J B Barry & Partners Ltd

Baldoyle Estuary Storm Water Outfall
Estuary Bed Erosion Study

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STUDY REPORT

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1.0 INTRODUCTION

J B Barry and Partners Ltd have been appointed by St Marnock's II DAC to design a storm water outfall to serve residentially zoned land south of Station Road, Portmarnock, Fingal, County Dublin.

The outfall consists of a 525mm diameter concrete pipe with a tideflex valve and concrete apron, the details of which are shown on J B Barry & Partners Ltd Drawing No. Y17205-C-204 Rev F. The proposed outfall is to discharge via an existing channel below the high water mark at a location approximately 125m south east of Portmarnock Bridge as shown in Figure 1.

Figure 1 Photo showing location of proposed storm water outfall discharge

A storm water outfall for a previous project was proposed for this location and the planning authority requested that a scour study be undertaken to assess the impacts on the estuary. This was carried out by RPS and the firm has now been commissioned to update this study for the proposed revised storm water outfall discharge.

2.0 STUDY METHODOLOGY

2.1 General

RPS used their suite of coastal process models to simulate the changes in the flow regime in the upper part of the Baldoyle Estuary. The flows in the estuary were simulated both with and without the proposed storm water outfall in place so that the regime with the outfall in operation could be compared to the present day conditions. The combined flow and sediment transport models include the simulation of bed level change under the flow regime which was used to assess the risk of bed erosion resulting from the operation of the storm water outfall.

2.2 Computational Model

The Mike21 FM coupled flexible mesh flow and sediment transport model was used for the study. The extent of the model is shown in Figure 2. The model was driven at its seaward boundary by data taken from the RPS tidal and surge model of the Irish coastal waters and the Irish Sea.

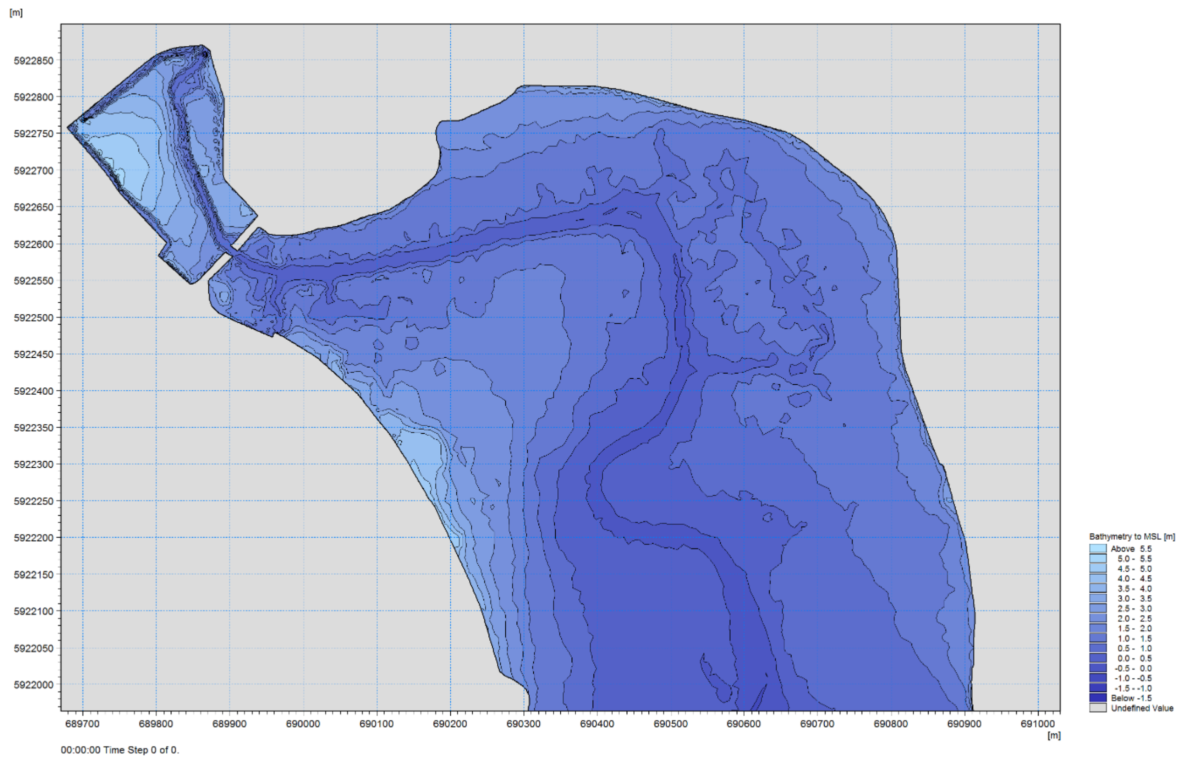


Figure 2 Extent of flexible mesh flow and sediment transport model

2.2.1 Bathymetry

The bathymetry for the model was taken from a variety of sources including LiDAR surveys, topographic surveys and local bathymetry surveys. The extent and resolution of the data sets is shown in the diagrams in Figure 3.

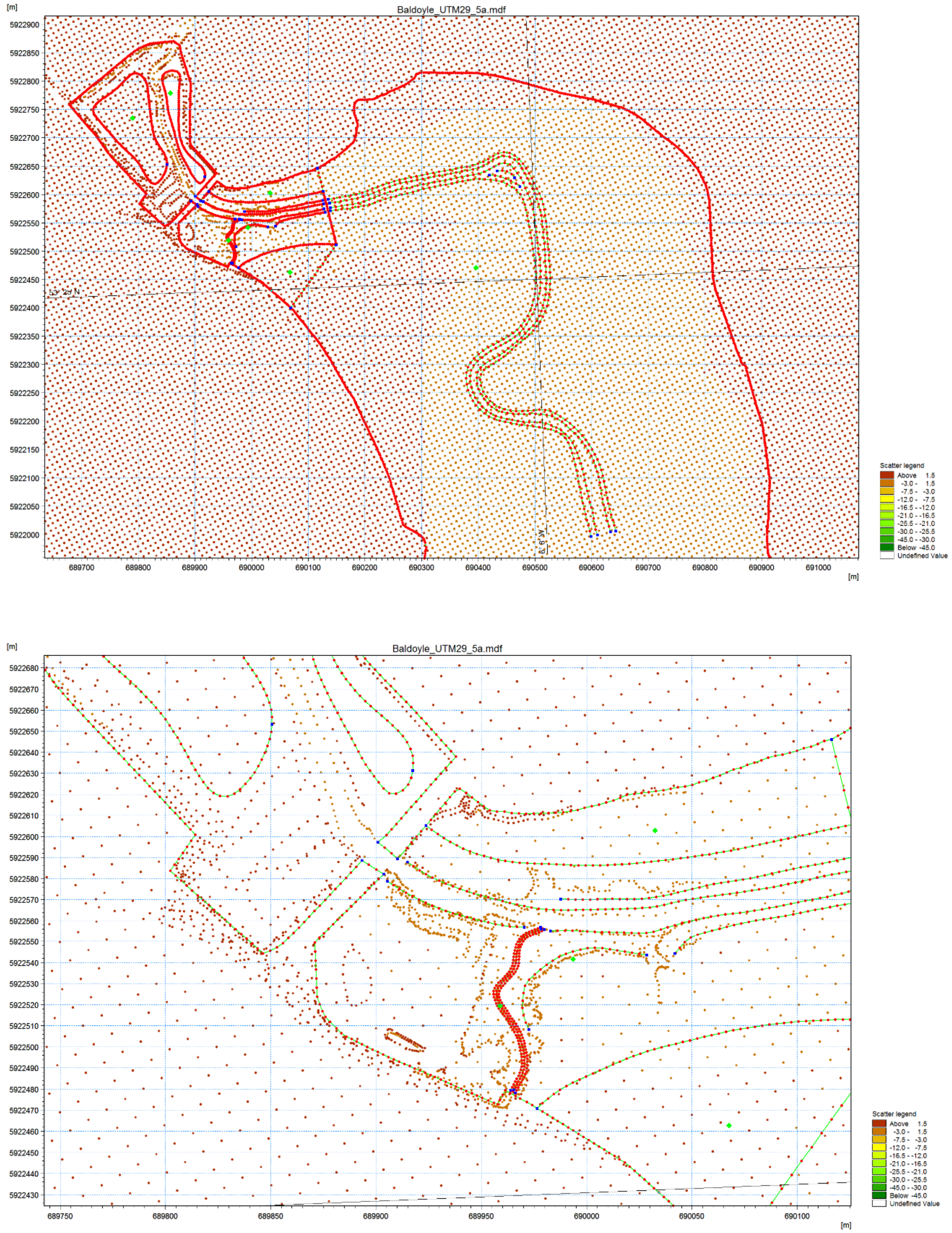


Figure 3 Extent and resolution of bathymetry data used in the model (overall extents and detail around discharge point shown in top and bottom diagram respectively)

2.2.2 Computational mesh

The coupled flow and sediment transport model was built with a flexible mesh grid system. The mesh resolution varied from 100m² in the outer parts of the model down to 10m² in the upper part of the estuary with a resolution of 2m² along the channel leading from the outfall discharge to the Sluice river channel. The overall model mesh is shown in in Figure 4 with the upper and lower diagrams showing the overall model mesh and detail in the proximity of the site respectively.

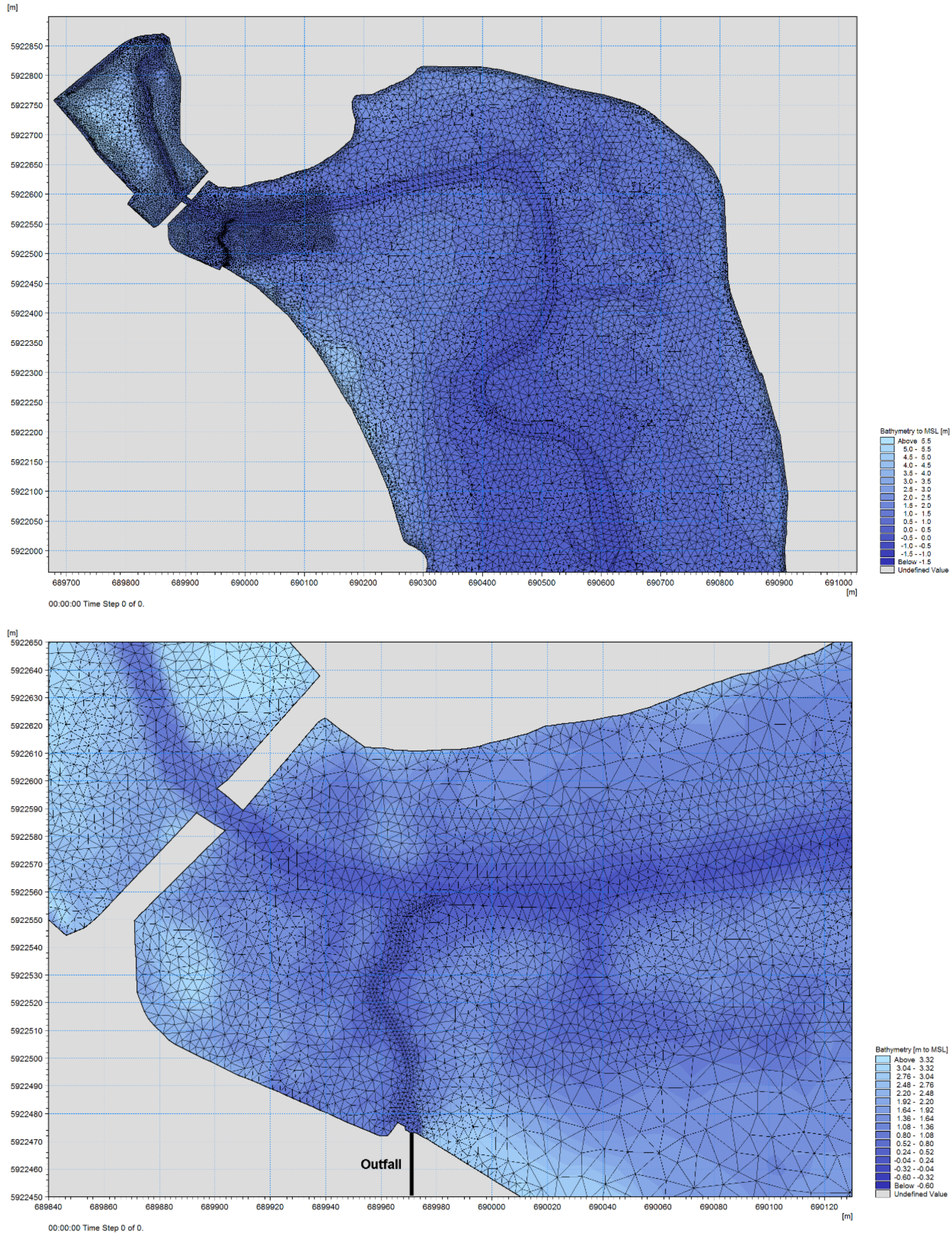


Figure 4 Mesh system used in computational model

2.2.3 Sediment data

The rate of sediment transport is governed by the flow velocity across the bed and the nature of the estuary bed sediments themselves. Samples of the bed sediments in the estuary channel leading from the proposed storm water outfall were taken as part of the previous outfall study. The location of the three pits is shown in Figure 5 and the particle size grading curves shown in Figure 6.

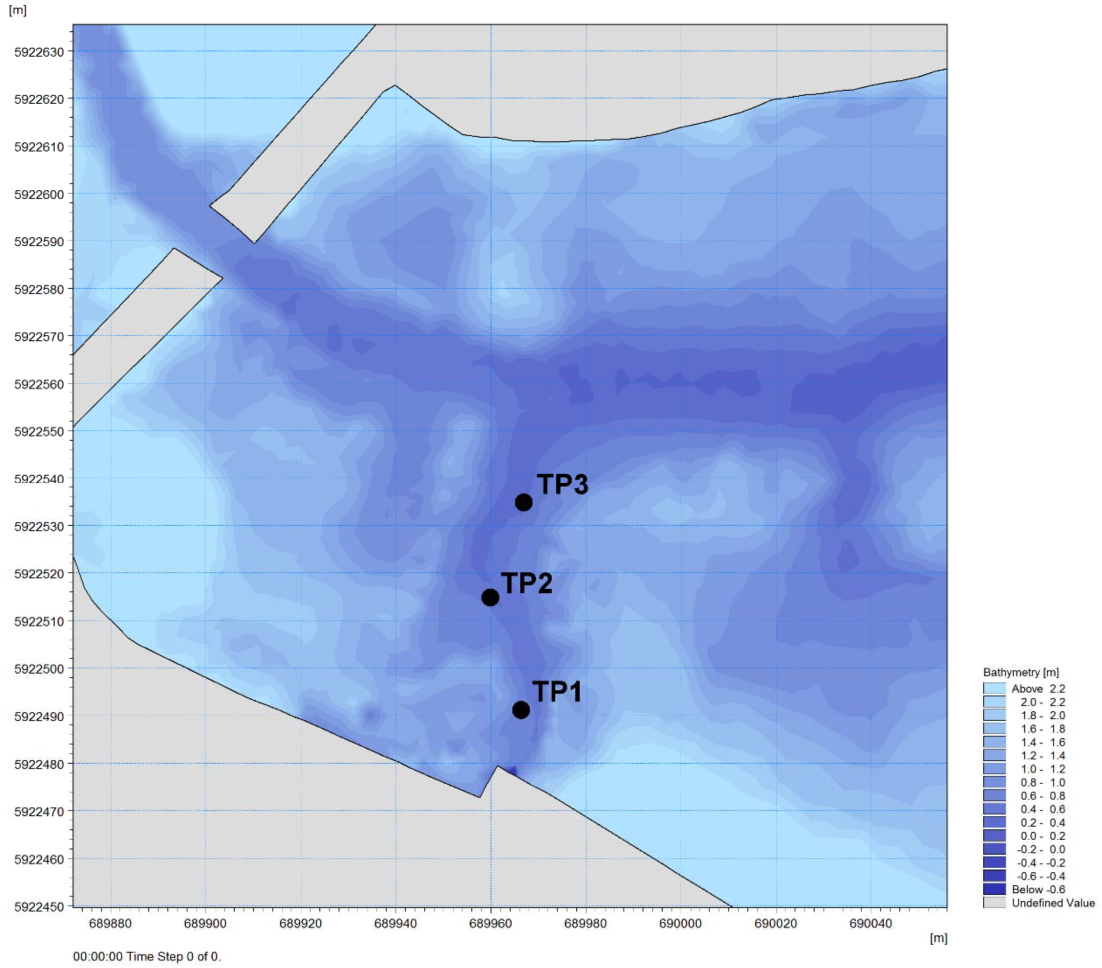
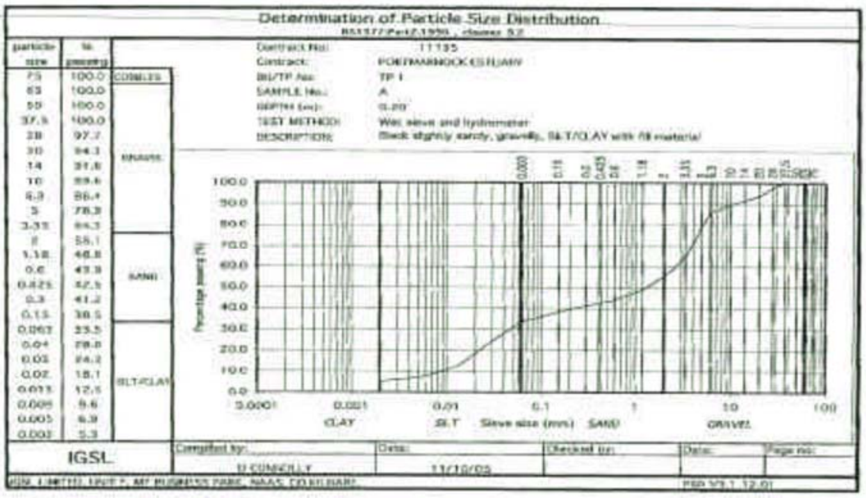
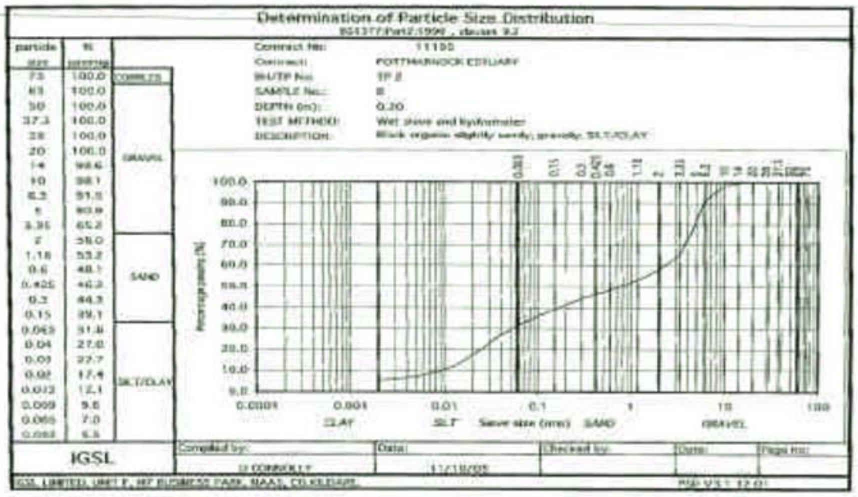


Figure 5 Location of sediment sampling pits in estuary channel.

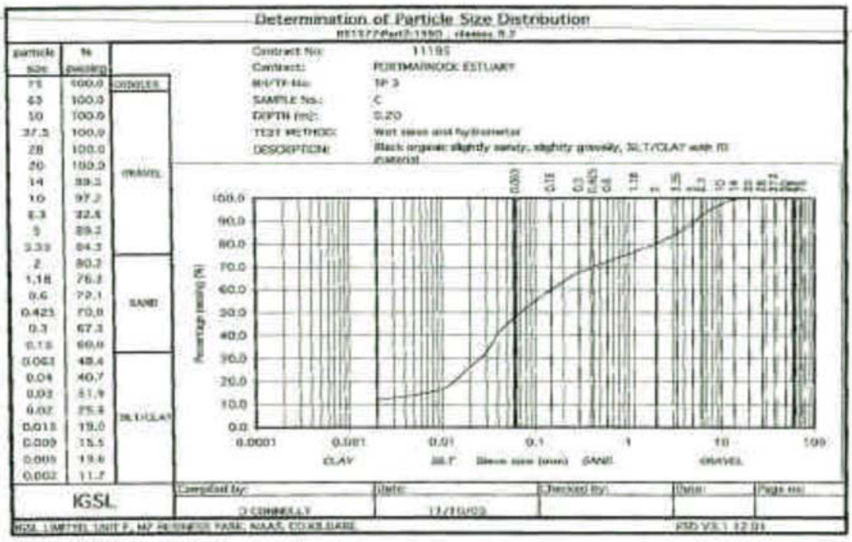
It will be seen from the grading curves in Figure 6 that the estuary bed sediments have a wide grading varying from fine silts to gravel sized material. Under high flows this type of bed sediment tends to “self armour” the surface as the finer fractions are initially carried away to leave the coarser fractions of the material in a layer on the surface which protects the material from further erosion. This process is already evident in Baldoyle Estuary where the surface of the river bed is composed of stony material while the embayments at the edges of the salt marsh have a muddy surface.



Particle Size Distribution – Sample Pit 1



Particle Size Distribution – Sample Pit 2



Particle Size Distribution – Sample Pit 3

Figure 6 Bed sediment particle size distributions

2.2.4 Fresh water flows

The storm water discharges from the proposed outfall have been supplied by J B Barry & Partners Ltd. The discharges and outlet current velocities area shown in Table 2.1 below. In the hydraulic modelling, to be conservative, the higher discharge rates and velocities associated with the high water level conditions were used in all the simulations.

Critical Storm Event	Discharge Conditions.	Pipe Flow (l/s.)	Velocity (m/s.)
1 YEAR	FREE DISCHARGE	145.2	0.67
1 YEAR	+3.70m. OD TIDE LEVEL	172.6	0.79
30 YEARS	FREE DISCHARGE	177.1	0.82
30 YEARS	+3.70m. OD TIDE LEVEL	184.8	0.85
100 YEARS	FREE DISCHARGE	190.5	0.88
100 YEARS	+3.70m. OD TIDE LEVEL	199.4	0.92

Table 2.1 Proposed outfall discharge conditions

In addition to the proposed outfall, fresh water flows into Baldoyle Estuary from the Sluice River. The catchment for this river is small at approximately 4.2 sq. km and there are no flow gauge records for this river. The freshwater flows in the river were therefore estimated using the Poots Cochrane formula for small catchments and by comparison of 10 years of daily gauge records from the nearby Ballyboghill River. The analysis of the flows for the various return period storm events yielded the following flows for the Sluice River at Baldoyle Estuary.

1 in 5 year return period storm	3.50 cumecs
1 in 30 year return period storm	4.75 cumecs
1 in 100 year return period storm	6.10 cumecs

In the computational model the fresh water inputs are included in the model by boundary source functions with specified flow rates and velocities.

2.3 Model Simulations

2.3.1 Flow Regime

As the flows from the proposed outfall are relatively small, it was decided to commence the model simulations using 1 in 100 year return period events and only examine lower return period events if the 1 in 100 year outfall discharge resulted in significant bed erosion. The simulations were undertaken with both the river and the outfall discharging at the storm peak conditions as it is likely that both sources will be subject to the same rainfall event. The model simulations were also run for the same events without the outfall discharge in place so that comparisons could be made with the existing flows in the estuary under storm conditions.

The combinations of extreme fluvial flows and high tidal levels has been studied during the CFRAM flood studies which have recently been completed for OPW. In the CFRAM studies it was considered that extreme 1 in 100 year return period fluvial events could be accompanied by high tidal events with a return period of 1 in 2 years. This combination of storm flows and high tidal water levels has been adopted for this study. Simulations were also undertaken with storm fluvial events and normal tidal levels to check that this combination was not more onerous for bed erosion than that with the extreme tidal conditions.

The flow model was run for 5 tidal cycles to ensure model stability with the tidal curve at the boundary derived from RPS Irish coastal waters and Irish Sea tidal and storm surge model. The 1 in 2 year return period tidal water level was taken from the results of the extreme tidal level analysis undertaken as part of the Irish Coastal Protection Strategy Study which was completed by RPS for the OPW. The extreme 1 in 2 year return period water level was 2.57 metres above MSL. The tidal curves used at the boundary of the upper Baldoyle Estuary model are shown in Figure 7.

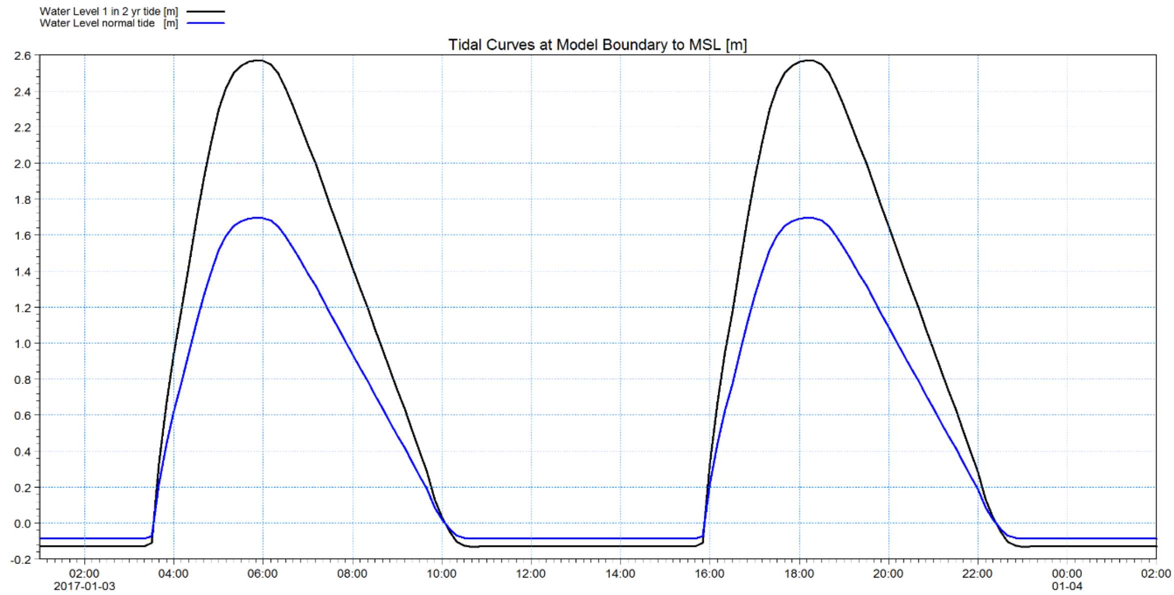


Figure 7 Tidal level profile at model boundary – extreme and normal tides

2.3.2 Sediment Transport

The sediment transport module, Mike21 FM ST uses currents from the hydrodynamic flow module together with bed sediment data to compute the sediment transport rate and the then calculates the resulting change in the bed levels. The model allows the user to define areas of the model where the bed is not permitted to erode, e.g where there is scour protection or the bed material is very coarse. As the study is concerned with possible erosion due to the effect of the storm water outfall discharge, areas of the model which are not affected by the discharge (e.g. areas upstream of the bridge) have been stabilized by including a minimum bed thickness map.

The sediment transport and bed level change was modelled over the complete tidal cycle using 1 in 100 year return period storm flows with both the extreme and normal tidal level profiles. Simulations were undertaken for bed sediment grain sizes of 5mm, 1mm and 0.1mm so that the impact of surface armouring could be correctly assessed from the model results. The bed level change was assessed in terms of the value that occurred at end of a tidal cycle simulation for each of the sediment grain sizes.

3.0 RESULTS OF THE MODEL SIMULATIONS

3.1 Flow Regime

3.1.1 1 in 100 year return period fluvial storm with 1 in 2 year return period tide

The results of the simulations are shown in terms of peak current speeds for the model with the storm water overflow in place in Figure 8 and for the model without the storm water overflow in Figure 9. As it is difficult to see the difference between the current regimes in these diagrams, a difference plot (current speeds with the outfall discharge in place minus the current speeds without the outfall discharge) is also shown in Figure 10.

As will be seen from these Figures 8, 9 and 10 the impact of the outfall discharge only has a noticeable effect in the area of the small channel leading from the outfall to the main river channel. Even then the velocities in the channel beyond the end of the concrete apron are generally only increased by less than 0.08 m/s due to the effect of the proposed outfall discharge. This is a very small increase in current speed.

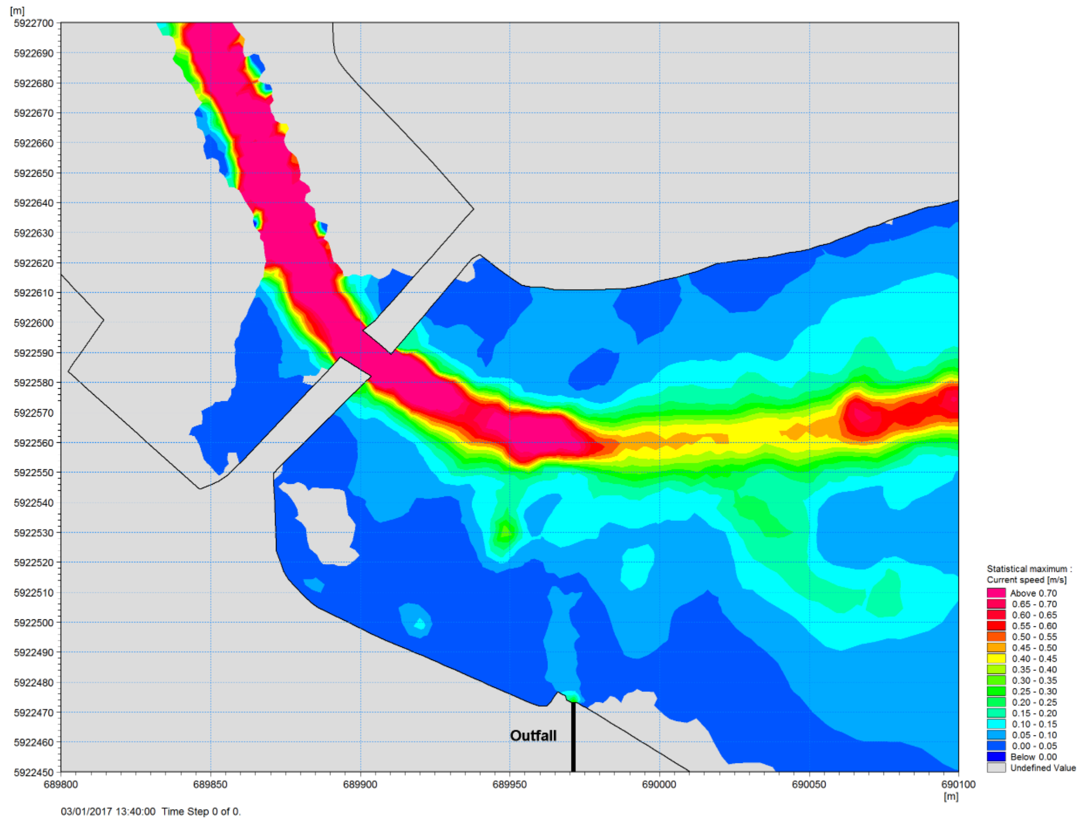


Figure 8 Peak current speed with the proposed outfall in place

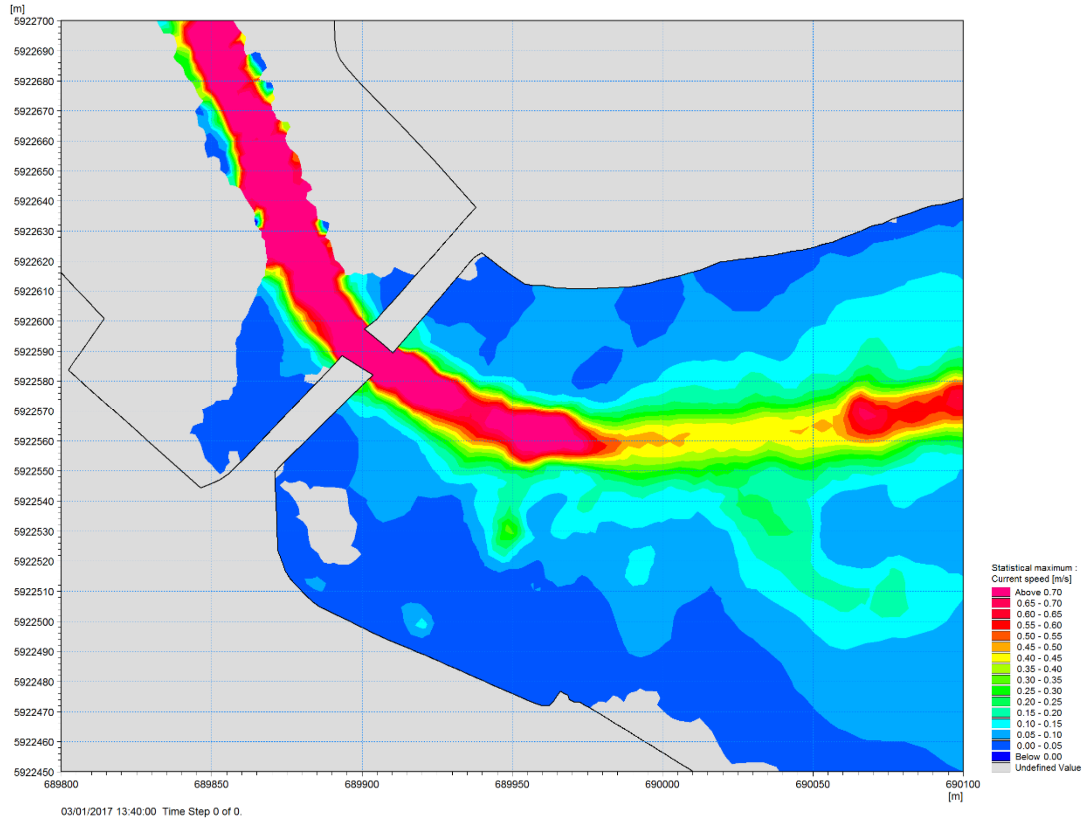


Figure 9 **Peak current speed with no outfall discharge**

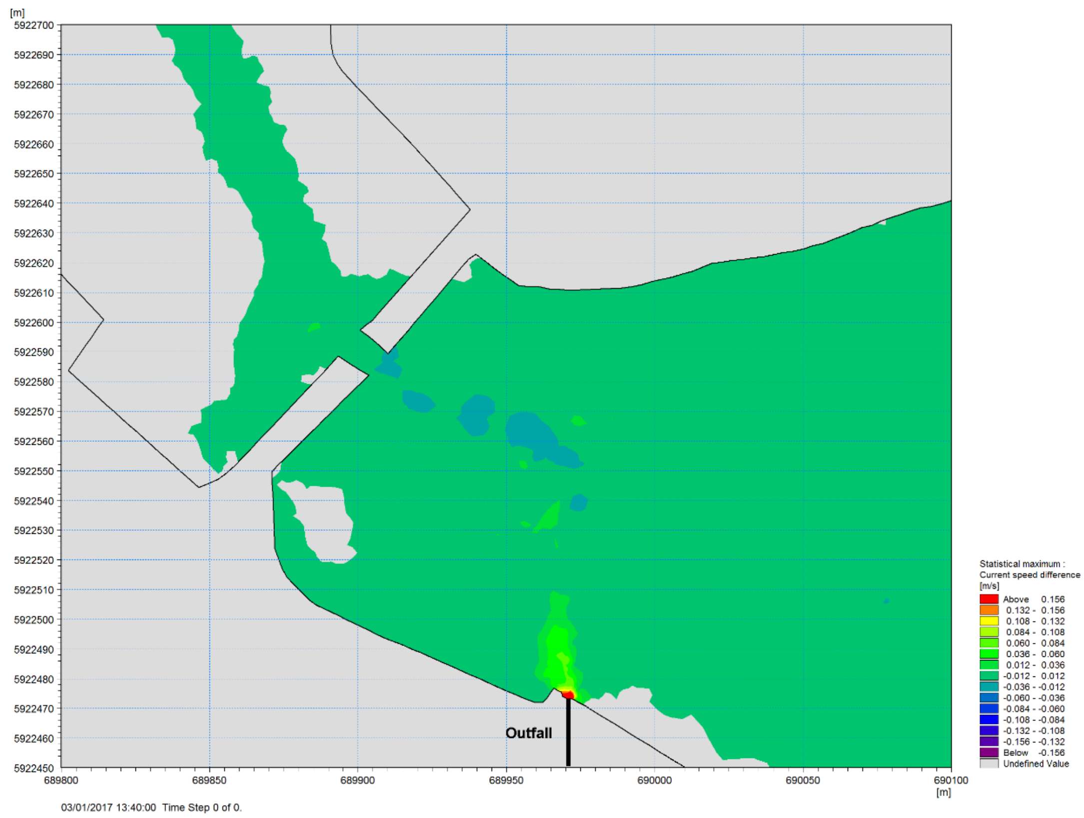


Figure 10 **Peak current speed difference (with outfall minus without outfall)**

3.1.2 1 in 100 year return period fluvial storm with average spring tide

As a check to see if a less extreme tidal regime would significantly change the peak current values around the proposed outfall area, simulations for the 100 year return period fluvial event were run with an average spring tide. The results of the simulations are shown in terms of peak current speeds for the model with the storm water overflow in place in Figure 11 and for the model without the storm water overflow in Figure 12. In order to see the difference between the current regimes in these diagrams, a difference plot (current speeds with the outfall discharge in place minus the current speeds without the outfall discharge) is also shown in Figure 13.

As with the simulation for the 1 in 2 year return period tide, it will be seen from the peak velocity figures and in particular from the difference plot, in Figure 13, that the impact of the outfall discharge is mainly confined to the area of the small channel leading from the outfall to the main river channel. Even then the velocities in this channel beyond the end of the concrete apron are generally only increased by less than 0.08 m/s due to the effect of the proposed outfall discharge. This is a very small increase in current speed.

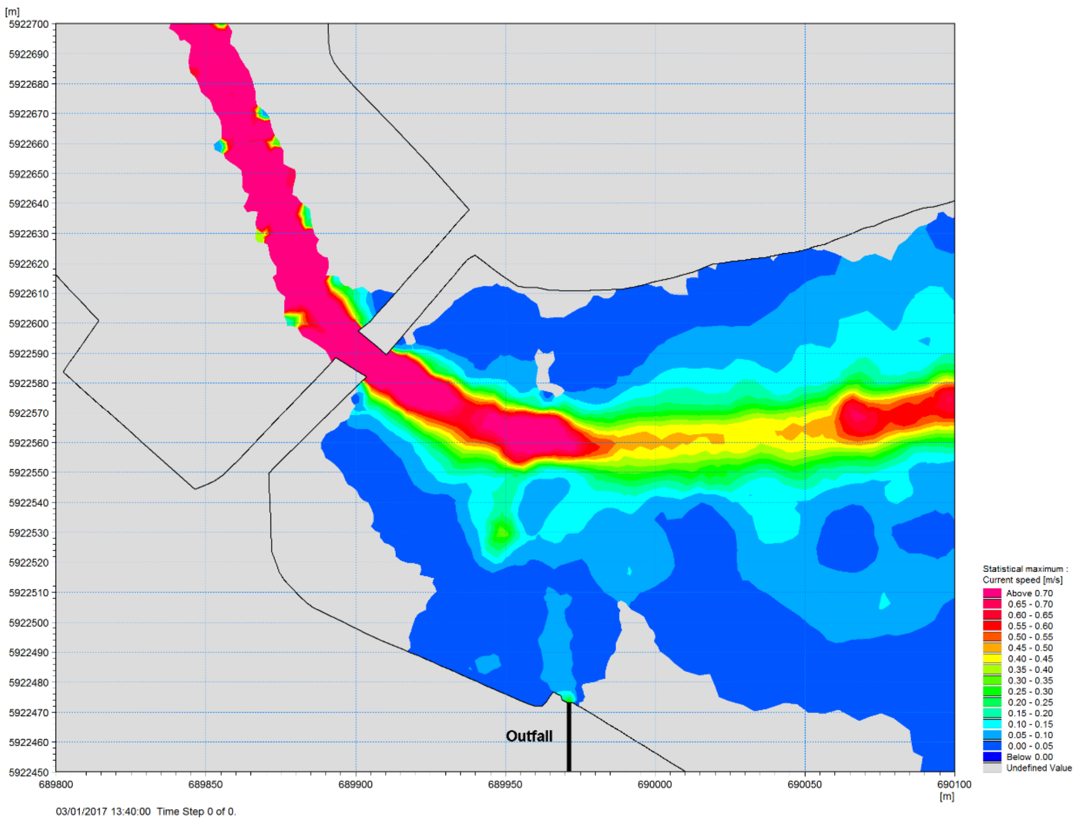


Figure 11 Peak current speed with the proposed outfall in place

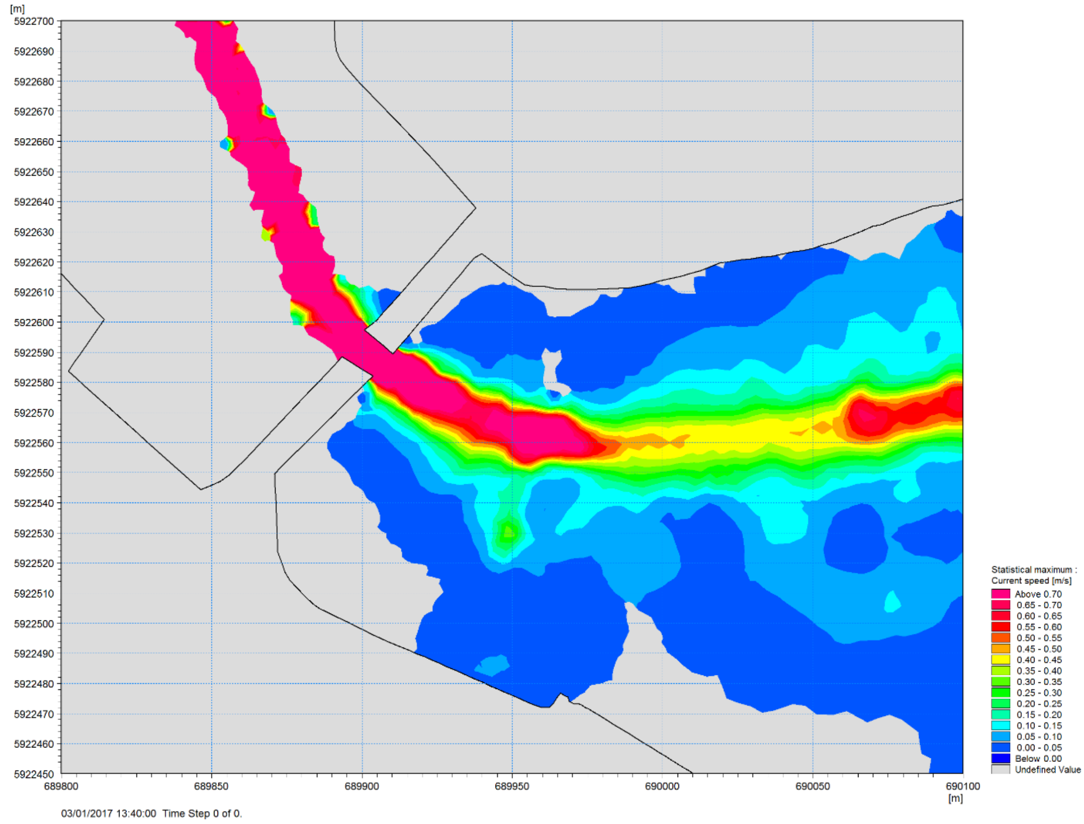


Figure 12 Peak current speed with no outfall discharge

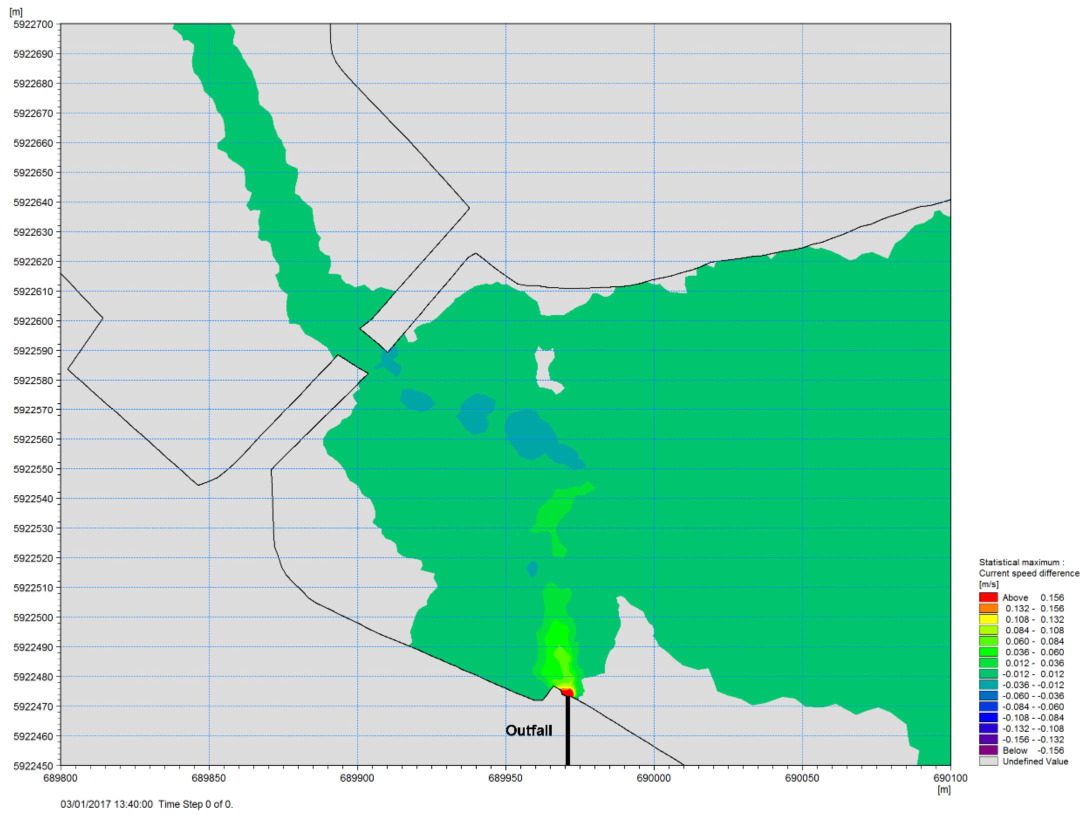


Figure 13 Peak current speed difference (with outfall minus without outfall)

3.2 Sediment Transport and Bed Erosion

3.2.1 1 in 100 year return period fluvial storm with 1 in 2 year return period tide

The sediment transport module includes the predicted bed level change in response to the flow regime. The predicted difference in the change in the bed levels over a tidal cycle (with minus without the outfall discharge in place) are shown in Figures 14, 15 and 16 for 5mm, 1mm and 0.1mm bed sediment grain size respectively.

It will be seen from these diagrams that there is no effect of the proposed outfall on the estuary bed levels as a result of 1 in 100 year return period storm water discharge during a 1 in 2 year return period tidal event. This result is not unexpected as the difference in the tidal currents resulting from the proposed outfall discharge is very small.

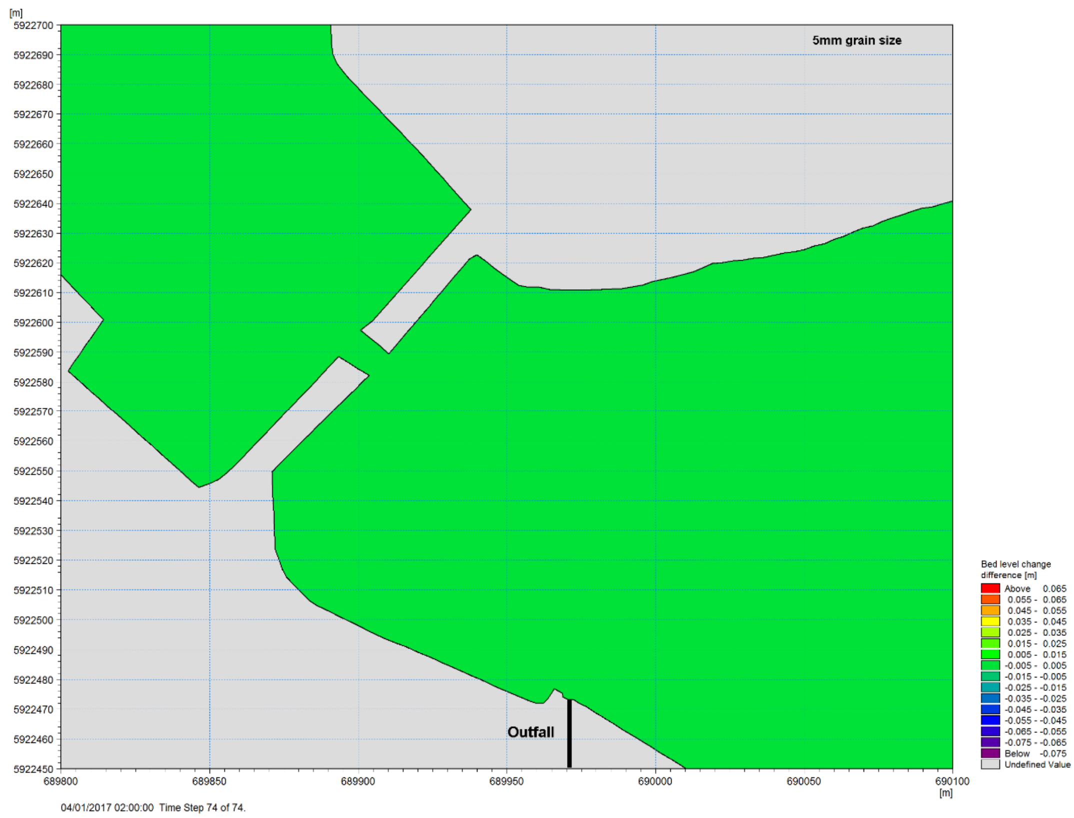


Figure 14 Bed level change difference - 5mm bed sediment grain size

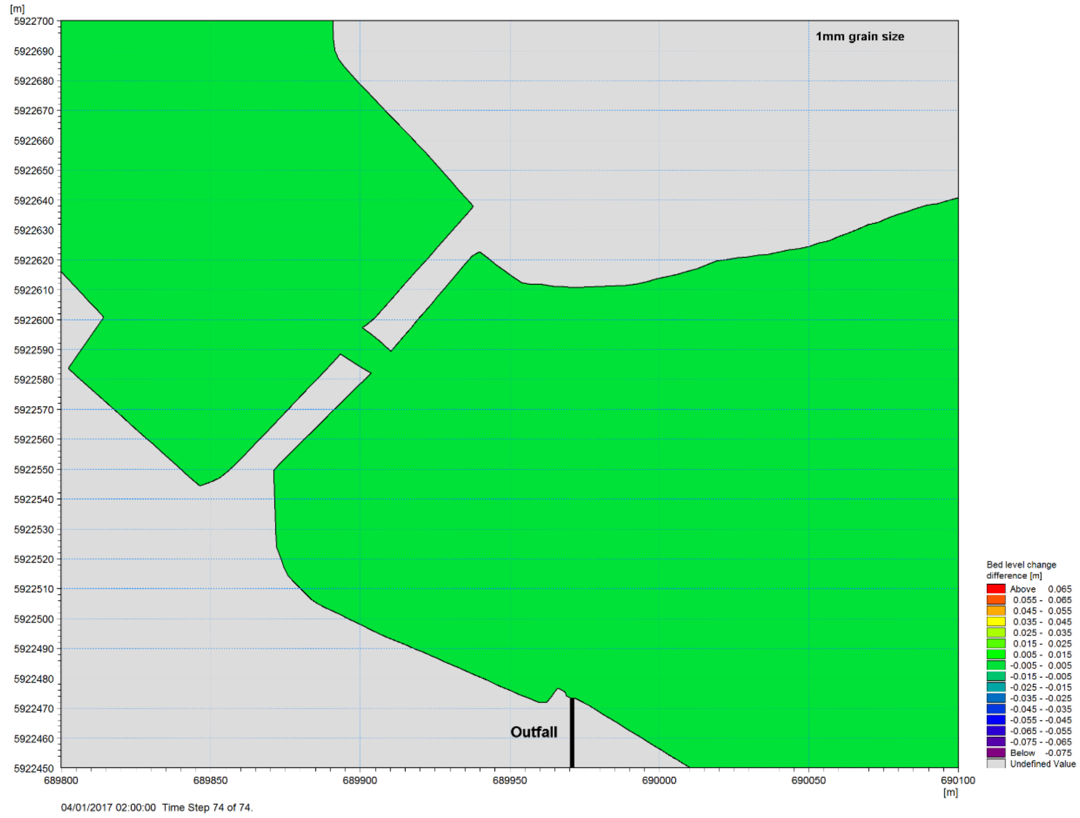


Figure 15 Bed level change difference - 1mm bed sediment grain size

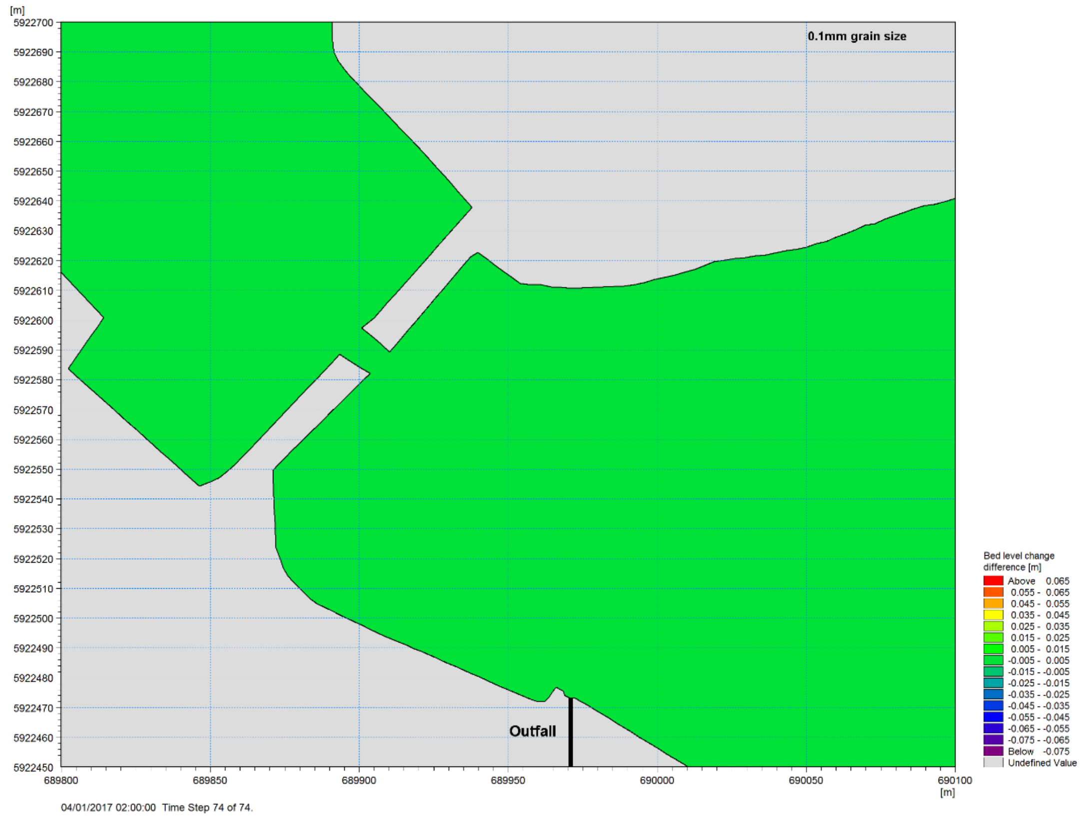


Figure 16 Bed level change difference – 0.1mm bed sediment grain size

3.2.2 1 in 100 year return period fluvial storm with average spring tide

Similarly to the 1 in100 year return period fluvial event with the 1 in 2 year return period tide, the tidal velocity differences between the estuary with and without the outfall discharge for the 1 in 100 year return period event with an average spring tide are very small. Thus it is no surprise that as shown in Figure 17, there is no difference in the change bed levels for the estuary with or without the proposed storm water outfall discharge. Figure 17 shows the bed level change difference for the simulation using 1mm bed sediment grain size. Similar effects were found with both the 5mm and the 0.1mm grain sized bed sediments.

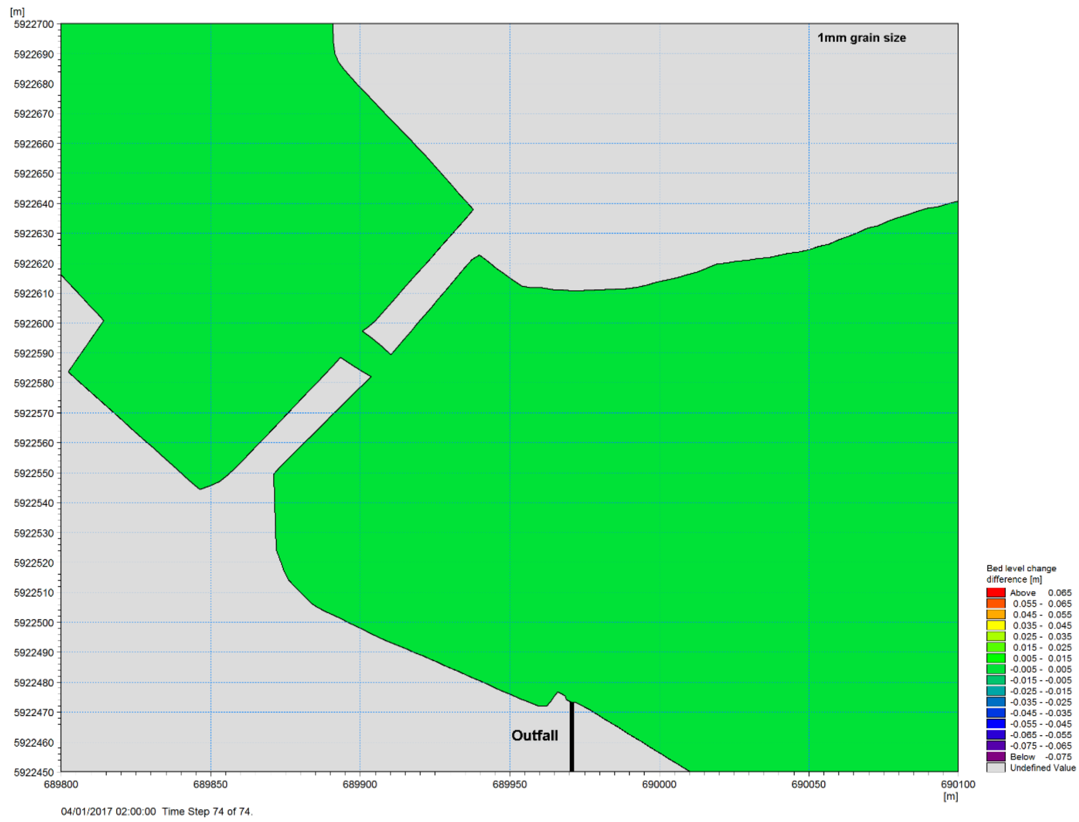


Figure 17 Bed level change difference - 1mm bed sediment grain size

4.0 CONCLUSIONS

The computational model studies have shown that any increase in the flow velocities due to the proposed storm water outfall discharge are restricted to the channel leading from the proposed outfall to the River Sluice channel. The increase in the flow velocities away from the immediate area of the outfall structure itself will be less than 0.08 m/s even during a 1 in 100 year return period storm event. Thus the proposed storm water outfall will have no significant impact on the overall flow regime of the Baldoyle Estuary.

Modelling of the changes in the sediment transport regime resulting from the operation of the proposed storm water outfall indicate that there will be no significant bed erosion in the estuary channels as a result of storm water discharge for return periods of up to and including 1 in 100 years. Thus the proposed storm water outfall is not expected to have any significant impact on the overall sediment transport regime of the estuary.

The results of the study which confirm that there will not be a significant impact on the hydraulic or sedimentation regime of the estuary from the proposed storm water discharge is consistent with the fact that the storm river flows in the Baldoyle Estuary are more than 30 times larger than the proposed storm water outfall discharge.