Dublin Port Company

**Dundalk Harbour Navigation Channel
Stability Study**

October 2011

Dublin Port Company

Dundalk Harbour Navigation Channel Stability Study

STUDY REPORT

DOCUMENT ISSUE

Client	Dublin Port Company					
Project Title	Dundalk Harbour Navigation Channel Stability Study					
Document Title	Study Report					
Document No.	IBE0623/AKB/Dundalk					
This Document Comprises	DCS	TOC	Text	Figures		
	x	x	x	x		

Rev.	Status	Author(s)	Reviewed By	Approved By	Office of Origin	Issue Date
0	Draft Final	AKB	NS	AKB	Belfast	06/10/11

RPS

CONTENTS

Page

RPS

1.0   INTRODUCTION

Dublin Port Company commissioned Hydrographic Surveys and RPS to undertake a programme of surveys and analysis to provide Dublin Port with information about the stability of the navigational channel to Dundalk Harbour when dredged to a level of -0.75m CD.

The study was undertaken using a combination of historical data review, bathymetric and sediment surveys and computational model studies. These studies were designed to examine the natural stability of the dredged channel rather than to determine the quantity and frequency of dredging required to keep the channel at a -0.75m CD depth.

2.0   DUNDALK BAY AND APPROACHES TO THE HARBOUR

Dundalk Bay stretches some 16 km from Castletown River and the Cooney Peninsula in the north to Annagassan and Dunany Point in the south. The inner bay is shallow, sandy and intertidal. The hydraulics of the bay are dominated by the sea but the bay encompasses the mouths and estuaries of the rivers Dee, Glyne, Fane, Castletown and Flurry. The bay is designated under the EU Habitats directive as a Special Area of Conservation (SAC). It is also a Ramsar Site and a Special Protection Area (SPA) under the EU Birds Directive.

The tidal range at Dundalk is relatively large for Irish waters with a mean spring range of 4.7 metres and a mean neap range of 2.6 metres. The bay is exposed to waves generated in the Irish Sea from an east north east to south south east direction. The Castletown River cuts through the intertidal zone in the north west corner of the bay and provides a channel which has been used by small ships to access to Dundalk Port for many years. Figure 1 shows the location of this channel within Dundalk Bay.
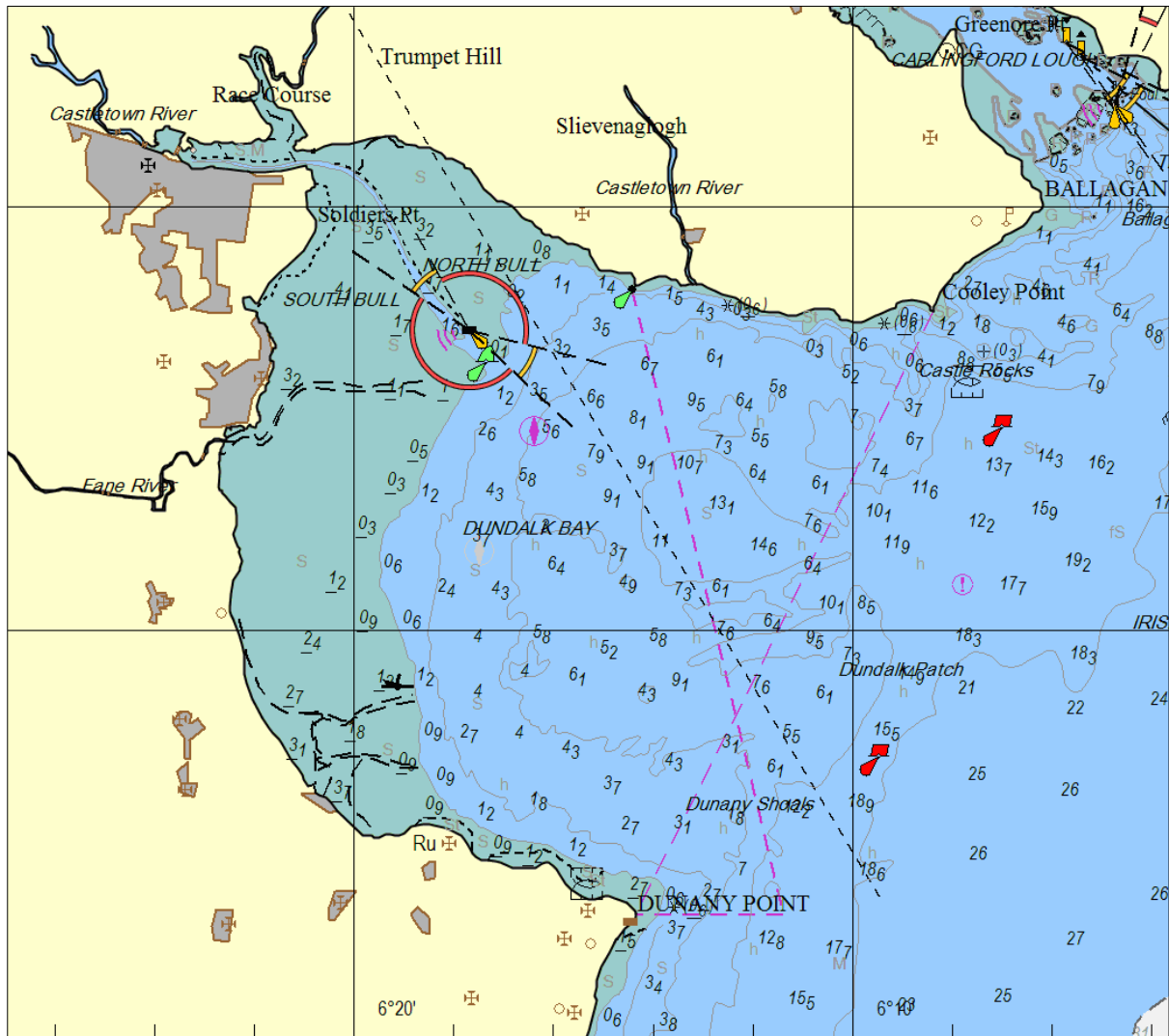
Figure 1   Dundalk Bay and Approaches to Dundalk

3.0   HISTORICAL SURVEYS OF THE NAVIGATION CHANNEL

The data for Dundalk Bay on the UK Admiralty chart of the north east coast of Ireland (44) and the chart of Dundalk and Approaches (1431) up to the late 1990s was largely based on old lead line surveys of 1881 with the levels in the navigation channel updated by surveys undertaken for the Dundalk Harbour Commissioners in 1965-72 and the bar area in 1986-89. Hydrographic Surveys Ltd have subsequently undertaken further surveys of parts of the channel in 1998, 2000, 2002, 2004 and 2005 mostly in relation to a pre and post dredging campaign undertaken by the Dundalk Harbour Commissioners in 2002 to 2004

In the last three years hydrographic surveys of the outer bay area and the navigational channel have been undertaken as part of the INFOMAR Irish national sea bed survey and LiDAR surveys have been completed around the coastal margins of the Bay to provide data for flood studies. However significant parts of the intertidal and low tide areas of Dundalk Bay have not been surveyed in recent times.

The assessment of siltation rates from the survey data collected by Hydrographic Surveys Ltd pre and post the 2002 - 2004 dredging campaign and the follow up survey in 2005, is hampered by the fact that the dredging was not well controlled. The work which was under taken by the Harbour Commissioners using a grab dredger resulted in humps and hollows in the sea bed rather than dredging to a consistent and required depth. Nevertheless the surveys tend to indicate that there had been some resiltation of the bar area in the year following the dredging and the formation of sand waves in the channel between markers 7 and 9 which indicate the potential for a reduction in depth post the completion of the dredging.

In view of the inconsistencies in the historical dredging records and survey data, it was decided that the stability of a dredged navigation channel into Dundalk should also be examined using computational modelling techniques.

RPS

4.0   COMPUTATIONAL MODELS AND DATA

The computational model studies were undertaken using the Mike21 suite of coastal process modelling software developed by the Danish Hydraulics Institute. The stability of the navigational channel to Dundalk harbour will be affected by a combination of tidal and littoral current, waves and sediment transport. The modelling was therefore undertaken using the Mike21 coupled model containing hydrodynamic flows, spectral wave and sand transport modules dynamically linked to provide the morphological evolution of the channel area.

The bathymetry for the model was taken from a combination of the latest INFOMAR and LiDAR sea bed surveys plus additional digital chart data supplied by C-Map of Norway. In addition specific hydrographic surveys of the banks on either side of the channel and some channel cross sections, Figure 2, were undertaken by Hydrographic Surveys Ltd for this study to provide additional data in the areas not covered by the INFOMAR and LiDAR surveys.
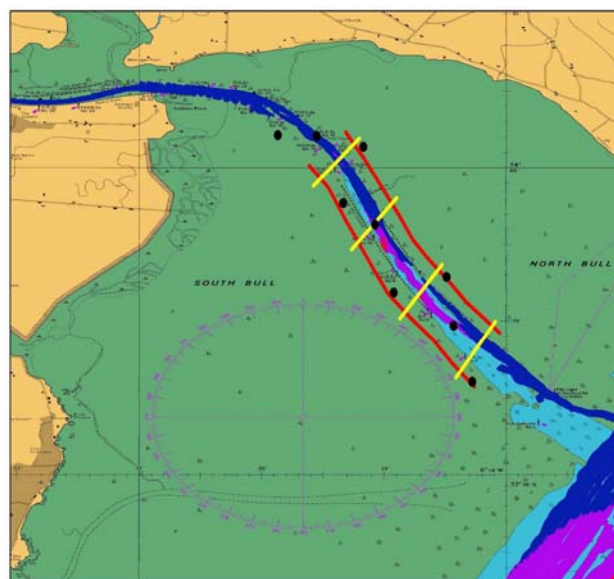

Figure 2   Lines of additional surveys of banks and channel cross sections

The simulations were undertaken using a flexible mesh modelling system which allows the model grid resolution to be varied over the model area with the finest resolution in the area of interest. The grid spacing of this model varied from about 720 metres at the boundary of the model to about 18 metres along the navigation channel. Figure 3a and 3b.show the extent and grid system of the model of Dundalk Bay used in this study.
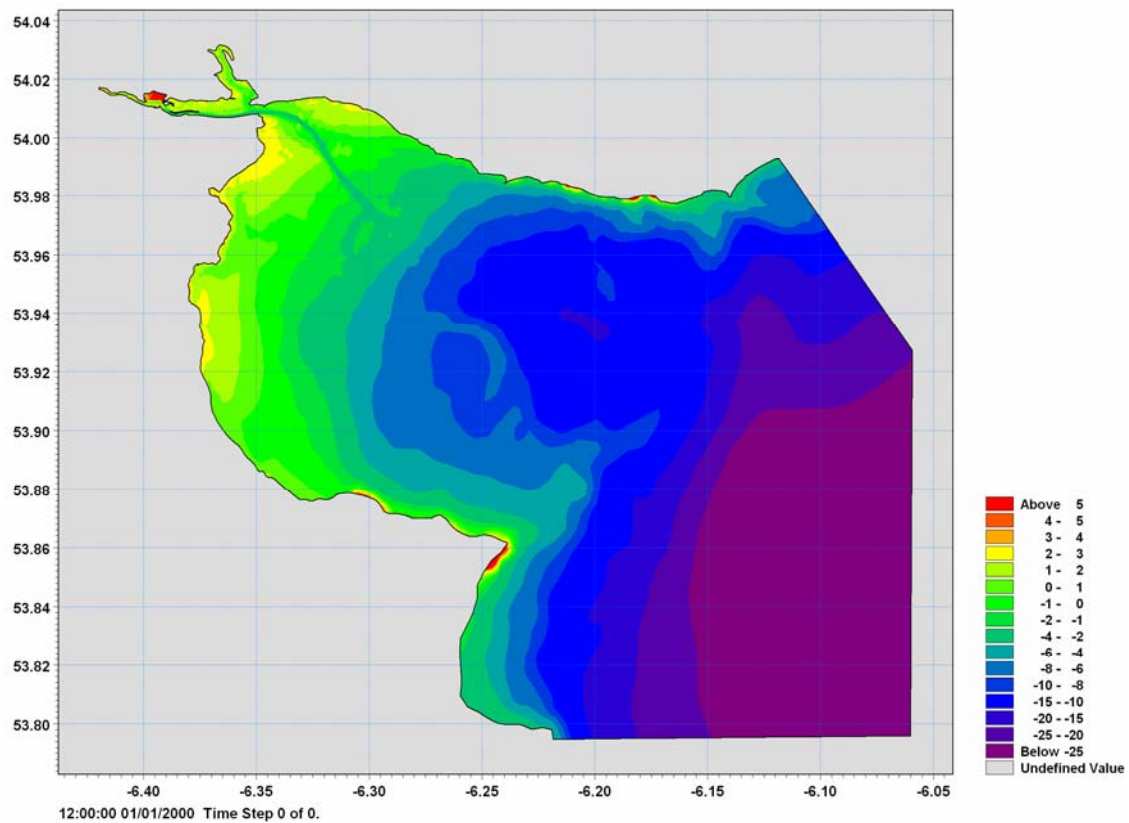
RPS

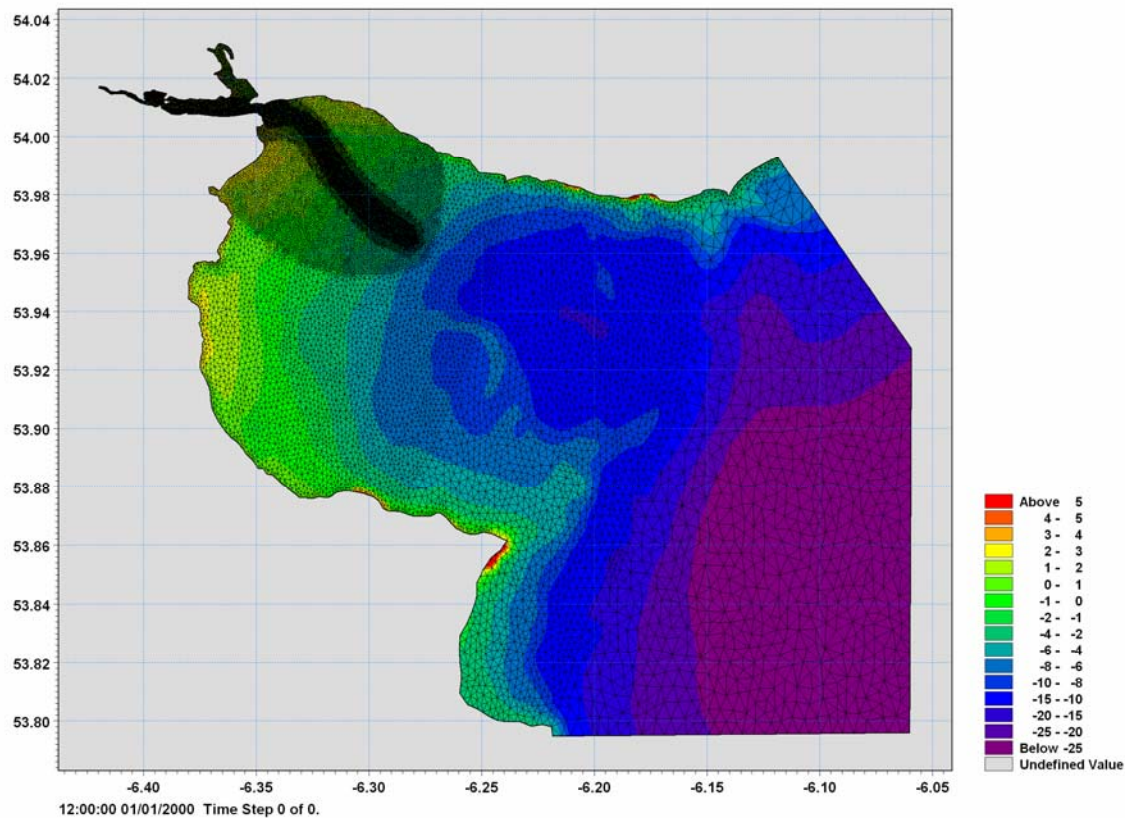**Figure 3a   Extent and bathymetry (to MSL) of model of Dundalk Bay**

Figure 3b   Flexible mesh model grid of Dundalk Bay

RPS

Sediment data for the study was taken from historical sediment samples plus the results of 9 sediment samples taken from the banks and channel in August 2011 at locations shown by the black dots in Figure 2 above. The results of the sediment analysis showed that the material on the banks on either side of the channel was mainly fine sand with a Dn_{50} size of 0.125mm. A typical grading curve for this material is shown in Figure 4.
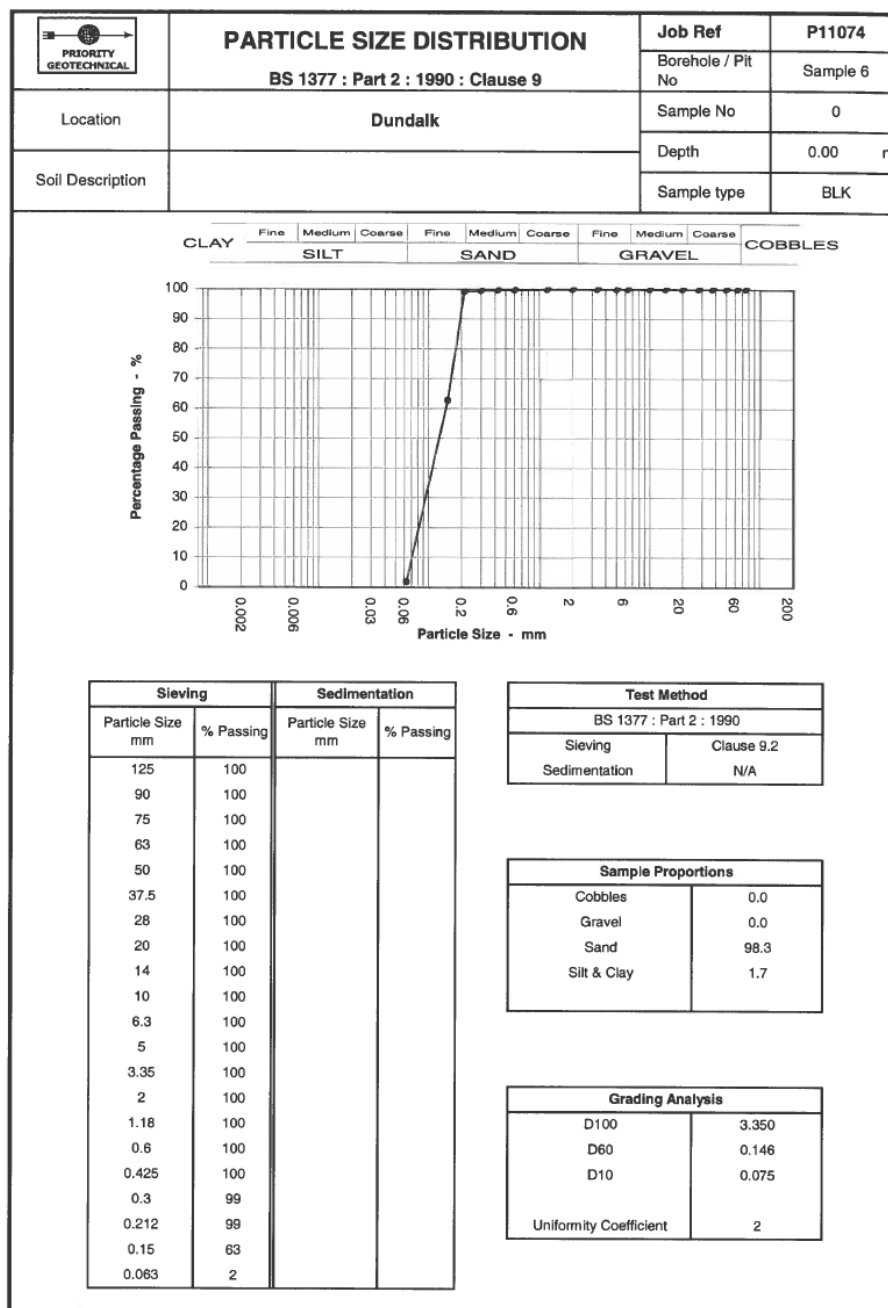

PARTICLE SIZE DISTRIBUTION		Job Ref	P11074
BS 1377 : Part 2 : 1990 : Clause 9		Borehole / Pit No	Sample 6
Location	Dundalk	Sample No	0
		Depth	0.00 m
Soil Description		Sample type	BLK

Sieving

Particle Size mm	% Passing
125	100
90	100
75	100
63	100
50	100
37.5	100
28	100
20	100
14	100
10	100
6.3	100
5	100
3.35	100
2	100
1.18	100
0.6	100
0.425	100
0.3	99
0.212	99
0.15	63
0.063	2

Test Method

BS 1377 : Part 2 : 1990	
Sieving	Clause 9.2
Sedimentation	N/A

Sample Proportions

Cobbles	0.0
Gravel	0.0
Sand	98.3
Silt & Clay	1.7

Grading Analysis

D100	3.350
D60	0.146
D10	0.075
Uniformity Coefficient	2

Figure 4 **Typical sediment grading curve of fine sand in the banks at the navigation channel into Dundalk Harbour.**

RPS

5.0   MODELLING PROCEDURE

As the channel infilling is most likely to occur during significant wave events, the model simulations were undertaken for both spring and neap tides under gale conditions. Dundalk Bay is open from the east to the south south east thus gales from the east, south east and a southerly direction were considered in the analysis.

The tidal flows and levels for the boundary of the Dundalk Bay model were derived from the RPS Irish coastal waters tide/surge model. This is a flexible mesh tidal and storm surge model which has been used to provide tidal water levels and storm surge forecasts for whole of the Irish coast. The extent of the model is shown in Figure 5.
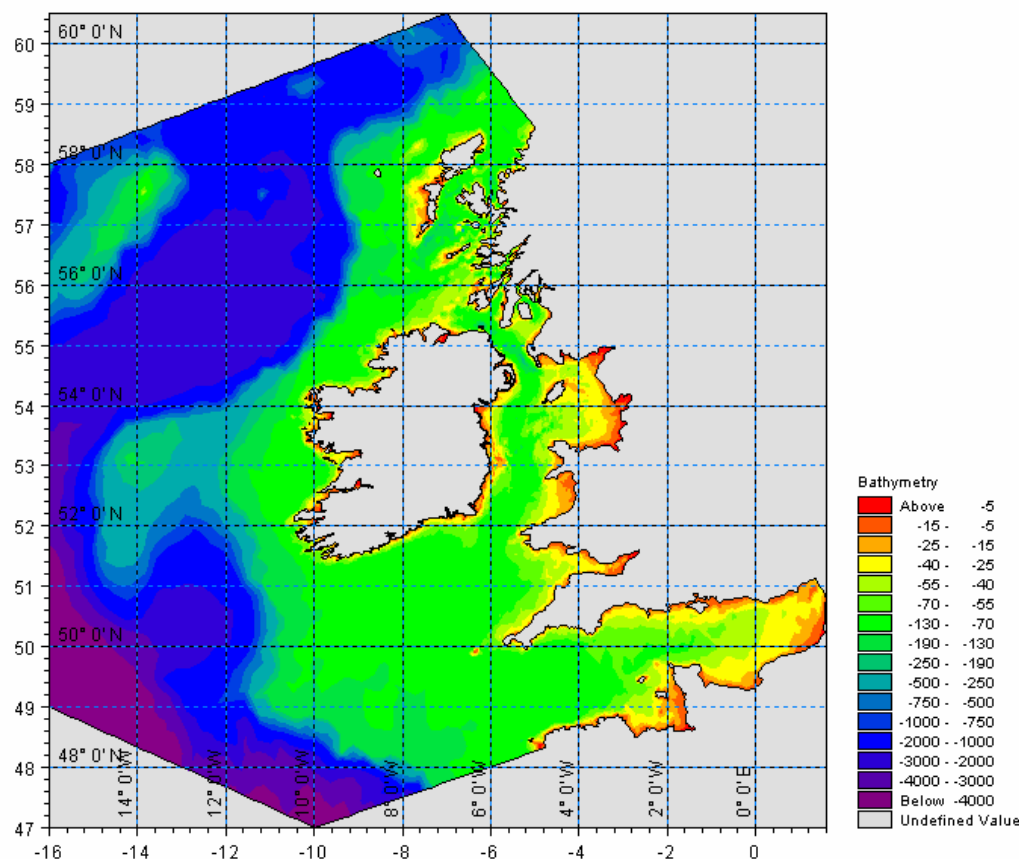
Figure 5   Extent of the RPS Irish coastal waters tidal and storm surge model

The wave data at the boundary of the Dundalk Bay model was taken from spectral wave model simulations of gale conditions in the Irish Sea. Figure 6 shows the significant wave height and mean wave directions of the waves in the northern part of the Irish Sea during typical gale conditions from the south east direction.
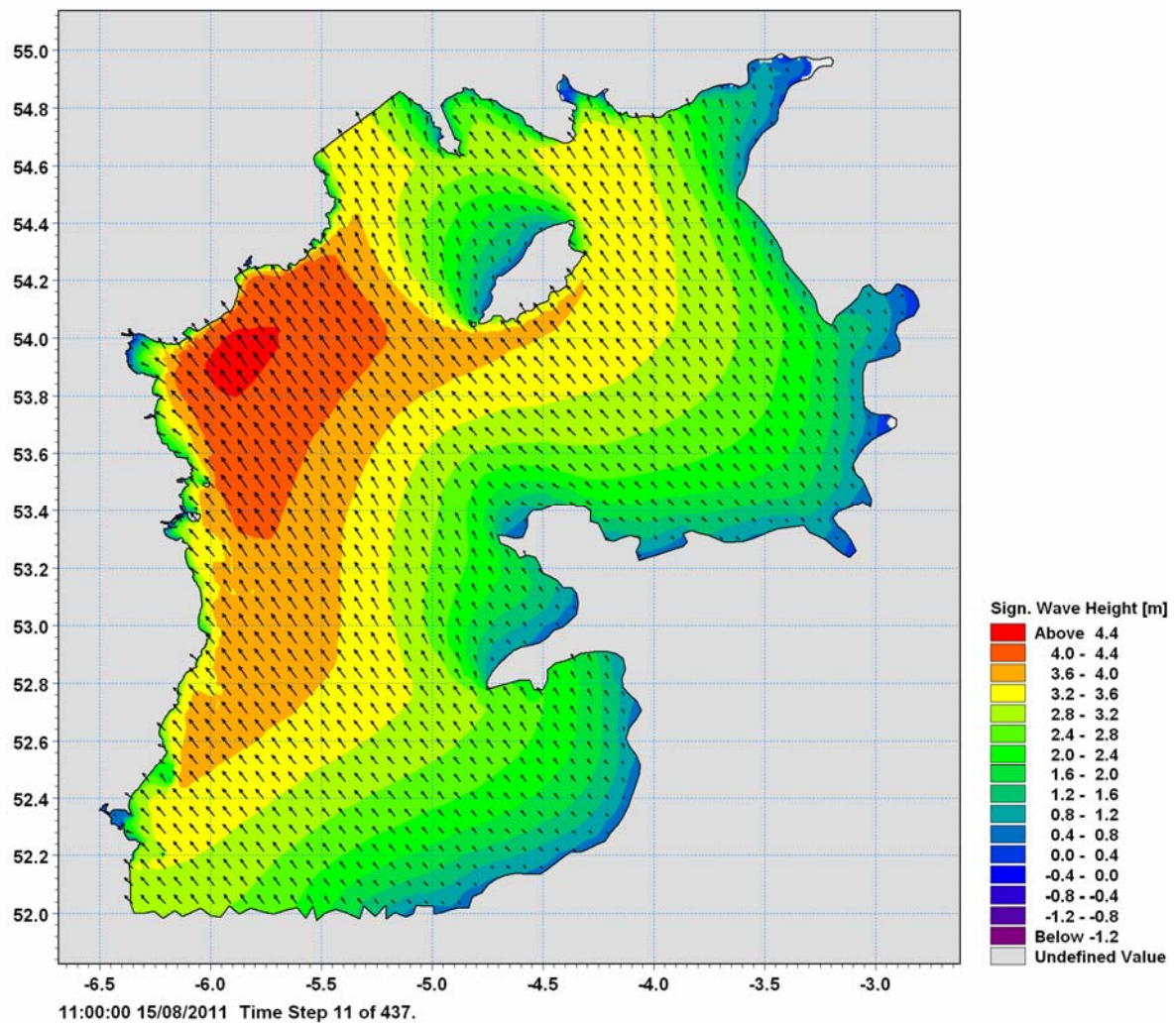
11:00:00 15/08/2011 Time Step 11 of 437.

**Figure 6   Significant wave heights and mean wave directions in the Irish Sea
With gale force winds from the south east**

The model simulations were run with the current flow, waves and sediment transport modules dynamically linked. The sea bed levels in the channel and on the adjoining banks in the wave and current flow modules were updated every 15 minutes throughout the simulation so that the impact of the morphological change on the coastal process regime of the channel area during the events could be included in the simulations.

An example of the wave climate in Dundalk Bay during south east gales is shown in Figure 7 and an example of the littoral current flow during an ebb spring tide and easterly gale is shown in Figure 8. The effect of the channel on the wave climate and littoral current flows can clearly be seen in these figures.
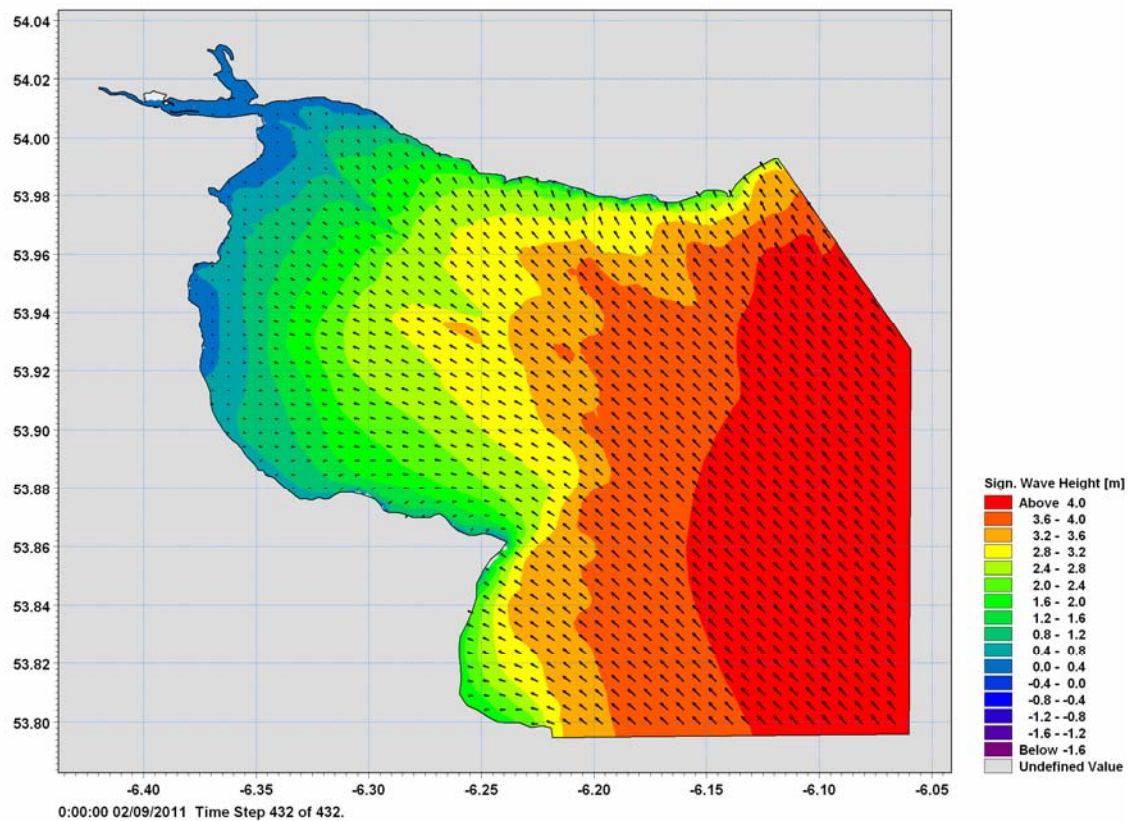
**Figure 7   Significant wave height and mean wave direction in Dundalk Bay
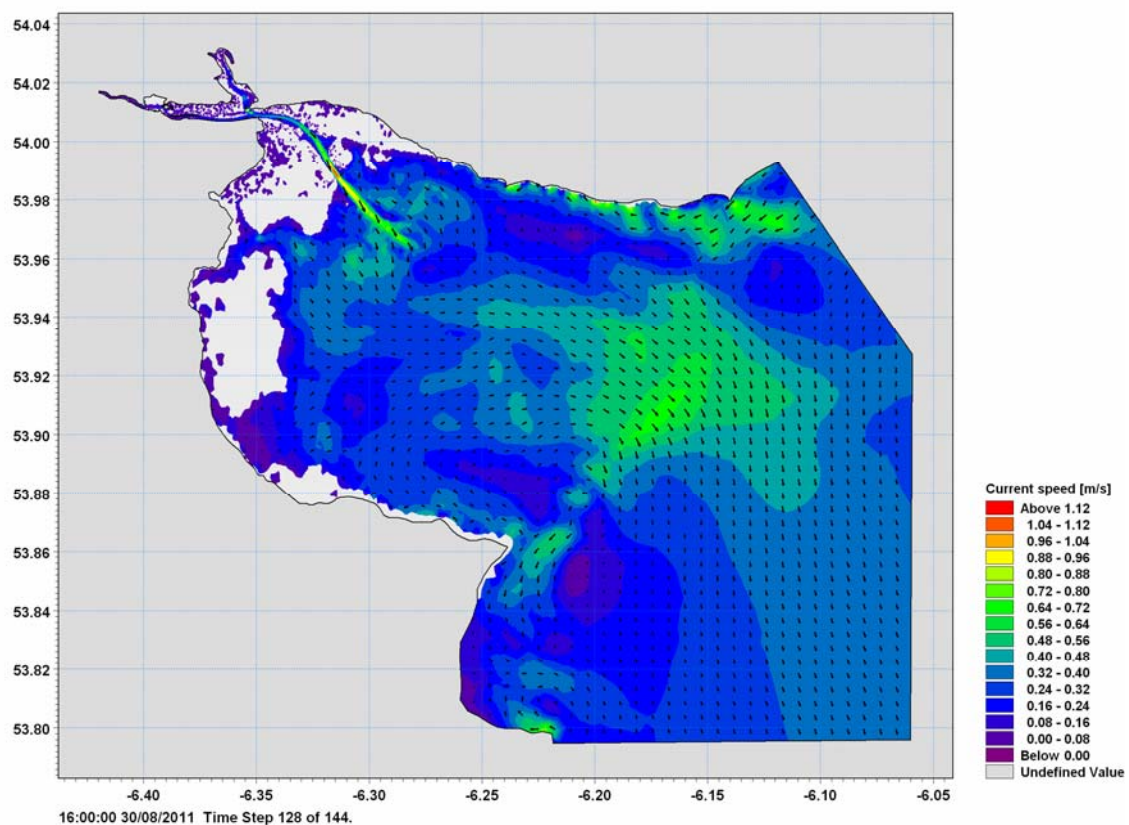South east gale at high tide.**

Figure 8   Littoral current flow during spring ebb tide with easterly gale

6.0   RESULTS OF THE CHANNEL STABILITY SIMULATIONS

The channel stability was initially run for a south east gale over a period of 15 day neap spring tidal cycle with the morphological updating of the bed being undertaken every 15 minutes through out the simulation.   In order to prevent any model instability in the morphological simulations the sediment layer thickness over the model area away from the area of interest, i.e. the channel and its adjoining banks, was reduced so that changes in other parts of the bay could be discounted.

Figure 9a and 9b show the bathymetry of the model before and after the 15 day simulation of the neap to spring tide period with south easterly gales. It will be seen from these diagrams that parts of the channel have infilled thus reducing the navigable depth in the channel. Figure 10 shows the changes in the bed levels over the simulation period with the location of the channel marked by dotted lines.
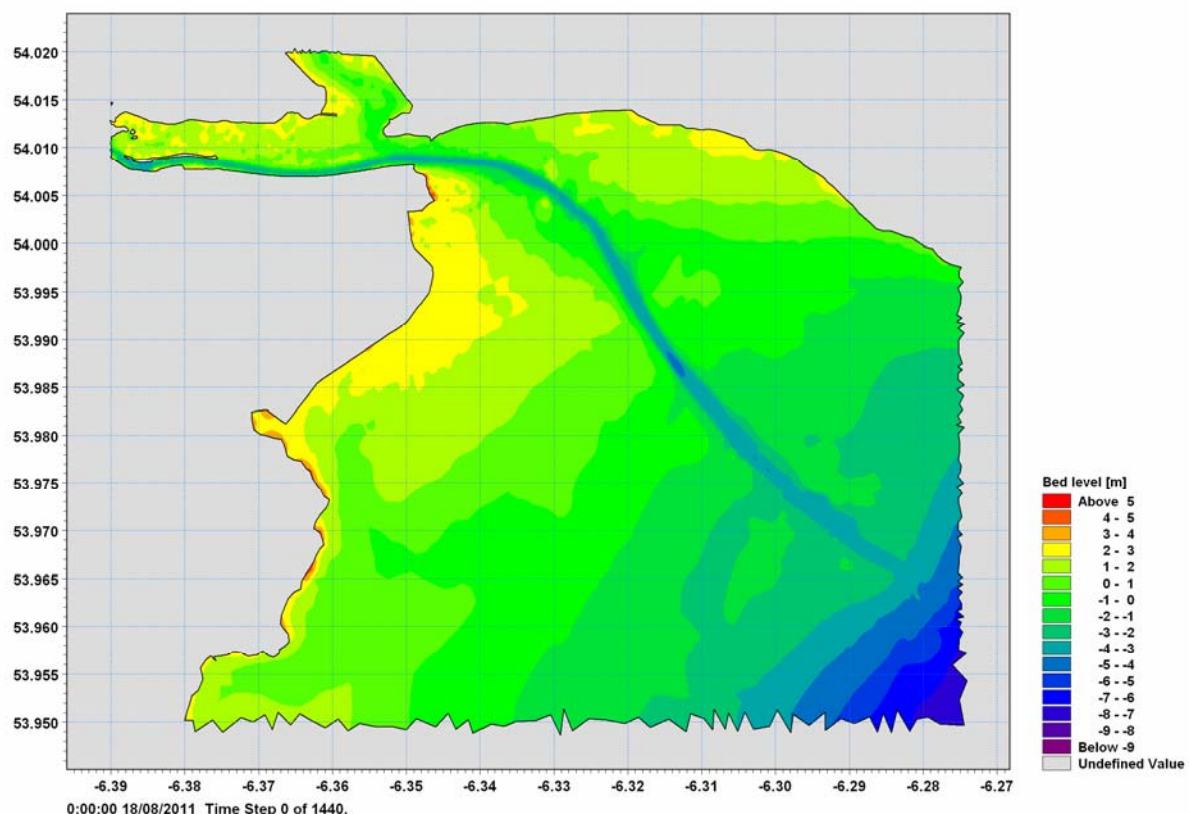

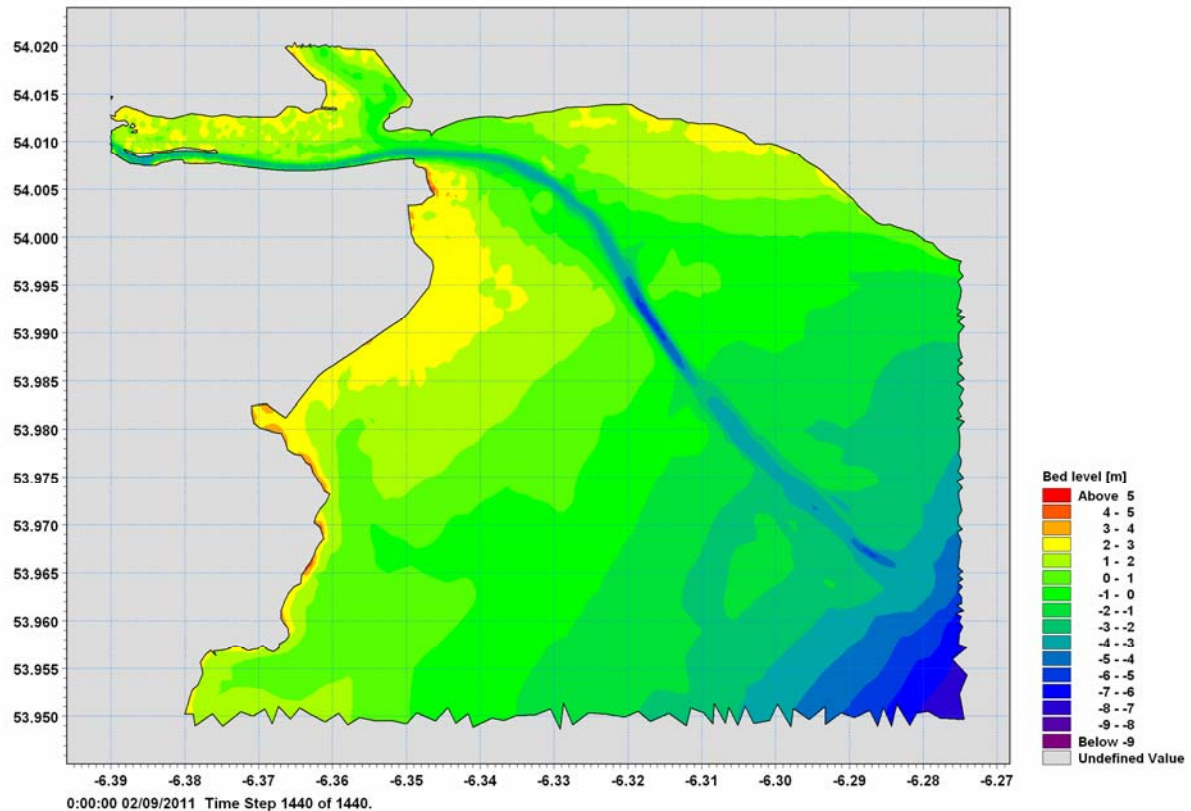**Figure 9a   Model bathymetry at the start of the 15 day SE gale simulation.**

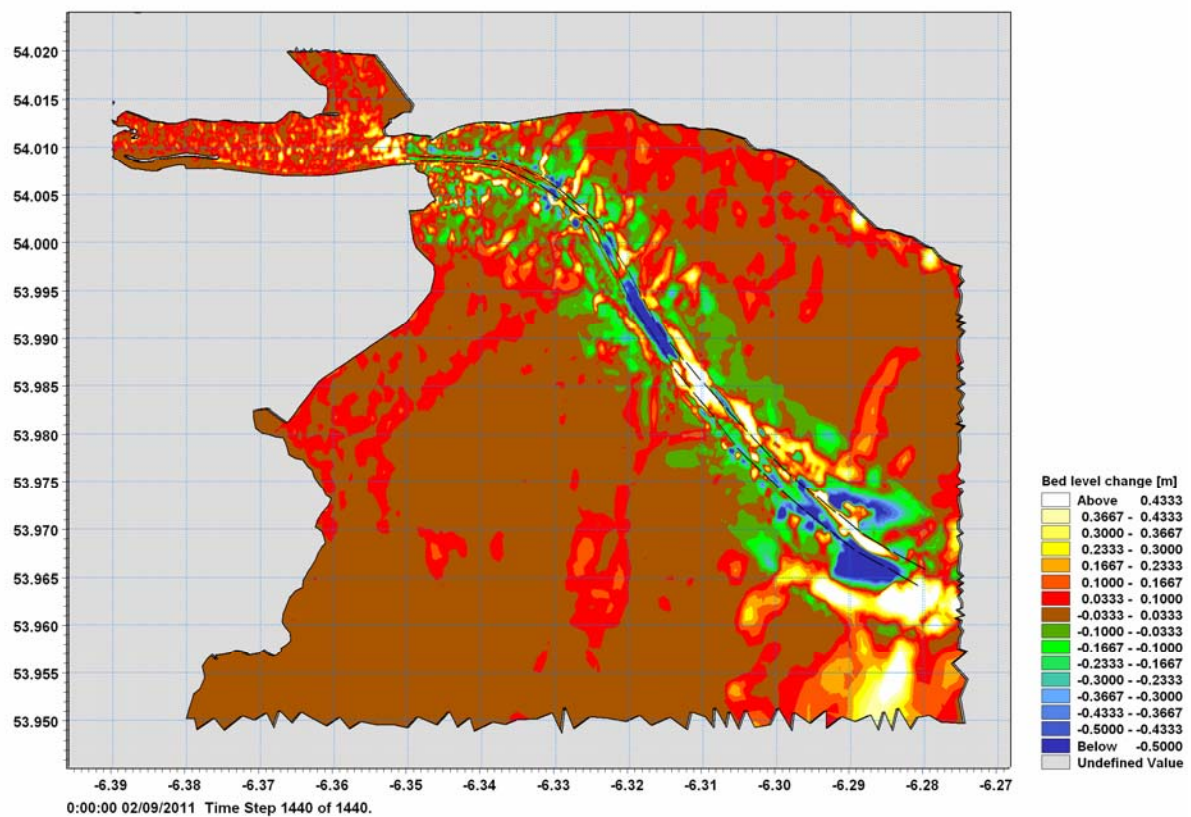**Figure 9b   Model bathymetry at completion of 15 day SE gale simulation**

Figure 10   Change in bed levels during 15 day neap-spring SE gale simulation

Following the completion of the simulations with south east gales further morphological model simulations were undertaken for easterly and southerly gales. In order to reduce the computational time these simulations were undertaken for 2 days of either spring or neap tides with a morphological speed up factor of 5 included in the model so that the simulation would effectively be for a period of 10 days of either spring or neap tides. Figure 11 shows the changes in bed levels during 10 days of spring tides with easterly gales while Figure 12 shows the changes in bed levels during 10 days of neap tides with a southerly gale. Figure 13 shows the results of the simulation of 10 days of spring tides with a southerly gale. It will be seen that the changes in the channel morphology are more pronounced with spring tides than neap tides but that in all cases there is a reduction in depth in parts of the channel that would restrict the navigable depth for ships entering or leaving Dundalk Harbour.
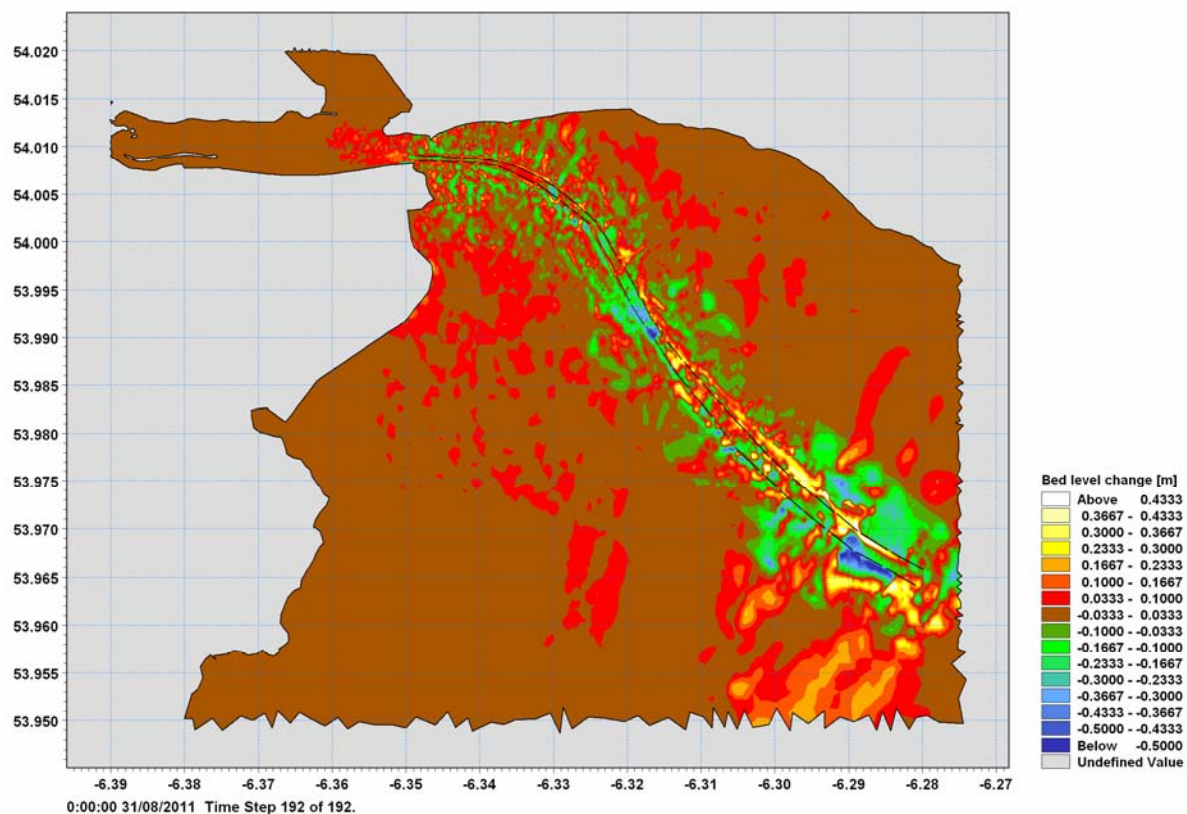

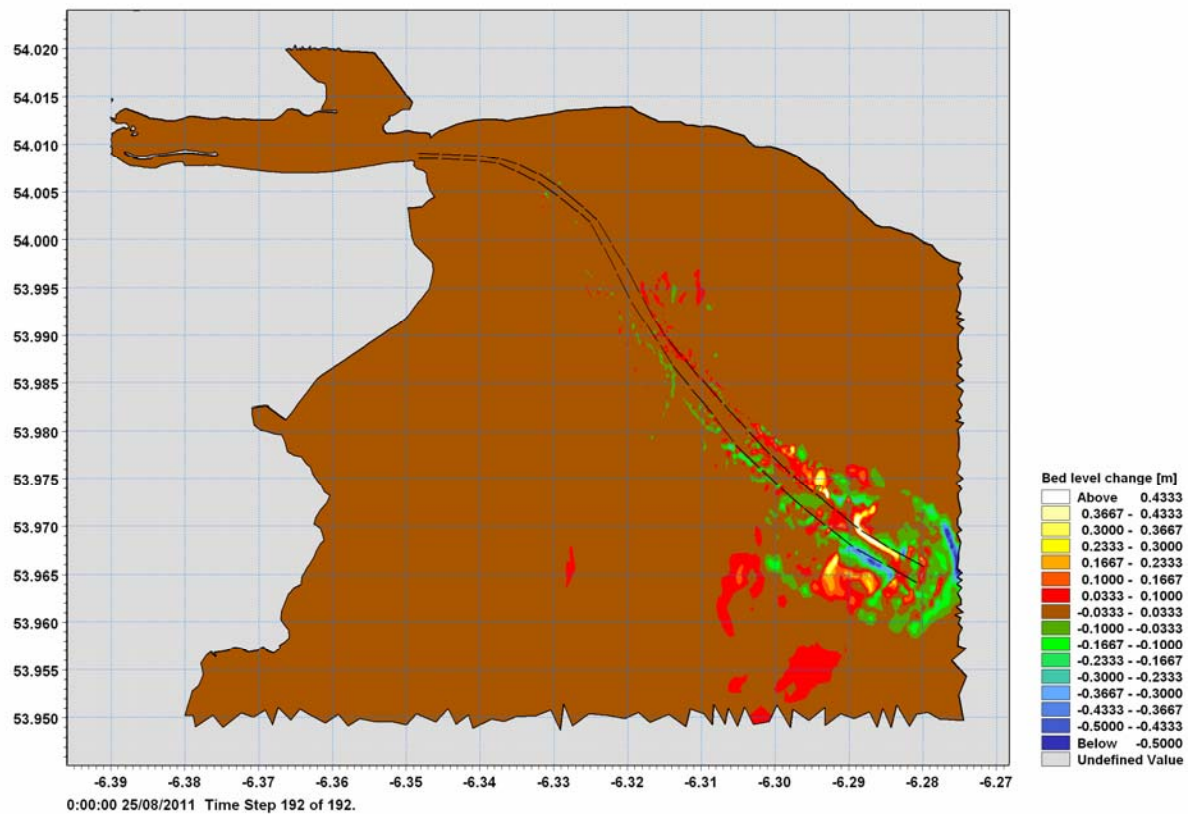**Figure 11   Change in bed levels during 10 days of spring tides with E gales**

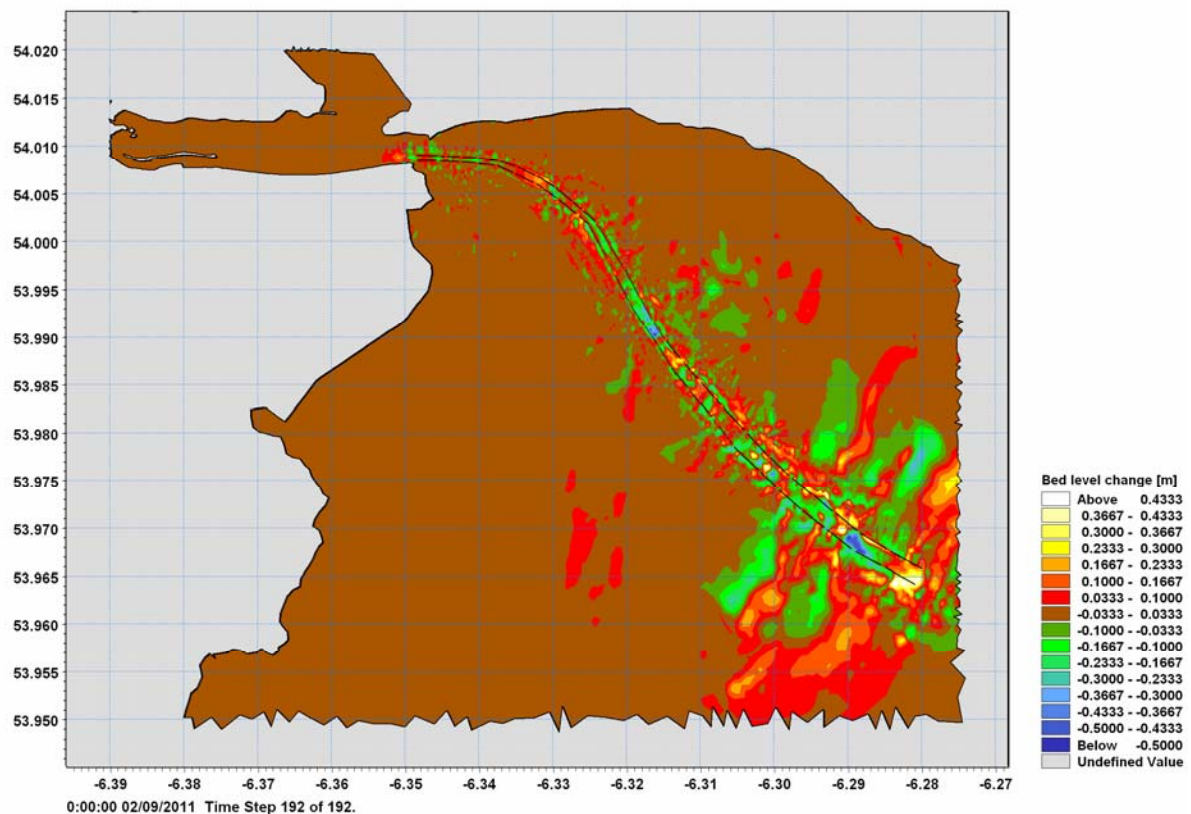**Figure 12   Change in bed levels during 10 days of neap tides with S gales**

Figure 13   Change in bed levels during 10 days of spring tides with S gales

7.0   CONCLUSIONS

The computational model simulations for the stability of the navigational channel dredged to -0.75 m CD indicate that there is likely to be infilling of parts of the channel during significant wave events. The model suggest that the infilling will be most likely in the areas around the bar, channel marker number 8 and at the bend in the channel approaching Soldiers point between markers 11 to 7. The limited historical survey results also tend to confirm the results of the model simulations and it is concluded that regular maintenance dredging will be required if the depths in the channel are to be maintained at a figure of -0.75m CD.

The amount and frequency of maintenance dredging required to keep the channel at -0.75m CD will depend upon prevailing weather conditions. For example a series of strong to gale south easterly winds could reduce the channel depth by 0.4m in a relatively short period of time.

RPS