Appendix C – Sediment Transport Modelling

- RPS Rosslare 5 Year Maintenance Dredging & Beach Nourishment Study (January 2016)
**Document Control Sheet**

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1 INTRODUCTION

1.1 OVERVIEW

Iarnród Éireann propose to make an application to the Department of Environment, Community and Local Government (DECLG) for a 5 year Foreshore License for maintenance dredging to complement an existing Dumping at Sea Permit. Rosslare Europort requires regular maintenance dredging to allow continued provision of the full operational facilities of the Port. It is proposed that the coarse sand dredged under any future dredging campaigns will be re-used as beach nourishment at Rosslare Strand whilst any fine silt-clay material will be disposed of at a licensed offshore disposal site.

RPS was appointed by Iarnród Éireann to undertake a technical study to determine the possible impacts, if any, of the proposed dredging and dumping activities on the surrounding environment. The study utilised an updated version of an existing flexible mesh model of Rosslare to undertake the numerical modelling of the coastal processes and the sediment transport regime.

1.2 BACKGROUND

Rosslare Europort is a major entry and exit point for passenger and freight traffic between Ireland and the UK/Continental Europe. It is located approximately 5 miles north of Carnsore Point in County Wexford as shown in Figure 1.1.
The Inner Harbour, Turning Circle and Approach Channel at Rosslare Europort are subject to continuous sedimentation from two distinct sources; a fine silt-clay material is deposited in the Inner Harbour, Turning Circle and Ballygeary harbour whilst coarse sand, which accumulates outside the Outer Breakwater, is deposited in the Approach Channel. Maintenance dredging is required on an ongoing basis to maintain the charted depth of -7.2m CD in the Port.

Recent maintenance dredging campaigns were carried out in 2011 and 2014 to remove depositions of sand from the Approach Channel. The sandy material dredged during these campaigns was deposited in a near-shore disposal site off Rosslare Strand to provide beach nourishment. Individual Foreshore Licenses were sought and received for each of these dredging campaigns.
In 2012, the Port received a Dumping at Sea Permit (No.S0016-01) from the Environmental Protection Agency (EPA) for the disposal of dredged material at an offshore disposal site approximately 6.5km North East of Rosslare Europort. The Dumping at Sea Permit is valid for an eight year period from 30th March 2012. To date, no material has been deposited at this offshore disposal site.

The Port now proposes to make an application to the DECLG for a 5 year Foreshore License for maintenance dredging to complement the existing Dumping at Sea Permit. It is proposed that the coarse sand dredged under any future campaigns will be re-used as beach nourishment material at Rosslare Strand while the fine silt-clay material will be disposed of at the offshore disposal site. The proposed dredge areas, the offshore disposal site and the 2011/2014 inshore beach nourishment site are identified in Figure 1.2.

Figure 1.2: Proposed dredge areas and the inshore and offshore disposal sites at Rosslare.
2 MODELLING METHODOLOGY

The numerical modelling for this study was undertaken using the MIKE suite of software developed by DHI of Denmark and employed a model of the Rosslare area that RPS had previously developed and calibrated. The coupled flexible mesh model was used to simulate tidal currents, wave climate (using Spectral Wave modelling) and sediment transport.

The model was updated and refined to reflect the specific needs of this study including improved resolution within the areas under examination, principally Ballygeary Harbour, Rosslare Europort, the inshore disposal site and the offshore disposal site.

The model was used to simulate one month of average tidal conditions, these data then were used to determine the fate of material arising from the dredging operations at Ballygeary and Rosslare Europort and the subsequent disposal of the spoil material at the inshore and offshore disposal sites. The range of simulations undertaken was as follows:

**Sediment Plume modelling**

- Dredging and spill of silt material from Ballygeary and Rosslare Europort;
- Dredging and spill of sand material from Rosslare Europort;
- Dumping of silt material from Ballygeary and Rosslare Europort at the offshore disposal site; and
- Dumping of sand material from Rosslare Europort at the inshore disposal site.

**Sediment Transport modelling**

- Subsequent transport of sediment from the disposal inshore site under:
  a) Calm weather conditions; and
  b) Wind waves under storm (F6) conditions from the east, north east and south east.
3 TIDAL MODELLING SYSTEM

The tidal flow simulations which formed the basis of the study were undertaken using the MIKE21 FM flexible mesh modelling system. The FM Module is a 2-dimensional, depth averaged hydrodynamic model can be used to simulate the water level variations and flows in response to a variety of forcing functions in lakes, estuaries and coastal areas. The water levels and flows are resolved on a mesh covering the area of interest when provided with bathymetry, bed resistance coefficient, wind field, hydrodynamic boundary conditions, etc.

The system solves the full time-dependent non-linear equations of continuity and conservation of momentum using an implicit ADI finite difference scheme of second-order accuracy.

The effects and facilities incorporated within the model include:

- Convective and cross momentum;
- Bottom shear stress;
- Wind shear stress at the surface;
- Barometric pressure gradients;
- Coriolis forces;
- Momentum dispersion (e.g. through the Smagorinsky formulation);
- Wave-induced currents;
- Sources and sinks (mass and momentum);
- Evaporation;
- Flooding and drying.
4 TIDAL MODEL

An existing tidal model of the Rosslare area was further developed for this particular study; the main aspects of the model are outlined in the following sections.

4.1 MODEL DOMAIN

The tidal domain covered a large area of the St George’s Channel as shown in Figure 4.1; this enabled the tidal currents to be accurately simulated within the model. The model resolution varied across the domain with coarser cells at the model boundaries and finer cells, in the order of 7.5m, in the vicinity of Ballygeary harbour and Rosslare Europort. The model resolution at the site is illustrated in Figure 4.2. This flexible mesh approach meant that the detailed bathymetry of the area could be accurately represented whilst maintaining computational efficiency.

Figure 4.1: Model domain of the Rosslare coastal model.
Figure 4.2: Mesh detail at Ballygeary harbour & Rosslare Europort (purple outline) and also the inshore and offshore (shown in inlay) disposal sites (red outline).
4.2 DATA SOURCES

The original Rosslare model used for the earlier 2014 Sediment Transport study was developed using several different sources of data including from digital admiralty charts and previous bathymetric surveys of the surrounding area which were collected as part of previous projects. The original flexible mesh model was further updated for this current study by including new bathymetry data collected during recent hydrographic surveys of Rosslare Europort and of the inshore disposal site. Where bathymetric survey data was available from multiple surveys for the same area the most recent data was used.

An example of the high resolution data used to develop the Rosslare model is presented in Figure 4.3 in which c.200,000 data points are shown, representing the bathymetry across a small section of the model.

Figure 4.3: Example of bathymetric survey data used to develop the Rosslare flexible mesh model.
4.3 BOUNDARY CONDITIONS

The tidal boundary data used for the Rosslare model was generated by RPS’ Irish Sea Surge model. This model stretches from the North-western end of France including the English Channel as far as Dover out into the Atlantic to 16° west, including the Porcupine Bank and Rockall. In the other direction it stretches from the Northern part of the Bay of Biscay to just south of the Faeroes Bank. Overall, the model covers the Northern Atlantic Ocean and UK continental shelf up to a distance of 600km from the Irish Coast as illustrated in Figure 4.4.

This model was also constructed using flexible mesh technology; along the Atlantic boundary the model features a mesh size of 13.125’ (24km). The Irish Atlantic coast has been described using cells of on average 3km size while in the Irish Sea the maximum cell size is limited to 3.5 km decreasing to 200m along the Irish coastline. The bathymetry of this model was generated from a number of different sources including digital chart data and surveys of several banks and coastal areas. This model is driven by astronomic tides generated using a global tidal model designed by a team at the Danish National Survey and Cadastre Department (KMS).

Figure 4.4: Extent of the RPS Irish Seas Tidal Surge model.
5 MODELLING SIMULATIONS

5.1 OVERVIEW

The Rosslare Dredging and Beach Nourishment Study utilised several MIKE modelling modules including the Hydrodynamic Module, the Mud Transport Module and also the Sand Transport Module (which includes Spectral Wave modelling). Each of these aspects is described further in the appropriate sections of this document.

5.1.1 Modelling System: Hydrodynamic module

The Hydrodynamic Module is the basic computational component of the entire MIKE 21 FM modelling system providing the hydrodynamic basis for other modules including the:

- Transport Module;
- ECO Lab Module;
- Mud Transport Module;
- Sand Transport Module; and
- Particle Tracking Module.

The hydrodynamic module is based on the numerical solution of the two-dimensional shallow water equations - the depth-integrated incompressible Reynolds averaged Navier-Stokes equations. Thus, the model consists of continuity, momentum, temperature, salinity and density equations. In the horizontal domain both Cartesian and spherical coordinates can be used.

The spatial discretisation of the primitive equations is performed using a cell-centred finite volume method. The spatial domain is discretised by subdivision of the continuum into non-overlapping element/cells. In the horizontal plane an unstructured grid is used comprising of triangles or quadrilateral elements. An approximate Riemann solver is used for computation of the convective fluxes, which makes it possible to handle discontinuous solutions. For the time integration, an explicit scheme is used.
5.2 EXISTING TIDAL FLOWS

The numerical model was used to simulate baseline data in order to assess the accuracy of the model and also to inform the timing of the dredging and dumping operations. Tidal flows in the Rosslare area were simulated over a typical spring neap tidal cycle, for the purposes of brevity spring tidal plots are presented in this document.

Figure 5.1 and Figure 5.2 show the typical ebb and flood patterns within the Rosslare Europort/South Strand area respectively. These figures provide ‘snapshots’ of the flow patterns at mid-tide when the current speeds are at their greatest. It can be seen that the principle flow directions are parallel to the coast and that, at these points of the tidal cycle, the ebb tide is marginally stronger than the flood. This differential in the ebb and flood tidal regimes also results in dissimilar levels of sediment transport associated with each element of the tide and is thus one of the primary factors in determining the nature of the sediment transport regime in this area.

Figure 5.1: Typical ebb flow pattern at Rosslare – Spring tidal conditions.
Figure 5.2: Typical flood flow pattern at Rosslare – Spring tidal conditions.
5.3 MODEL CALIBRATION

The model was calibrated using published Admiralty tidal diamonds to ensure that the complex eddying system around the Rosslare and Wexford Harbour area was accurately recreated. The tidal diamonds are generally related to a limited amount of drogue data and will not be associated with the same period in time as the modelling; but they can be used effectively to ensure the relevant flow patterns are simulated. However it should be noted that the data reported by the Admiralty charts is historical data and therefore may not entirely reflect current conditions which are affected by the morphology of the sea bed in the area. Despite this, in absence of specifically collected hydrographic survey data they provide a reasonable indication of baseline conditions at the site.

In the case of the diamond located offshore of the Rosslare Europort (Chart 1772) the ebb tidal currents are double that of those on the flood tide and the duration of the flood is noticeably shorter due to eddying. This localised eddying and asymmetric tide gives rise to large offshore residual currents. The location of this diamond in relation to Rosslare Europort is shown in Figure 5.3 below.

![Figure 5.3: Location of Admiralty tidal diamond 1772 in relation to Rosslare Europort.](image_url)
Figure 5.4 and Figure 5.5 show the modelled current speeds and directions compared with the recorded data at the tidal diamond during typical spring and neap tidal conditions respectively. It will be seen from Figure 5.4 that the model accurately represents the tidal asymmetry and that the current speeds are of the right order of magnitude. From Figure 5.5 it can also be seen that the eddying at the tidal diamond persists for the correct proportion of the tidal cycle within the model. Furthermore, by comparing figures it will be seen that the current speeds during a typical neap tide are approximately half of those observed during a typical spring tidal regime.

Figure 5.4: Modelled and recorded current speeds (upper figure) and directions (lower figure) at Tidal Stream 1772 B during typical spring tide conditions.
Figure 5.5: Modelled and recorded current speeds (upper figure) and directions (lower figure) at Tidal Stream 1772 B during typical neap tide conditions.
5.4 MODEL RATIONALE

The scope of the study identified three phases of the dredging operations for investigation using modelling:

- The dredging of material from Ballygeary harbour and Rosslare Europort
- The disposal of material at the offshore and inshore disposal sites, depending on the nature of the spoil material.
- The subsequent transport of the material disposed of at the inshore disposal site during typical storm conditions.

Each of these phases has been presented separately in the following sections.

5.5 DREDGING AND DISPOSAL OF SAND AND SILT MATERIAL

The first component of the proposed campaign to be examined is the dredging of sand and silt material from Ballygeary harbour and Rosslare Europort for subsequent deposition within the inshore disposal site designated as a re-nourishment area and the offshore disposal site respectively. The proposed dredging areas and both the offshore and inshore disposal sites are presented in Figure 5.6 overleaf. The coordinates of the inshore beach re-nourishment area are also presented in Table 5.1 below.

It is expected that 320,000m$^3$ of sand material and 180,000m$^3$ of silt will be dredged over the course of a 10 year period at 2 yearly intervals; the modelling was consequently based on one dredging campaign which would involve the following:

- A volume of 64,000m$^3$ of sand material being removed from the Approach Channel and Outer Breakwater area before being disposed of at the inshore disposal site to be used as beach re-nourishment material for south Rosslare Strand.
- A volume of 36,000m$^3$ of silt material being removed from the Inner Harbour, the Turning Circle and Ballygeary harbour before being disposed of at the offshore disposal site.

Table 5.1: Coordinates of inshore disposal site used for beach re-nourishment.

<table>
<thead>
<tr>
<th>Corner of site</th>
<th>X Coordinate</th>
<th>Y Coordinate</th>
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<td>Top Left</td>
<td>06° 22.48' W</td>
<td>52° 16.19' N</td>
</tr>
<tr>
<td>Top Right</td>
<td>06° 22.04' W</td>
<td>52° 16.27' N</td>
</tr>
<tr>
<td>Bottom Left</td>
<td>06° 21.92' W</td>
<td>52° 16.09' N</td>
</tr>
<tr>
<td>Bottom Right</td>
<td>06° 22.38' W</td>
<td>52° 16.00' N</td>
</tr>
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Figure 5.6: Layout of dredging and nourishment sites.
5.5.1 Modelling System

The Mud Transport (MT) module describes erosion, transport and deposition of mud or sand/mud mixtures under the action of currents and (if appropriate) waves. The hydrodynamic basis for the MT Module is calculated using the Hydrodynamic Module of the MIKE 21 Flow Model FM modelling system and the MT is implemented as a coupled model with the two running concurrently. The following processes may be included in the simulation.

- Forcing by waves;
- Salt-flocculation;
- Detailed description of the settling process;
- Layered description of the bed; and
- Morphological update of the bed.

In the MT-module, the settling velocity varies, according to the salinity, if included, and the concentration taking into account flocculation in the water column. Bed erosion can be either non-uniform, i.e. the erosion of soft and partly consolidated bed, or uniform, i.e. the erosion of a dense and consolidated bed. The bed is described as layered and is characterised by the density and shear strength.

5.5.2 Model simulations

The model simulations for the dredging and disposal of sand and silt material followed by the subsequent disposal of these materials were designed to reflect the anticipated programme as closely as possible. The works are likely to be undertaken using a trailer suction hopper dredger with a 1,500m³ hopper capacity, carrying out the dredging and disposal works over a period of 10 and 21 days for the silt and sand material respectively (based on a 24/7 basis).

The composition of the material to be dredged and subsequently used for re-nourishment was examined as part of an earlier study. The sediment characteristics derived from this previous sampling programme indicated that the material in the Inner Harbour, Turning Circle and Ballygeary Harbour consisted primarily of a fine-silt clay material whilst the material in the Approach Channel and Outer Breakwater consisted primarily of coarse sand which was considered ideally suited for re-nourishment.
As such the sand material introduced into the model simulation was characterised by three distinct fractions with mean diameters of 0.1785mm, 0.75mm and 2.00mm whilst the silt material introduced into the model was characterised by two discrete fractions with mean diameters of 0.0233mm and 0.0467mm, this is summarised in Table 5.2 below.

**Table 5.2: Modeled material characteristics.**

<table>
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<tr>
<th>Representative Material</th>
<th>Fraction</th>
<th>Class</th>
<th>Mean Size [mm]</th>
<th>Settlement Velocity [m/s]</th>
<th>Proportion [%]</th>
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<tr>
<td>Silt</td>
<td>1</td>
<td>Medium Silt</td>
<td>0.0233</td>
<td>0.000367</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Coarse Silt</td>
<td>0.0467</td>
<td>0.001472</td>
<td>50</td>
</tr>
<tr>
<td>Sand</td>
<td>3</td>
<td>Fine Sand</td>
<td>0.1875</td>
<td>0.0194</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Coarse Sand</td>
<td>0.7500</td>
<td>0.07997</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Very Coarse Sand</td>
<td>2.0000</td>
<td>0.143</td>
<td>33</td>
</tr>
</tbody>
</table>

The simulations undertaken aimed to determine the concentration and distribution of sediment lost to the water column during the dredging of the silt and sand. The dredging rate of the trailer suction hopper dredger was specified as 175m$^3$/hr or 72.91kg/s, the losses associated with this method of dredging have been reported to be c.3%, consequently a spill rate of 2.18 kg/s was employed in the model.

The filled dredger which has a capacity of 1,500m$^3$ will dispose of the spoil material at either the inshore or offshore disposal site depending on the nature of the material. Each dumping operation will take circa 15 minutes, which equates to a spill rate of 6,000m$^3$/hr or 2,916.67 kg/s. In both instances, the releases will be undertaken as the dredger traverses the disposal sites. Hence for the modelling the spoil material was released across the entirety of each respective site and allowed to settle through the water column under the influence of the tide.

The campaign implemented within the modelling accounted for technical aspects which would be encountered in reality. The material was assumed to be dredged and deposited over the course of multiple spring-neap tidal cycles, which not only reflects the duration required but also ensures all tidal states and their influence on the dispersion of the dredged material are assessed. The model did not include the impact of wind or wave action; as the proposed programme itself could only be undertaken during a suitably calm sea-state.
The envisaged use of split hopper barge with a capacity of 1,500m³ means that sufficient underkeel clearance is required to permit safe access to the relatively shallow inshore deposition area (circa 4m CD); therefore the placement of the dredged material at this site was limited to periods when tidal conditions afforded this depth. During the simulation the timing of each discharge was varied slightly to allow for natural variability, however a slight bias to flood tide was also introduced to counter residual currents which run to the south west of the re-nourishment site. The spill cycle with respect to the tidal cycle is shown in Figure 5.7.

Figure 5.7: Re-nourishment timing with respect to tidal phase.
5.5.3 Dredging simulation results

An overview of the maximum suspended sediment plume envelopes in the Rosslare area as a result of the dredging in Ballygeary harbour and Rosslare Europort is presented in Figure 5.8. This Figure represents the maximum suspended sediment concentration experienced in each mesh element over the course of the simulation. These values may therefore not have occurred simultaneously nor have persisted for any significant period. It should be noted that a log scale has been used to demonstrate the range of values encountered.

The low settling velocities of the silty material which was dredged from the Inner Harbour, Turning Circle and Ballygeary and dumped offshore meant that this material remained suspended in the water column significantly longer than the sandy material from the approach channel. As such the maximum suspended sediment plume envelopes indicate a relatively far-field impact, however, it will be noted that the furthest extending envelope has a suspended sediment concentration [SSC] value of between 0.001 - 0.010 kg/m³, this is equivalent to 0.001-0.010 g/L which is virtually an undetectable quantify of sediment. The greatest SSC values were observed within Ballygeary harbour, although concentrations did not exceed 10kg/m³, or 10g/L and can be attributed to the lack of dispersion in this area due to the shelter afforded by the harbour.
Figure 5.8: Maximum SSC during the dredging of Ballygeary and Rosslare Europort.

5.5.4 Dumping simulation results

Figure 5.9 illustrates the increase in bed thickness following the disposal of the sand material at the inshore disposal site where the red outline indicates the boundaries of the re-nourishment site. It can be seen that virtually all of the material remains within the site boundary; furthermore, the resulting thickness indicates that the spoil material has been evenly distributed across the entire site resulting in a relatively uniform increase in bed thickness of between 0.36-0.44m. An assessment of the simulation results indicate that the bed mass across the site increased by approximately 590kg/m², equating to a total volume increase across the entire site of c. 65,750m³ which is only 3.3% lower than the modelled dredge volume of 68,000m³. These results therefore indicate that approximately 97% of the proposed dredged material volume will be successfully deposited within the confines of the designated inshore disposal site.
Figure 5.9: Increase in bed thickness following deposition of sand material at the inshore disposal site.

The average suspended sediment plume envelope for silty material over the course of a complete tidal cycle as a result of the disposal of one barge load of material at the offshore disposal site is presented in Figure 5.10. It will be seen from this figure that silty material is dispersed over a wide area but that the average suspended sediment concentrations [SSC] are typically <0.0001 kg/m$^3$ (or 0.0001g/L). This indicates that the disposal of silty material at the offshore site is unlikely to result in any significant environmental impacts through the unwarranted transportation of the material or complete removal from the local sediment cell.
Figure 5.10: Mean SSC plume envelope of sand material over a full tidal cycle as a result of depositing silt material at the offshore disposal site.
The maximum suspended sediment plume envelope resulting from the disposal of the silty material at the offshore disposal site is presented in Figure 5.11 whilst Figure 5.12 presents the maximum suspended sediment plume envelope resulting from the disposal of the sand at the inshore disposal site. These Figures represent the maximum suspended sediment concentration which was experienced in each mesh element over the course of the simulation. These values may therefore not have occurred simultaneously nor have persisted for any significant period. As such, the values seen at each of these locations are relatively high as these are associated with the initial release of material into the water column, whilst beyond the respective site boundary the values are very small. It should be noted that a log scale has been used to demonstrate the range of values encountered.

It will be seen from Figure 5.11 that the dumping of silty material at the offshore site results in significant far field dispersion of the material. The envelope which represents the SSC plume of between 0.001 – 0.01kg/m$^3$ extends beyond Carnsore Point to the South and close to Cahore Point to the North, however it should be noted that a SSC of between 0.001 – 0.01kg/m$^3$ is equivalent to 0.001 – 0.01g/L which is a virtually undetectable quantity of material. It will be seen that the plume envelope of the silty material is confined to the offshore areas only and that there are no detectable impacts in the inshore region.

The characteristics of the sandy material dredged from the Approach Channel and Outer Breakwater coupled with the spill being initiated over the inshore disposal site when there is sufficient draft, which is predisposed to being during periods of lesser current speed meant that the sandy material was seen to settle within the confines of the beach re-nourishment area and did not cause significant increases in suspended sediment concentration during the placement. Therefore very little in the way of a discharge plume is predicted during the disposal of sandy material at the inshore disposal site and as such the operation is not anticipated to impinge on the sensitive berthing/fishing areas to the south of the site.
Figure 5.11: Maximum SSC plume envelope of silt material as a result of depositing silt material at the offshore disposal site.

Figure 5.12: Maximum SSC plume envelope of sand material as a result of depositing sand material at the inshore disposal site.
5.6 SEDIMENT TRANSPORT

The final modelling phase of this study was undertaken to determine the fate of the dredged sand material once deposited at the inshore beach re-nourishment site. This was achieved by assessing the transport of this material under the effect of relatively frequent wave conditions. These were modelled for each of the principle directions from which waves would approach the re-nourishment site.

5.6.1 Modelling System

The hydrodynamic basis for the Transport Module was calculated using the Hydrodynamic Module of the MIKE 21 Flow Model FM modelling system. The transport module calculates the resulting transport of material based on these flow conditions coupled with other appropriate modules, which for this specific stage of the study this is the wave modelling module. A number of components may be specified with each component defining a separate transport equation. The time integration of the transport (advection-dispersion) equations is then performed using an explicit scheme to calculate the resulting sediment transport.

The wave climate was derived using the Mike21 Spectral Wind-wave Flexible Mesh model (SW). The SW model is a third generation spectral wind-wave model with two modes of operation, using either the directional decoupled parametric or fully spectral formulations. For this study, the directional decoupled parametric formulation was used, as it was not necessary to separate out the individual wind and swell components of the waves. The SW module describes the propagation, growth and decay of waves in nearshore areas. The model can take into account the effects of refraction and shoaling due to varying depth, local wind generation and energy dissipation due to bottom friction, white capping and wave breaking. It may also include non-linear wave-wave interaction, wave-current interaction and the effect of time varying water depth and flooding and drying. The SW model has an optimal degree of flexibility in describing bathymetry and ambient flow conditions using depth-adaptive and boundary-fitted unstructured mesh.
## 5.6.2 Model Simulations

Four scenarios were examined with respect to wave induced sediment transport. In each case a wind of Beaufort Force 6 (12m/s) was applied across the model domain in addition to the tidal current. The four scenarios were:

- A storm approaching from the north east;
- A storm approaching from the east;
- A storm approaching from the south east; and
- A storm approaching from the south east including offshore swell conditions.

These represent ‘typical’ storm conditions experienced in the area and were used to examine the stability of the beach re-nourishment material and the performance of the re-nourishment site. Under more extreme conditions there would be greater levels of sediment transport however this would also involve the movement of sediment in the wider domain.

### 5.6.1 Sediment Transport simulation results

Each of the scenarios was run separately. In each of the four individual cases the sea bed thickness that resulted from the sediment deposition under calm conditions presented in Section 5.5.4 was used as the starting condition. Each storm was run in over a period of two complete tide cycles using the appropriate wind/wave climate conditions and the change in bed profile and sediment transport was evaluated.

Figure 5.13 and Figure 5.14 show the transport response of the re-nourishment material during the north east and easterly storms respectively. In each case the average transport load during the course of the event is presented along with the residual transport vectors. This illustrates the net transport of material during the course of the storm taking account of tidal currents. They demonstrate that the effect of the typical storm wave climate is to transport material in a westerly direction towards the shoreline whilst the residual currents give rise to a small amount of southerly sediment transport.
Similarly, transport profiles are presented in Figure 5.15 and Figure 5.16 for the south easterly event, excluding and including swell waves respectively. For the event without the swell component of the wave climate the transport is largely related to residual tidal currents however there is some contribution to shoreward transport due to wave reflection around the Port. As anticipated a greater amount of material is moved with the inclusion of the longer period swell waves. These waves are also reflected around the Port and provide movement of material in a south-westerly direction.

It may therefore be concluded that, during storm conditions from any direction, the deposited material is gradually transported towards the shoreline. It is therefore anticipated that material deposited on the inshore disposal site will, over time, be transported onshore and act as beach re-nourishment material. However it should be noted that given the relatively slow transport rates across the disposal site, it will take a prolonged period of time for the disposal site to return to baseline conditions. As such, care should be taken not to overload the disposal site over successive dredging/nourishment campaigns.

Figure 5.13: Net movement of nourishment material due to F6 Storm from North East
Figure 5.14: Net movement of nourishment material due to F6 Storm from the East

Figure 5.15: Net movement of nourishment material due to F6 Storm from South East
Figure 5.16: Net movement of nourishment material due to F6 Storm from SE & Swell
6 SUMMARY AND CONCLUSIONS

A range of numerical modelling techniques have been used to examine the transport of sandy and silty material suspended during the dredging of Ballygeary harbour and Rosslare Europort followed by the subsequent disposal of the dredged material at the inshore beach re-nourishment site and the offshore disposal site where the sandy and silty materials were deposited respectively. These initial simulations were followed by further modelling to determine the fate of the deposited material at the inshore beach re-nourishment site in response to a range relatively frequent storm conditions.

Dredging Simulations

It was found that the maximum suspended sediment concentration [SSC] as a result of dredging Ballygeary harbour and Rosslare Europort did not exceed 10kg/m$^3$ (or 10g/l) these values were observed within Ballygeary harbour and can be attributed to the non-dispersive nature of the tidal regime in the harbour. The furthest extending plume envelope had a SSC of between 0.001 - 0.010 kg/m$^3$ and was found not to extend beyond Greenore Point to the south.

Dumping Simulations

Results demonstrated that the total volume across the entire site increased by c. 65,750m$^3$ which is only 3.3% lower than the modelled dredge volume of 68,000m$^3$ indicating that approximately 97% of the proposed dredged material volume was successfully deposited within the confines of the designated inshore disposal site. This resulted in a relatively uniform increase in bed thickness across the site of between 0.36-0.44m.

It was found that disposing of the silty material resulted in a widely dispersed suspended sediment plume envelope, however sediment concentrations [SSC] were typically <0.0001 kg/m$^3$ (or 0.0001g/l). The maximum suspended sediment plume envelope was observed within the immediate vicinity of the offshore disposal site, the SSC of this envelope did not exceed 10.0kg/m$^3$.

Due to the characteristics of the sandy material there was virtually no discharge plume beyond the confines of the re-nourishment site during the disposal of sandy material. As such, the disposal of sandy material at the inshore site did not result in any significant increases in SSCs.
Sediment transport Simulations

The sediment transport simulations demonstrated that the effect of the typical wave climate is to transport material from the inshore disposal site in a westerly direction towards the shoreline whilst the residual currents give rise to a small amount of southerly sediment transport. It can therefore be concluded that during storm conditions from any direction, the deposited material is transported towards the shoreline and will ultimately act as beach re-nourishment material along Rosslare Strand.

However it should be noted that given the relatively slow transport rates across the disposal site, it would take a prolonged period of time for the disposal site to return to baseline conditions. As such, care should be taken not to overload the disposal site over successive dredging/nourishment campaigns.