply from the western section of Weeroona Bay due to the degree of cross-shore transport expected under the higher wave energy conditions is supplanted by beach nourishment maintenance programme.

3.3.6 Portsea Front Beach Groyne

This conceptual option considers the construction of a terminal rock groyne some 90m long, 200m east of Portsea Pier. The position and length of the groyne has been selected to provide sufficient beach volume to advance the shoreline some 20m in front of the rock revetment, and hold it in place for the duration of the 50 year lifespan of the conceptual design.

Figure 3-21 shows the predicted change in shoreline position over the 50 year design life. Assuming that no beach nourishment takes place, an equilibrium shoreline is achieved after approximately 10 years, and sediment bypassing could be expected to return to present levels approximately 15 years after construction.

If the groyne is constructed with beach nourishment to the suggested equilibrium beach plan shape, the position of the shoreline would be expected to remain stable over the 50 year design life – assuming that indecent wave obliquity and height along Weeroona Bay remains constant and does not evolve over time, for example due to changes in wave focussing patterns due to movement of Quarantine Bank, and bypassing of the groyne that will occur at rates in excess of supply from the western section of Weeroona Bay due to the degree of cross-shore transport expected under the higher wave energy conditions is supplanted by beach nourishment maintenance programme.
Figure 3-20: Predicted change in shoreline position during 50 year design life of Point Franklin Groyne conceptual option.
3.3.7 Beach Nourishment

Beach Nourishment involves maintaining the design beach profile and specified distance from the shoreline. As such the evolution of the shoreline would be fixed at the design shape and orientation and not evolve over the lifespan of the works. As such the evolution of the shoreline is not assessed for a pure ‘Beach Nourishment’ conceptual Engineering Option. The frequency and volume of nourishment activity is informed by the littoral drift assessment in Section 3.2.

Figure 3-21: Predicted change in shoreline position during 50 year design life of Portsea Beach Groyne conceptual option.
3.3.8 Removal of Foreshore Revetment

Under this scenario the geotextile revetment presently fronting the dune line adjacent to the Portsea Hotel would be removed, and not replaced.

The shoreline change model predicts rapid erosion would take place as the shoreline ‘rotates’ to become aligned with the incident wave angle. Maximum erosion would occur at the western edge of the geotextile revetment (Figure 3-22). Here the model predicts average erosion rates in the order of 10 m per year over the first 5 years, which is in the order of the level of beach erosion observed immediately east of Portsea Pier in satellite imagery for the period 2009 to 2010 (i.e., immediately prior to the construction of the geotextile revetment; Figure 3-3).

The ultimate position of the shoreline at Portsea Pier is controlled primarily by the incident wave angle. Assuming that the present wave obliquity remains constant over the 50 year lifespan of the conceptual option, the shoreline fronting would be expected to evolve towards an equilibrium position some 80 m landward of its present location. The realisable rate of shoreline change would be modified by the presence of calcarenite and other rocky material behind the dune line. Topographic levels at the Portsea Hotel are particularly low relative to the shore immediately east and west, making this section of coastline vulnerable to erosion as there is less material ‘reserved’ as a buffer in the dunes or cliff fronting the Hotel.

The presence of rock armouring immediately west and landward of Portsea Pier would likely exacerbate erosion under this scenario through edge effects, as the shoreline is anchored in place instead of being able to adapt to a new equilibrium shoreline position and provide beach material to lessen erosion to the east.
Figure 3-22: Predicted change in shoreline position during 50 year design life of Remove Revetment conceptual option.
4 Cross-Shore Transport & Storm Erosion

Cross-shore transport has been assessed at beach profile P300200 using Delft3D configured as a 2DV model. The model was configured with 5 vertical sigma-layers spaced logarithmically through the water column. The bottom layer thickness was imposed as 5% of the local water depth, while the surface layer was imposed as 30% of the local water depth. The model included full wave-current interaction, plus an additional 'roller model' that accounts for the onshore movement of the wave breaking position due to transfer of momentum from breaking waves to the underlying water column. This provides an additional mechanism for rip generation and undertow, and is known to improve substantially simulations of beach erosion in the nearshore.

Sediment transport calculations used the van Rijn (2007) algorithm. Various scaling parameters are available in this sediment transport algorithm for model calibration. For the purposes of this assessment, the van Rijn algorithm was retained with parameters used in the calibrated sediment transport model in Section 5, with the exception of the scaling factor due to wave processes, \( f_{\text{wave}} \). This parameter is responsible for assigning suspended sediment transport in the direction of wave propagation (van Rijn et al., 2004). User experience with Delft3D suggests that the default value of 1 results in excessive onshore movement of sediment and that, for 3D models, a value of 0.2 is more appropriate.

Additional parameters for bedload transport were tuned to maximise offshore bedload transport under wave conditions. In this way the simulation is designed to maximise offshore transport under storm waves while retaining reasonable estimates of onshore movement of sediment during calmer periods.

4.1 Cross-Shore Distribution of Sediment Transport

4.1.1 Existing ('Baseline') Conditions

Figure 4-1 shows the beach profile is active for cross-shore transport out to about 60 m from the shoreline, and that most transport mostly occurs between Mean Low Water and the −3 m AHD contour.

The sediment transport results integrated across the profile suggest that approximately 6,000 m\(^3\)/a is lost from the beach profile to deeper water. This compares with a long-shore littoral transport rate in the order of 32,000 m\(^3\)/a.
4.1.2 Offshore Configuration Dredging

This option has been shown to exacerbate beach erosion to the west of Portsea Pier and, hence, is not considered further in the sediment transport analysis.

4.1.3 Nearshore Configuration Dredging

Figure 4-2 shows the simulated distribution of cross-shore transport at profile P300200 for wave conditions pertaining to Nearshore Configuration Dredging. The amount of beach erosion is greatly reduced, while the onshore movement of sediment remains approximately the same as baseline conditions. The profile-integrated transport is approximately in balance, which suggests that no material would be lost in the long term to cross-shore transport when considering Nearshore Configuration Dredging.
4.1.4 Detached Breakwater

Figure 4-2 shows the simulated distribution of cross-shore transport at profile P300200 for wave conditions pertaining to Shore Detached Breakwater. This corresponds to conditions directly behind the breakwater, at the estimated tip of the salient expected to form.

The sediment transport is shown to become entirely on-shore directed (i.e. beach profile accretion), and the total magnitude of profile integrated cross-shore transport is reduced to roughly 10% of Baseline conditions.
4.1.5  **Point Franklin Groyne**

Cross-shore transport will remain unmodified from ‘Baseline’ conditions.

4.1.6  **Portsea Front Beach Groyne**

Cross-shore transport will remain unmodified from ‘Baseline’ conditions.

4.1.7  **Beach Nourishment**

Cross-shore transport will remain unmodified from ‘Baseline’ conditions.

4.1.8  **Removal of Foreshore Revetment**

Cross-shore transport will remain unmodified from ‘Baseline’ conditions.
4.2 Beach Profile Storm Erosion

Beach erosion is assessed at profile P300200 for a storm considered approximately equivalent to that expected to occur on average once per year. The storm event was derived from analysis of the wave record at Point Nepean, and then transformed inshore to the toe of beach profile P300200, which fronts the geotextile revetment immediately to the east of Portsea Pier. The beach profile corresponds to the area of maximum wave focussing. The time series of wave height and period used is shown in Figure 4-4.

Figure 4-4: Storm characteristics used for beach profile erosion at profile P300200.

Beach erosion was simulated over the 49 hour storm profile assuming a static water level of +0.5m AHD. This corresponds approximately to Mean Spring High Water. Large swell wave events at Portsea are known to occur simultaneously with surge events (higher surge typically being associated with larger swell waves). However in the absence of knowledge about surge levels at Portsea for storm events, it is assumed that using the Mean Spring High Water level is a reasonable approximation.

Predicted beach profile erosion is shown in Figure 4-5, below. Although beach erosion is a complex process, the model results suggest that material eroded from the upper beach at Portsea typically is not deposited as a sub-tidal bar but, instead, is distributed smoothly along the beach profile between Low Water and approximately −3 m AHD. This is consistent with the distribution of annual-average cross shore transport shown in Figure 4-1, which also suggests that the beach profile is not active below a level of about −3 m AHD, or 60m from the shoreline.
Figure 4-5: Simulated erosion of beach profile P300200 for approximately the annual average storm.
5 Sub-Tidal Sediment Transport

Sub-tidal sediment transport is estimated for relevant engineering options using the calibrated sediment transport model developed previously by Advisian in support of coastal process assessment at Portsea.

5.1 Recap: Validation of Tidal Sediment Transport Model

Advisian (2106) present a detailed calibration and validation of a depth-averaged hydrodynamic and sediment transport model. The most salient aspects of the validation are summarised below.

5.1.1 Water Levels and Tidal Currents

Positions of tide gauges within Port Phillip Bay used to validate the simulated water levels are given in Figure 5-1. With the exception of Portsea, tidal constituents for tide gauges within Port Phillip Bay were supplied by Port of Melbourne Corporation. Tidal constituents at Portsea were obtained by analysis of tidal elevation recorded by AWAC at approximately 6m below AHD during deployments between July 2014 and February 2015. Model hindcast skill\(^1\) over a 29 day lunar cycle was in excess of 0.9 at each tide gauge, proving the very high accuracy of the model. Figure 5-1 shows the correlation of simulated and observed water levels at available tide gauges.

\[\text{Figure 5-1: Correlation of simulated water levels from calibrated hydrodynamic model against tide gauge data}\]

\(^1\) The model ‘skill score’ is a non-dimensional number related to the Mean Average Error, varying between the limits of 0 to 1. Where value of 1 means that the model perfectly reproduces measured data (‘perfect skill’) and a value of 0 means that the model does not reproduce the measured data at all (‘no skill’).
5.1.1.1 Tidal Currents

Tidal current data was collected by Advisian in the form of AWAC deployments at Portsea between July 2014 and February 2015, and ADCP data at two locations along the crest of the sand shoal in April 2015.

![Locations of AWAC and ADCP current meter deployments for validation of hydrodynamic model. Underlying seafloor bathymetry also shown. Sites ‘AWAC-1’ and ‘AWAC-2’ correspond to AWAC deployments between June 2014 and February 2015. Sites ‘ADCP Station Day 2’ and “ADCP Station Day 3’ correspond to ADCP observation sites over tidal cycles established during sediment transport field work undertaken in April 2015](image)

Figure 5-3 compares the simulated depth-averaged tidal currents against those obtained from the ADCP data. The MAE was 0.15 m/s, which corresponds to about 10% error at peak tidal flow. Time series comparisons of measured and simulated depth-averaged current speeds at Portsea Front Beach, for the two AWAC deployments, are shown in Figure 5-4. The Mean Average Error of the simulation over a typical 29-day lunar cycle was in the order of 0.1 m/s when averaged across both AWAC locations.
Figure 5-3: Comparison of simulated depth-averaged current speed against ADCP data on the crest of the Quarantine Sand Bank.

Figure 5-4: Example time series of hindcast depth-averaged velocity, compared to that derived from AWAC observations at Portsea. Both AWAC deployments occurred in ~6m water depth.
5.1.2 Bed Load Transport

The van Rijn sediment transport algorithms were calibrated against the field data obtained over an ebb/flood tidal cycle at site ‘ADCP2’ and validated against data obtained over another tidal cycle at site ‘ADCP1’. The model reproduced the 10-minute ensemble-average sediment transport observed on Quarantine Bank with a skill of 0.8 (‘ADCP2’) and 0.69 (‘ADCP1’) respectively. The Mean Average Error at both sites varied between 0.02 and 0.03 kg / m / s.

The calibrated model is used to derive residual transport vectors and magnitudes due to tidal currents at Quarantine Bank and the nearshore area of Portsea.

Figure 5-5: Validation of the transport model for at Quarantine Bank location ‘ADCP1’ and ‘ADCP-2’.

5.2 Residual Sediment Transport for Conceptual Options

5.2.1 Baseline

Residual transport vectors are shown in Figure 5-6. Contours of the residual transport magnitude for the area between Quarantine Bank and Portsea are given in Figure 5-7. Residual transport approaches 5,000 m³/a along the crest of Quarantine Bank, directed south-westerly with ebb-tidal currents towards Port Phillip Heads. East of the Bank Crest sediment transport diminishes rapidly, and is an order-of-magnitude lower at the −10 m AHD contour along the rock platform fronting
Portsea Front Beach. Tidal currents landward of the ~10 m AHD contour are small enough that sediment transport in the nearshore area is effectively negligible.

**Figure 5-6: Residual Bedload Transport Vectors – Baseline**

**Figure 5-7: Residual Sediment Transport Contours - Baseline**
5.2.2 Offshore Dredged Configuration

Residual transport magnitudes for the offshore dredge configuration are shown in Figure 5-8. The trench is expected to migrate eastward in the direction of net transport at Quarantine Bank. Although sediment transport rates at the southern end of the trench are relatively low, the position of the north-west end of the trench adjacent to the crest of Quarantine bank means that migration and infilling in this region would be severe enough to necessitate annual dredging to maintain the effectiveness of the trench in deflecting swell wave energy away from Portsea Beach.

![Figure 5-8 Residual Sediment Transport Contours – Offshore Dredged Configuration](image)

5.2.3 Nearshore Dredged Configuration

Residual transport magnitudes for the offshore dredge configuration are shown in Figure 5-9 Tidal currents in the nearshore are small enough to remain essentially unaffected for (for the trench and side-cast geometry considered). Sediment transport rates are predicted to remain as ‘Baseline’ condition. Under this scenario, the side cast material would be expected to remain in place for approximately 10 years. However, if side-cast material consists of hard-pan or rocky material then ambient hydrodynamic processes (waves, currents) will be insufficient to cause erosion or infilling. The trench would not be expected to require maintenance dredging over the 50 year design life.
5.2.4 Detached Breakwater

Due to the position of the shore detached breakwater, residual sub-tidal sediment transport rates will remain as ‘baseline’ conditions.

5.2.5 Point Franklin Groyne

Shore-attached structures will not affect tidal currents or sub-tidal transport seaward of the active beach profile.

5.2.6 Portsea Front Beach Groyne

Shore-attached structures will not affect tidal currents or sub-tidal transport seaward of the active beach profile.

5.2.7 Beach Nourishment

This option will not affect tidal currents or sub-tidal transport seaward of the active beach profile.

5.2.8 Remove Revetment

This option will not affect tidal currents or sub-tidal transport seaward of the active beach profile.
6  References


