TRUSKY EAST HOUSING DEVELOPMENT

Assimilative Capacity Modelling Study

September 2020

MSN Hydro

Hydro-Environmental Engineering Consultants

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Disclaimer

Model results in this report are based on the inherent assumptions and formulations under which the models have been developed. Any decisions made based on these results must be informed by an understanding of the model assumptions and formulations.

MSN_HYDRO Ltd. is a registered company with offices in Galway, Ireland.

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1. Introduction

Burkeway Homes Ltd. is in the process of preparing an application to An Bord Pleanála (ABP) for permission in respect of a strategic housing scheme [SHD] on lands located in the townlands of Trusky East, Trusky West, Freeport and Ahaglugger, Bearna, Co. Galway.

The subject lands are located to the north of Bearna, approximately 7 km west of Galway City. The entire site drains to the Trusky East Stream. At the downstream end of the subject site, the Trusky East Stream has a catchment of 1.79km^2.

In the context of preparing the Appropriate Assessment Screening Report [AASR] and Environmental Impact Assessment Report [EIAR] in respect of the proposed development, it was considered that an Assimilative Capacity study of Galway Bay should be carried out, and that results from the study should be submitted with AASR and EIAR which will accompany the planning application.

Burkeway Homes Ltd. commissioned MSN_HYDRO to undertake the Assimilative Capacity Study. The purpose of this study is to determine the capacity of Galway Bay to assimilate a pollutant discharge from the Trusky East Stream that drains the proposed SHD lands.

2. Methodology

MSN_HYDRO staff have considerable experience in modelling many bay and estuaries around Ireland. As part of this study, an existing model of Galway Bay has been used to undertake an assessment of the capacity of Galway Bay to assimilate flood runoff and associated potential pollutant loads.

The computational model which has been used in this study is the DIVAST model; this model has ben used on over 100 water quality studies around the world. An existing hydrodynamic model of Galway Bay has been adapted for the prediction of water quality in Galway Bay after a potential discharge from the proposed SHD into the Trusky East Stream. A module has been integrated within the existing model that will enable the concentration of potential pollutants be predicted throughout Galway Bay in a scenario where pollutant loads from an extreme event enter Galway Bay from the Trusky East Stream.

The extent of the existing detailed Galway Bay model is shown in Figure 1. Figure 1 also shows the bathymetry contours used to develop the computational model.

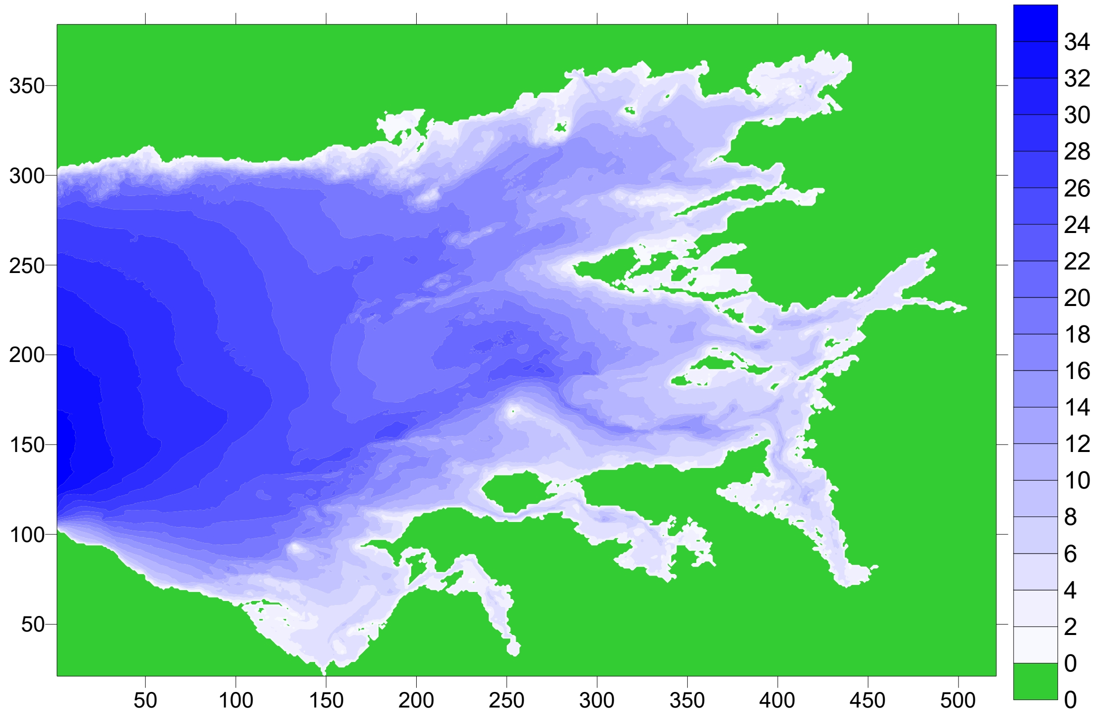


Figure 1: Contour map showing model extents and depths relative to high tide.

The Galway Bay model is composed of 2 modules:

- Hydrodynamic module (HM) – based on the 2D Navier-Stokes equations
- Pollutants transport module (PTM) – based on the advection diffusion equation

The hydrodynamic module is used to calculate water circulation patters (currents) throughout Galway Bay, based on tidal dynamics and River Corrib flows. Using these currents, the pollutant transport module calculates the transport of pollutants around the bay based on a scenario where pollutant loads from an extreme event are introduced into Galway Bay from the site, through the Trusky East Stream from the SHD site, see Figure 2. The Galway Bay model is highly resolved both spatially and temporally. The model resolves all parameters on a 100m x 100m grid throughout the bay at every 40 seconds. The model contains 176 grid points north-south and 290 grid points east-west, giving a total of 51,040 computational cells in the model.

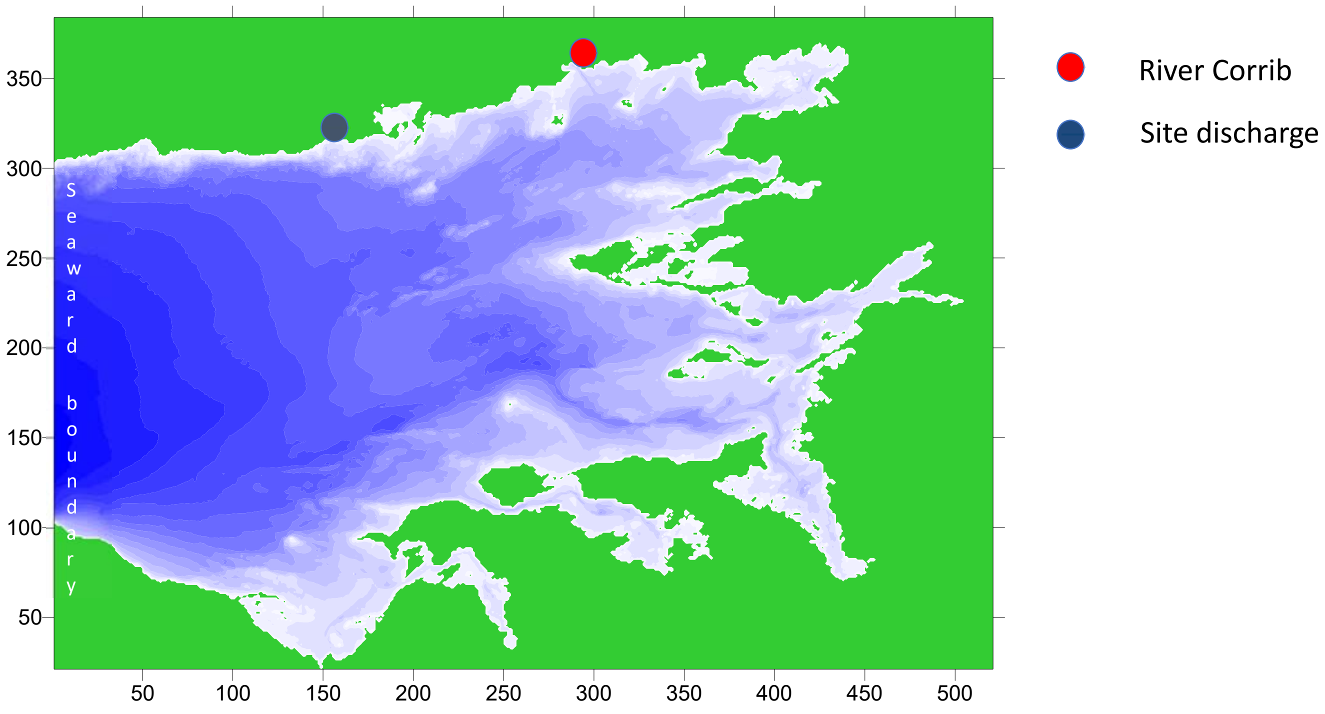


Figure 2: Galway Bay location map

The following tasks were completed as part of this study:

- Galway Bay hydrodynamic model developed based on:
    - River Corrib annual flows of 104.8m^3/s - this flow is based on OPW data
    - Tidal dynamics specified at the seaward model boundary. The tidal dynamics varied between neap tidal amplitude of 1m to spring tidal amplitude of 2.2m
- The hydrodynamic module was run and a comparison was made between model output and current measurements taken in the middle of Galway Bay to assess model performance.
- The Trusky East Stream enters Galway Bay at Bearna Pier. This location was specified to the model.

Adopting a precautionary approach, a pollutant discharge scenario was devised for the highly unlikely event of a diesel spill into the Trusky East Stream. In this scenario, a potential pollution event has been modelled, in the absence of any mitigation measures, involving 300l of diesel, containing 250mg/l of active pollutant, is accidentally spilled and enters the stream during an extreme flood event. The peak of a large flow event will bring the pollutant load to Galway Bay in the shortest time and hence in a highly concentrated mass; this is a conservative approach to specifying the pollutant load.

- During the flood event the stream flow hydrograph shown in Figure 3 was used.

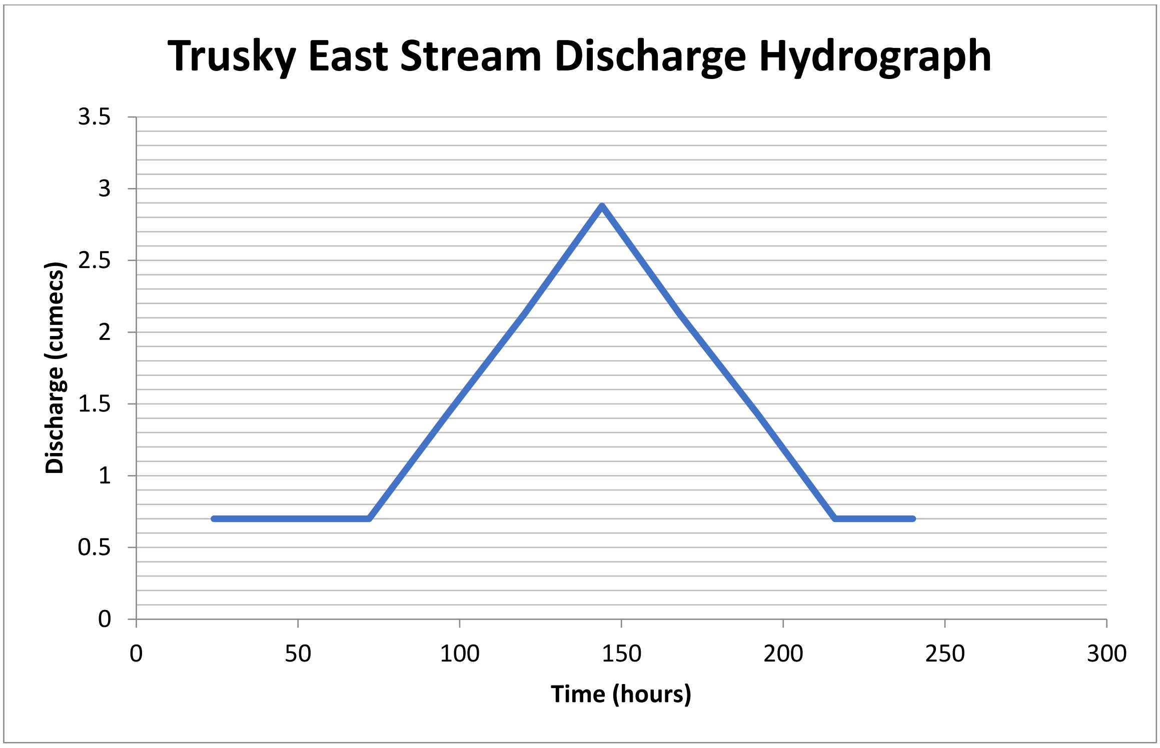


Figure 3: Discharge hydrograph

The above hydrograph presents river discharge, Q(m^3/s), as a function of time. The baseflow of the stream is 0.7m^3/s. It is considered that the diesel spill occurs during a flood event with a 0.1% AEP (Annual Exceedence Probability). This flood event is considered to rise linearly from the baseflow to a peak of 2.88m^3/s over a 72-hour period, and to recede to baseflow over a further 72-hour period. For this study is was assumed that the spill occurred over a short duration of an hour around the peak of the discharge hydrograph. The peak of a large flow event will bring the pollutant load to Galway Bay in the shortest time and hence in a highly concentrated mass; this is a conservative approach to specifying the pollutant load.

It has been conservatively assumed that the pollutant is not diluted along the stream as it travels from the site to the confluence with Galway Bay.

These pollutant and hydraulic loads were specified to the model and the model was run for 2 full 14-day spring-neap tidal cycles.

- Model outputs are presented in four graphical forms:
    - time series graphs at 6 locations throughout Galway Bay illustrating how the pollutant concentration changes with time at each location
    - time series graphs at 6 locations throughout Galway Bay illustrating how the dilution values changes with time at each location
    - synoptic charts of pollutant contours throughout Galway Bay for 6 times during the model simulations
    - synoptic charts of dilution contours throughout Galway Bay for 6 times during the model simulations

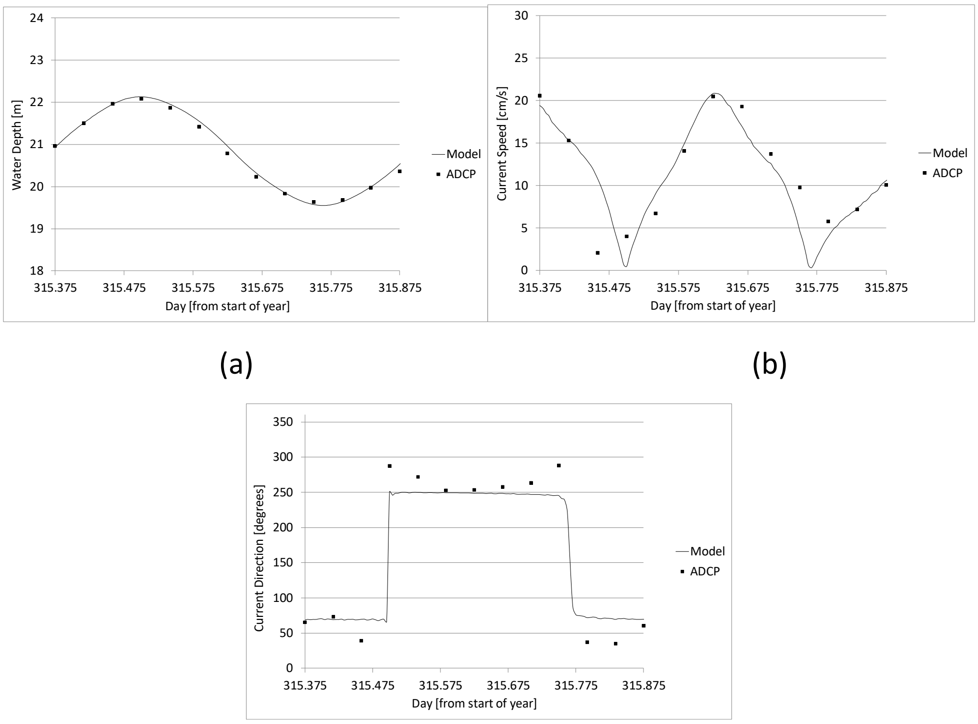
- Results are then analysed and assimilative capacity is assessed.

3. Results

Comparison between model calculated hydrodynamics and data

Prior to using the model for detailed salinity scenario modelling, the performance of the hydrodynamic was assessed.

The hydrodynamic model was compared against measured velocities collected by an Acoustic Doppler Current Profiler (ADCP). The ADCP recorded water levels, magnitudes of water velocities (m/s) and direction of water velocities. Data was recorded in the centre of Inner Galway Bay during November 2013. The ADCP, being located in the middle of Galway Bay, provided a very good indicator of how the overall Galway/Kinvara Bay hydrodynamic model is working. The hydrodynamic model was run for the period of ADCP data collection. Figure 4 presents comparisons between ADCP data and calibrated model results for water level, magnitudes of water velocities (m/s) and direction of water velocities.



(a) (b)

(c)

Figure 4: Comparison of model (a) water levels; (b) current speeds and (c) current directions between model results and ADCP data for period 09:43–21:43 on 11/11/2013

Results of concentrations and dilution factors

Once the hydrodynamic model was shown to be well-behaved, the model was then set to perform the diesel spill transport scenario as detailed in Section 2 above. The model was set to begin at low spring tide, this represents the most conservative tidal phase as the volume of the bay is at it lowest and, therefore, so is dilution. Further, by beginning the simulation at low spring tide the next flood tide will transport the pollutant towards Inner Galway Bay SPA and Galway Bay Complex cSAC with high velocity currents. Plots of water circulation patterns in Galway Bay are presented in the Appendix. Figure A1 shows circulation patterns throughout Galway Bay; Figures 2-5 show circulation patterns local to the discharge point at 4 stages of the tide.

Time series have been included at 10 analysis points in Galway Bay; these 10 points include the three specific points that are the nearest points of three European Sites as shown in Figure 5 - locations marked by green stars. In addition, Figure 6 shows the modelled area in relation to other European Sites that are located further west in Galway Bay.

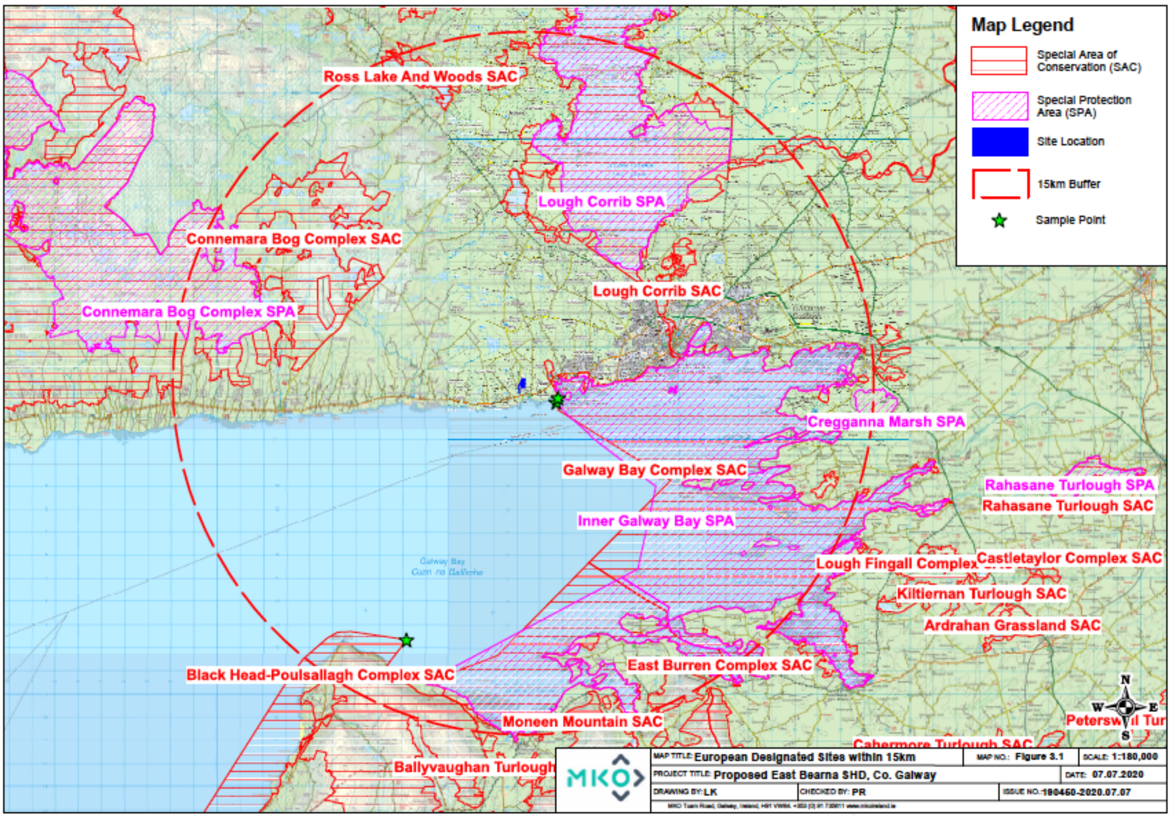


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Figure 5: Locations of analysis points and designated sites within 15km

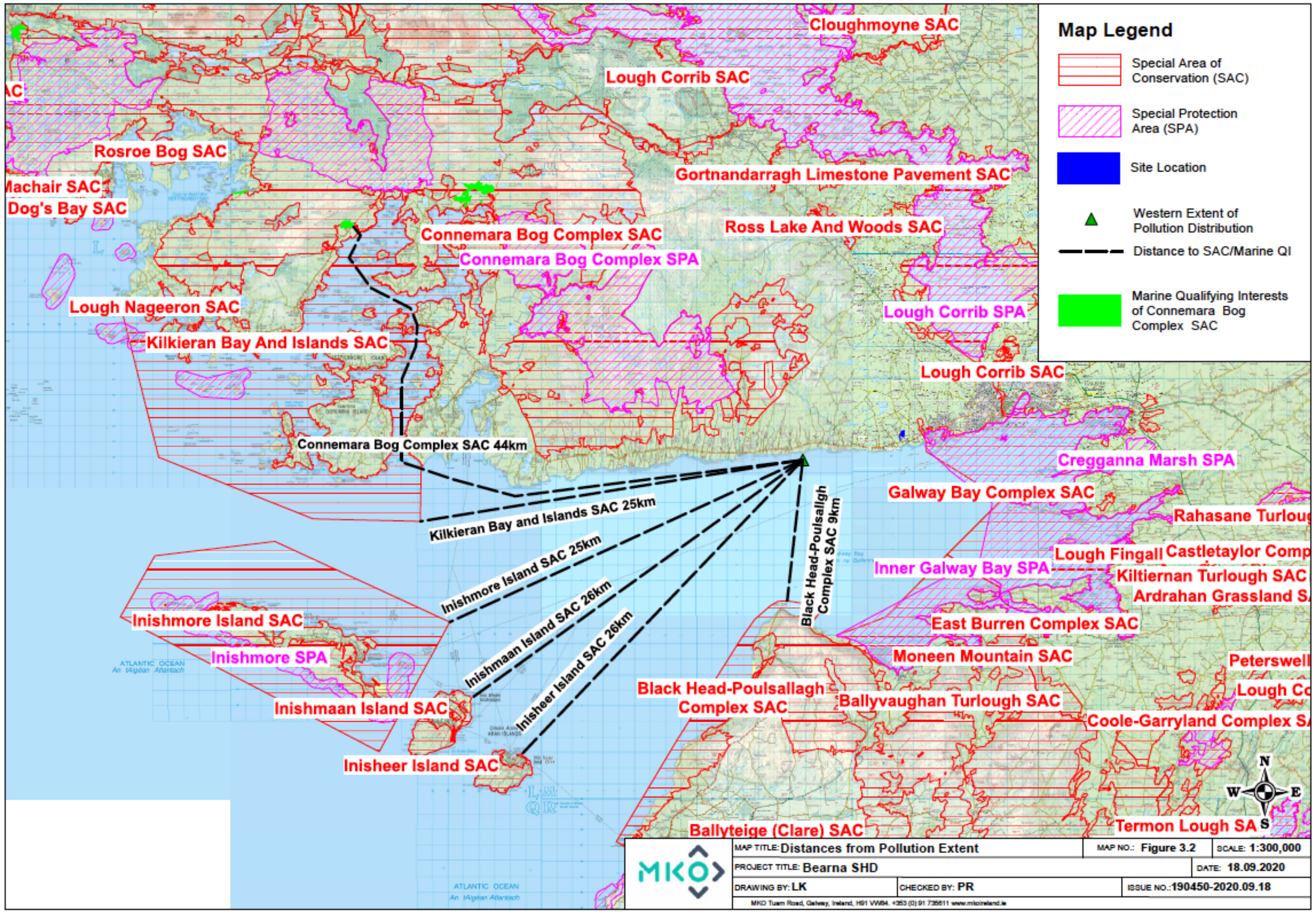

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Figure 6: Modelled area in relation to other European Sites located further west

The 3 locations shown in Figure 5 above are:

1. Inner Galway Bay SPA (E124675 N 222655) (approx. 1.4km east of Trusky Stream mouth)
2. Galway Bay Complex cSAC (E124755 N222784) (approx. 1.5km east of Trusky Stream mouth)
3. Black Head-Poulsallagh Complex cSAC (E118193 N212362) (approx. 11.5km south west of Trusky Stream mouth)

In addition to the above, Figure 6 shows a fourth point at the location where the pollutant was reduced to trace levels in terms of both concentration and dilution (as described below). This shows the context of the potential pollutant dispersal in relation to European Sites that are located to the west within Galway Bay.

In order to provide further information on the transport of the diesel spillage throughout Galway Bay additional analysis points were included. All points are shown in Figure 7.

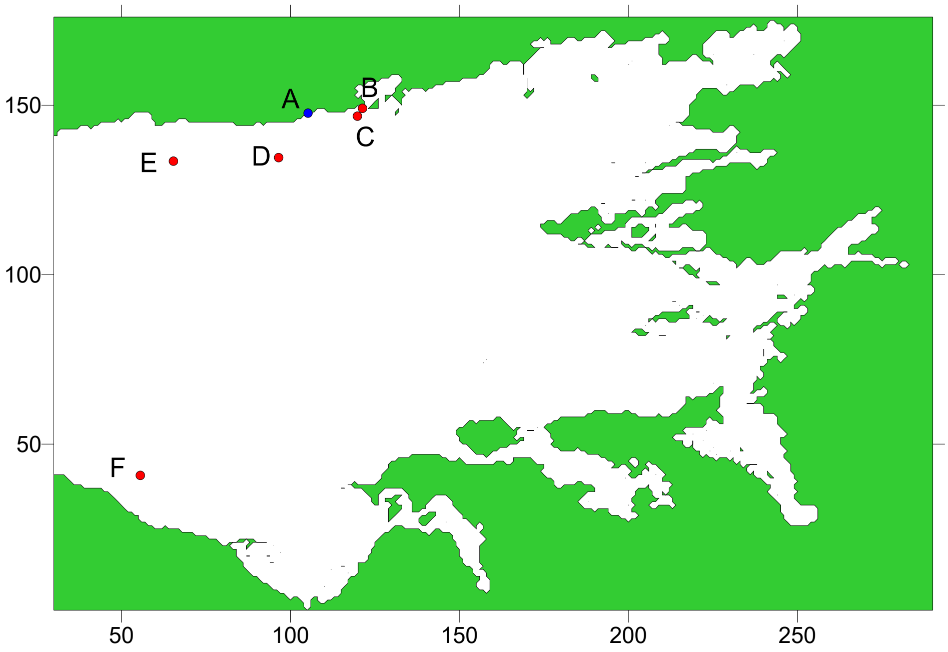


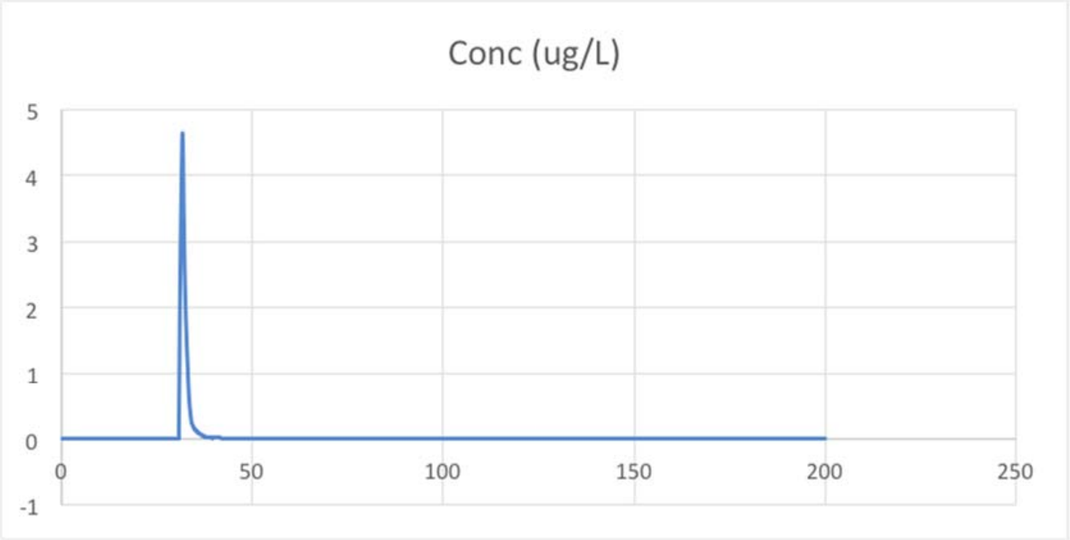
Figure 7: Location of all model output points

The most significant points in Figure 7 are:

- Point A - the point where the discharge enters Galway Bay.
- Point B - Inner Galway Bay SPA (E124675 N 222655)
- Point C - Galway Bay Complex cSAC (E124755 N222784)
- Point F - Black Head-Poulsallagh Complex cSAC (E118193 N212362)

Points D and E have been included to illustrate the levels of pollutants within the discharge plume.

In the Figures 8-12 below, time series of both pollutant concentrations (μg/l) and dilutions as a function of time (hours) are presented for each analysis point where a pollutant concentration is detected. No pollutant was detected at analysis point ‘F’, so no results are presented for this point.



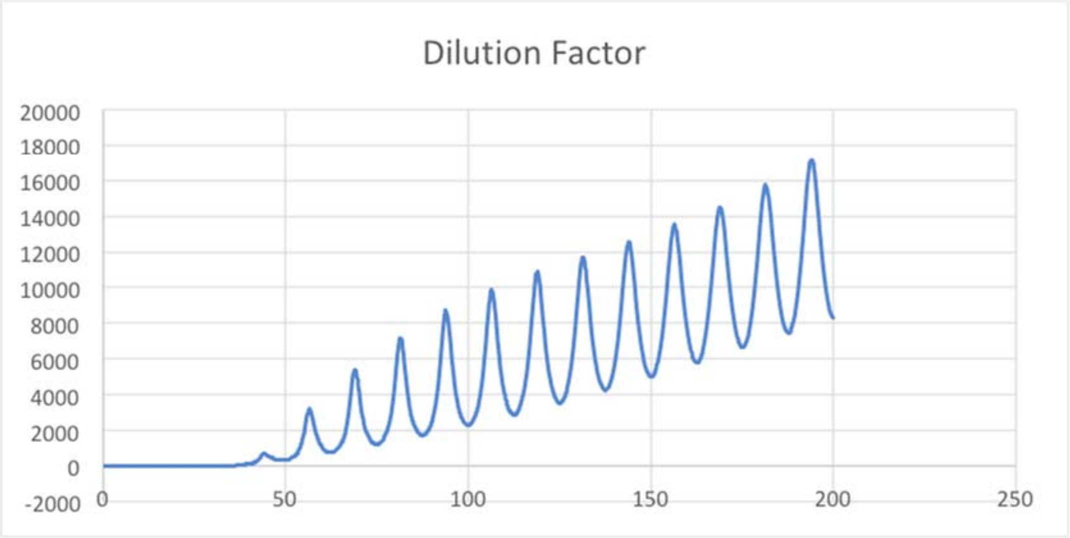


Figure 8: Concentration and Dilution at 'A'

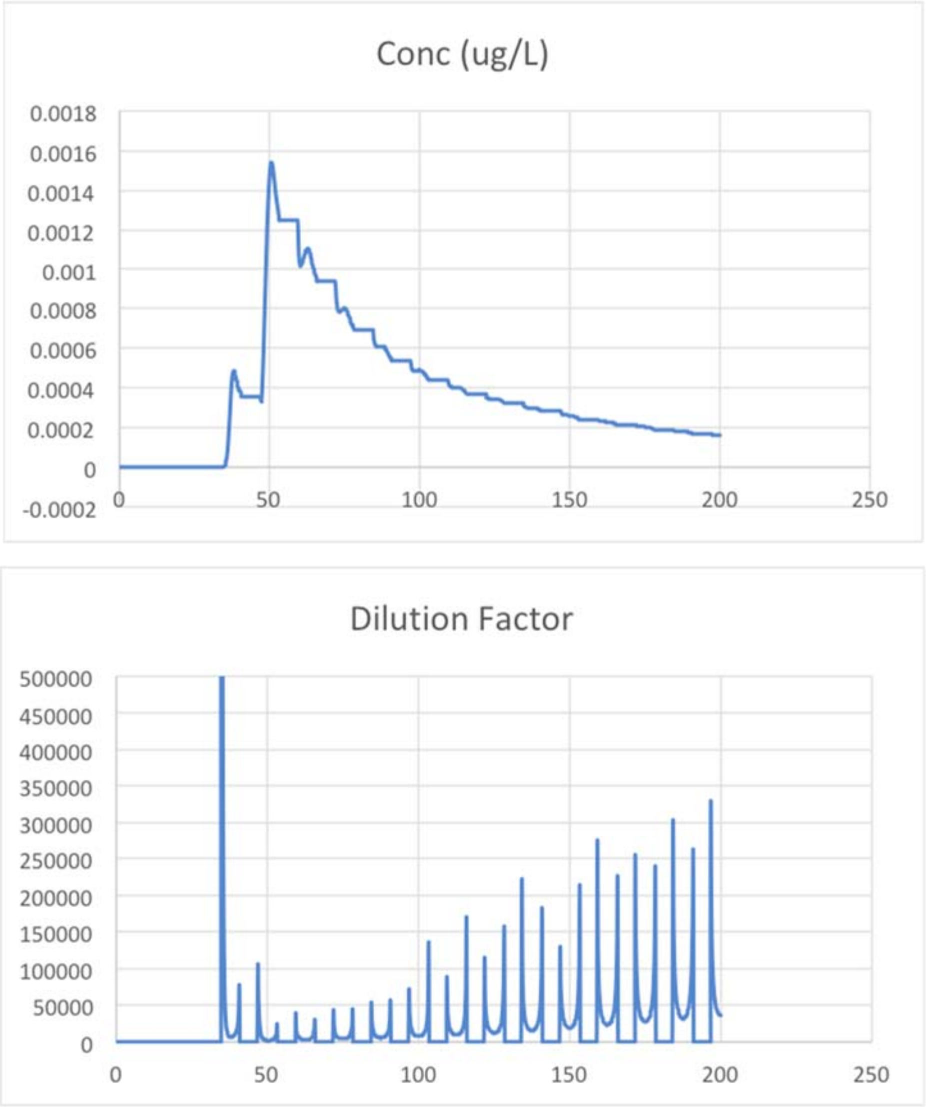


Figure 9: Concentration and Dilution at ‘B’

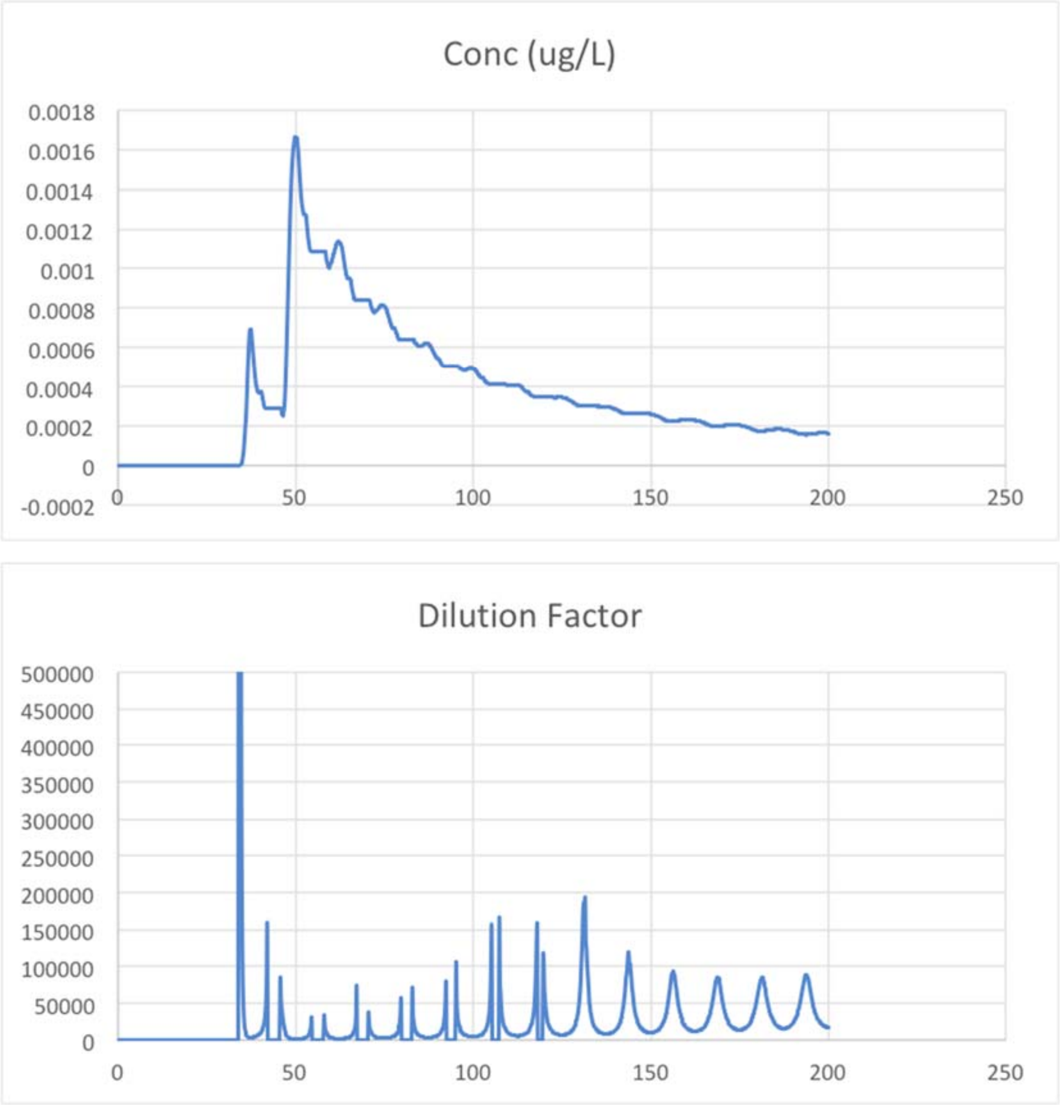


Figure 10: Concentration and Dilution 'C'

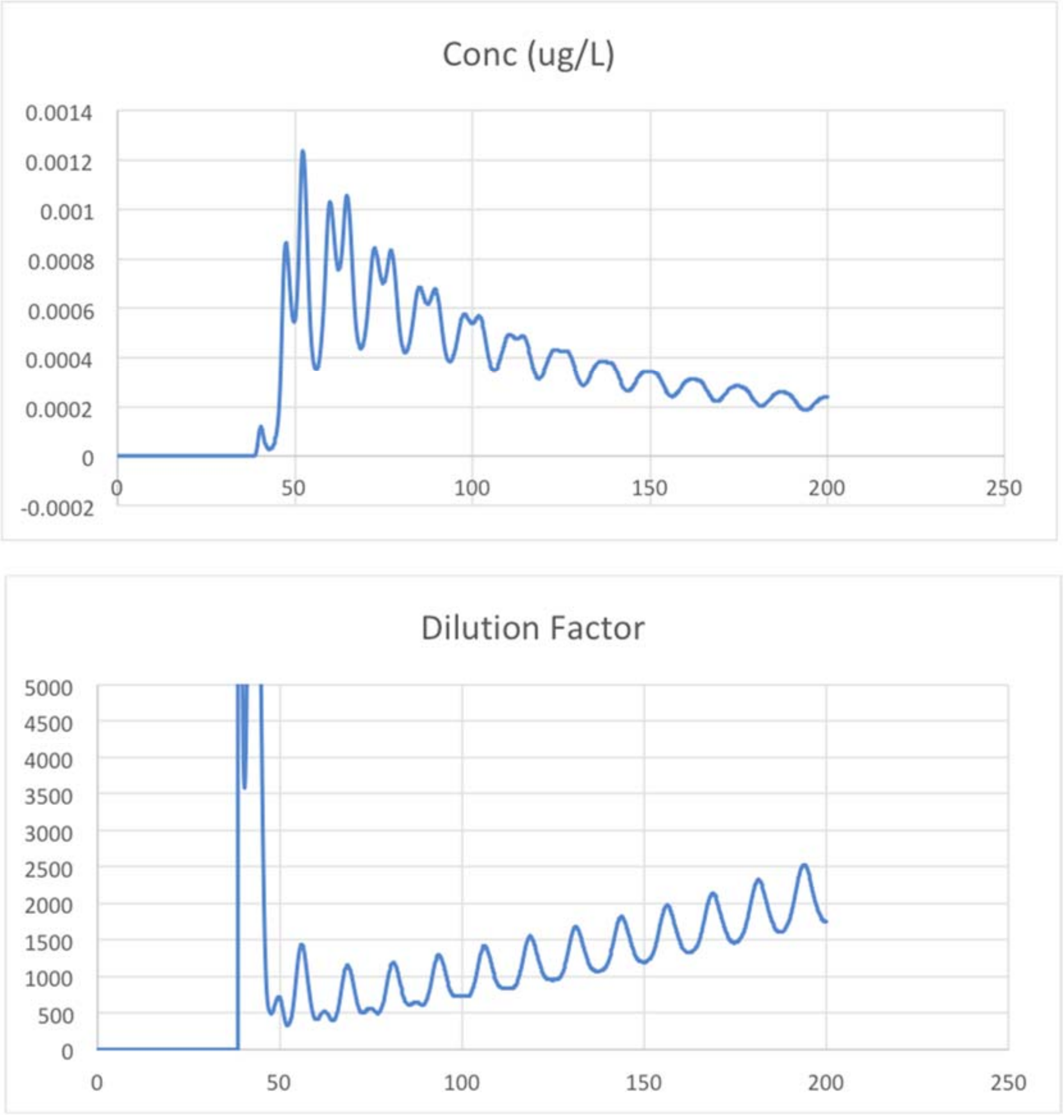


Figure 11: Concentration and Dilution ‘D’

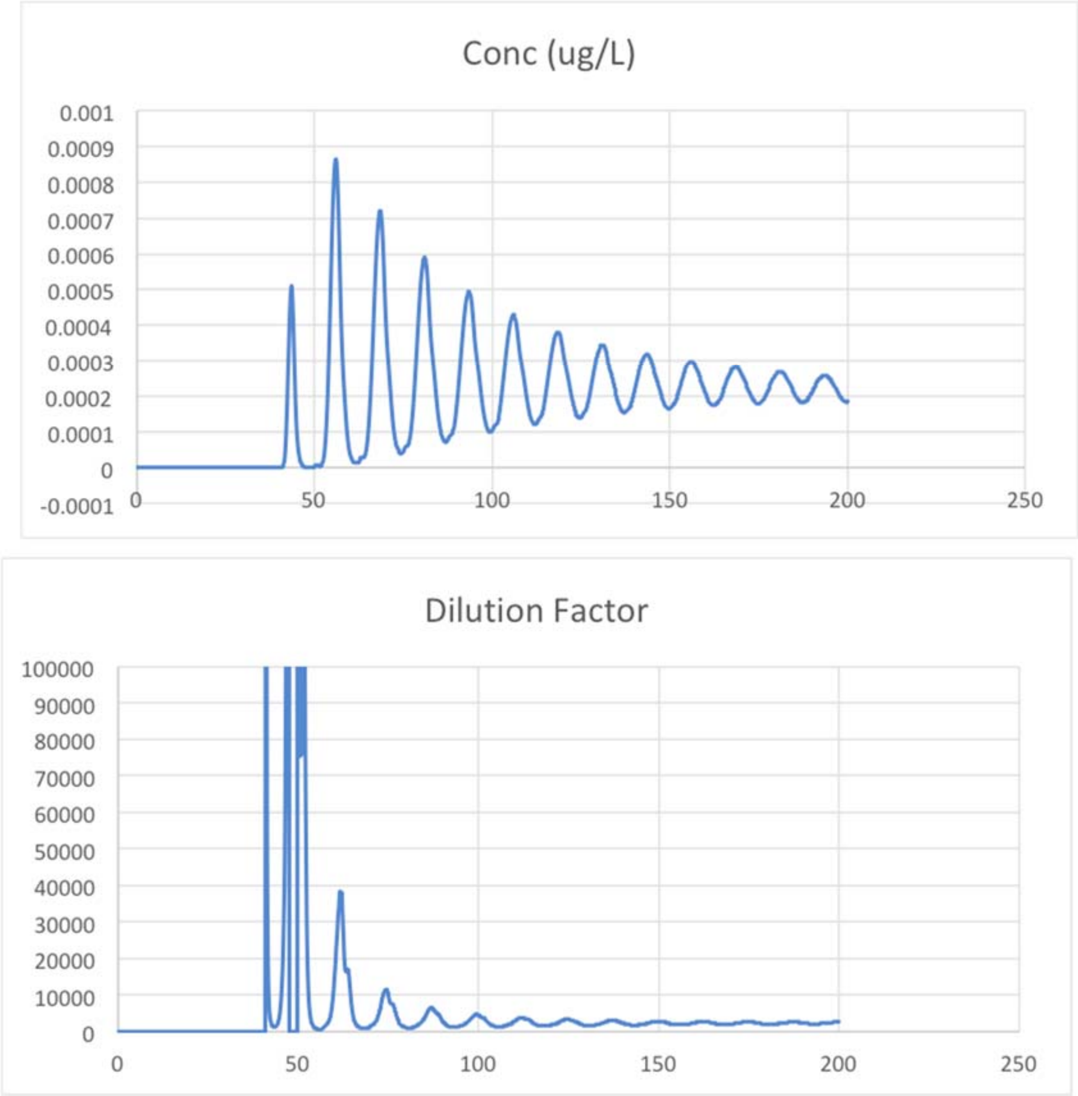


Figure 12: Concentration and Dilution ‘E’

In the Figures 13-18 below synoptic maps of pollutant concentrations (μg/l) are presented for the following times after the diesel spill: 12.5 hours; 25 hours; 31.25 hours; 37.5 hours; 43.75 hours; 62.5 hours.

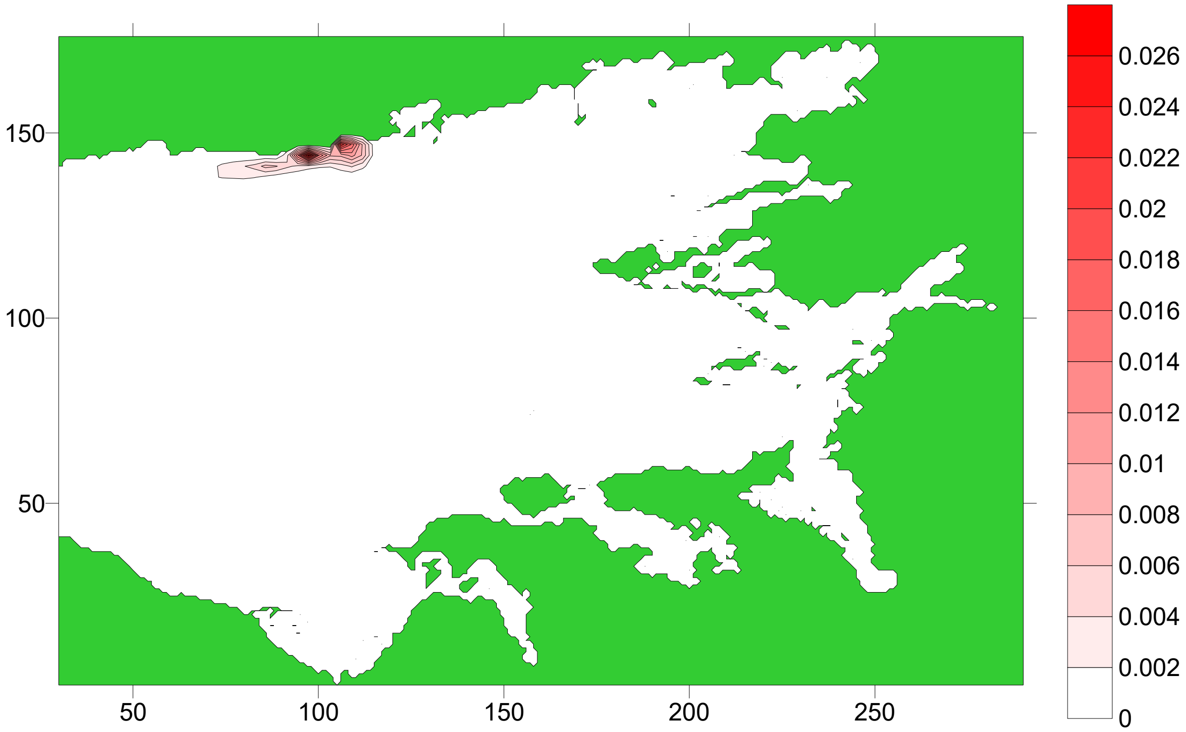


Figure 13: Concentration map 12.5 hours after spill – low tide

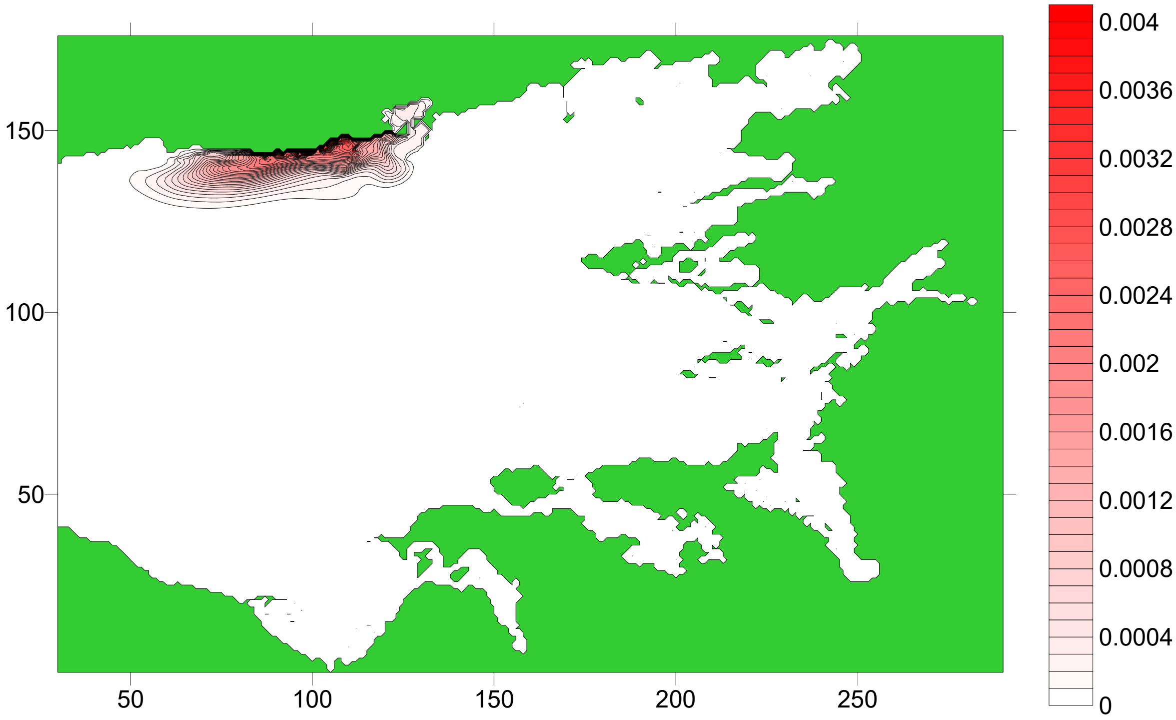


Figure 14: Concentration map 25 hours after spill – low tide

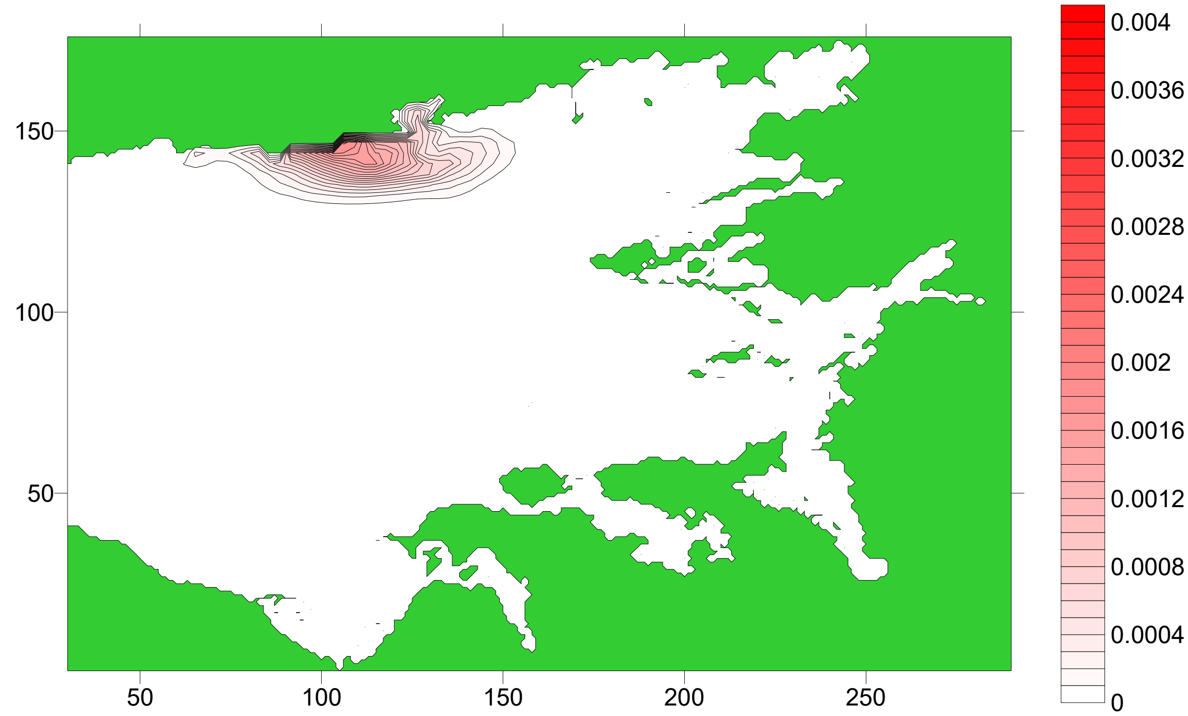


Figure 15: Concentration map 31.25 hours after spill – high tide

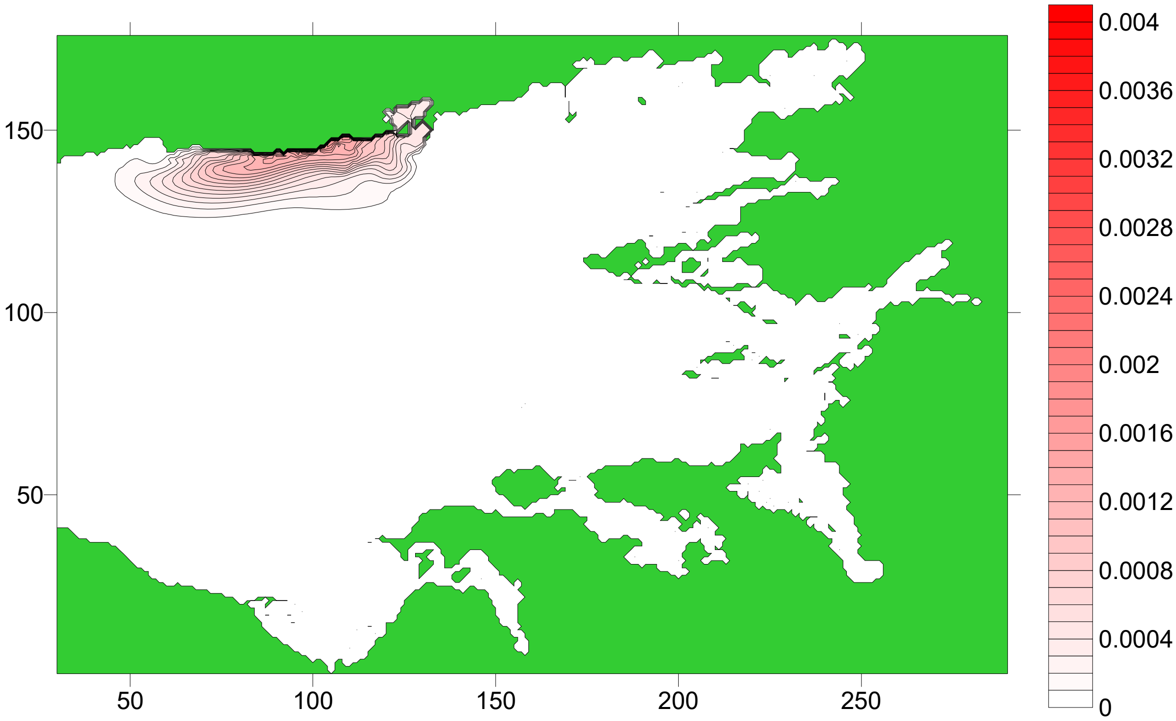


Figure 16: Concentration map 37.5 hours after spill – low tide

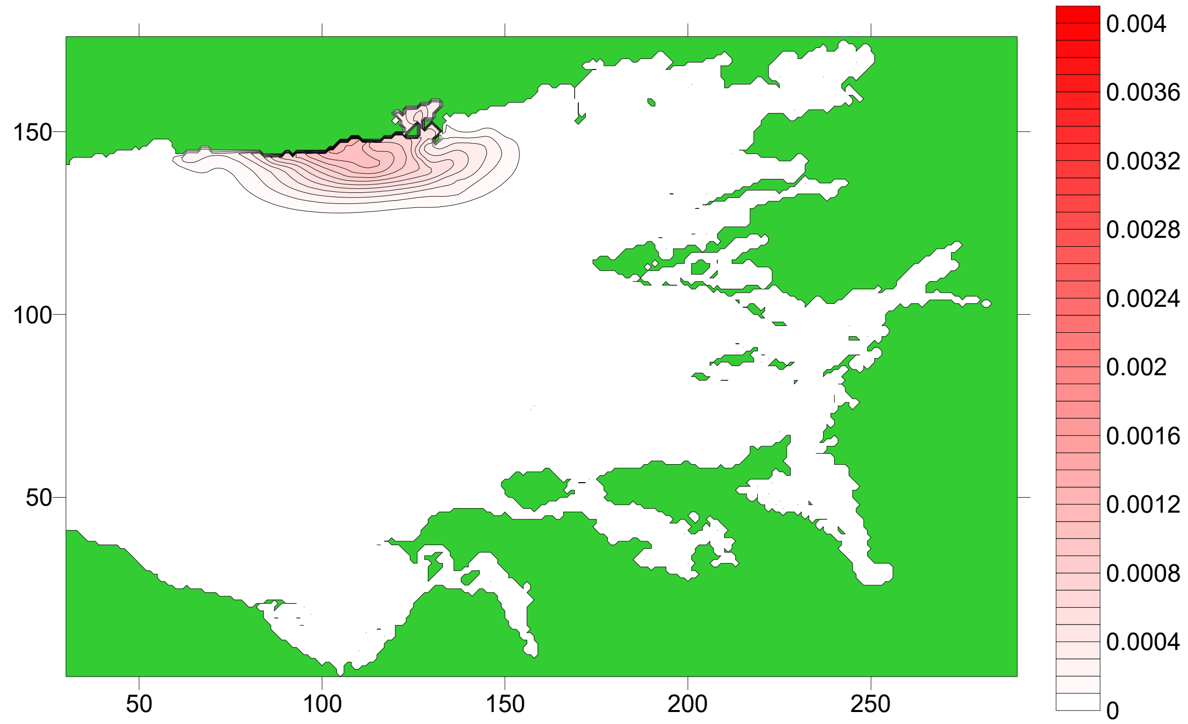


Figure 17: Concentration map 43.75 hours after spill – high tide

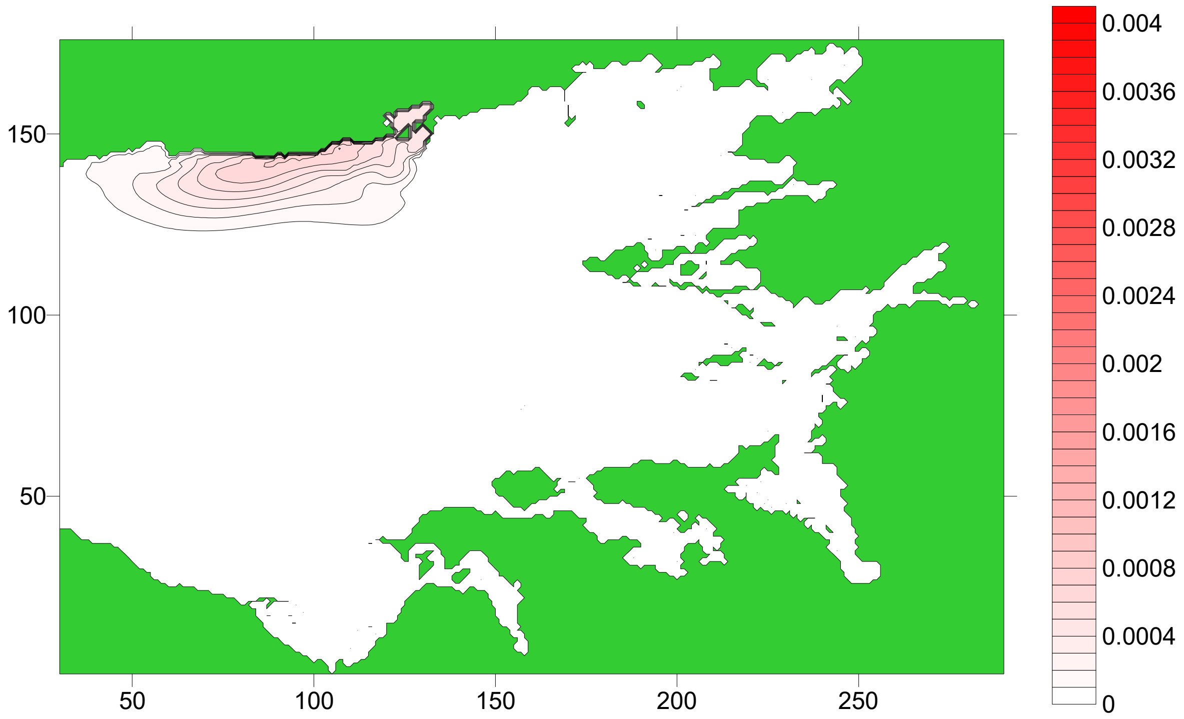


Figure 18: Concentration map 62.5 hours after spill – low tide

In the Figures 19-24 below synoptic maps of dilution factors are presented for 6 times during the diesel spill scenario.

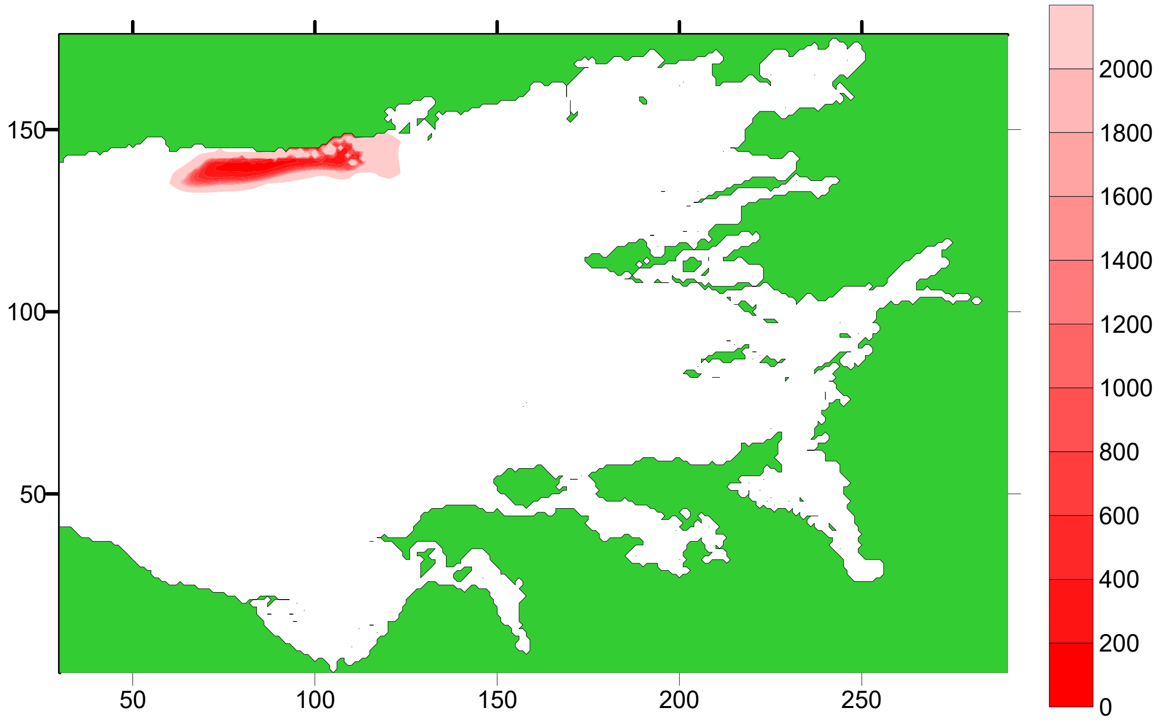


Figure 19: Dilutions map 12.5 hours after spill – low tide

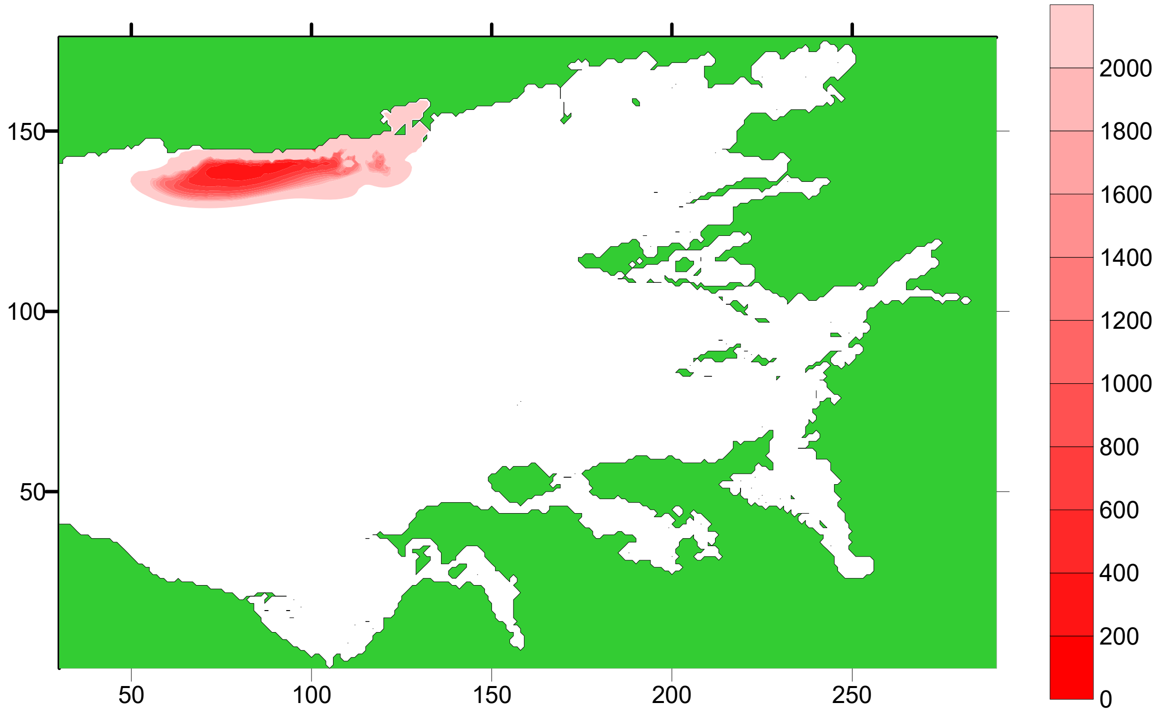


Figure 20: Dilutions map 25 hours after spill – low tide

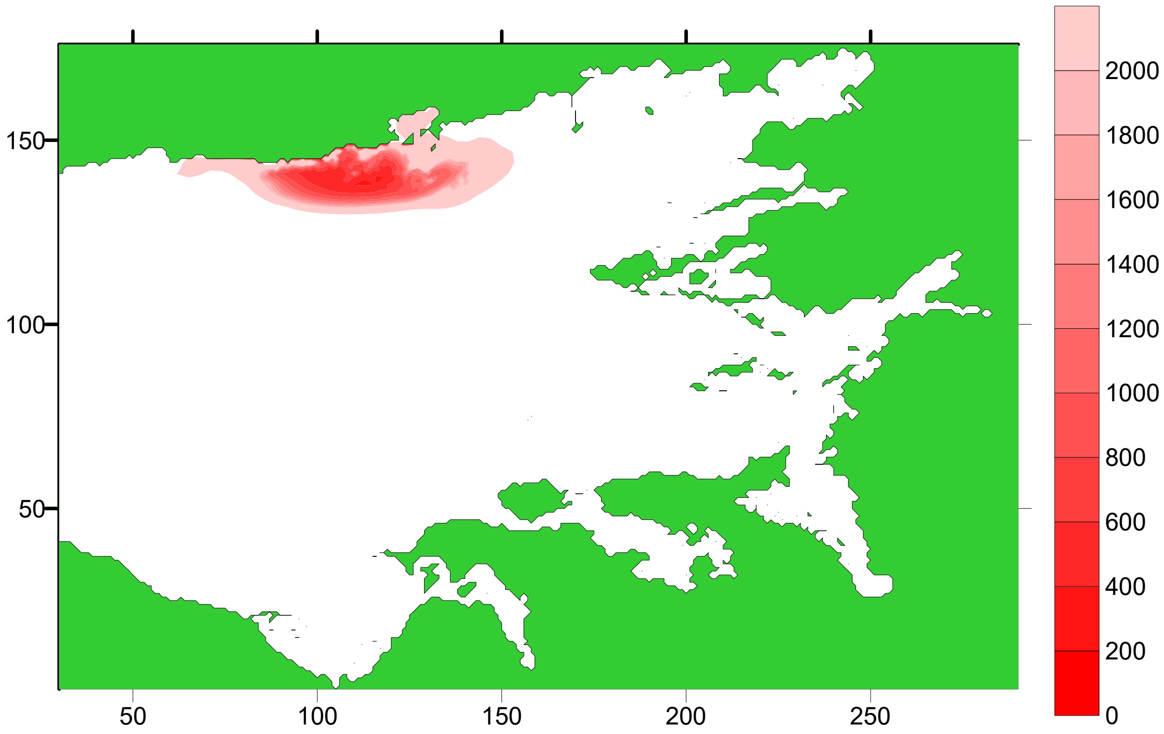


Figure 21: Dilutions map 31.25 hours after spill – high tide

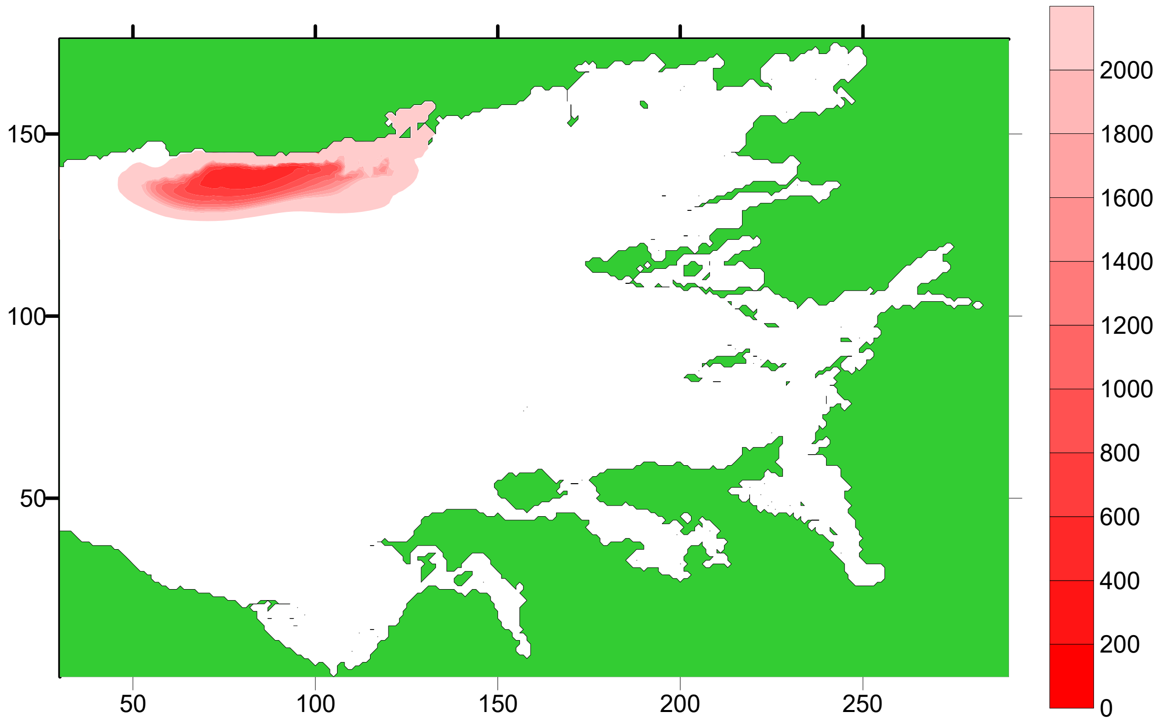


Figure 22: Dilutions map 37.5 hours after spill – low tide

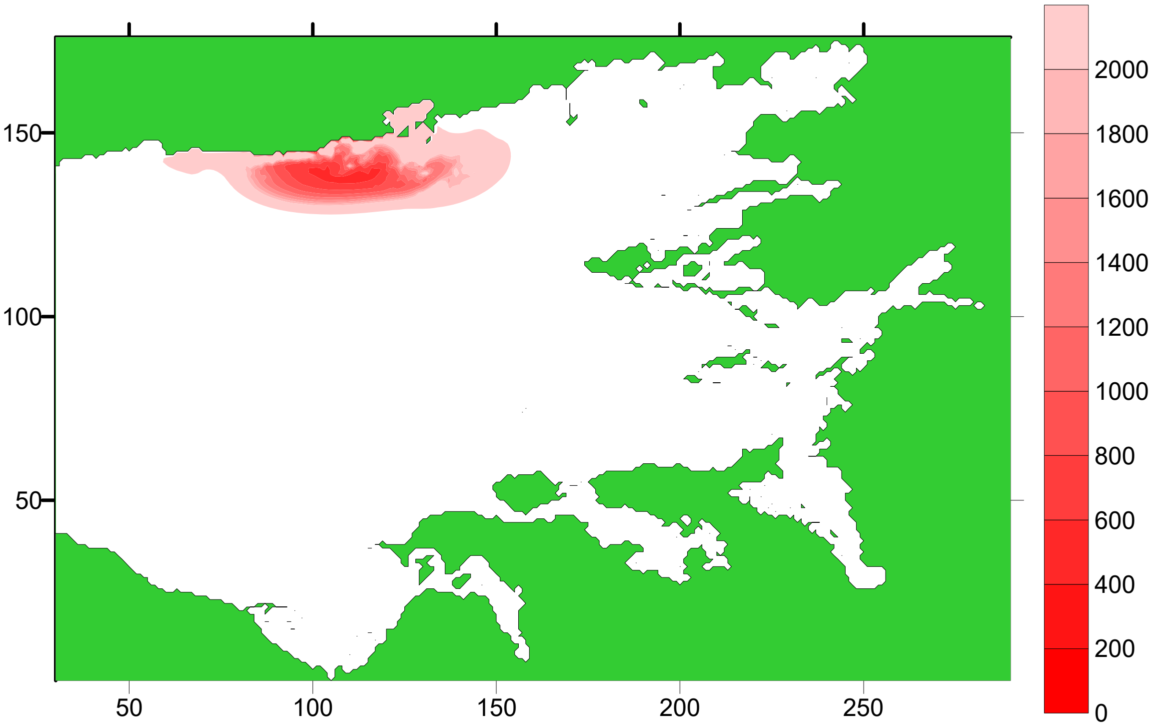


Figure 23: Dilutions map 43.75 hours after spill – high tide

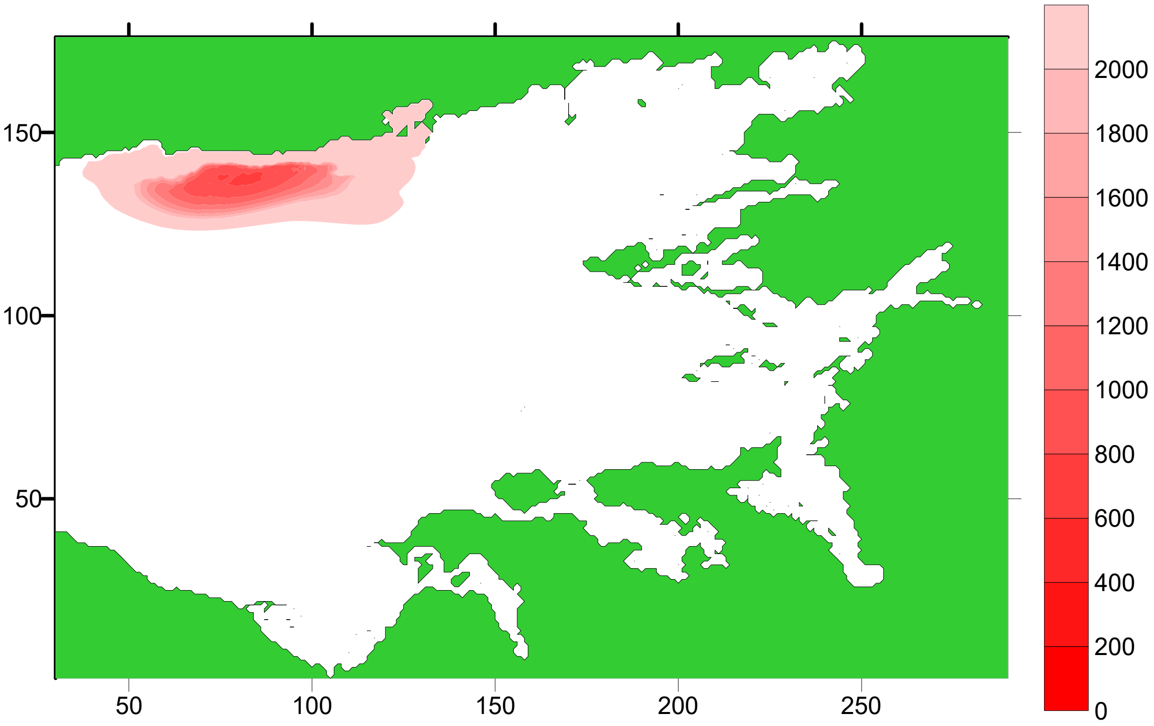


Figure 24: Dilutions map 62.5 hours after spill – low tide

4. Summary and Conclusions:

This study undertook a detailed analysis of a potential pollution event, namely, the transport of diesel spilled into Trusky East Stream and thence to Galway Bay, without any consideration of mitigation measures. The scenario considered was a spill of 300l of diesel, containing 250mg/l of active pollutant, into the stream during a 0.1% AEP flood event.

A hydrodynamic model of Galway Bay was run for 200 hours to simulate water circulation patterns on a 100m x 100m rectangular grid every 40 seconds. The reason the simulation duration was 200 hours is because after 200 hours concentrations of diesel in Galway Bay waters dropped off to very low levels. The model contains 176 grid points north-south and 290 grid points east-west, giving a total of 51,040 computational cells in the model. A pollutant transport model then used these hydrodynamics to transport the pollutant about Galway Bay; this model calculated pollutant concentrations and dilution factors at each grid point every 40 seconds.

In particular, this study focused on analysing concentrations and dilution factors at 3 points:

1. Inner Galway Bay SPA (E124675 N 222655) - Point B
2. Galway Bay Complex cSAC (E124755 N222784) - Point C
3. Black Head-Poulsallagh Complex cSAC - Point D

In addition, a point was plotted to show where the concentration and dilution of the pollutant are reduced to trace levels to the west of the entry point into the bay. Figure 6 above, shows the spill in the context of the European Sites that are located further west in Galway Bay.

The model results are shown in Section 3, and water circulation patterns presented in the Appendix. The time series plots, Figure 8-12, show how concentrations and dilutions vary at each analysis point based on the transport of pollutant and on the stage of the tide. From these figures we see that the values oscillate with a regular frequency; these oscillations are tidally induced. During high tides lower concentrations and higher dilutions are observed due to the larger volume of water in the bay; we observe the converse at low tides. Over time concentrations die off, or remain very low, and dilutions increase.

Figures 13-18 present synoptic maps of concentration contours throughout Galway Bay. These figures show:

- The pollutant plume tends to spread out along the northern side of Galway Bay and is not transported widely throughout the domain
- Either no pollutant or very low levels of pollutant are observed in large parts of Galway Bay
- Concentrations reduce rapidly with distance from the discharge location
- Concentrations reduce rapidly with time

Figures 19-24 present synoptic maps of dilution contours throughout Galway Bay. These figures show similar features to the concentration contour figures. Dilutions increase with time and distance form the discharge point.

The main conclusions from this analysis are:

- The highest concentration calculated is at point A, the outfall site. At this point the peak concentration is 5μg/l once the diesel has mixed within the grid cell where it enters Galway Bay. This is a low value, and after this peak the concentrations fall off rapidly. The dilution factor just after the time of peak concentration is around 2000; dilution rapidly increases to around 17,000 over time.
- At point B peak concentration was approximately 0.0016 μg/l, with dilution factors soon after of 15,000. The dilution factors vary with tidal volume and transport of the pollutant plume.

- At point C results are very similar to results at point B, peak concentration was approximately 0.0016 μg/l, with dilution factors soon after of 15,000. The dilution factors vary with tidal volume and transport of the pollutant plume.
- At point D the model results indicate that the pollutant does not get transported to this location.
- All other points show concentrations less than at points A, B and C.
- Based on the above analysis it appears that Galway Bay has adequate capacity to assimilate the diesel spillage specified above.

APPENDIX

GALWAY BAY WATER CIRCULATION PATTERNS

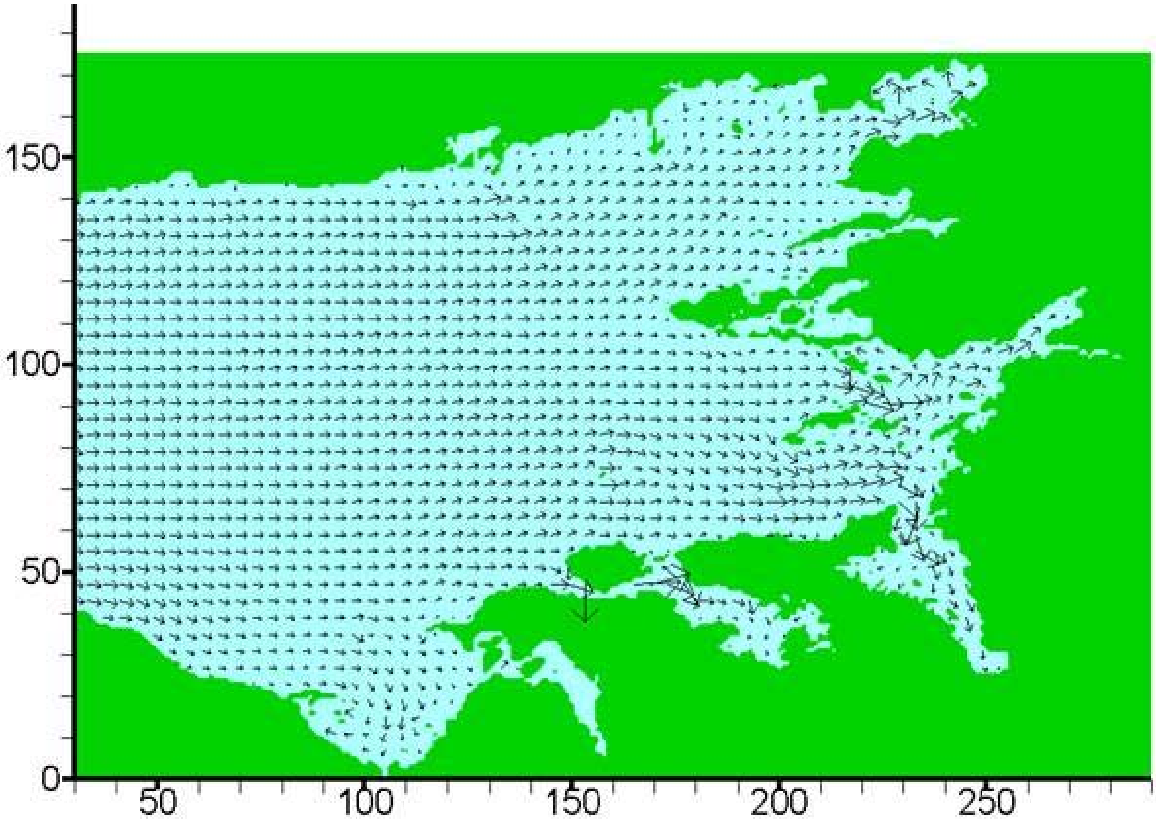


Figure A1: Large scale synoptic circulation map – mid flood tide

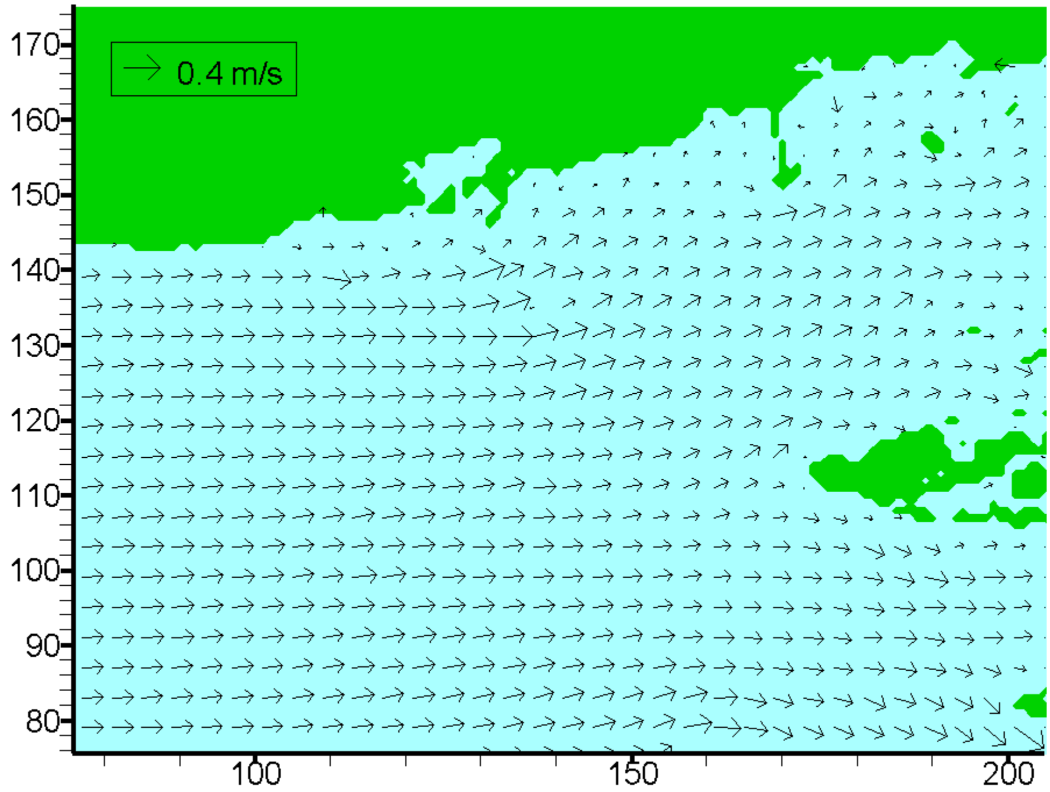


Figure A2: Local scale synoptic circulation map – spring tide, mid flood

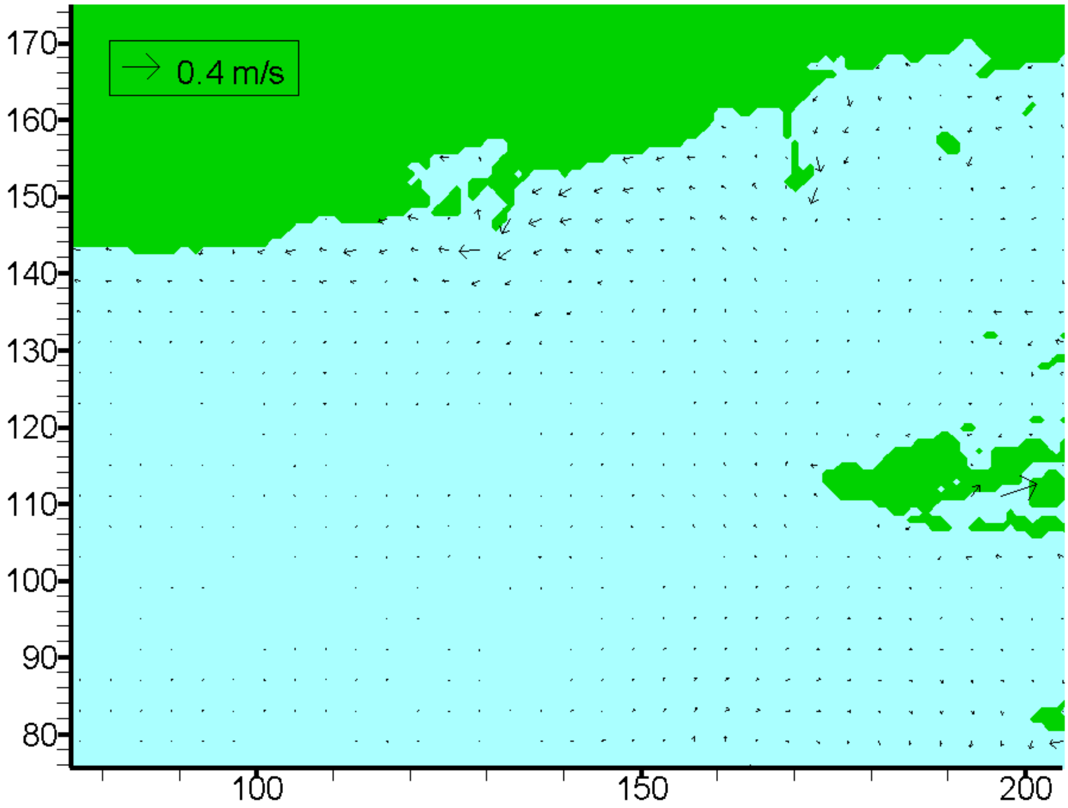


Figure A3: Local scale synoptic circulation map – spring tide, high water

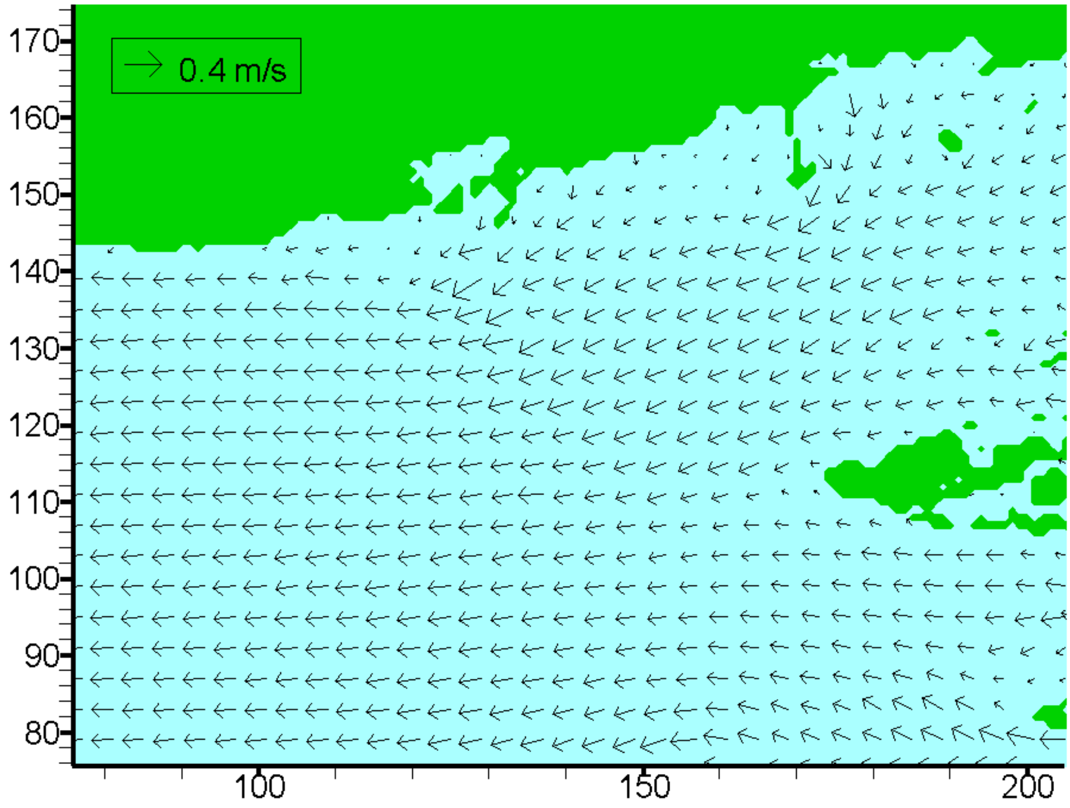


Figure A4: Local scale synoptic circulation map – spring tide, mid ebb

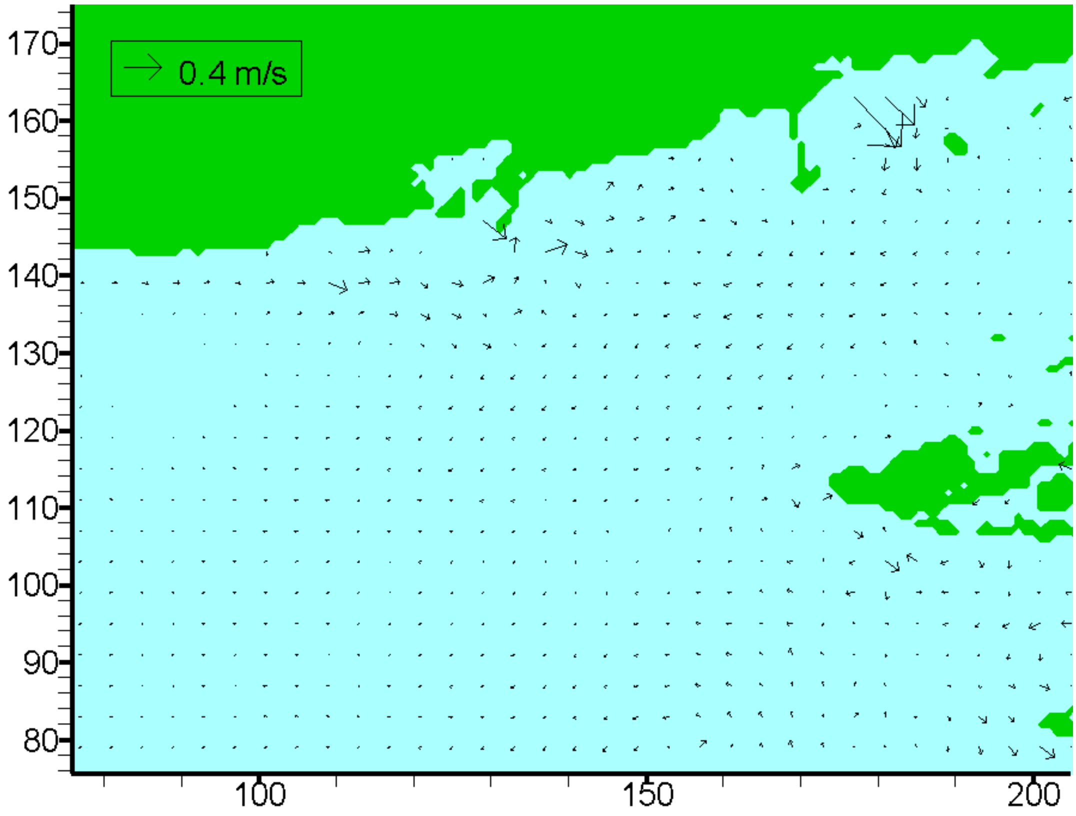


Figure A5: Local scale synoptic circulation map – spring tide, low water