ATTACHMENT B

RPS DROGHEDA PORT COMPANY MAINTENANCE DREDGING LICENCE APPLICATION HYDRAULIC MODELLING STUDY, 25 MAY 2019

DROGHEDA PORT COMPANY

MAINTENACE DREDGING LICENSE APPLICATION

HYDRAULIC MODELLING STUDY

IBE1618
Maintenance dredging
hydraulic modelling study
1
25 May 2019

rpsgroup.com

Document status

Version	Purpose of document	Authored by	Reviewed by	Approved by	Review date
1	Final	A K B	NS	Adrian.Bell	25/05/19

Approval for issue

Adrian Bell	*Adrian K Bell*	25 May 2019

Prepared by:

RPS

Adrian Bell

Technical Director – Coastal Engineering & Environment

Elmwood House

74 Boucher Road, Belfast

Co. Antrim BT12 6RZ

T +44 2890 667 914

E adrian.bell@rpsgroup.com

Prepared for:

Drogheda Port Company

Captain Martin Donnelly

Harbour Master

Harbourville

Mornington Road

Drogheda, Co. Meath

T 041 983 8378

E maritimehouse@droghedaport.ie

Contents

1 INTRODUCTION **1**

2 BOYNE ENTRANCE CHANNEL DREDGING **2**

2.1 Impact on Coastal Sediment Cell 2

3 MAINTENANCE DREDGING PLUME MODELLING **5**

3.1 General 5

3.2 Maintenance Dredging at the Bar 8

3.3 Maintenance Dredging - Tom Roe's Berth and the Swing Basin 13

3.4 Maintenance Dredging - Channel at Queensburough 19

4 CONCLUSIONS **24**

APPENDIX 1 RPS 2012 Report "Boyne Entrance Channel Dredging – Impact on Sediment Cell"

Figures

Figure 2.1 **Significant wave height and mean wave direction during storm Emma** 3

Figure 2.2 **Significant wave height and mean wave direction during storm Emma simulated peak** 3

Figure 2.3 **Maintenance dredging history at the Boyne entrance 1990 - 2018** 4

Figure 3.1 **Extent of existing flexible mesh flow model of the Boyne and adjoining sea areas** 5

Figure 3.2 **Extent of tidal and storm surge model for the coasts of Ireland** 6

Figure 3.3 **Model surface elevation at entrance to the Boyne over a month of tides** 6

Figure 3.4 **Trailer suction dredger "Sospan Dau"** 7

Figure 3.5 **Period of maintenance dredging at the bar used in the model simulations** 8

Figure 3.6 **Deposition depth of sediment lost to the water column at end of dredging period** 9

Figure 3.7 **Dredging plume for dredging during a period of a flood neap tide** 10

Figure 3.8 **Dredging plume for dredging over a period around a high neap tide** 10

Figure 3.9 **Dredging plume for dredging during period of an ebb neap tide** 11

Figure 3.10 **Dredging plume for dredging during a period of a flood spring tide** 11

Figure 3.11 **Dredging plume for dredging over a period around a high spring tide** 12

Figure 3.12 **Dredging plume for dredging during period of an ebb spring tide** 12

Figure 3.13 **Period of maintenance dredging at the Tom Roe's berth/Swing Basin used in the model simulations** 13

Figure 3.14 **Deposition depth of sediment lost to the water column at end of dredging period** 14

Figure 3.15 Dredging plume with vessel dredging along Tom Roe's berth during a period of a flood neap tide....15
Figure 3.16 Dredging plume immediately after vessel completed dredging along Tom Roe's berth during a period of a flood neap tide....15
Figure 3.17 Dredging plume with vessel dredging along Tom Roe's berth over a period around a high neap tide....16
Figure 3.18 Dredging plume with vessel dredging along Tom Roe's berth during a period of an ebb neap tide....16
Figure 3.19 Dredging plume with vessel dredging at the Swing Basin during a period of a flood spring tide....17
Figure 3.20 Dredging plume with vessel dredging at the Swing Basin over a period around a high spring tide....17
Figure 3.21 Dredging plume with vessel dredging in the Swing Basin during a period of an ebb spring tide....18
Figure 3.22 Period of maintenance dredging at Queensburough used in the model simulations....19
Figure 3.23 Deposition depth of sediment lost to the water column at end of dredging period....20
Figure 3.24 Dredging plume with vessel dredging along the channel during a period of a flood neap tide....21
Figure 3.25 Dredging plume with vessel dredging along the channel over a period around a high neap tide....21
Figure 3.26 Dredging plume with vessel dredging along the channel during a period of an ebb neap tide....22
Figure 3.27 Dredging plume with vessel dredging along the channel during a period of a flood spring tide....22
Figure 3.28 Dredging plume with vessel dredging along the channel over a period around a high spring tide....23
Figure 3.29 Dredging plume with vessel dredging along the channel during a period of an ebb spring tide....23

1 INTRODUCTION

Drogheda Port Company is preparing an application for the renewal of its maintenance dredging license. RPS has undertaken numerous studies of the coastal processes around the Boyne Estuary and the adjoining beaches of counties Meath and Louth including a report in 2012 "*Boyne Entrance Channel Dredging – Impact on Sediment Cell*", on the impact of the entrance channel maintenance dredging on the sediment balance of the coastal sediment cell.

Drogheda Port Company have appointed RPS to update the 2012 report in the light of any changes since 2012 and to undertake dredging plume model simulations to provide supporting information for the Port's application for the renewal of its maintenance dredging license.

2 BOYNE ENTRANCE CHANNEL DREDGING

2.1 Impact on Coastal Sediment Cell

The RPS report of February 2012, Appendix A, looked at the volume of sediment entering and moving along the shoreline of the coastal sediment cell which contains the Boyne Estuary. The movement of the sediments into and around this sediment cell is governed by the tidal currents and by waves, particularly when combined with storm surges.

The main supply of sediment to the coastal cell is from the South and South East and there have been no significant physical infrastructure developments (coastal protection schemes, harbour works etc.) since 2012 that would result in a negative impact on the incoming sediment supply to the Boyne coastal cell. There have been some changes to the entrance channel to Dublin Port but detailed studies for the EIA for this project have shown that this development will have no impact on the coastal process of Dublin Bay let alone have an impact on the annual volume of sediment passing by Skerries.

As part of the Irish National Coastal Protection Strategy in 2010 the Office of Public Works commissioned RPS to establish the extreme water levels (due storm surges, high tides etc) around the whole of the Irish coast. This was followed by an assessment of the appropriate extreme inshore wave climate. In 2018 the OPW asked RPS to undertake studies to review the extreme water levels to see what, if any, changes had taken place since 2010. The results of the 2018 study showed that there had been no change in the expected extreme water levels (due to combinations of high tides and storm surges) from those established in 2010.

There are indications from the recorded values of the wave climate at the M2 buoy that the offshore extreme storm wave heights may have increase slightly in recent years. However, as the sediment transport rates along the beaches on either side of the entrance to the Boyne are driven by inshore wave climate, it is the inshore wave conditions that affect the movement of sediment along the coast. Although the extreme offshore wave heights may have increased in recent years these waves will be depth limited as they approach the coast and thus it is the occurrence of extreme water levels that are most important in determining the changes in the sediment transport rates along the shoreline.

The effect of water levels controlling the inshore wave climate can be seen in the simulations of the inshore wave climate around the entrance to the Boyne that occurred during storm Emma. Storm Emma had peak offshore wave heights, measured at the M2 buoy, of 6.25 metres significant wave height at about 06.00 hrs. This however occurred at a time of low tide. There was a storm surge with water levels of about 5.64m (just above HAT levels) at about 11.20 hrs when the offshore significant wave heights were 5.45m. The results of the simulation of the inshore wave heights at 11.20 hrs is shown in Figure 2.1. Had the peak of the storm occurred at the time of high tide when the offshore waves had a significant wave height of 6.25m, then the inshore wave heights around the Boyne entrance would have been as shown in Figure 2.2.

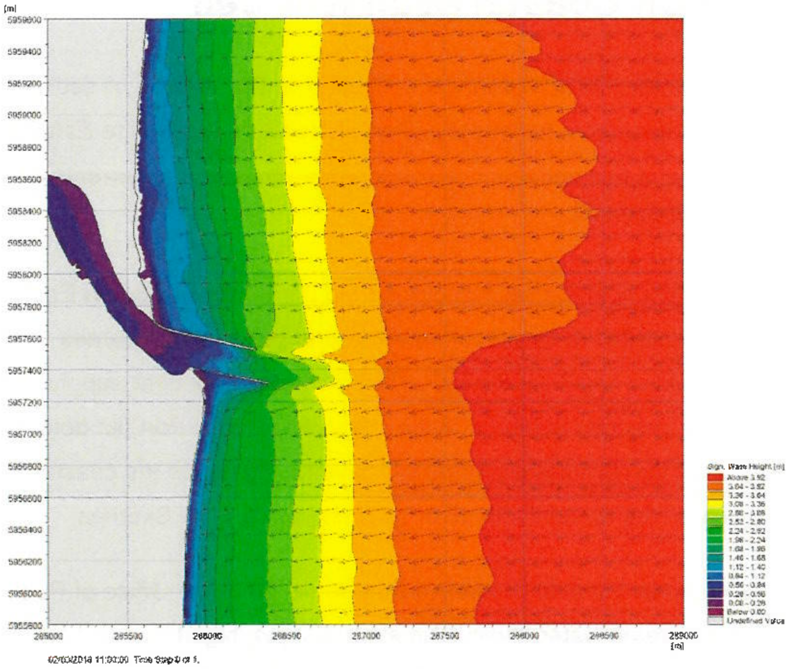


Figure 2.1 Significant wave height and mean wave direction during storm Emma Water Level 5.64 m CD - Offshore wave height Hm0 5.45 m

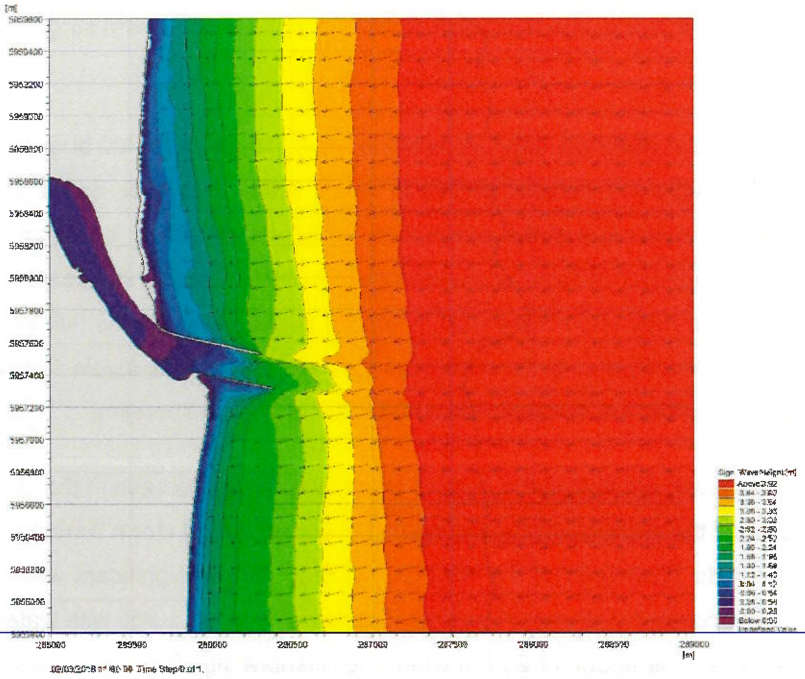


Figure 2.2 Significant wave height and mean wave direction during storm Emma simulated peak Water Level 5.64 m CD - Offshore wave height Hm0 6.25 m

By comparing Figure 2.1 and 2.2 it will be seen that while the offshore wave heights were greater in Figure 2.2 the inshore wave climate in the area of the major longshore sediment transport (from the yellow colour inshore) is similar in both diagrams. Thus, it is the extreme water levels which strongly influences the inshore wave climate along the Meath and Louth beaches during major storms.

As there has been no change in the extreme water levels, the sediment transport rates along the beach are unlikely to have changes significantly over the 7-8 years since the 2012 report. This conclusion is also confirmed by the fact that, as can be seen from the Boyne bar maintenance dredging history, Figure 2.3, there has been no increasing trend in the amount of maintenance dredging required to keep the Boyne entrance maintained to its navigational depth.

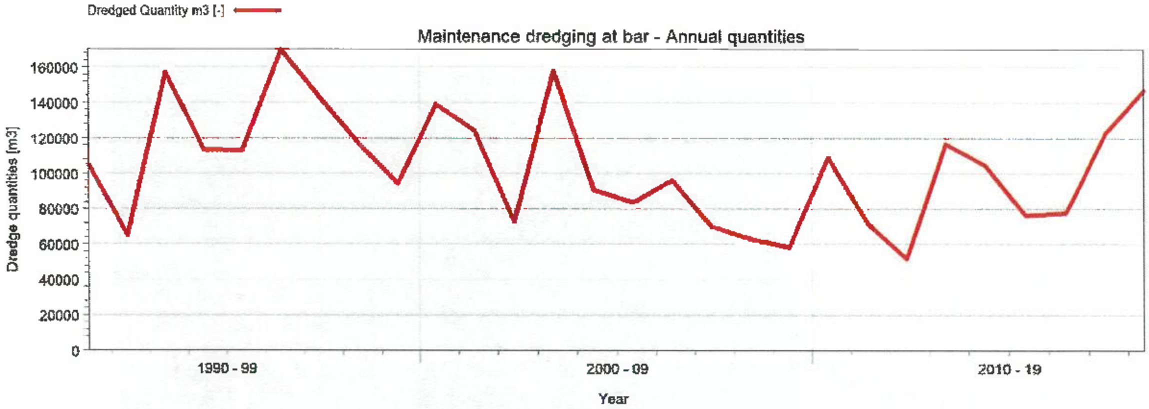


Figure 2.3 Maintenance dredging history at the Boyne entrance 1990 - 2018

From the foregoing it is concluded that the 2012 Report "Boyne Entrance Channel Dredging – Impact on Sediment Cell" is still relevant to Drogheda Port's 2019 maintenance dredging license application.

3 MAINTENANCE DREDGING PLUME MODELLING

3.1 General

The model simulations of the plumes from the dredger carrying out the maintenance dredges has been undertaken using RPS existing flexible mesh Mike21 flow model of the River Boyne and the adjoining beaches and waters of counties Louth and Meath. The model has previously been used for a number of projects for the Drogheda Port Company as well as for various coastal and flood studies. The extent of the model is shown in Figure 3.1 and the boundaries data for the model is taken from the Irish Coastal Tidal and Storm surge mode, Figure 3.2 which RPS currently runs for the OPW on a 24/7 basis.

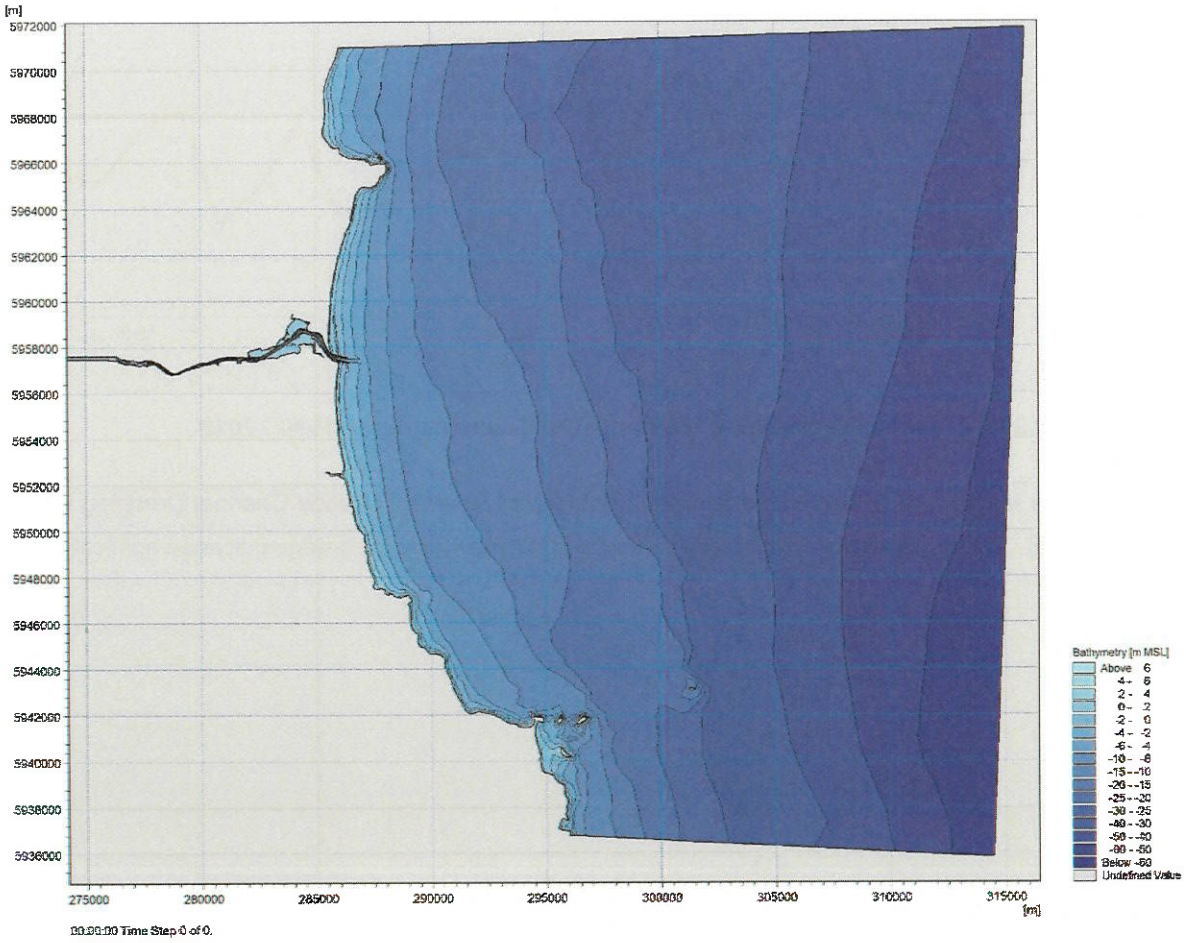


Figure 3.1 **Extent of existing flexible mesh flow model of the Boyne and adjoining sea areas**

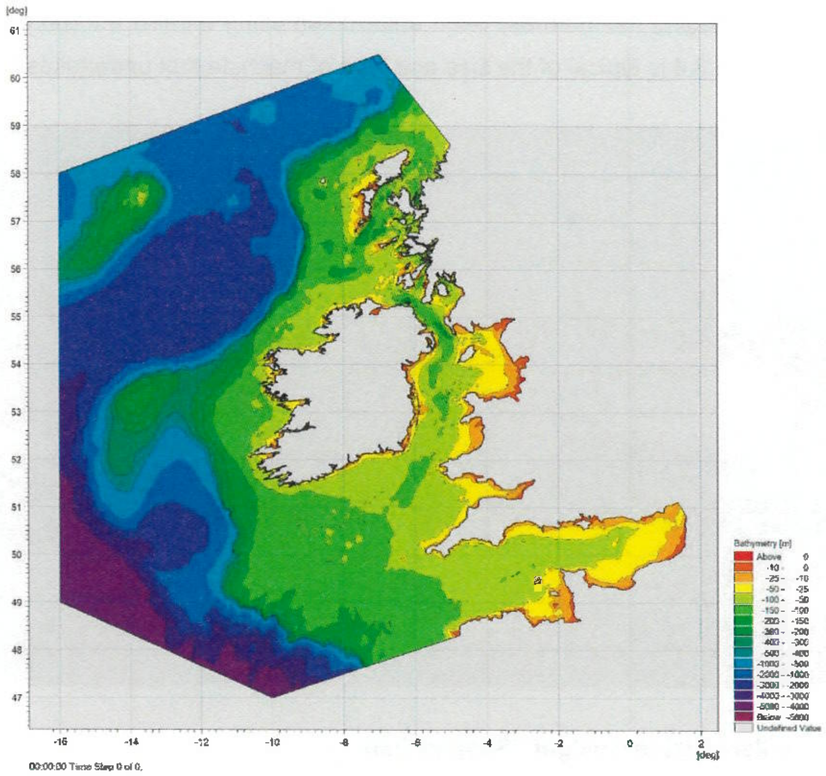


Figure 3.2 Extent of tidal and storm surge model for the coasts of Ireland

The flow model was run for a full month of tides to give both spring and neap tides as shown in Figure 3.3. The maintenance dredging simulations were taken over a period from neap to springs and the simulations allowed to run on for several days to ensure that all the sediment had either dispersed or settled out. A river flow of 70 m^3, which is an average winter river flow in Boyne was used in all the simulations.

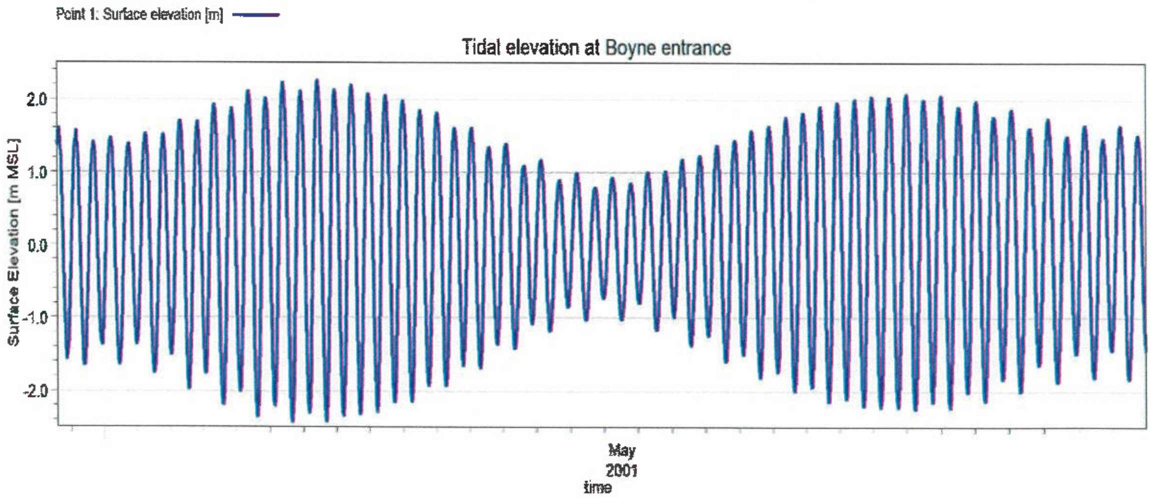


Figure 3.3 Model surface elevation at entrance to the Boyne over a month of tides

The maintenance dredging has normally been undertaken using a trailer suction dredger, the vessel the "Sospan Dau", Figure 3.4 is typical of the size and type of machine that undertakes this work.

Figure 3.4 Trailer suction dredger "Sospan Dau"

The Sospan Dau is 72.8m long with a beam of 14.3m and a hopper capacity of 1,500 m^3. The draught when empty is 1.8 m and 3.30 m when loaded. Thus, the vessel is tidally restricted when dredging in the river or at the bar where the ruling depth is -2.2m CD. The Sospan Dau or similar vessel has been assumed to be the dredger in the maintenance dredging plume simulations.

3.2 Maintenance Dredging at the Bar

In this simulation it is assumed that 43,000 m^3 of sand will be dredged from the bar over a 7 day period starting during neap tides and finishing at a time of spring tides.

The ships logs of the Sospan Dau from a recent maintenance dredging campaigns at the Boyne entrance bar have been examined to establish the dredging sequence and typically the vessel dredges for about 100 minutes taking about 1000m^3 into the hopper. The vessel needs about 25 to 30 minutes to sail to the dump site and a similar period to return. The dumping operation typically takes about 10 minutes. Thus, the total rotation time is about 2.67 to 2.75 hours.

Due to depth restrictions the maintenance dredger cannot work at low tide and therefore it is only possible to get about three loads dredged per 12.3 hour tidal cycle and this has been assumed in the model simulations. The tidal height curve and the time of the dredges used in the simulation is shown in Figure 3.5 with the red vertical lines denoting the time of the dredging operation at the bar.

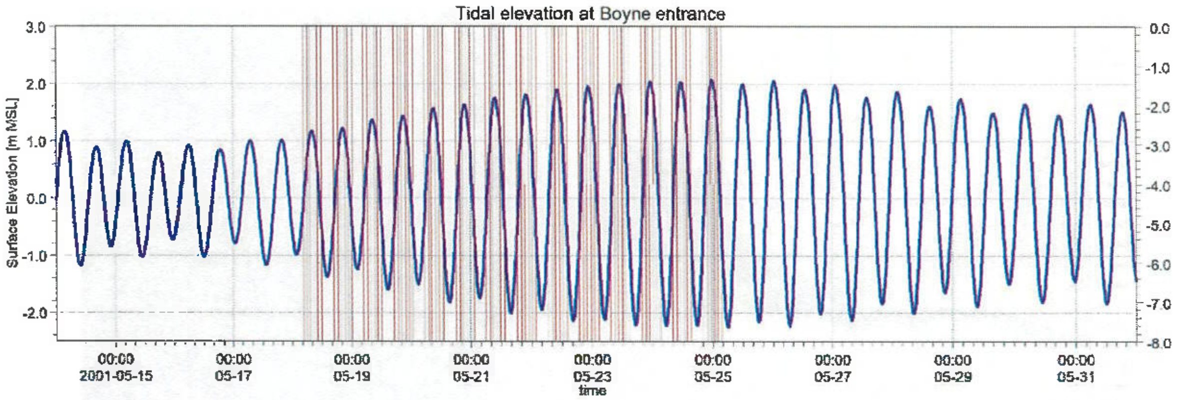


Figure 3.5 Period of maintenance dredging at the bar used in the model simulations

The material to be dredged from the bar is a fine to medium sand. Particle size gradings have previously been taken of this sand and the material has been found to have a D_{n50} size of 0.16 - 0.18mm with sigma grading ration of 1.1. Thus, for this simulation the material has been represented by 3 fractions as shown in Table 3.1.

Table 3.1 Grading of sand material at the bar

Distribution	Size
16%	0.240 mm
68%	0.160 mm
16%	0.083 mm

The losses to the water column are typically 3% with 1.5% at the drag head and 1.5% from overspill. The dredging rate is 10m^3/minute with each of the three loads per dredging cycle being 1000m^3.

The results of the simulations are shown in terms of the deposition of sediment at the end of the dredging process, Figure 3.6, and individual suspended sediment plume diagrams, Figures 3.7 to 3.12, for each of the three dredging runs per tidal cycle, i.e. one for the dredge on the rising tide, one for the dredge over high tide and one for the dredge on the falling tide. Separate diagrams are given for the dredging plume during neap tides and spring tides.

Figure 3.6 shows that the amount of sediment deposited around the bar and estuary area resulting from the 7 day maintenance dredging operations is very small with thickness less than 0.0025 mm.

It will be seen from the suspended sediment diagrams that, away from the immediate area around the dredger, the total suspended sediment concentrations are very low and the plume does not approach the area where the little terns nest on the northern side of the training walls. It should also be noted that the area around the bar is subject to regular storm events which lift sediment into suspension with concentrations of up to 380 mg/l (0.380 kg/m^3) which is much higher than the levels of suspended sediment that occurs during the maintenance dredging of the bar.

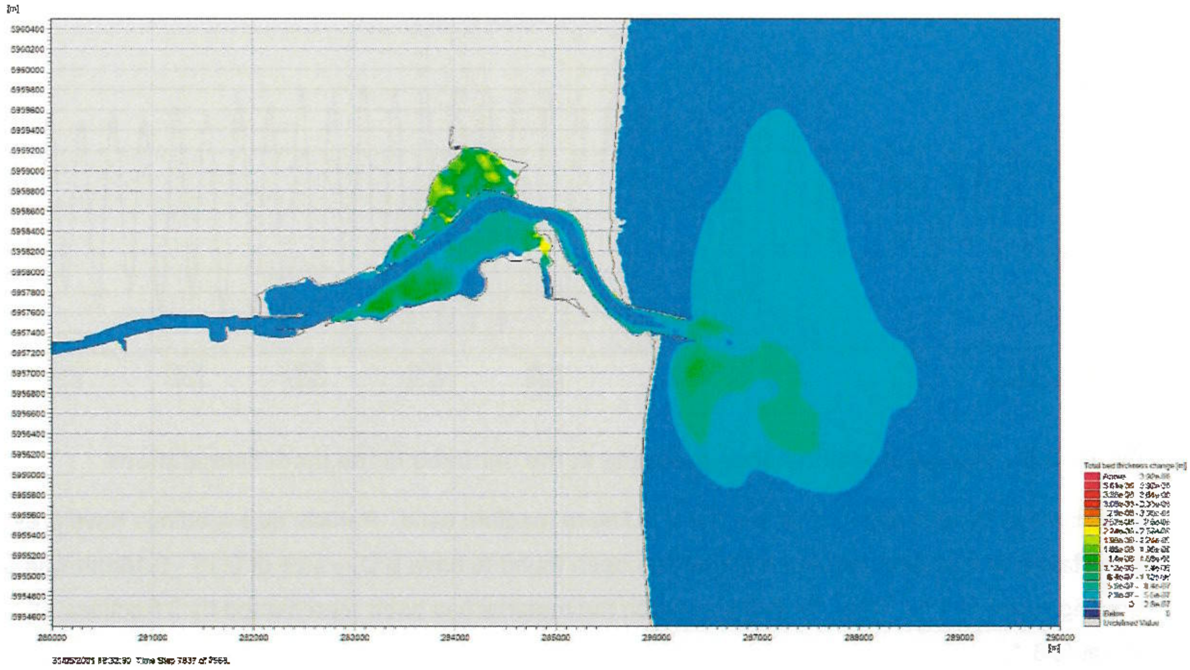


Figure 3.6 Deposition depth of sediment lost to the water column at end of dredging period

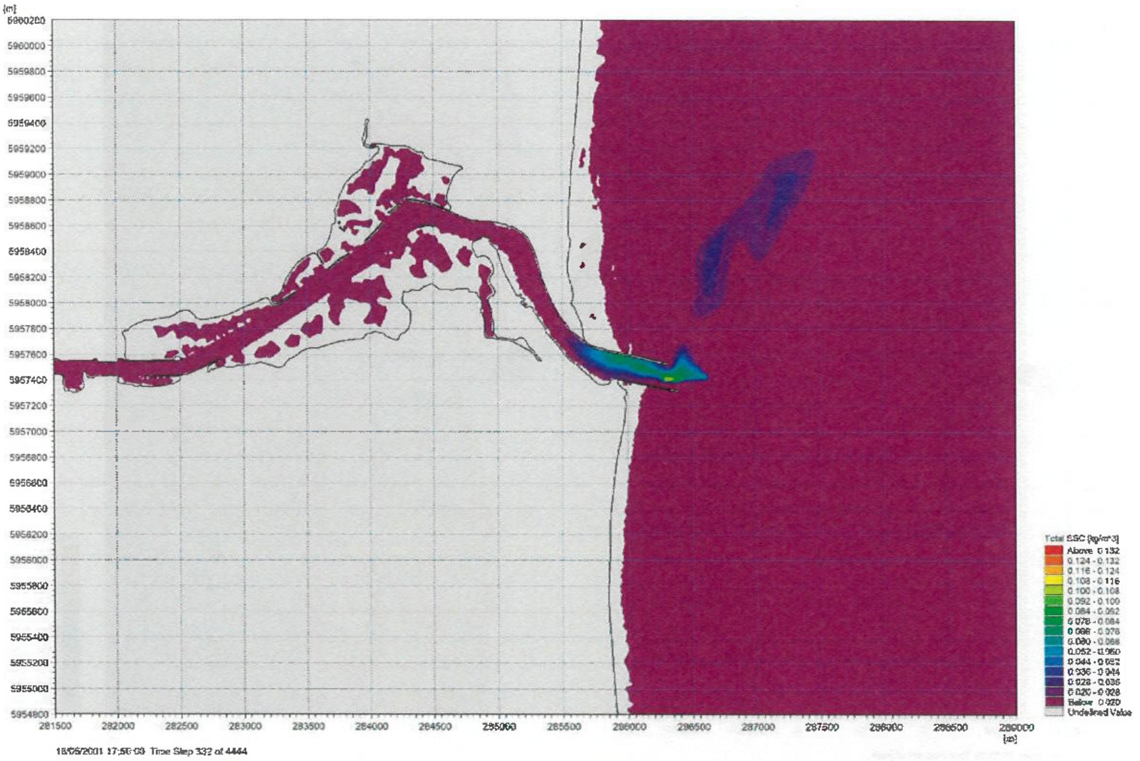


Figure 3.7 Dredging plume for dredging during a period of a flood neap tide

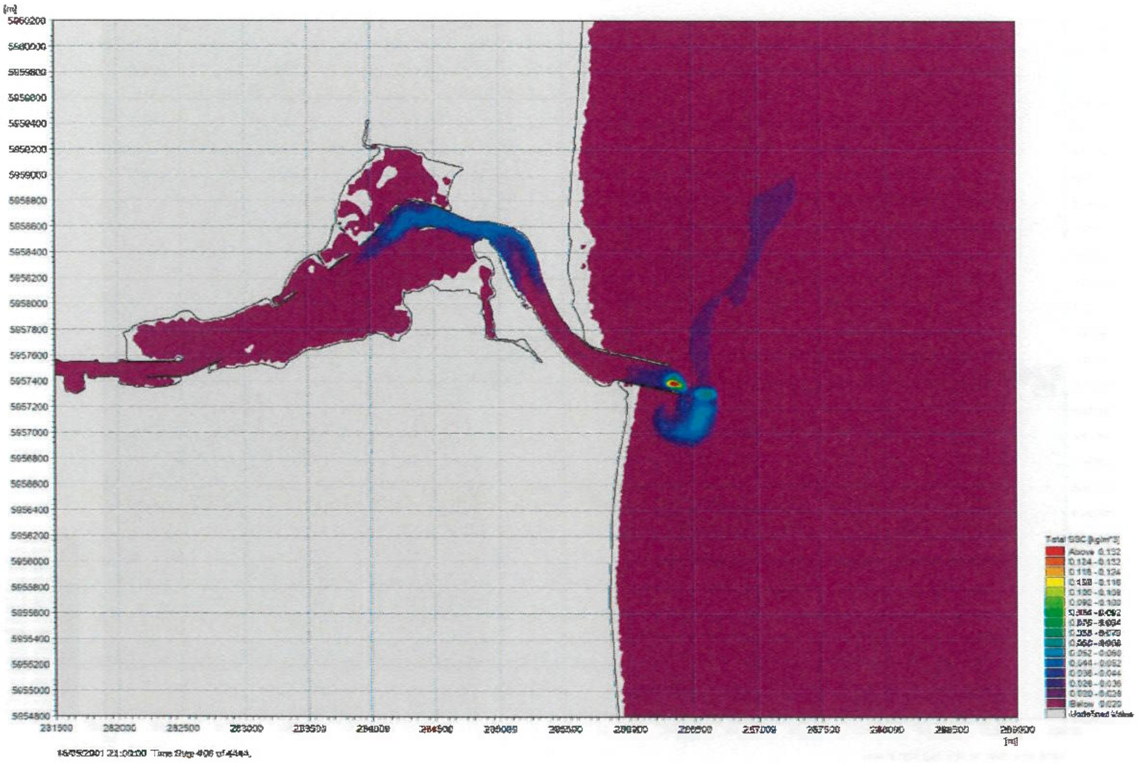


Figure 3.8 Dredging plume for dredging over a period around a high neap tide

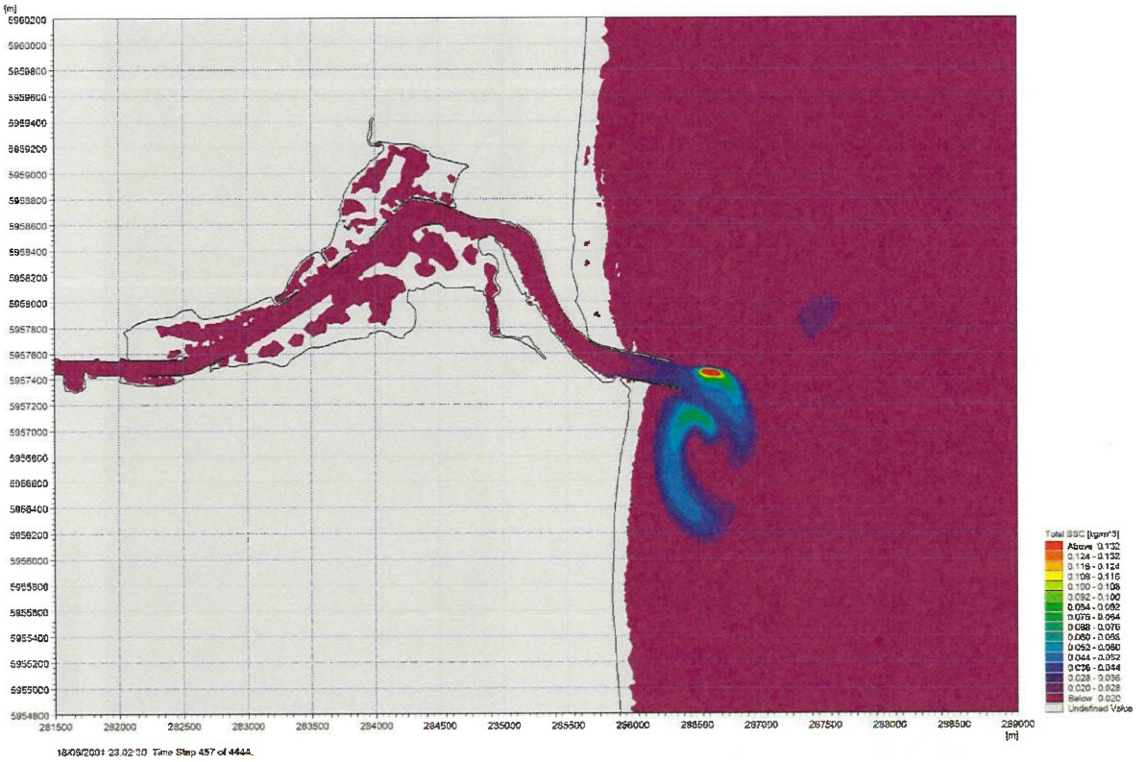


Figure 3.9 Dredging plume for dredging during period of an ebb neap tide

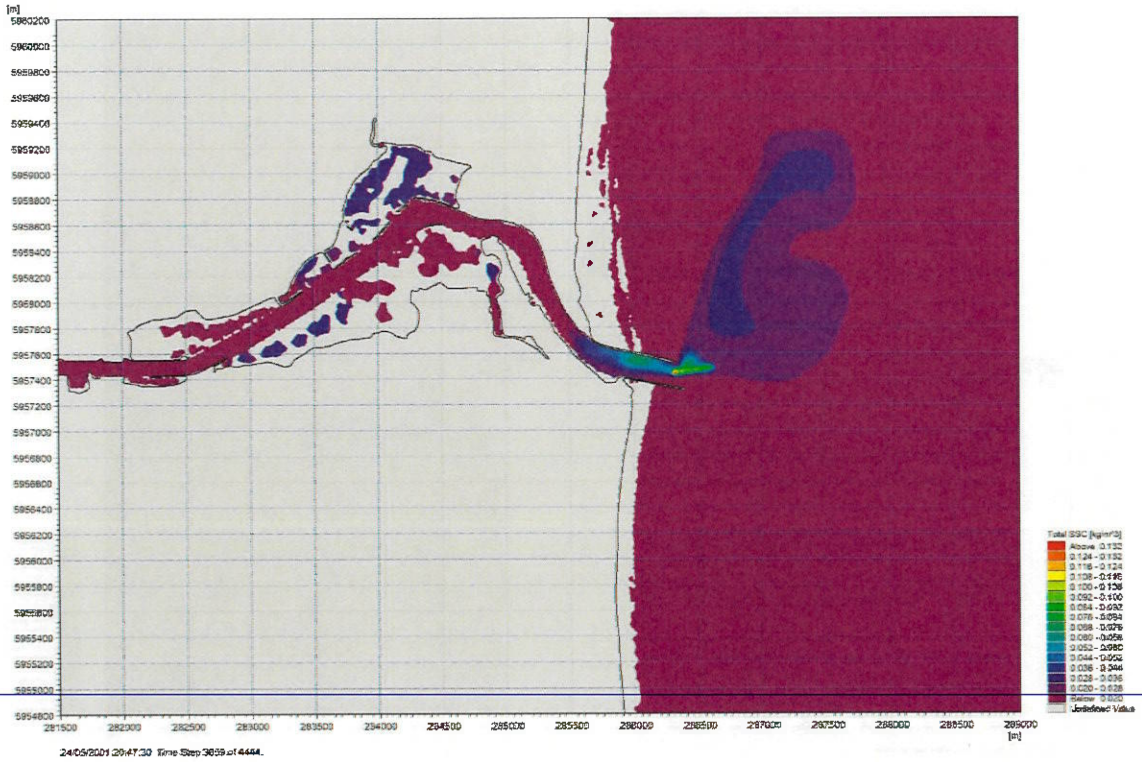


Figure 3.10 Dredging plume for dredging during a period of a flood spring tide

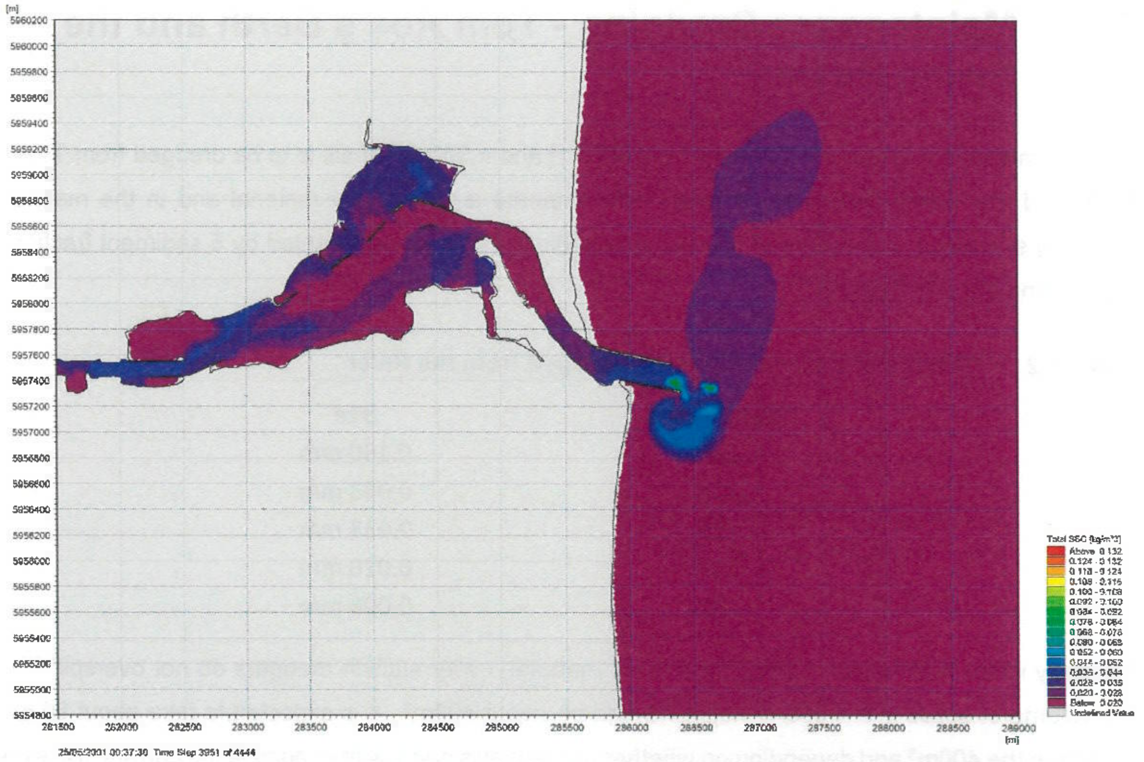


Figure 3.11 Dredging plume for dredging over a period around a high spring tide

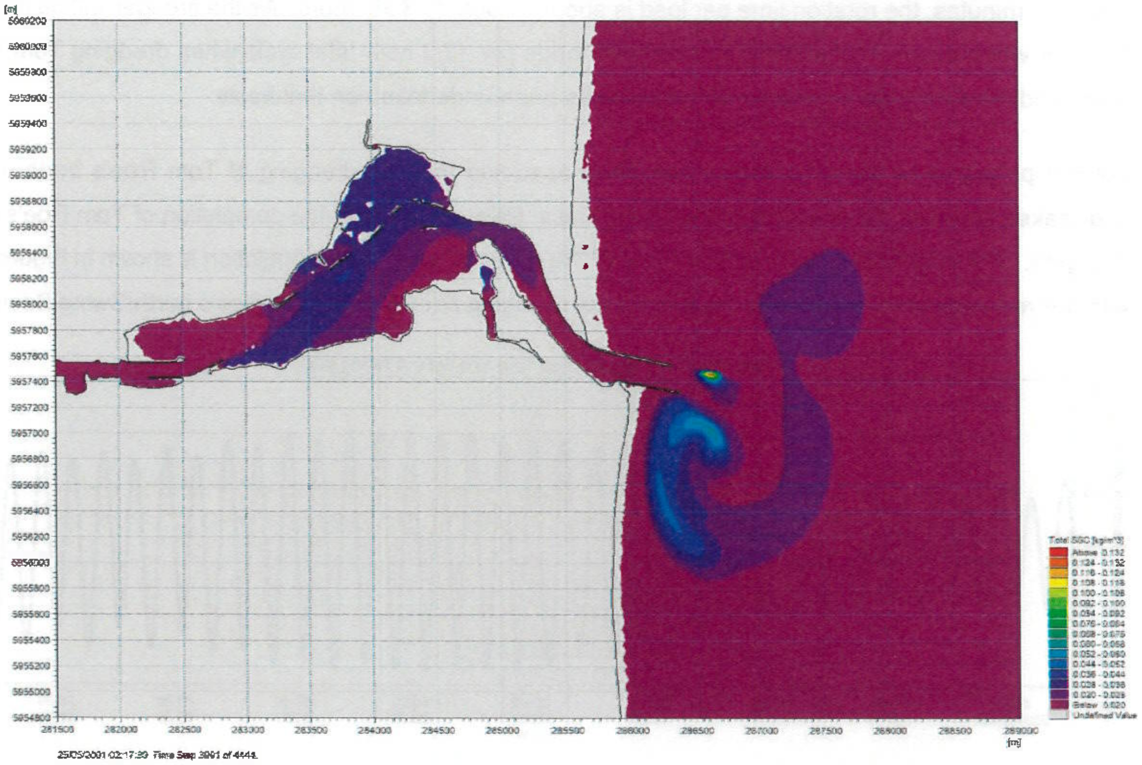


Figure 3.12 Dredging plume for dredging during period of an ebb spring tide

3.3 Maintenance Dredging - Tom Roe's Berth and the Swing Basin

In this simulation it is assumed that some 8,000 m^3 and 4,000 m^3 of silt is to be dredged from Tom Roe's berth and the Swing Basin respectively. The material is a fine silty material and in the maintenance dredging simulation it is assumed that this fine sediment can be represented by 5 sediment fractions with the grading show in Table 3.2.

Table 3.2 Grading of silt material to be dredged from the River

Distribution	Size
10%	0.100 mm
20%	0.063 mm
25%	0.033 mm
25%	0.020 mm
20%	0.008 mm

Normally when maintenance dredging fine silt material, trailer suction dredgers do not overspill and thus the volume of solids in a 1,500m^3 hopper would be about 400m^3. It is expected to take about 50 minutes to dredge the 400m^3 and depending on whether the vessel is going with or against the current, it is expected to take about 60 to 75 minutes to travel the distance to or from the dumpsite. Thus, with dumping taking about 10 minutes, the rotation time per load is about 3 hours to 3 25 hours. As the dredger will be entering the river when empty it is possible to achieve 3 loads per 12.3 hour tidal cycle when dredging Tom Roe's Berth and the Swing Basin and the simulation has been undertaken on that basis.

For the purposes of the simulation it has been assumed that the dredging of Tom Roe's berth will be undertaken first with the dredging of the Swing Basin following on after the completion of Tom Roe's berth dredging. The tidal height curve and the time of the dredges used in the simulation is shown in Figure 3.13 with the red vertical lines denoting the time of the dredging operation at Tom Roe's berth/Swing Basin.

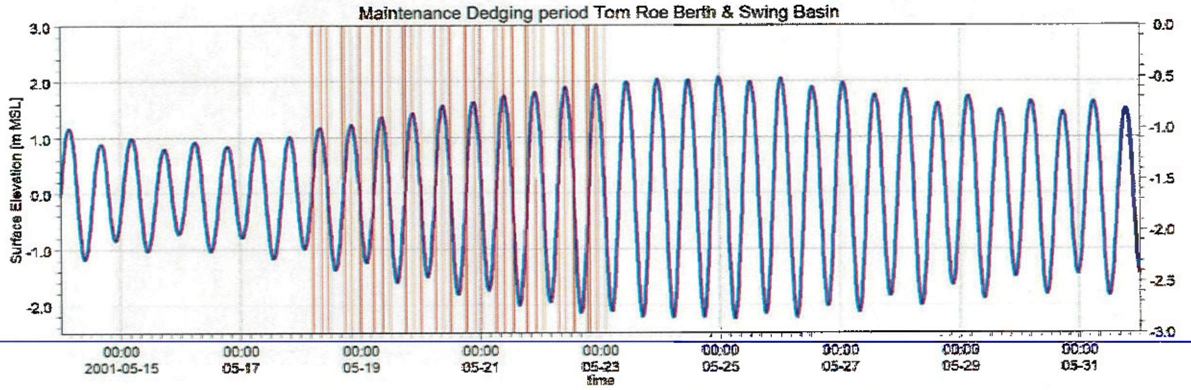


Figure 3.13 Period of maintenance dredging at the Tom Roe's berth/Swing Basin used in the model simulations

As there is no overspill from the dredger hopper, the losses to the water column have been taken as the 1.5% of the dredged volume at the drag head.

The results of the simulations are shown in terms of the deposition of sediment at the end of the dredging process, Figure 3.14, and individual suspended sediment plume diagrams, Figures 3.15 to 3.21, for each of the three dredging runs per tidal cycle, i.e. one for the dredge on the rising tide, one for the dredge over high tide and one for the dredge on the falling tide. Separate diagrams are given for the SSC plumes during the dredging of Tom Roe's berth at neap tides and the plumes from the dredging of the Swing Basin at spring tides

Figure 3.14 shows that the amount of sediment deposited around the Tom Roe's berth/Swing Basin and the estuary area resulting from the 5.5 day maintenance dredging operations is very small indeed with thickness less than 0.0005 mm. Therefore, it can be deduced that sediment from the maintenance dredging plumes are completely dispersed by the combination of tidal and river flows.

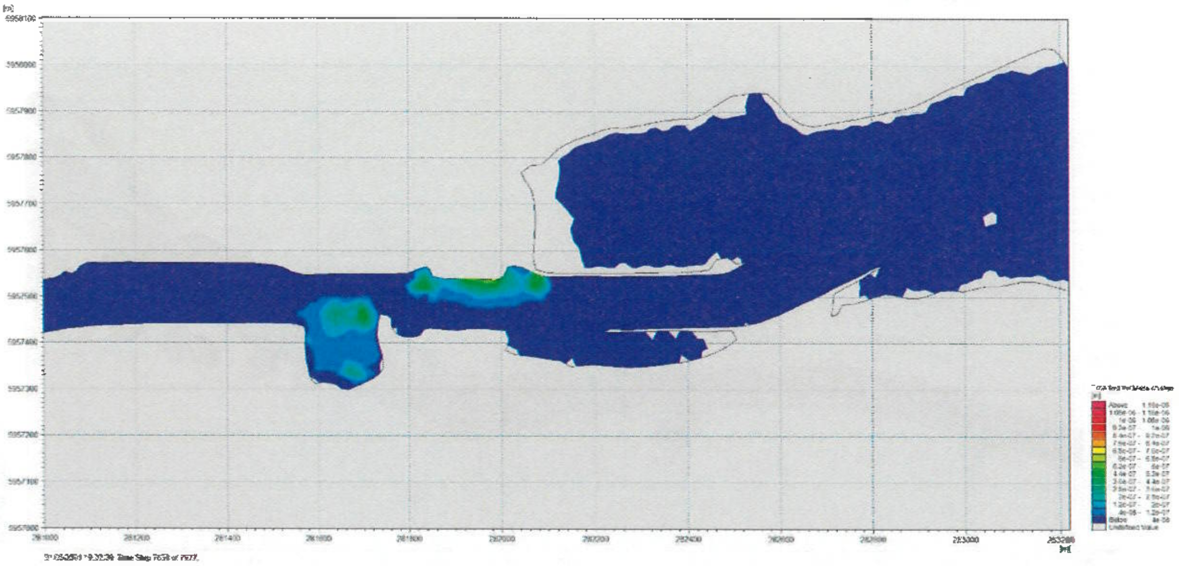


Figure 3.14 Deposition depth of sediment lost to the water column at end of dredging period

It will be seen from the sediment plume diagrams that the highest suspended sediment concentrations occur close to the dredger during the dredging operation with a rising neap tide. At this time the river flow greatly reduces the rising tide current speed in the river so there is less dispersion of the sediment around the dredger then at any other time in the tidal cycle. Apart from the area around the dredger, the suspended sediment plume concentrations are generally low with values typically less than about 60 mg/l and they further disperse relatively quickly.

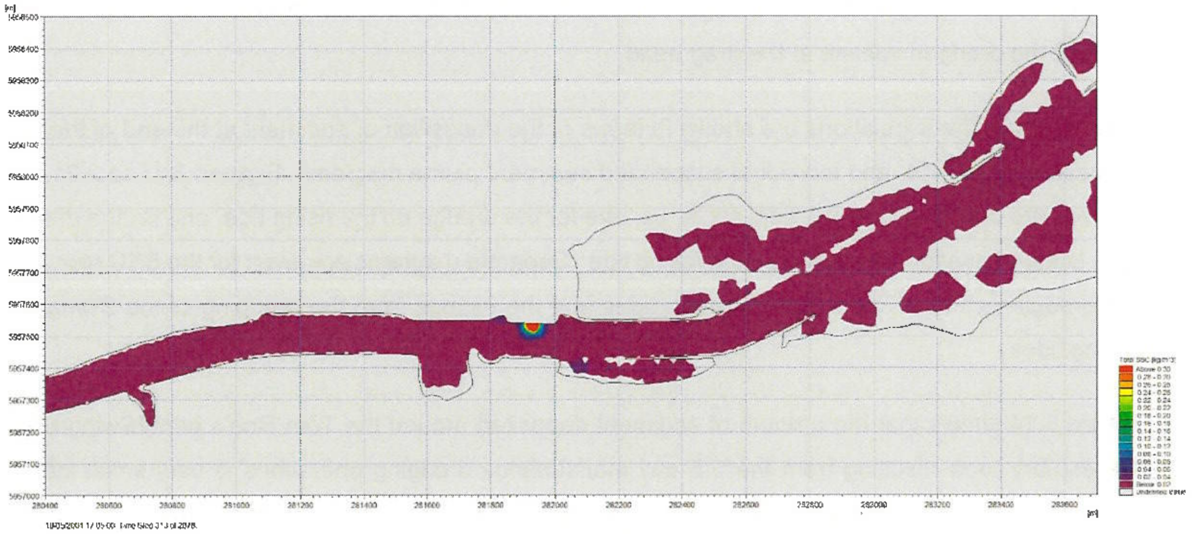


Figure 3.15 Dredging plume with vessel dredging along Tom Roe's berth during a period of a flood neap tide

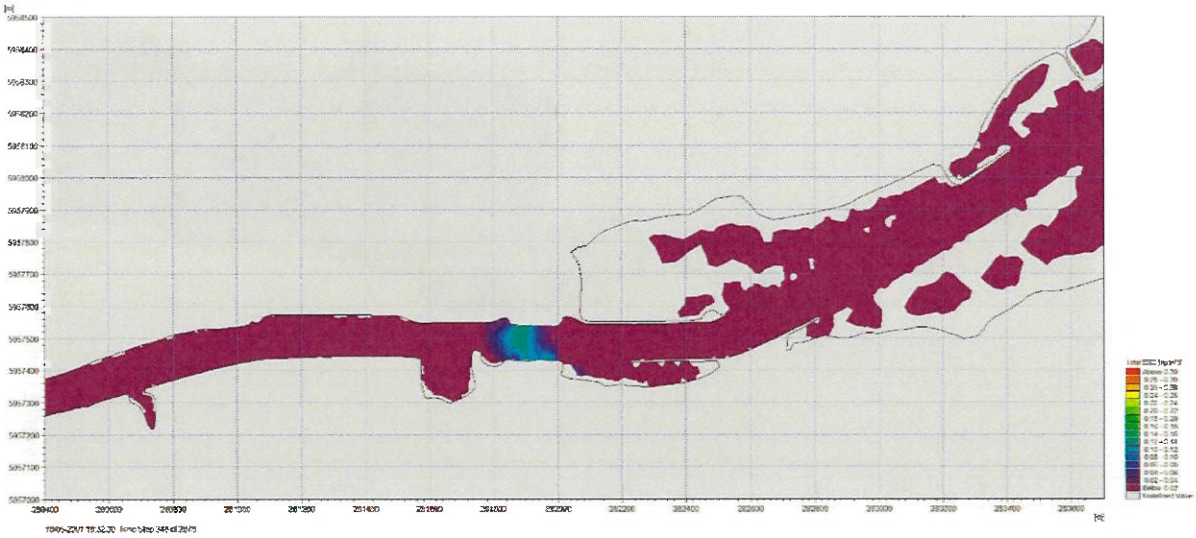


Figure 3.16 Dredging plume immediately after vessel completed dredging along Tom Roe's berth during a period of a flood neap tide

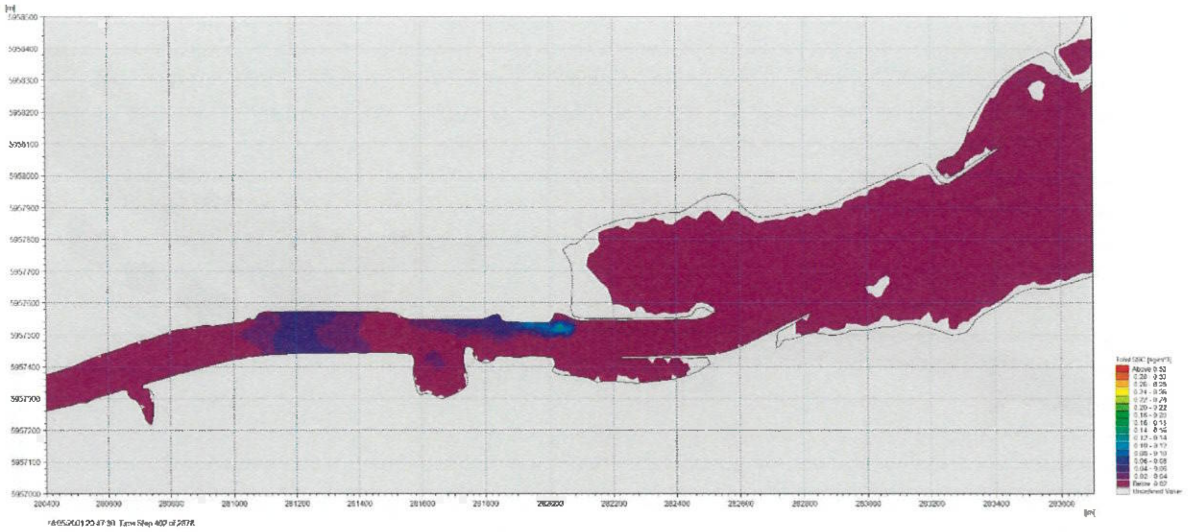


Figure 3.17 Dredging plume with vessel dredging along Tom Roe's berth over a period around a high neap tide

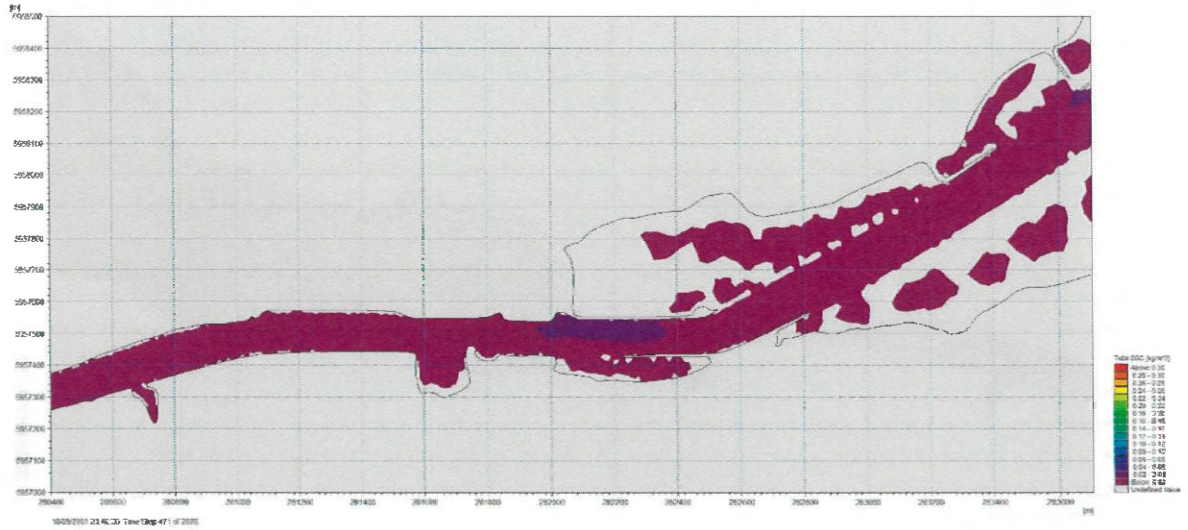


Figure 3.18 Dredging plume with vessel dredging along Tom Roe's berth during a period of an ebb neap tide

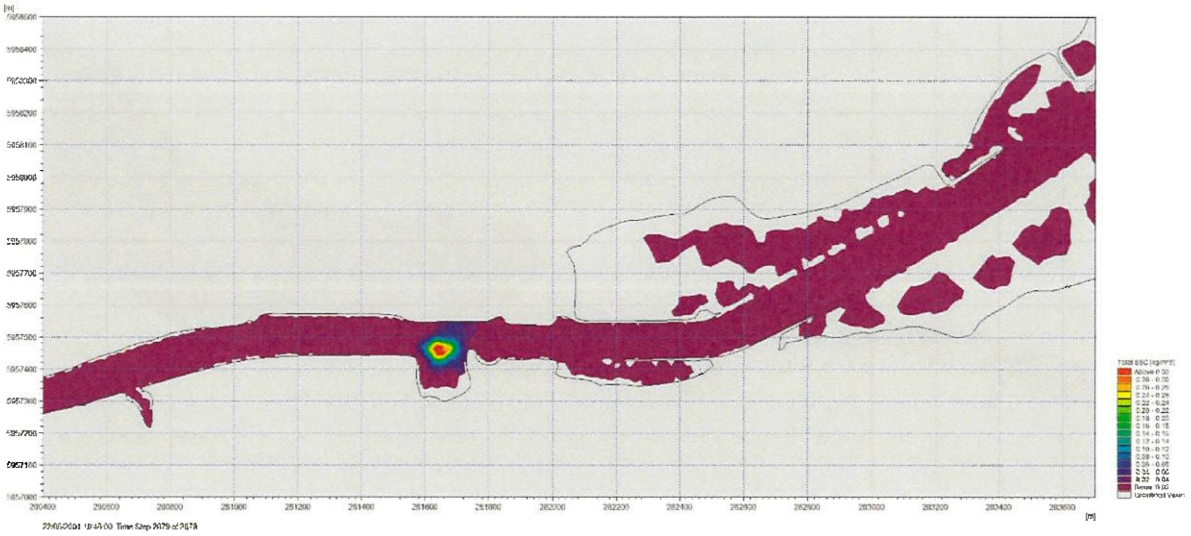


Figure 3.19 Dredging plume with vessel dredging at the Swing Basin during a period of a flood spring tide

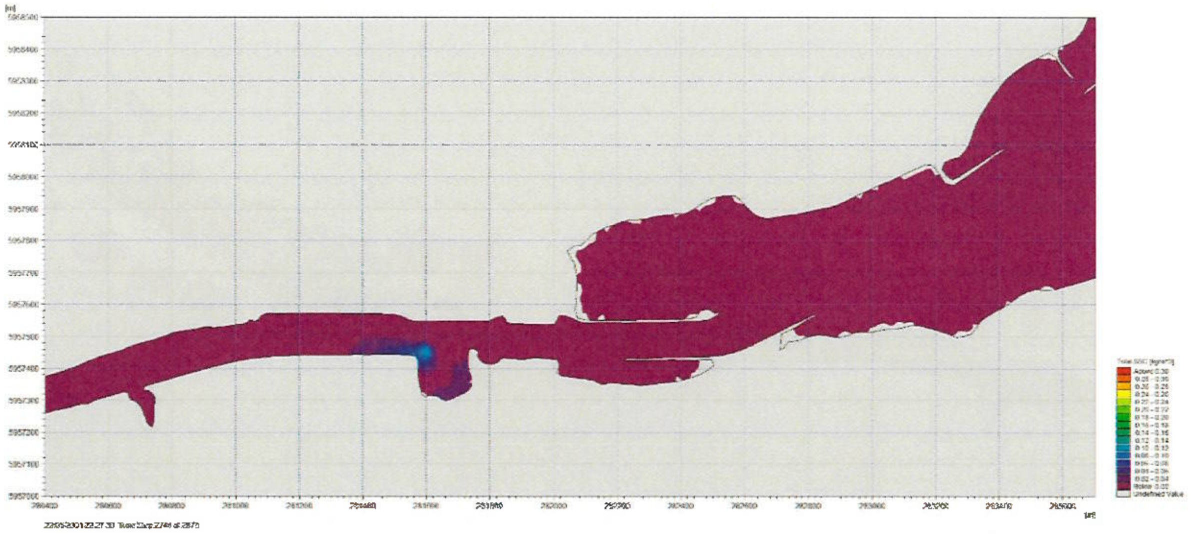


Figure 3.20 Dredging plume with vessel dredging at the Swing Basin over a period around a high spring tide

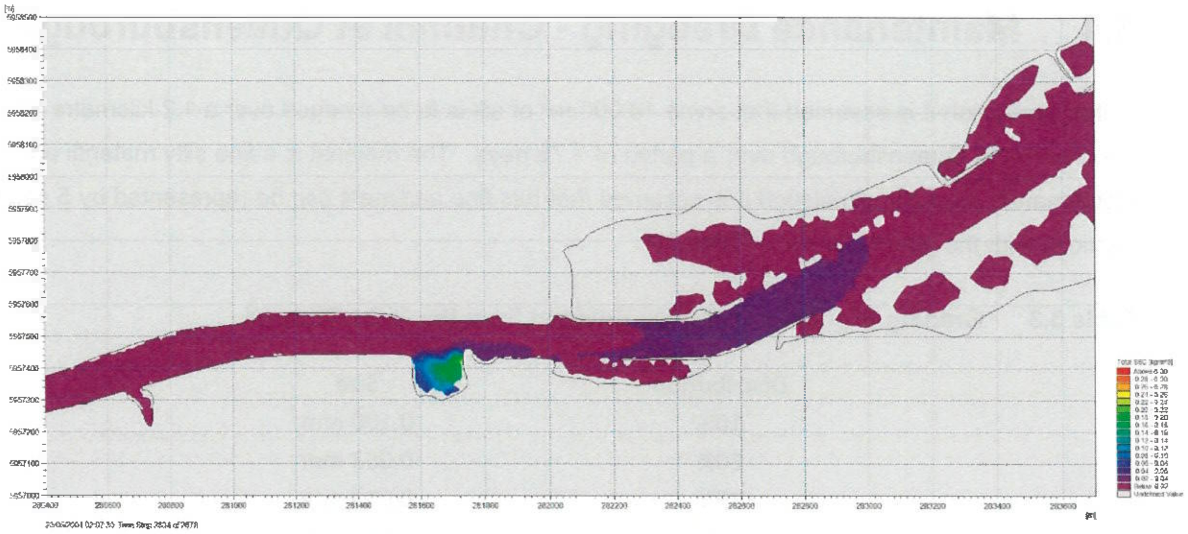


Figure 3.21 **Dredging plume with vessel dredging in the Swing Basin during a period of an ebb spring tide**

3.4 Maintenance Dredging - Channel at Queensburough

In this simulation it is assumed that some 18,000 m^3 of silt is to be dredged over a 1.2 kilometre length of the channel at Queensburough over a period of 7.75 days. The material is a fine silty material and in the maintenance dredging simulation it is assumed that this fine sediment can be represented by 5 sediment fractions with the grading show in Table 3.3.

Table 3.3 Grading of silt material to be dredged from the River Channel

Distribution	Size
10%	0.100 mm
20%	0.063 mm
25%	0.033 mm
25%	0.020 mm
20%	0.008 mm

Normally when maintenance dredging fine silt material, trailer suction dredgers do not overspill and thus the volume of solids in a 1,500m^3 hopper at the completion of a dredging run would be about 400m^3. It is expected to take about 50 minutes to dredge the 400m^3 and depending on whether the vessel is going with or against the current, it is expected to take about 55 to 65 minutes to travel the distance to or from the dumpsite. Thus, with dumping taking about 10 minutes, the rotation time per load is a little over 3 hours. As the dredger will be entering the river when empty it is possible to achieve 3 loads per 12.3 hour tidal cycle when dredging the river channel at Queensburough.

In this simulation it is assumed that the dredger will dredge the channel working downstream. However, it will make little difference to the plume concentration should the dredging be undertaken from the seaward end of the section working upstream. It is assumed that the dredging will commence at a time of neap tides as shown in Figure 3.22 with the red vertical lines denoting the time of the dredging operation in the channel.

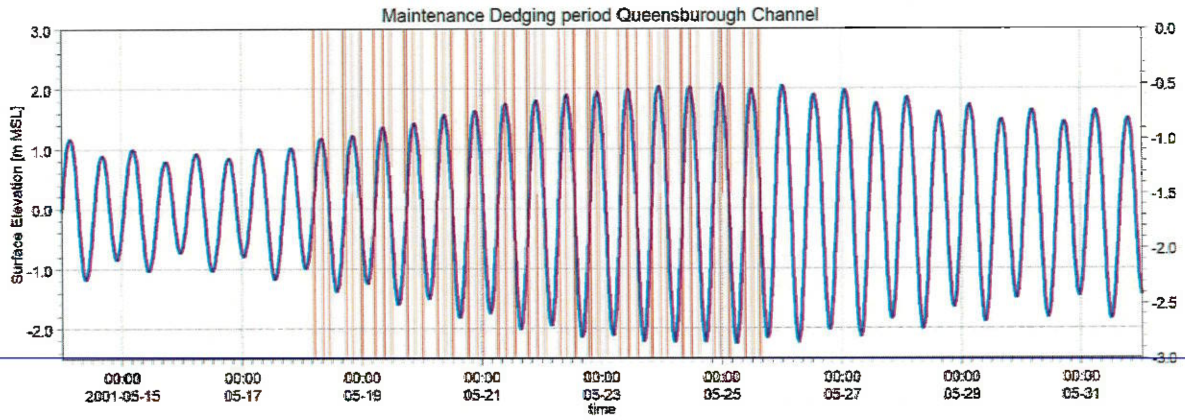


Figure 3.22 Period of maintenance dredging at Queensburough used in the model simulations

As there is no overspill from the dredger hopper, the losses to the water column have been taken as the 1.5% of the dredged volume at the drag head.

The results of the simulations are shown in terms of the deposition of sediment at the end of the dredging process, Figure 3.23, and individual suspended sediment plume diagrams, Figures 3.24 to 3.29, for each of the three dredging runs per tidal cycle, i.e. one for the dredge on the rising tide, one for the dredge over high tide and one for the dredge on the falling tide.

Figure 3.23 shows that the amount of sediment deposited around the Channel and the estuary polder area resulting from the 7.75 day maintenance dredging operations is very small indeed with thickness less than 0.0002 mm. Therefore, it can be deduced that sediment from the maintenance dredging plumes are completely dispersed by the combination of tidal and river flows.

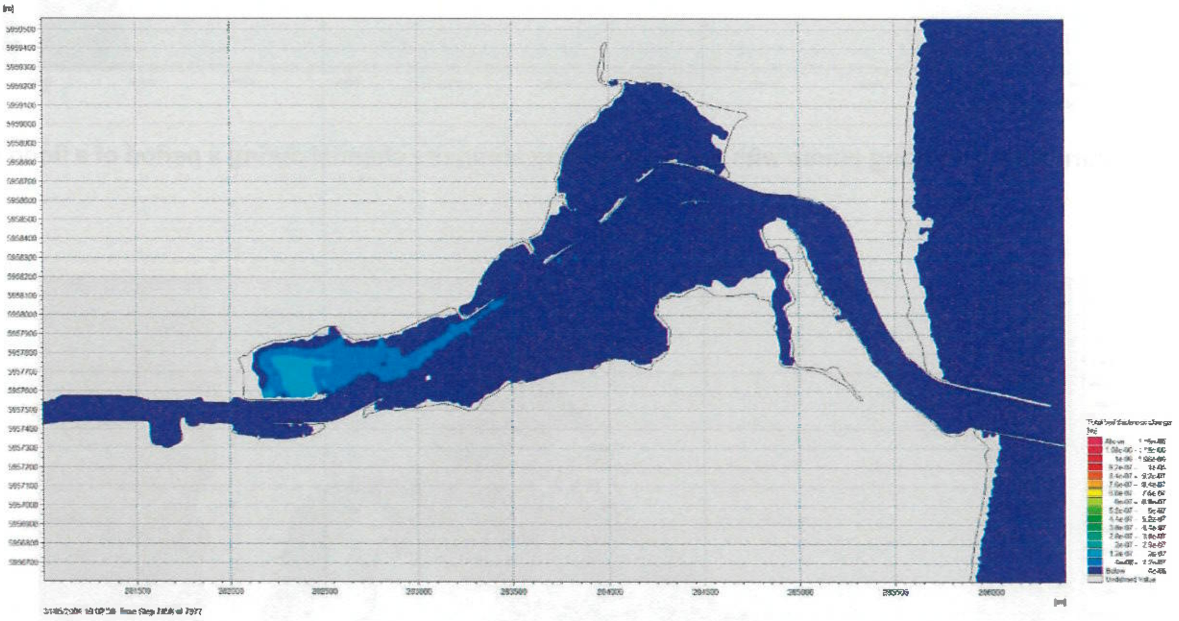


Figure 3.23 Deposition depth of sediment lost to the water column at end of dredging period

It will be seen from the sediment plume diagrams that the highest suspended sediment concentrations occur close to the dredger during the dredging operation with a rising neap tide. At this time the river flow greatly reduces the rising tide current speed in the river so there is less dispersion of the sediment around the dredger then at any other time in the tidal cycle. Apart from the area around the dredger, the suspended sediment plume concentrations are generally low with values typically less than about 80 mg/l and they further disperse relatively quickly.

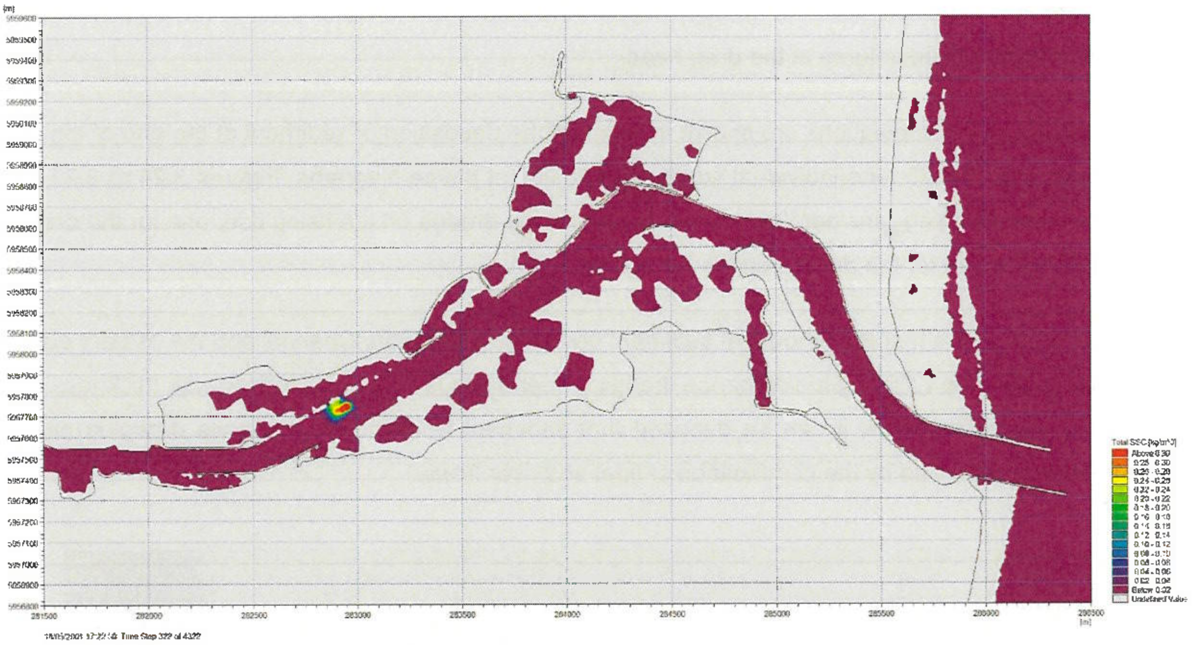


Figure 3.24 Dredging plume with vessel dredging along the channel during a period of a flood neap tide

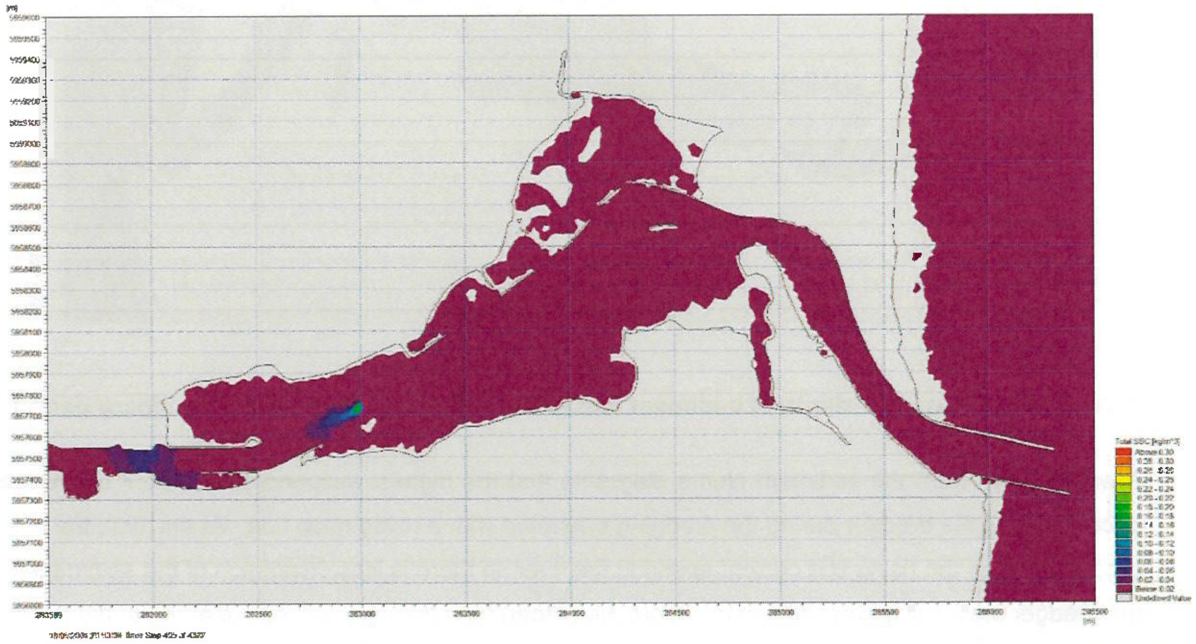


Figure 3.25 Dredging plume with vessel dredging along the channel over a period around a high neap tide

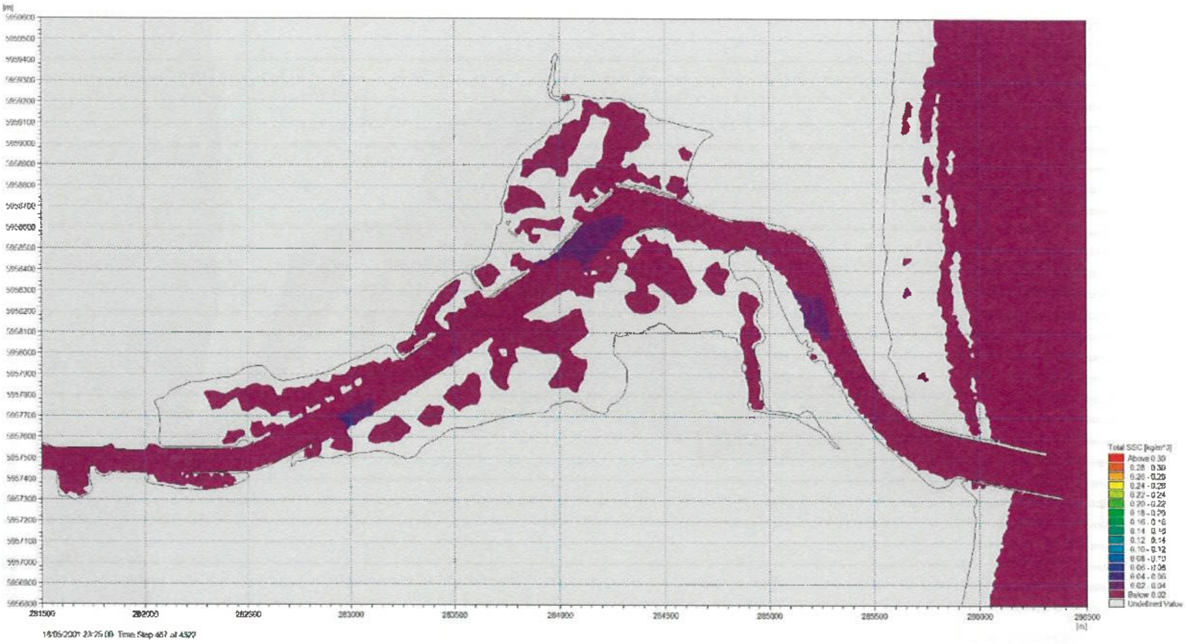


Figure 3.26 Dredging plume with vessel dredging along the channel during a period of an ebb neap tide

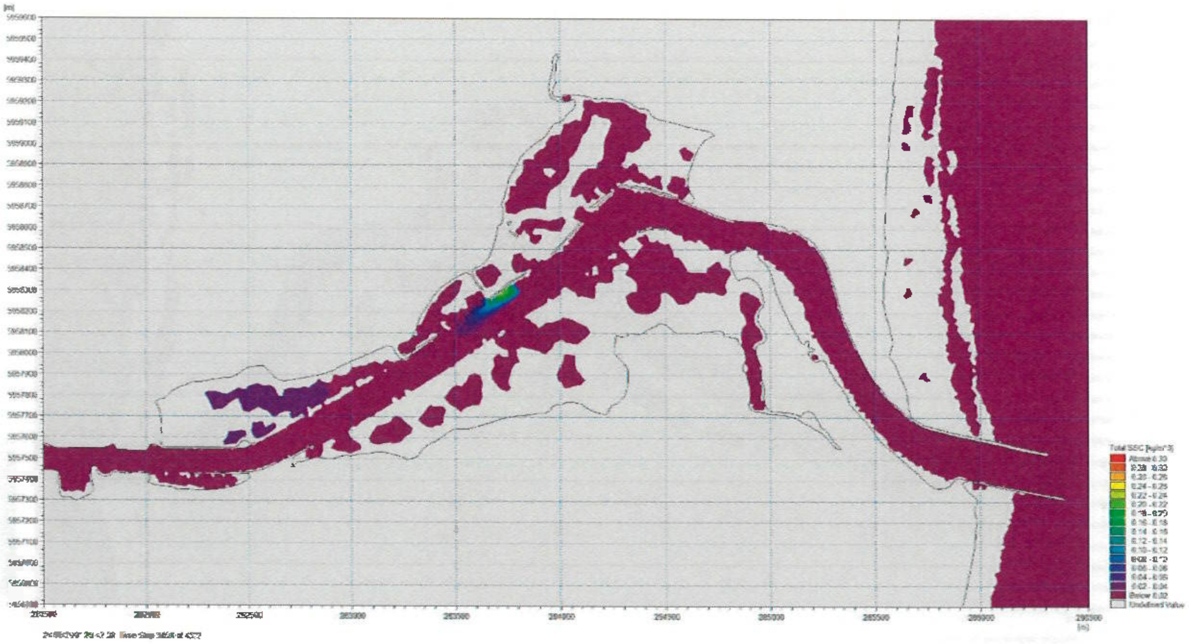


Figure 3.27 Dredging plume with vessel dredging along the channel during a period of a flood spring tide

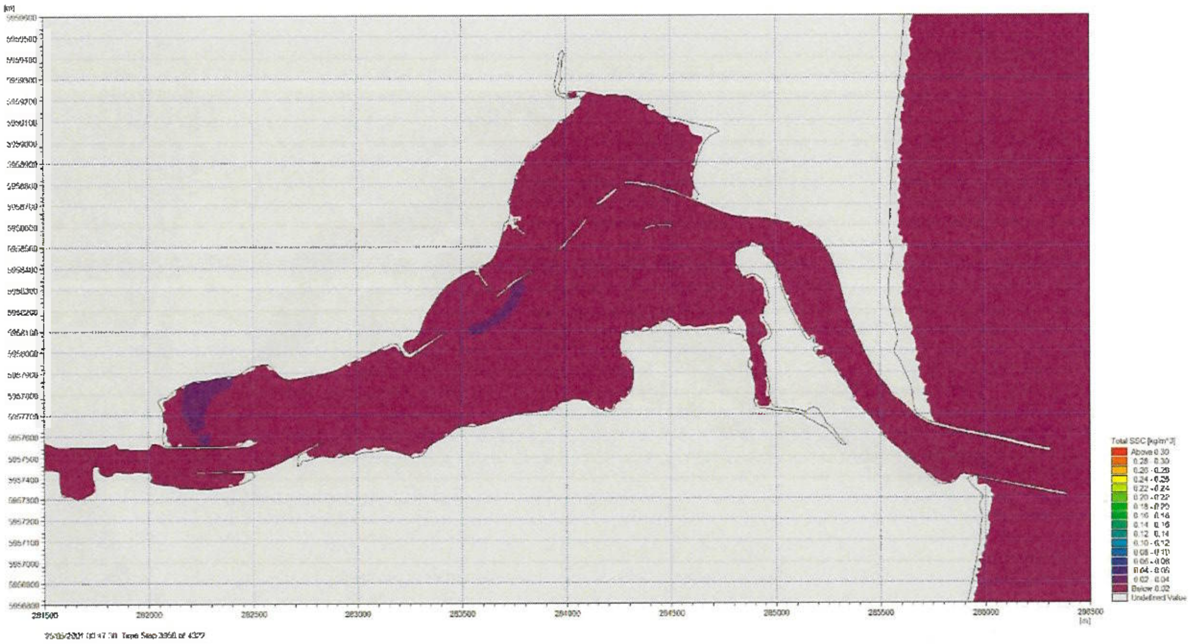


Figure 3.28 Dredging plume with vessel dredging along the channel over a period around a high spring tide

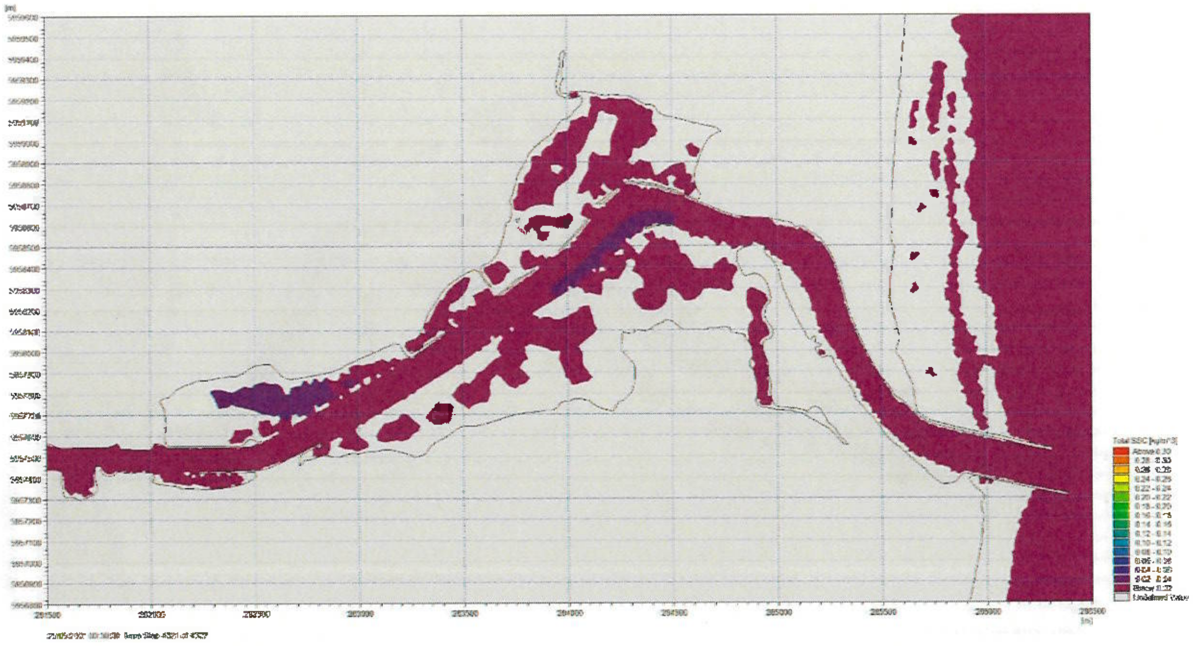


Figure 3.29 Dredging plume with vessel dredging along the channel during a period of an ebb spring tide

4 CONCLUSIONS

RPS has undertaken numerous studies of the coastal processes around the Boyne Estuary and the adjoining beaches of counties Meath and Louth including a report in 2012, on the impact of the entrance channel maintenance dredging on the sediment balance of the coastal sediment cell.

In 2018 the OPW asked RPS to undertake studies to review the extreme water levels occurring along the east coast of Ireland to see what if any changes had taken place in the extreme water levels since 2010. The results of the 2018 study showed that there had been no change in the expected extreme water levels (due to combinations of high tides and storm surges) established in 2010.

There are indications from the recorded values of the wave climate at the M2 buoy that the offshore extreme storm wave heights may have increase slightly in recent years. However, as the sediment transport rates along the beaches on either side of the entrance to the Boyne are driven by inshore wave climate, it is the inshore wave conditions that affect the movement of sediment along the coast. Although the extreme offshore wave heights may have increased in recent years these waves will be depth limited as they approach the coast and thus it is the occurrence of extreme water levels that are most important in determining the changes in the sediment transport rates along the shoreline.

As there has been no change in the extreme water levels, the sediment transport rates along the beach are unlikely to have changed significantly over the 7-8 years since the 2012 report. This conclusion is also confirmed by the fact that there has been no increasing trend in the amount of maintenance dredging required since the 1990s to keep the Boyne entrance maintained to its navigational depth. Thus the 2012 Report "Boyne Entrance Channel Dredging – Impact on Sediment Cell" which concluded that," *in order to ensure there are no impacts on the overall coastal cell from the dredging operations, not more than an annual average quantity of 60,000m^3 of dredged sand should be brought ashore for beneficial reuse. The remaining 30,000 m^3 of material that is required on average to be dredged from the Boyne Estuary entrance is only equivalent to about 0.6mm sand depth over the active beach area. Nevertheless, the 30,000m^3 (average) of additional material to be dredged should be retained within the coastal cell, either within the active system (dumped at the northern or southern dump sites) subject to weather and tidal restrictions or placed in the offshore dump site.*" is still relevant to Drogheda Port's 2019 maintenance dredging license application.

Advanced computer modelling simulations have been undertaken of suspended sediment plumes for the maintenance dredging at the bar, Tom Roe's terminal berth and swing basin as well as the river navigation channel. The work was undertaken using RPS existing Mike21 models of the Boyne River estuary and adjoining sea area.

The results of the simulations of the maintenance dredging at the bar showed that away from the immediate area around the dredger, the total suspended sediment concentrations are very low at less than 80 mg/l and the plume does not approach the area where the little terns nest on the northern side of the training walls. It should also be noted that the area around the bar and the adjoining beaches is subject to regular storm wave events which lift sediment into suspension with concentrations of up to 380 mg/l which is much higher than the levels of suspended sediment that occurs during the maintenance dredging of the bar.

The simulation of the maintenance dredging of the fine silt deposits from Tom Roe's terminal berth, the swing basin and the river channel has shown that, apart from the area around the dredger, the suspended sediment plume concentrations are generally low with values typically less than about 80 mg/l and they further disperse relatively quickly.

APPENDIX 1

RPS 2012 Report

“Boyne Entrance Channel Dredging – Impact on Sediment Cell”

Drogheda Port Company

Boyne Entrance Channel Dredging Impact on Sediment Cell

February 2012

RPS CONSULTING ENGINEERS
ELMWOOD HOUSE
74 BOUCHER ROAD
BELFAST BT12 6RZ
Telephone 028 90 667914
Facsimile 028 90 668286
e-mail info@kmm.co.uk

Drogheda Port Company

Boyne Entrance Channel Dredging Impact on Sediment Cell

February 2012

DOCUMENT ISSUE

Client	Drogheda Port Company					
Project Title	**Boyne Entrance Channel Dredging – Impact on Sediment Cell**					
Document Title	Study Report					
Document No.	IBE0676/AKB/Drogheda/Feb12					
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	AKB	s	AKB	Belfast	16/02/2012
1	Draft Final	AKB	CR	AKB	Belfast	23/02/2012
2	Final	AKB	CR	AKB	Belfast	07/03/2012

CONTENTS

1.0 Introduction 1

2.0 Data Sources 1

3.0 Analysis 2

- 3.1 Transport from the offshore dump site 2
- 3.2 Net sediment transport into the sediment sub cell at the Boyne 3
  - 3.2.1 Sediment distribution 3
  - 3.2.2 Net sediment movement 4

4.0 Conclusions 7

5.0 References 7

1.0 Introduction

The entrance to Drogheda Port is located on a shallow shoaling coastline and is subject to rapid siltation from easterly and south easterly gales. Drogheda Port Company, the port authority and regulator of safe navigation to and from Drogheda Port, dredges the entrance channel to the Boyne Estuary to maintain safe access for shipping to and from Drogheda Port particularly following an easterly gale event. Although the quantities of dredging vary from year to year, the average over an eleven year period was about 90,000 m^3 per annum of sand from the entrance channel. Historically the port has disposed of the material to an offshore dump site located about 2.5 nautical miles north east of the entrance to the Boyne where the water depth is greater than about 14m.

Dredging at Drogheda Port is a licenced activity. The dredging at the entrance is primarily driven by weather events that affect safe navigation depths. Meeting the licence conditions, the Port has brought a portion of the dredged sand ashore for use in the aggregate industry under a trial beneficial reuse scheme.

The Port Company is now preparing to renew its maintenance dredging licence and is anxious to ensure that its proposed dredging procedures are sustainable in terms of the impact on the coastal processes of the adjoining areas. Thus RPS was commissioned to estimate how much of the spoil disposed of at the offshore dump site would return to the inshore sediment regime and in addition to investigate the average annual quantity of sediment entering the sediment sub cell adjoining the Boyne to assess what quantity of material could be beneficially reused in a sustainable manner.

2.0 Data Sources

The data sources used in the study consisted of 3 hourly wind and wave data for the offshore area derived from the UK Met Office European waters wave model together with bathymetric survey and sediment data derived from surveys undertaken for various coastal process studies commissioned by Drogheda Port for the period 1994 to 2008 and carried out by RPS formally Kirk McClure Morton.

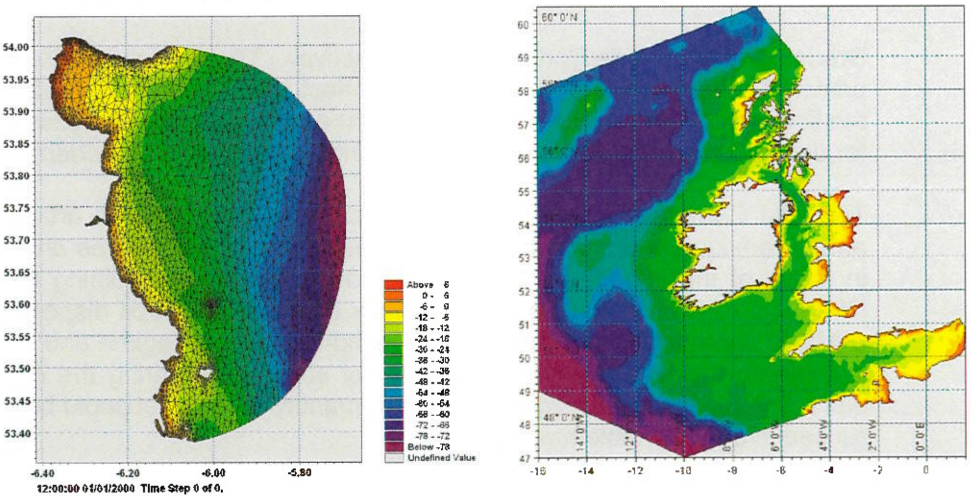
In addition to the basic hydrodynamic and sediment data, information regarding the sediment transport regime in the area was taken from the following study reports.

- Hydraulic Studies of the Dredging of the Boyne Entrance and Bar by Kirk McClure Morton 2001(1) and 2002(2).
- Beach Restoration at Laytown/Bettystown studies by RPS Kirk McClure Morton 2005(3).
- Hydraulic and Coastal Engineering study by DHI, 2008(4) (unpublished).
- Morphodynamic modelling of the Irish Sea, Project report by MarCon Computations International Ltd, 2008(5).

3.0 Analysis

3.1 Transport from the offshore dump site

The assessment of the movement of dredged material from the offshore dump site area which is centred at 6° 10.5'W, 53° 44.5'N, was simulated by computing the sediment transport rates for every 3 hours through a typical year. The wave climate at the site was established by modelling the transformation of the 3 hourly offshore data set to the site using RPS Mike21 SW wave model and the tidal currents were extracted from the RPS Irish Coastal tidal and surge model. The extent of the wave and tidal models is shown in Figure1.



SW wave model **Irish coastal tide and surge model**

Figure 1 Extent of wave and tidal models used for dump site analysis

The results of the sediment transport simulations for the offshore dump site showed that sediment would only move at the site during significant storm events when the larger waves with the longer wave periods could disturb the seabed sediment at this location. However the amount of dredged material which would be moved towards the beaches by these events was very small and generally less than about 500 m^3/annum. The analysis was also checked against the bed load transport results shown in the MarCon 3D morphodynamic modelling of the Irish Sea(5). Although the size of the grid spacing in this model is rather large (2km x 1.6km) compared to the Mike21 models, the results of the bed load transportation are of the same order of magnitude with transport rates of about 1,500m^3 per annum in the area around the offshore dump site. Thus it is concluded that only about 1% of the dredged material dumped on the offshore dumpsite is likely to find its way back onto beaches of Counties Louth or Meath.

3.2 Net sediment transport into the sediment sub cell at the Boyne

3.2.1 Sediment distribution

The distribution of non cohesive sediment (mainly sand) around the Irish Sea is shown in Figure 2 which is taken from Figure 9 of the report of the Morphodynamic Modelling in the Irish Sea(5). It will be seen from this diagram that the sea bed to the west of a line from about Clogher Head to east of Skerries, including the coasts of Co Meath and Louth around Drogheda is comprised of sand. Sediment sampling undertaken as part of the Kirk McClure Morton studies(1) (2) indicates that the median sediment size is about 0.13 to 0.15 millimetres. The sea bed to the north east of this area becomes more cohesive as the tides become more dominated by the central part of the western Irish Sea gyre.

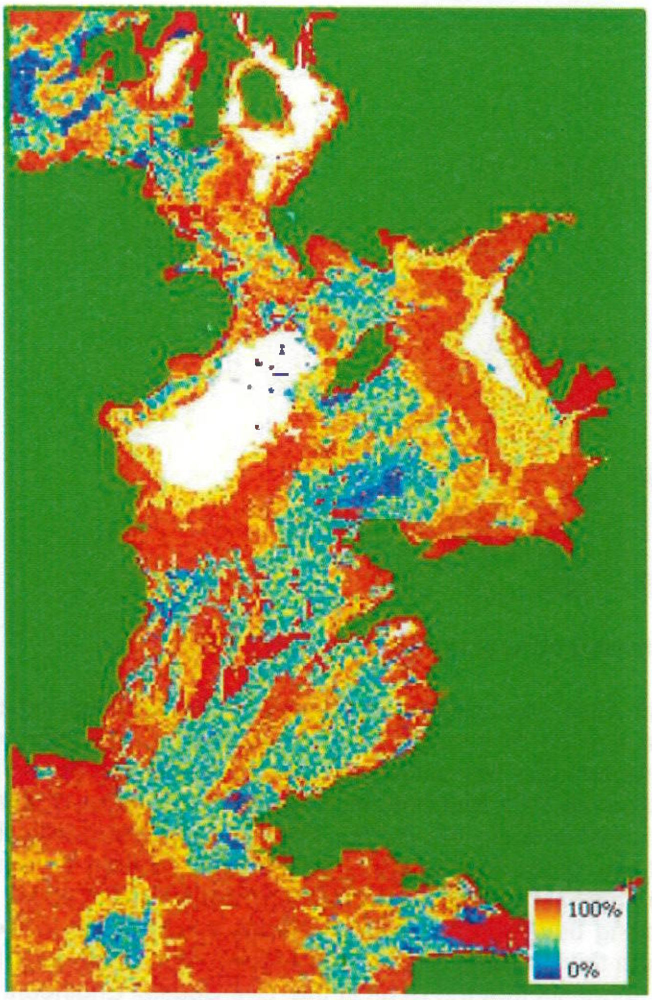


Figure 2 **Distribution of non cohesive sediments in the Irish Sea**
(taken from Figure 9 of Morphodynamic Modelling of Irish Sea(5))

3.2.2 Net sediment movement

The net sediment drift around the coastal sub cell which includes the entrance to the Boyne runs north west to north along the coast from Skerries to Clogher Head. Thus the main source of sediment supply to the coastal cell comes from the south past Skerries and to seaward of Bremore Point. A Hydraulic and Coastal Engineering report by DHI, estimated the annual net drift quantities along the coast as shown in Figure 3 below (taken from Figure 5-27 of the report). It will be seen that these net rates are in the region of 30,000 m^3 at Bremore Point to 90,000 m^3 at the entrance to the Boyne.

Figure 3 **Estimated annual net sediment drift rates.**$^{4)}$

The net annual drift rates calculated were based on the synthesizing of seven years of wave data applied to a single coastal profile with tidal data based on Howth. The KMM reports give the same general movement of sediment but with somewhat higher rates as they had a more extensive time series of events and used a variation in profiles along the coast. The rates derived during the KMM studies(1) (2) have been calibrated against the dredging records for the Boyne entrance. The 2002 KMM report showed that there was a total of about 350,000 m^3 of sediment moving both north and south across the entrance to the Boyne with more going north than coming south. Comparison of the drift rates between the various reports suggests that the rates in the DHI Coastal Engineering report are low. The DHI report also notes that there is some uncertainty about their estimated drift rates past Bremore Point due to the two dimensional nature of the drift in this area.

The 3 dimensional morphological modelling of the Irish Sea undertaken as part of the Interreg IMAGIN study (5) shows a similar north westerly movement of bed sediment into the Co Meath and Louth coastal areas around the Boyne. The morphodynamic modelling considered two formulations for the bed sediment transport, one based on the Bagnold formula and the other based on the formula of Meyer-Peter and Mueller. The predicted transport vectors for an average month are shown for the two formulations in Figures 4 and 5.

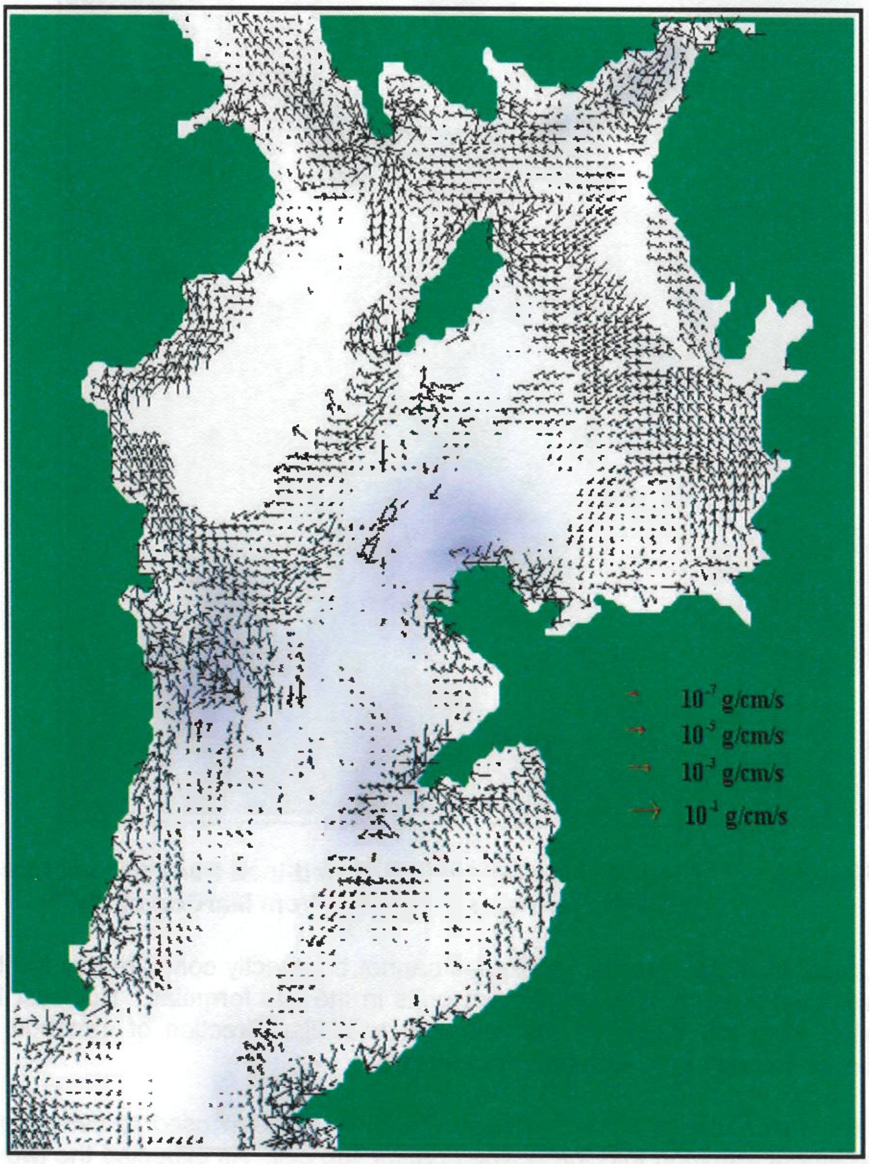


Figure 4 **Predicted average monthly bed-load transport vectors (after Bagnold) from MarCon study(5)**

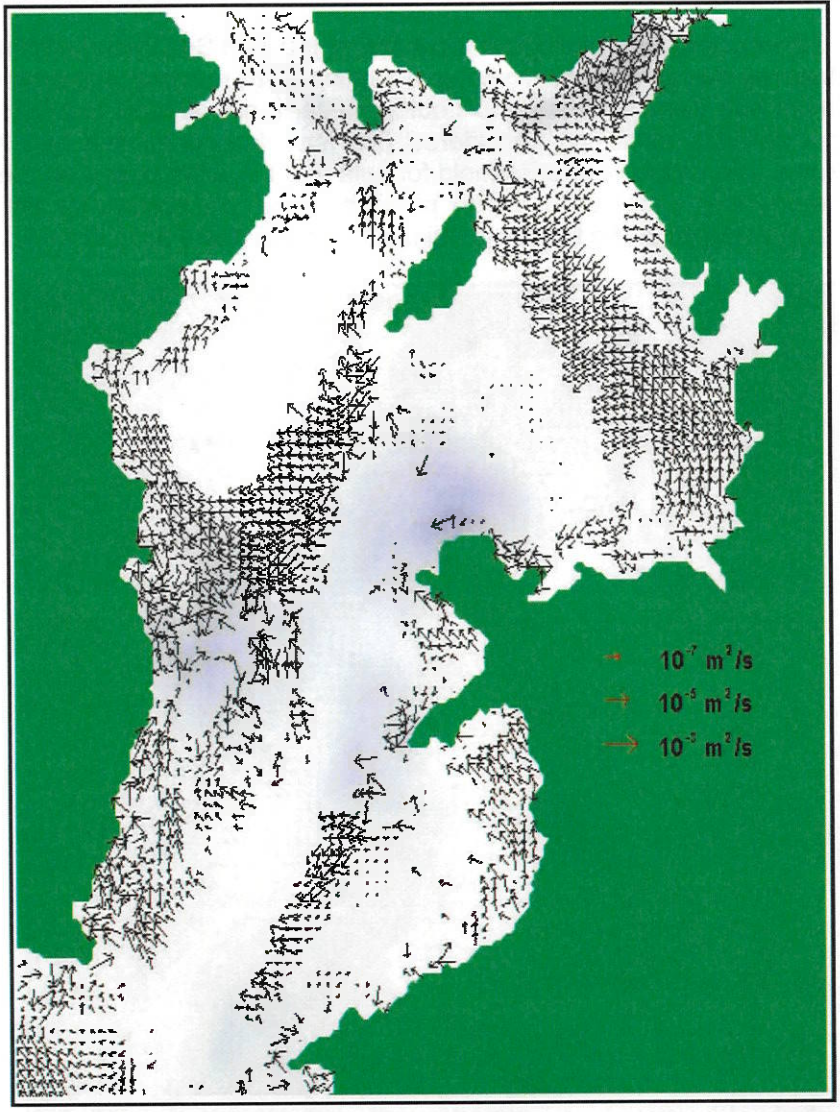


Figure 5 **Predicted average monthly bed-load transport vectors (after Mayer-Peter & Mueller) from MarCon study[(5)]**

Output from the two methodologies cannot be directly compared as the bed load transport is expressed in different units in the two formulas. However it will be seen from the diagrams that there is a similar direction of transport into the Boyne Estuary area with both formulations.

The vector results for an average month have been used to calculate the net sediment transport into the Boyne coastal sub cell. As expected the two different formulations yield somewhat different average annual transport rates but the average of the two values at 60,000 m^3 per annum is in line with the drift rates from other studies and is in accord with the overall sediment transport mass balance for the area.

4.0 Conclusions

The work undertaken for this study indicates that there is only a small movement of the dredged sand which has been deposited in the offshore dump site area back towards the beaches around the Boyne entrance. Consequently dredged material dumped at this offshore site contributes very little to the inshore coastal processes along the Co Meath and Co Louth beaches adjacent to the Boyne Estuary. Beneficial re-use of this material is wholly appropriate in lieu of disposal at the off shore site given the insignificant movement of this material.

The sediment movement into and around the coastal sub cell at the Boyne entrance has been studied in various reports. The most recent report on the hydraulic and coastal engineering by DHI indicated a net north going sediment bypass of 30,000m^3 at Bremore Point. However the drift rates in this report had been calibrated against a drift rate across the Boyne entrance given in a study by KMM in 1994 which was subsequently found to be too low by a factor of about 2.

The analysis of the results of the modelling undertaken for the IMAGIN project indicates a net annual bed sediment transport into the Co Meath and Co Louth beach system from the south east of 60,000m^3 per year. This figure is consistent with the historical dredging practices and the changes observed on the beaches around the entrance to the Boyne Estuary.

On the basis of the information available at the time of this study it is concluded that, in order to ensure there are no impacts on the overall coastal cell from the dredging operations, not more than an annual average quantity of 60,000m^3 of dredged sand should be brought ashore for beneficial reuse. The remaining 30,000 m^3 of material that is required on average to be dredged from the Boyne Estuary entrance is only equivalent to about 0.6mm sand depth over the active beach area. Nevertheless, the 30,000m^3 (average) of additional material to be dredged should be retained within the coastal cell, either within the active system (dumped at the northern or southern dump sites) subject to weather and tidal restrictions or placed in the offshore dump site.

5.0 References

1) Kirk McClure Morton, - *Drogheda Port Company – Entrance Channel Stability,* November 2001.
2) Kirk McClure Morton, - *Dredging of Boyne Estuary & Barr to -6m CD – Hydraulic Feasibility Study,* November 2002.
3) RPS Kirk McClure Morton, *beach restoration and Laytown/Bettystown – Feasibility Study,* August 2005.
4) DHI, *Hydraulic and Coastal Engineering Study,* October 2008 (unpublished).
5) MarCon Computations International Ltd, *Morphodynamic Modelling in the Irish Sea – Project Report,* March 2008