# Greater Dublin Drainage Project

Irish Water

## Environmental Impact Assessment Report: Volume 3 Part A of 6

## Chapter 8 Marine Water Quality

June 2018

## Contents

# 8. Marine Water Quality

**This Chapter assesses the impact of the Proposed Project on the proposed outfall pipeline route (marine section) on the water quality of the receiving marine environment. The impacts of the Proposed Project were assessed against relevant national and European legislation. The assessments were undertaken using a detailed three-dimensional numerical model to predict the extent of the treated wastewater plumes from the operation of the proposed Wastewater Treatment Plant in the receiving waters, along with the transport of suspended sediments arising from the construction of the proposed outfall pipeline route (marine section).**

**The predicted impacts arising from the construction of the proposed Wastewater Treatment Plant were assessed for a simulated 60-day dredging operation involving the on-site temporary disposal of dredge spoil material on flooding tides. The suspended sediment concentrations in the upper layers of the water column were predicted to dissipate to background levels within hours. High suspended sediment concentrations near the seabed were predicted within the proposed construction corridor. The model predicted that the construction of the proposed outfall pipeline route (marine section) will have a Slight, Temporary impact for a brief duration on the receiving waters.**

**The predicted impacts arising from the operation of the proposed Wastewater Treatment Plant were assessed for the proposed daily average discharge regime of treated wastewater, peak discharge of treated wastewater, and a three-day duration discharge of untreated wastewater. The impacts were assessed with reference to existing, or baseline, conditions and accounted for the proposed future upgrade to Ringsend Wastewater Treatment Plant.**

**The model predicted that the operation of the proposed outfall pipeline route (marine section) and its associated discharge will have an Imperceptible impact on the receiving waters, on its own or in combination with all other discharges. The model predicted that the proposed outfall pipeline route (marine section) and its associated discharge will not affect any of the designated bathing water**

## 8.1 Introduction

This Chapter of the Environmental Impact Assessment Report (EIAR) contains an assessment of the impact of the proposed outfall pipeline route (marine section) which is an element of the proposed Greater Dublin Drainage Project (hereafter referred to as the Proposed Project) on the water quality of the receiving marine environment. Mitigation measures, where required, are proposed to mitigate the impact of the Proposed Project.

The Proposed Project will form a significant component of a wider strategy to meet future wastewater treatment requirements within the Greater Dublin Area as identified in a number of national, regional and local planning policy documents. The plant, equipment, buildings and systems associated with the Proposed Project will be designed, equipped, operated and maintained in such a manner to ensure a high level of energy performance and energy efficiency.

The table below includes a summary of the Proposed Project elements. A full description of the Proposed Project is detailed within Volume 2 Part A, Chapter 4 Description of the Proposed Project, of this EIAR.

| Proposed Project Element | Outline Description of Proposed Project Element |
|---|---|
| Proposed Wastewater Treatment Plant (WwTP) | • WwTP to be located on a 29.8 hectare (ha) site in the townland of Clonshagh (Clonshaugh) in Fingal.<br>• 500,000 population equivalent wastewater treatment capacity.<br>• Maximum building height of 18m.<br>• Sludge Hub Centre (SHC) to be co-located on the same site as the WwTP with a sludge handling and treatment capacity of 18,500 tonnes of dry solids per annum.<br>• SHC will provide sustainable treatment of municipal wastewater sludge and domestic septic tank sludges generated in Fingal to produce a biosolid end-product.<br>• Biogas produced during the sludge treatment process will be utilised as an energy source.<br>• Access road from the R139 Road, approximately 400m to the southern boundary of the site.<br>• Egress road, approximately 230m from the western boundary of the site, to Clonshaugh Road.<br>• A proposed temporary construction compound to be located within the site boundary. |
| Proposed Abbotstown pumping station | • Abbotstown pumping station to be located on a 0.4ha site in the grounds of the National Sports Campus at Abbotstown.<br>• Abbotstown pumping station will consist of a single 2-storey building with a ground level floor area of 305m$^2$ and maximum height of 10m and a below ground basement 17m in depth with floor area of 524m$^2$ incorporating the wet/dry wells.<br>• The plan area of the above ground structure will be 305m$^2$ and this will have a maximum height of 10m.<br>• A proposed temporary construction compound to be located adjacent to the Abbotstown pumping station site. |
| Proposed orbital sewer route | • The orbital sewer route will intercept an existing sewer at Blanchardstown and will divert it from this point to the WwTP at Clonshagh.<br>• Constructed within the boundary of a temporary construction corridor.<br>• 13.7km in length; 5.2km of a 1.4m diameter rising main and 8.5km of a 1.8m diameter gravity sewer.<br>• Manholes/service shafts/vents along the route.<br>• Odour Control Unit at the rising main/gravity sewer interface.<br>• Proposed temporary construction compounds at Abbotstown, Cappoge, east of Silloge, Dardistown and west of Collinstown Cross to be located within the proposed construction corridor. |
| Proposed North Fringe Sewer (NFS) diversion sewer | • The NFS will be intercepted in the vicinity of the junction of the access road to the WwTP with the R139 Road in lands within the administrative area of Dublin City Council.<br>• NFS diversion sewer will divert flows in the NFS upstream of the point of interception to the WwTP.<br>• 600m in length and 1.5m in diameter.<br>• Operate as a gravity sewer between the point of interception and the WwTP site. |
| Proposed outfall pipeline route (land based section) | • Outfall pipeline route (land based section) will commence from the northern boundary of the WwTP and will run to the R106 Coast Road.<br>• 5.4km in length and 1.8m in diameter.<br>• Pressurised gravity sewer.<br>• Manholes/service shafts/vents along the route.<br>• Proposed temporary construction compounds (east of R107 Malahide Road and east of Saintdoolaghs) located within the proposed construction corridor. |
| Proposed outfall pipeline route (marine section) | • Outfall pipeline route (marine section) will commence at the R106 Coast Road and will terminate at a discharge location approximately 1km north-east of Ireland's Eye.<br>• 5.9km in length and 2m in diameter.<br>• Pressurised gravity tunnel/subsea (dredged) pipeline.<br>• Multiport marine diffuser to be located on the final section.<br>• Proposed temporary construction compounds (west and east of Baldoyle Bay) to be located within the proposed construction corridor. |
| Proposed Regional Biosolids Storage Facility | • Located on an 11ha site at Newtown, Dublin 11.<br>• Maximum building height of 15m.<br>• Further details and full impact assessment are provided in Volume 4 Part A of this EIAR. |

The total Construction Phase will be approximately 48 months, including a 12 month commissioning period to the final Operational Phase. The Proposed Project will serve the projected wastewater treatment requirements of existing and future drainage catchments in the north and north-west of the Dublin agglomeration, up to the Proposed Project's 2050 design horizon.

Please note that there is no marine water quality assessment of the RBSF, as the site is located inland.

### 8.1.1 Legislative Requirements

This Section sets out the regulatory and legislative framework that defines the water quality requirements pertaining specifically to the proposed outfall pipeline route (marine section) discharge point and covers the:

- Water Framework Directive (WFD);
- Urban Waste Water Treatment Directive;
- Shellfish Waters Directive;
- Bathing Waters Regulations; and
- Marine Strategy Framework Directive.

### 8.1.2 Water Framework Directive

Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive (WFD)) commits member states to preventing deterioration and achieving at least "Good" status in all of their rivers, lakes, transitional, coastal and groundwaters by the year 2015. Extensions have been applied to certain water bodies to 2021 or 2027, where justified in line with the reasons specified in the legislation.

The WFD was transposed into Irish law under the European Communities (Water Policy) Regulations 2003 (S.I. No. 722 of 2003) (as amended) and the European Communities Environmental Objectives (Surface Waters) Regulations 2009 (S.I. No. 272 of 2009) (as amended). The WFD takes a holistic approach to water resources management. The key objective of the WFD is to protect and improve the quality of rivers, lakes, transitional and coastal waters, and groundwater.

The WFD specifies the factors which must be used in determining the ecological status or ecological potential and the surface water chemical status of a surface water body. The Environmental Protection Agency (EPA) has developed classification systems and Environmental Quality Standards for the purpose of assessing the status of surface waters. Classification systems provide a way of comparing waters and looking at changes in status over time. This enables improvements to be planned and the environmental benefits of these actions to be demonstrated.

Under the WFD, River Basin Management Plans (RBMPs) and Programmes of Measures were prepared for each of the eight River Basin Districts within the island of Ireland. RBMPs take an integrated approach to the protection, improvement and sustainable management of the water environment. The planning process revolves around a six-year planning cycle of action and review, so that every six years a revised RBMP is produced. The existing RBMPs were valid for a six-year period from 2009 to 2015.

The RBMPs summarised the waterbodies that may not meet the environmental objectives of the WFD by 2015 and identified which pressures are contributing to the environmental objectives not being achieved. The RBMPs described the classification results and identified measures that can be introduced in order to safeguard waters and meet the environmental objectives of the WFD. The Eastern River Basin District RBMP 2009–2015 (Department of Environment, Heritage and Local Government 2010) covered the implementation of the WFD for the east coast of Ireland and covered the study area for the Proposed Project.

Preparation of the second cycle RBMPs (2015 to 2021) is now underway. For the second cycle, the Eastern, South Eastern, South Western, Western and Shannon River Basin Districts will be merged to form one national River Basin District. Consultation on the significant water management issues for second cycle RBMPs, led by the Local Authorities at regional level, closed in August 2017. In total, 956 local submissions were received covering a broad range of issues and interests. These submissions have been collated to assist the Department of Housing, Planning and Local Government in the development of the pending River Basin Management Plan, due to be published early 2018.

Under the WFD:

- ‘Transitional waters’ are bodies of surface water in the vicinity of river mouths which are partly saline in character as a result of their proximity to coastal waters but which are substantially influenced by freshwater flows; and
- ‘Coastal waters’ are defined as waters out to a distance of one nautical mile beyond the baseline from which territorial waters are measured.

As the proposed outfall pipeline route (marine section) discharge point is located in coastal waters, the WFD standards are applicable to this study. Figure 8.1 Coastal and Transitional Waterbodies shows the water body boundaries under the WFD and the proposed outfall pipeline route (marine section).

The European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2015 (S.I. No. 386 of 2015) came into effect in 2015 and apply to all surface waters and give effect to the measures needed to achieve the environmental objectives established for surface waterbodies by the WFD. Wastewater Discharge Authorisations must set standards (emission limits) that will contribute to the receiving waters complying with the standards for environmental quality laid out in these regulations.

The water quality standards proposed for the general physico-chemical conditions supporting the biological elements in transitional and coastal waters are listed in Table 8.1.

**Table 8.1: Environmental Quality Objectives from Environmental Objectives (Surface Waters) (Amendment) Regulations 2015 (S.I. No. 386 of 2015)**

| Parameter | Transitional | Coastal |
|---|---|---|
| **Biochemical Oxygen Demand (BOD) (mg/l $O_2$)** | n/a | Good status ≤ 4.0 ($95^{th}$ percentile) |
| **Dissolved Inorganic Nitrogen (DIN) (mg/l N)** | | |
| 0 psu[1] | Good status ≤ 2.60 | Good status ≤ 2.60 |
| 34.5 psu | Good status ≤ 0.25 | Good status ≤ 0.25 |
| 34.5 psu | High status ≤ 0.17 | High status ≤ 0.17 |
| **Molybdate Reactive Phosphorus (MRP) (mg/l P)** | | n/a |
| 0–17 psu | ≤ 0.06 | |
| 35 psu | ≤ 0.04 | |
| psu: The practical salinity unit defines salinity in terms of a conductivity ratio of a sample to that of a solution of 32.4336g of Potassium Chloride (KCl) at 15ºC in 1kg of solution. A sample of seawater at 15°C with a conductivity equal to this KCl solution has a salinity of exactly 35 psu. | | |

The principal quality standard of concern in relation to wastewater discharges to coastal waters is for nutrients in the form of Dissolved Inorganic Nitrogen (DIN). DIN is considered to be the limiting nutrient in coastal waters, and a breach of the environmental quality standard may lead to eutrophic conditions (e.g. algal blooms). Consequently, the only nutrient standards in place for coastal waters are for DIN.

### 8.1.3 Urban Wastewater Treatment Directive

Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment (Urban Waste Water Treatment Directive), is transposed into national legislation by the Urban Waste Water Treatment Regulations

2001 (S.I. No. 254 of 2001) (as amended). The Urban Waste Water Treatment Regulations 2001 place a responsibility on sanitary authorities to provide secondary treatment of urban wastewater, for every agglomeration with a population equivalent of more than 15,000, to monitor discharges from agglomerations and to transmit the results of such monitoring to the EPA. The agglomerations with a population equivalent >15,000 are Balbriggan, Malahide, Portrane/Donabate, Ringsend, Shanganagh and Swords. The Water Services (No. 2) Act 2013 states that all references in legislation to a 'sanitary authority' are to be read, from 1 January 2014, as references to Irish Water, thereby imposing these responsibilities on Irish Water.

To date, 20 estuaries and bays have been designated as Nutrient Sensitive Waters by the Minister for the Environment, Heritage and Local Government and are listed in Parts 1 to 3 of Schedule 1 of the Urban Waste Water Treatment (Amendment) Regulations 2010 (S.I. No. 48 of 2010). Certain measures, such as treating wastewater to reduce nitrogen and/or phosphorus, must be implemented in these areas to ensure adequate treatment and to prevent eutrophication.

The proposed outfall pipeline route does not discharge to, or impinge on, any Nutrient Sensitive Waters. Therefore, implementation of nitrogen and/or phosphorus reduction measures are not required.

### 8.1.4 Waste Water Discharge (Authorisation) Regulations 2007

A system for the licensing or certification of wastewater discharges from areas served by local authority sewer networks was brought into effect on 27 September 2007 with the introduction of the Waste Water Discharge (Authorisation) Regulations 2007 (S.I No. 684 of 2007) and as amended by the Waste Water Discharge (Authorisation) (Amendment) Regulations 2010 (S.I. No. 231 of 2010), and further amended by the Waste Water Discharge (Authorisation) (Environmental Impact Assessment) Regulations 2016 (S.I. No. 652 of 2016). This licensing and certification process gives effect to a number of EU Directives by imposing restrictions or prohibitions on the discharge of dangerous substances and implementing measures required under the WFD, thus preventing or reducing the pollution of waters by wastewater discharges. All discharges to the aquatic environment from sewerage systems owned, managed and operated by water service authorities require a wastewater discharge licence or certificate of authorisation from the EPA.

The authorisation process allows the EPA to place conditions on the operation of wastewater discharges to ensure that potential effects on the receiving water bodies are limited and controlled, with the aim of achieving good surface water status and good groundwater status by 2015 or, at the latest, by 2027.

The proposed WwTP will require a wastewater discharge licence to be granted by the EPA under the Waste Water Discharge (Authorisation) Regulations 2007 (S.I No. 684 of 2007) prior to commissioning. Wastewater discharges from the proposed WwTP must comply with this licence.

### 8.1.5 Shellfish Waters Directive

Directive 2006/113/EC of the European Parliament and of the Council of 12 December 2006 on the quality required of shellfish waters (Shellfish Waters Directive), transposed into Irish law through the European Communities (Quality of Shellfish Waters) Regulations 2006 (S.I. No. 268 of 2006), requires Member States to designate waters that need protection to support shellfish life and growth. The Directive sets physical, chemical and microbiological requirements that designated shellfish waters must either comply with or endeavour to improve compliance. The Directive also provides for the establishment of pollution reduction programmes for the designated waters. Two of the designated shellfish waters are located near the proposed outfall pipeline route; Malahide and Balbriggan/Skerries, as shown in Figure 8.2 Designated Areas.

### 8.1.6 Bathing Waters Regulations

Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC (Bathing Water Directive) came into force on 24 March 2006 and repealed the 1976 Quality of Bathing Waters Directive with effect from 31 December 2014. The Bathing Water Directive provides greater benefits than its predecessor in relation to improved health protection for bathers and a more proactive approach to beach management including public involvement.

The Bathing Water Quality Regulations 2008 (S.I. No. 79 of 2008), as amended, transposed the Bathing Water Directive into Irish Law on 24 March 2008. It established a new classification system for bathing water quality based on four classifications: ‘Poor’, ‘Sufficient’, ‘Good’ and ‘Excellent’. The Regulations generally require that a classification of ‘Sufficient’ be achieved by 2015 for all bathing waters. The classification criteria are detailed in Table 8.2.

The Directive establishes tighter microbiological standards for two new parameters: intestinal enterococci and Escherichia coli. Since 2011, these two parameters have been monitored and used to classify bathing waters. Designated bathing waters in the study area are presented in Figure 8.2 Designated Areas and the standards presented in Table 8.2.

**Table 8.2: Bathing Water Quality Regulations 2008 (S.I. No. 79 of 2008)**

| Parameter | Excellent | Good | Sufficient |
|---|---|---|---|
| Escherichia coliform (colony forming units (cfu)/100ml) | 250[1] | 500[1] | 500[2] |
| Intestinal enterococci (cfu/100ml) | 100[1] | 200[1] | 185[2] |

1 By 95% or more samples
2 By 90% or more samples
‘Poor’ quality values are any values worse than the ‘Sufficient’ quality value.

### 8.1.7 Blue Flag Status

The Blue Flag programme is a voluntary programme to identify high-quality bathing water areas, administered in Ireland by An Taisce. To receive a blue flag, a bathing site, in addition to maintaining a high standard of water quality, must meet specified objectives with regard to the provision of safety services and facilities, environmental management of the beach area and environmental education. For EU countries implementing the Blue Flag programme, it is imperative that a beach is classified as being 'Excellent'. These imperative Blue Flag standards are shown in Table 8.3.

Only one beach in north Dublin was awarded a Blue Flag Award for 2017, that being Portmarnock Velvet Strand Beach.

**Table 8.3: Blue Flag Standards**

| Parameter Limit | Value[1] |
|---|---|
| Escherichia coliform (cfu/100ml) | 250 |
| Intestinal enterococci (cfu/100ml) | 100 |

1. For the evaluation of an applicant beach, the Blue Flag programme requires 95th percentile compliance of the above limit values. This is in accordance with the EU Bathing Water Directive 2006 as well as the recommendation of the World Health Organisation. The percentile has to be calculated for each parameter and also met for each parameter.

### 8.1.8 Marine Strategy Framework Directive

Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) was formally adopted by the European Union in June 2008. It established a legal framework for the development of marine strategies designed to achieve good environmental status in the marine environment by the year 2020. The Marine Strategy Framework Directive was transposed into Irish law on 31 May 2011 by the EC (Marine Strategy Framework) Regulations (S.I. No. 249 of 2011).

At present, there are no standards for the discharge of treated wastewater to the open sea apart from the emission standards contained in the Urban Waste Water Treatment Regulations 2001.

## 8.2 Methodology

MarCon Computations International were commissioned in 2011 by Jacobs Engineering Ireland Ltd. to undertake a mathematical modelling study of the coastal waters of north Dublin for the Proposed Project to assess the discharge of treated wastewater on the receiving waters.

### 8.2.1 Evolution of Water Quality Modelling

Alternative Sites Assessment

A preliminary modelling study was undertaken (MarCon 2011) to identify a range of potential outfall locations along the north Dublin coastline. That study showed that two discrete areas existed within the Proposed Project area where locating a proposed outfall would minimise the impact on the receiving marine environment.

The results from that preliminary modelling study identified the preferable location(s) for the proposed outfall pipeline route (marine section) discharge point and portrayed the dispersion patterns and concentrations of treated wastewater discharges from each potential outfall pipeline route (marine section) discharge point option.

Alternative Sites Assessment – Near-Field Mixing

A subsequent near-field modelling study (MarCon 2013) to determine the relative merits between the above two locations off the coast of north Dublin for a new proposed outfall pipeline route (marine section) discharge point was undertaken. That study showed that the southern outfall study area exhibited more favourable coastal hydrodynamic characteristics (larger current speeds and greater water depths), which allows for faster and greater dilution of treated wastewater than the northern outfall study area.

Water Quality Modelling for the Environmental Impact Assessment Report

Following publication of the *Alternative Sites Assessment and Route Selection Report (Phase 4): Final Preferred Site and Routes* (Jacobs Tobin 2013), a detailed hydrodynamic and water quality model was developed and calibrated to assess both the Construction Phase and Operational Phase impacts of the proposed outfall pipeline route (marine section) on the marine environment. The detailed model extended from Balbriggan in the north to Shankill in the south to accurately assess the potential impacts on the receiving waters from the proposed outfall pipeline route (marine section) discharge point, both alone and in combination with other discharges to the receiving waters.

### 8.2.2 Model Development

A Mike-by-DHI 3D Flexible Mesh (Mike3-FM) hydrodynamic, solute and sediment transport model was developed to predict tidal circulation patterns in the region; treated wastewater dispersion, plume trajectories and compliance with EU Water Quality standards in the water off Dublin; along with the advection, dispersion and settling of sediment arising from dredge operations associated with construction of the proposed outfall pipeline route (marine section).

A field data collection campaign described in Section 8.2.3 below was undertaken to provide field data for calibration and verification of the model to ensure there would be full confidence in the model predictions.

Modelling System

The MIKE3-FM model used in this study is a state-of-the-art hydrodynamic, sediment and solute transport model which can accurately compute water circulation, temperature, salinity, and mixing and transport of conservative parameters, deposition and re-suspension of cohesive and non-cohesive sediments.

The Mike-by-DHI range of products, including MIKE3-FM, is a market-leading software suite, utilised by consultants and regulators worldwide, and represent the state-of-the-art in terms of commercial modelling software.

The MIKE3 modelling system is three-dimensional and based on an unstructured flexible mesh. MIKE3 uses a finite volume solution technique and is an industry standard modelling system for analysing free-surface flow hydrodynamics and dispersion in coastal areas and seas. The meshes are based on linear triangular elements as shown in Diagram 8.1.

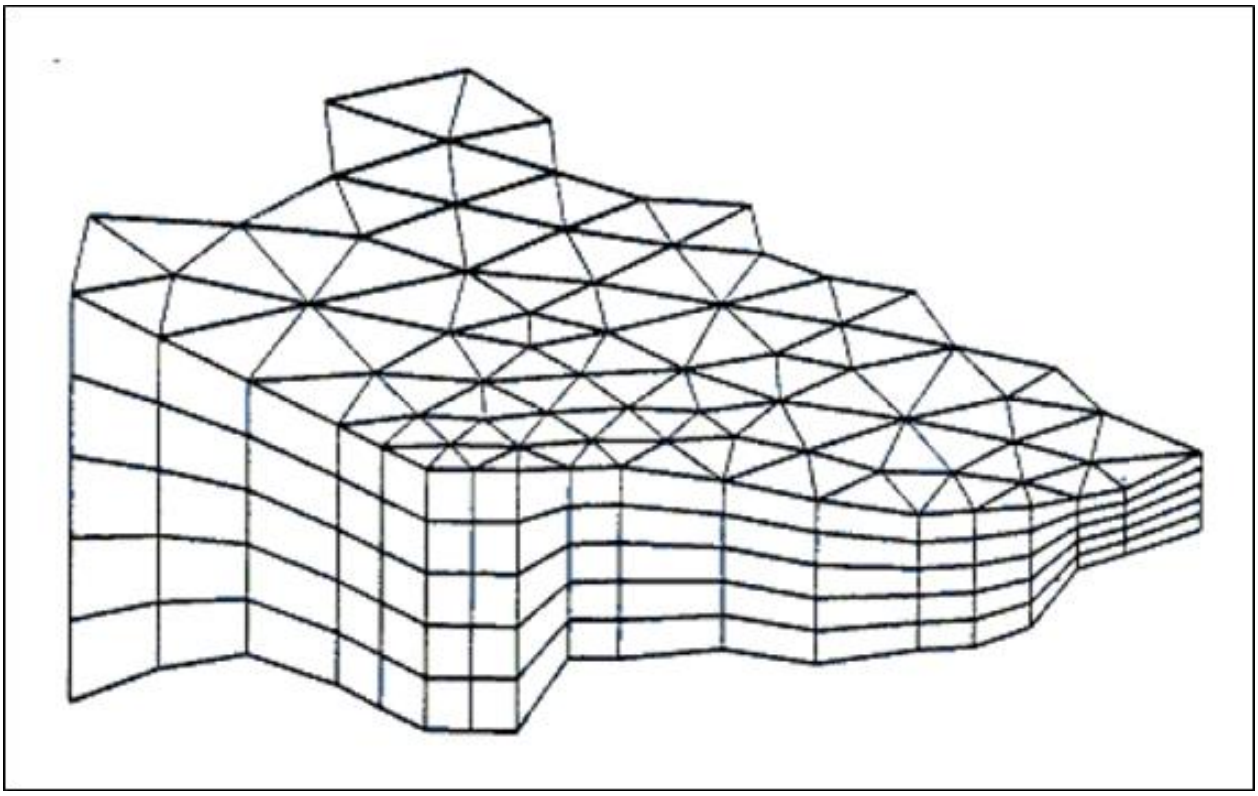


**Diagram 8.1: Example of Three-Dimensional Triangular Grid using the MIKE3-FM Solution Technique**

Bathymetry

The seabed bathymetry for the model was obtained from the most recent bathymetry datasets available from the Irish seabed survey INFOMAR project. INFOMAR surveys began in 2003. In 2008, surveying around the area of the Kish Bank commenced and coverage of a large portion of seabed to the east of the bank was achieved. Surveying was concentrated to an area north of the Ben of Howth up to Skerries. In 2010, the Celtic Voyager surveyed a large area. It stretches from offshore County Louth in the north to offshore County Wicklow in the south. In 2010, the RV Keary survey operations were focused in Dublin Bay and Approaches, extending from Howth Head in the north of the bay to Dalkey Island in the south. The Celtic Voyager returned to survey an area east of Lambay Island, parts of the Codling Bank, and west of Kish Bank in 2012. The M.V. Cosantóir Bradán and RV Geo surveyed around Lambay Island and the shallower waters on the coast north of Howth in 2013. The RV Keary, RV Tonn and RV Geo surveyed some gaps in coverage to the south in 2016. The INFOMAR dataset was augmented with digitised bathymetric data from the United Kingdom Hydrographic Office Admiralty Charts 44, 633, 1415 and 1447. The extent of the INFOMAR bathymetric data used to define the model bathymetry is presented in Diagram 8.2. The extent of the model domain, and the underlying bathymetry, is presented in Figure 8.3 Model Mesh and Bathymetry.

The computational model mesh was generated on the basis of the above bathymetric data. The model had a very high resolution in the vicinity of the proposed outfall pipeline route (marine section), as shown in Figure 8.4 High Resolution Mesh. Driving forces in the model are water levels, wind, salinity and water temperature. The model domain covers a wide area of the Irish Sea to ensure that it is sufficient to contain the maximum excursion of the treated wastewater.

The model encompasses the coastal waters of north Dublin, from Balbriggan in north Dublin to Shankill in south Dublin. The model resolution is variable, as enabled by the flexible meshing approach, thus allowing for higher resolution in and around areas of interest (the proposed outfall pipeline route (marine section) and its discharge point) while allowing resolution to reduce as appropriate towards the model open sea and land boundaries, in order to maintain computational efficiency. The sides of the flexible triangular model mesh decrease from 500m at the boundaries to 50m in the area of interest, resulting in 16,707 computational elements.

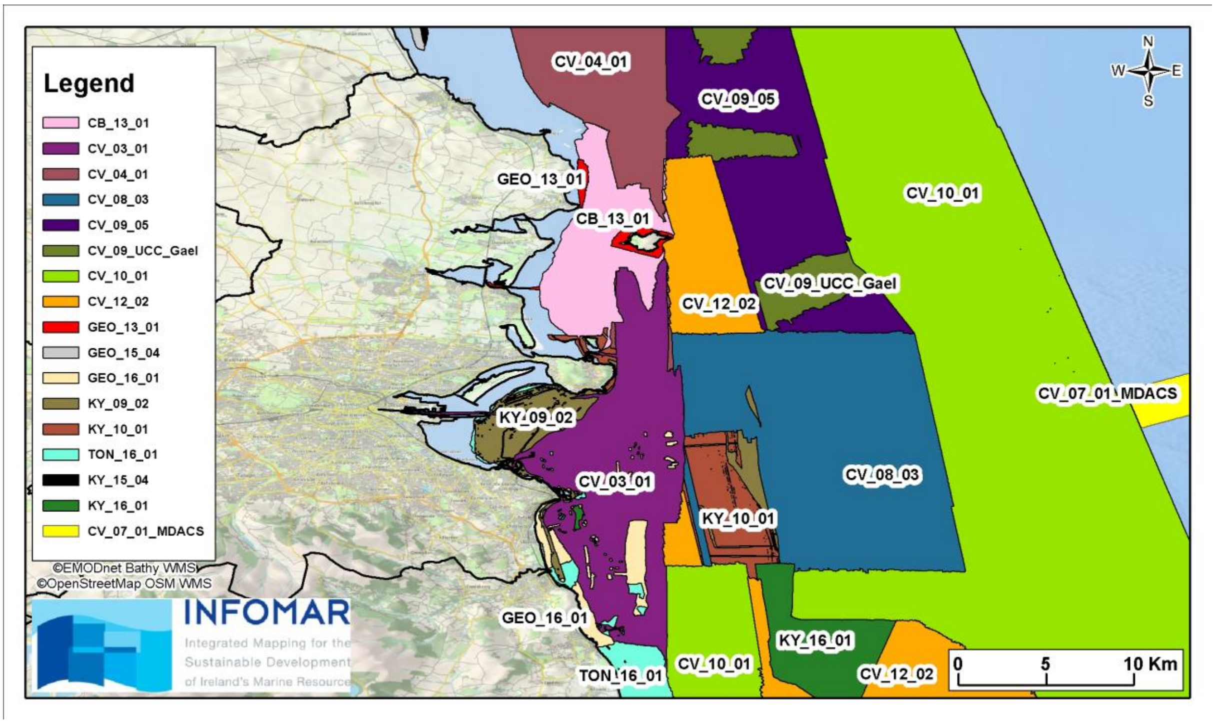



**Diagram 8.2: INFORMAR Seabed Surveys used to Define Model Bathymetry**

### 8.2.3 Hydrodynamic Calibration

Calibration is achieved by varying calibration coefficients in order to match modelled predictions to observed data. The degree of fit between modelled and observed values determines the level of model calibration: poor fit suggests poor calibration; good fit suggests good calibration. The degree of fit will vary from location to location, depending on local conditions and how well these conditions can be represented in the model. Model fit-to-field data can be assessed in two ways:

- Visual comparison of the model output against observed data: the shape, trend, range and limits of model output and observed data; and
- Statistical comparison of the difference between observation and the model to determine the frequency with which the model fits observation within defined limits.

During July 2012 and August 2012, a hydrographic survey was undertaken off the north Dublin coastline. Two tide gauges were deployed, one each at Skerries and Howth, and three acoustic Doppler current profilers (ADCPs) were also deployed on the seabed. Further ADCP surveys and dye-dispersion studies were undertaken over the course of March 2015, April 2015 and June 2015, against which to validate the model predictions. The locations of the deployed instruments are detailed in Figure 8.5 Calibration Locations. Full details of the hydrodynamic model calibration and validation are presented in Appendix A8.1 in Volume 3 Part B of this EIAR.

The following standards (Foundation for Water Research (FWR) 1993) are commonly applied to coastal models throughout the water industry:

- Water levels: an absolute tolerance of ±0.1m or a relative tolerance of ±10% of the measured spring tidal range; and
- Current speed: an absolute tolerance of ±0.1m/s or a relative tolerance of ±10% of the peak measured current speed.

In an attempt to further describe the relative levels of calibration between sites, a qualitative scale of fit has been applied (FWR 1993) as follows:

- 'Excellent Fit': Calibration tolerances are achieved >90% of the time;
- 'Very Good Fit': Calibration tolerances are achieved >80% of the time;
- 'Good Fit': Calibration tolerances are achieved >70% of the time;
- 'Reasonable Fit': Calibration tolerances are achieved >60% of the time; and
- 'Poor Fit': Calibration tolerances are achieved <60% of the time.

In addition to allowing comparison of the relative level of calibration between sites to be made, this qualitative scale also assists in making a comparison between the visual 'fit' of the data (as provided, for example, by a time-series plot of modelled versus measured data) and the statistical assessment of model performance.

Further to the above assessment, ABPmer have put forward a set of statistical tests against performance metrics (ABPmer 2011). They are similar to the FWR standards (FWR 1993) (although less stringent, so the FWR Guidelines have been applied here) but with the addition of the following statistics to be derived from the difference between the measured and modelled data:

- For levels, the Root Mean Square (RMS) of the differences should be less than 0.2; and
- For magnitudes, the RMS of the differences should be less than 0.2 and the Scatter Index less than 0.5.

Modelled tidal levels were compared against measured data at both the Skerries and Howth tide gauge locations in order to provide a quantitative assessment of inaccuracies in tidal characterisation.

Modelled current speeds and directions were compared against measured data at the ADCP locations A, B and C in order to provide a quantitative assessment of inaccuracies in tidal characterisation.

To quantify model calibration, a series of quantitative statistics have been calculated to compare water levels, current speeds and directions. The statistical assessment includes the derivation of the metrics listed above. The results are presented in Table 8.4 to Table 8.6 with Pass and Fail of the above metrics highlighted where applicable in Table 8.4 and Table 8.5.

**Table 8.4: Calibration of Modelled Current Speeds Against Tide Gauge Data**

| Location | Water Level Bias (m) | Water Level Bias (% Mean Spring Range (msr) | Water Level Root Mean Square |
|---|---|---|---|
| Skerries | 0.11 | 3.2 | 0.19 (Pass) |
| Howth | 0.02 | 0.67 | 0.15 (Pass) |

- Positive values denote model is over-predicting; negative values denote model is under-predicting.

**Table 8.5: Calibration of Modelled Current Speeds Against Acoustic Doppler Current Profilers Data**

| Location | Flow Speed Bias (m/s) | Flow Speed Bias (% max) | Flow Speed Root Mean Square | Scatter Index |
|---|---|---|---|---|
| ADCP A | -0.05 | -4.71 | 0.13 (Pass) | 0.36 (Pass) |
| ADCP B | 0.04 | 5.19 | 0.10 (Pass) | 0.28 (Pass) |
| ADCP C | 0.02 | 1.86 | 0.11 (Pass) | 0.25 (Pass) |

**Table 8.6: Qualitative Summary of Hydrodynamic Model Fit Against Calibration Data.**

| Location | % Time Tolerances Are Met | | Qualitative Description |
|---|---|---|---|
| | Water Level | Current Speed | |
| **Water levels** | | | |
| Skerries | 92 | | Excellent |
| Howth | 96 | | Excellent |
| **Current Speed** | | | |
| ADCP A | | 63 | Reasonable |
| ADCP B | | 63 | Reasonable |
| ADCP C | | 75 | Good |

In general, the comparison of the modelled and measured datasets, both statistically and visually, would suggest a robust calibration agreement. Overall, Table 8.6 shows that the model is providing an 'excellent' representation of water levels and, at the ADCP location closest to the proposed outfall pipeline route (marine section), a 'good' representation. Generally, the model is providing between a 'good' and 'reasonable' representation of current speeds and directions at the ADCP locations.

The summary of results presented above show that the numerical model has been successfully calibrated and validated against field measurements to provide an accurate representation of the hydrodynamics within the study region.

### 8.2.4 Solute Transport Calibration

The transport model was calibrated against dye-dispersion data from locations denoted ADCP A and ADCP B for 2015 (as shown in Figure 8.5 Calibration Locations) around the area of interest, with four releases taking place on a spring tide and again on a neap tide (20 April 2015 and 9 June 2015 respectively). The calibration was underpinned by the calibrated hydrodynamic module, and involving adjustment of the dispersion parameters within the advection-dispersion module and the Smagorinsky formulation within the HD module.

Dye dispersion, particularly in an area of complex flows such as this, is a chaotic process, with the likely generation of numerous smaller patches moving at differing speeds and directions than the main patch. A single survey vessel can usually only run transects on one patch. The model, which is not chaotic, will generally generate a single patch, with model dispersion coefficients seeking to parameterise the average, net effect of the chaotic processes of the real world.

In general, the calibrated model reproduces the complex advection and the dispersion of the dye patch very well, with each measured patch well characterised by the model. Full details of the solute transport model calibration and validation are presented in Appendix A8.1 in Volume 3 Part B of this EIAR.

### 8.2.5 Model Scenarios

The calibrated and validated hydrodynamic and solute dispersion model outlined above was employed to assess impacts on the receiving waters of Dublin arising from both the Construction Phase and Operational Phase of the Proposed Project. In particular, the following scenarios were examined.

Construction Phase

The trench for the proposed outfall pipeline route (marine section) will be dredged to a depth of 5m below bed level for a distance of 3.9km, as indicated in Figure 8.6 Vibrocore and Borehole Locations. A back-hoe dredger or similar will be used for the dredging activity.

It has been estimated by the Proposed Project team that the volume of material to be excavated is approximately 300,000m$^3$ and that the dredging operation will take approximately 78 days. For the impact assessment, it has been assumed that the dredging operations will occur 24 hours per day. This gives a constant dredging rate of approximately 160m$^3$ per hour. The dredge spoil material will be deposited within the proposed construction corridor route on flood tides only (approximately 12.25hr intervals), from two split-hull hopper barges of 1,000m$^3$ capacity each

The simulated dredging operation used the recorded tidal and meteorological forcing conditions as employed for the calibration of the hydrodynamic and solute dispersion models. The particle-tracking model simulates the fate of the loss of material from the dredge disposal barges by releasing particles into the water column and tracking each particle throughout the simulation process. Section 8.2.6 below includes details on the particle size distribution classes used in the model and the percentage mass distribution of particle sizes in each class along the route of the proposed construction corridor. This caters for the variation in sediment grading of the bed sediment material.

The dredging operation was assumed to commence at the inshore section of the proposed outfall pipeline route (marine section) trench route with the dredger working its way out toward the deeper waters in the direction of the proposed outfall pipeline route (marine section) discharge point. The sources of sediments released to the model were moved to keep track of the dredger and spoil disposal barge.

Operational Phase

The Operational Phase of the proposed outfall pipeline route (marine section) modelled the continuous discharge of secondary treated wastewater into the receiving waters (ambient concentrations) for:

- average flow conditions; and
- flow to full treatment conditions.

A scenario to assess the impacts of discharging untreated wastewater over a three-day period, simulating a process failure at the proposed WwTP, was also undertaken.

### 8.2.6 Model Inputs

The data inputs to the modelling study are described in the following sections. These include a description of the hydraulic flows from WwTPs and rivers, pollutant loads from WwTPs and rivers, background concentrations within the coastal waters and bed sediment composition.

Hydraulic Flows – Rivers

The 15 riverine hydraulic flows defined in the numerical model consisted of the Dodder River, Camac River, Liffey River, Santry River, Tolka River, Mayne River, Sluice River, Ward River, Broadmeadow River, Turvey River, Ballyboghil River, Ballough River and the Mill Stream, Elm Park Stream and Trimlestown Stream. The rivers were included in the modelling study to assess the potential in-combination effects with the proposed outfall pipeline route (marine section) discharge point. The locations of the rivers, and hydrometric gauging stations referenced in this section, are presented in Figure 8.7 Modelled Rivers and Hydrometric Stations. The river flows are presented in Table 8.7.

Derivation of the flow in each of the rivers was undertaken as follows:

- Ward River: The average flow was derived from hydrometric gauging station 8009 data from 1980 to 1996. The gauge measured flow from the complete catchment;
- Broadmeadow River: The average flow was derived from hydrometric gauging station 8008 for the available period of record from 2005 to 2008. The gauge measured flow from 107.9km$^2$ of the catchment. The remaining ungauged catchment area was calculated as being 1.7km$^2$. Gauge 8008 was used to calculate flows in the ungauged portion of the catchment;
- Turvey River: There is no hydrometric station on the Turvey River. Gauge area transposition from Gauge 8008 on the Broadmeadow River was used to calculate flows for the Turvey River catchment area of 10.7km$^2$;
- Ballyboghil River: The average flow was derived from hydrometric gauging station 8012 for the available period of record from 1989 to 1991. The gauge measured flow from 26km$^2$ of the catchment. The remaining ungauged catchment area was calculated as being 28.47km$^2$. Gauge 8012 was used to calculate flows in the ungauged portion of the catchment;
- Ballough River: There is no hydrometric station on the Ballough River. Gauge area transposition from Gauge 8012 on the Ballyboghil River was used to calculate flows for the Ballough River catchment area of 32.76 km$^2$; and
- Mill Stream: The average flow was derived from hydrometric gauging station 8014 for the available period of record from 1984 to 2001. The gauge measured flow from the complete catchment.

Hydraulic flows for the Liffey River, Dodder River, Tolka River, Camac River, Santry River, Mayne River and Sluice River and the Elm Park Stream and Trimlestown Stream were developed in the same manner for the Ringsend WwTP Upgrade Project EIAR (Irish Water 2018). These are used in this study to ensure consistency in modelling parameters between both the Proposed Project and the Ringsend WwTP Upgrade Project so that any in-combination effects could be accurately assessed.

**Table 8.7: River Flows Defined to Numerical Model**

| River Name | Flow rate ($m^3/s$) |
|---|---|
| Dodder | 1.50 |
| Camac | 0.40 |
| Liffey | 6.10 |
| Tolka | 1.10 |
| Mayne | 0.20 |
| Sluice | 0.40 |
| Ward | 0.81 |
| Broadmeadow | 1.05 |
| Turvey | 0.20 |
| Ballyboghi | 0.85 |
| Ballough | 0.62 |
| Mill | 0.10 |
| Santry | 0.10 |
| Elm Park | 0.05 |
| Trimlestown | 0.05 |

### Hydraulic Flows – Wastewater Treatment Plants

The hydraulic flows defined in the numerical model consisted of the WwTPs at Shanganagh, Ringsend, Swords, Malahide, Portrane, Barnageeragh and the proposed WwTP discharge under consideration in this study. The WwTPs were included in the modelling study to assess the potential in-combination effects with the proposed outfall pipeline route (marine section) discharge point. Average flow and flow to full treatment (FFT) for the existing Ringsend WwTP discharge were provided by Irish Water and accord with values used in the Ringsend WwTP Upgrade Project EIAR (Irish Water 2018). Average discharge rates for the remaining WwTPs were provided by Irish Water as published in the respective annual environmental reports to the EPA.

The locations of the WwTPs as defined in the numerical model are presented in Figure 8.8 Wastewater Treatment Plants. The associated hydraulic flows are presented in Table 8.8.

**Table 8.8: Wastewater Treatment Plant Flows Defined in the Numerical Model**

| Wastewater Treatment Plant | Flow rate ($m^3/s$) |
|---|---|
| Barnageeragh | 0.09 |
| Portrane | 0.06 |
| Malahide | 0.05 |
| Swords | 0.16 |
| Shanganagh | 0.36 |
| Ringsend (existing average) | 4.91 |
| Ringsend (existing FFT) | 8.04 |
| Ringsend (proposed upgrade future average) | 6.95 |
| Ringsend (proposed upgrade future FFT) | 11.1 |
| Proposed Project (average) | 1.63 |
| Proposed Project (FFT) | 3.78 |

Pollutant Loads – Rivers

Water quality data for the period 2013 to 2015 for the Ward River, Broadmeadow River, Turvey River, Ballyboghil River, Ballough River, discharging to the model domain were provided by the EPA, with data for the Mill Stream provided by Fingal County Council.

Ward River: The average pollutant loads were calculated from the annual mean EPA data over the period 2013 to 2015. (EPA, 2017a);

- Broadmeadow River: The average pollutant loads were calculated from the annual mean EPA data over the period 2013 to 2015. (EPA, 2017b);
- Turvey River: The average pollutant loads were calculated from the annual mean EPA data over the period 2013 to 2015. (EPA, 2017c);
- Ballyboghil River: The average pollutant loads were calculated from the annual mean EPA data over the period 2013 to 2015. (EPA, 2017d);
- Ballough River: The average pollutant loads were calculated from the annual mean EPA data over the period 2013 to 2015. (EPA, 2017e); and
- Mill Stream: The average pollutant loads were calculated from data provided by Fingal County Council over the period of record from 2007 to 2013.

Water quality data for the period 2013 to 2015 for the Liffey River, Dodder River, Camac River, Tolka River, Santry River, Mayne River, Sluice River and both the Elm Park Stream and Trimlestown Stream were developed in the same manner for the Ringsend WwTP Upgrade Project EIAR (Irish Water 2018). This data was used in this study to ensure consistency in modelling parameters between both the Proposed Project and the Ringsend WwTP Upgrade Project so that any in-combination effects could be accurately assessed.

The locations of the river sampling stations are presented in Figure 8.9 Modelled Rivers and Quality Stations. Table 8.9 summarises the average values for DIN, molybdate reactive phosphate (MRP), BOD and Escherichia coliforms (COLI) defined in the numerical model. Where no sampled data existed for Escherichia coliforms, a value of 250/100ml was used, in line with the approach adopted for the Ringsend WwTP Upgrade Project EIAR (Irish Water 2018).

**Table 8.9: River Pollutant Loads Defined in the Numerical Model**

| River | Dissolved Inorganic Nitrogen (DIN) (mg/l N) | Molybdate Reactive Phosphate (MRP) (mg/l P) | Biochemical Oxygen Demand (BOD) (mg/l) | Escherichia coliforms (COLI) (/100ml) |
|---|---|---|---|---|
| Dodder | 1.290 | 0.029 | 1.00 | 250 |
| Camac | 1.328 | 0.036 | 1.50 | 250 |
| Liffey | 2.555 | 0.052 | 1.50 | 250 |
| Tolka | 1.674 | 0.045 | 1.00 | 250 |
| Mayne | 2.210 | 0.090 | 5.00 | 250 |
| Sluice | 2.199 | 0.097 | 3.00 | 250 |
| Ward | 2.730 | 0.120 | 2.00 | 250 |
| Broadmeadow | 2.309 | 0.121 | 2.00 | 250 |
| Turvey | 1.890 | 0.070 | 1.50 | 250 |
| Ballyboghil | 3.067 | 0.179 | 1.00 | 250 |
| Ballough | 2.937 | 0.157 | 2.00 | 250 |
| Mill | 6.175 | 0.070 | 2.00 | 250 |
| Santry | 1.962 | 0.056 | 2.00 | 250 |
| Elm Park | 0.000 | 0.000 | 0.00 | 250 |
| Trimlestown | 0.000 | 0.000 | 0.00 | 250 |

### Pollutant Loads – Wastewater Treatment Plants

Pollutant loads for both the existing Ringsend WwTP and Ringsend WwTP Upgrade were sourced from Irish Water and confirmed to be consistent with data used in the Ringsend WwTP Upgrade Project EIAR (Irish Water 2018). Pollutant loads for the proposed discharge of treated wastewater from the proposed WwTP were provided by the Proposed Project team. Pollutant loads for the remaining WwTPs were sourced from the respective annual environmental reports. Table 8.10 summarises the average values for DIN, MRP, BOD and COLI defined in the numerical model for each of the WwTPs.

**Table 8.10: Wastewater Treatment Plant Pollutant Loads Defined in the Numerical Model**

| Wastewater Treatment Plant | Dissolved Inorganic Nitrogen (DIN) (mg/l N) | Molybdate Reactive Phosphate (MRP) (mg/l P) | Biochemical Oxygen Demand (BOD) (mg/l) | Escherichia coliforms (COLI) (Most Probable Number (mpn)/100ml) |
|---|---|---|---|---|
| Barnageeragh | 8.63 | 3.46 | 3.75 | 1,000 |
| Portrane | 21.88 | 5.33 | 92.04 | 1,000 |
| Malahide | 13.56 | 3.20 | 7.02 | 1,500 |
| Swords | 9.38 | 0.89 | 4.50 | 100,000 |
| Shanganagh | 14.40 | 3.00 | 7.00 | 100,000 |

| Wastewater Treatment Plant | Dissolved Inorganic Nitrogen (DIN) (mg/l N) | Molybdate Reactive Phosphate (MRP) (mg/l P) | Biochemical Oxygen Demand (BOD) (mg/l) | Escherichia coliforms (COLI) (Most Probable Number (mpn)/100ml) |
|---|---|---|---|---|
| Ringsend (existing average) | 14.00 | 2.49 | 20.60 | 300,000 |
| Ringsend (existing FFT) | 14.00 | 2.49 | 35.50 | 300,000 |
| Ringsend (proposed upgrade future average) | 8.00 | 0.70 | 12.00 | 300,000 |
| Ringsend (proposed upgrade future FFT) | 8.00 | 0.70 | 21.70 | 300,000 |
| Proposed Project (average) | 50.00 | 4.80 | 25.00 | 39,105 |
| Proposed Project (FFT) | 50.00 | 2.07 | 25.00 | 39,105 |
| Proposed Project (process failure) | 60.00 | 4.80 | 210.00 | 100,000 |

### Ambient Concentrations

Background concentrations in the coastal waters were sourced from the most recent EPA sampling records for the period 2006 to 2013. No monitoring of the waters north of Howth has been undertaken in the interim period. The average background concentrations for each parameter were derived from the EPA sampled data and defined as a constant value in the numerical model as summarised in Table 8.11. The locations at which the EPA monitor the coastal waters are presented in Figure 8.10 Marine Sampling Stations.

**Table 8.11: Background Concentrations in the Coastal Waters**

| Parameter | Average Concentration |
|---|---|
| Dissolved Inorganic Nitrogen (DIN) | 0.090 (mg/l N) |
| Molybdate Reactive Phosphate (MRP) | 0.013 (mg/l P) |
| Biochemical Oxygen Demand (BOD) | 2.000 (mg/l $O_2$) |
| Escherichia coliform (COLI) | 0.00 (/100ml) |

### Bed Sediment Composition

In order to gain knowledge of the physical properties of the sediments along the proposed outfall pipeline route (marine section) a series of borehole (BH) samples were acquired. The locations of the BH samples are indicted in Figure 8.6 Borehole Locations, namely BH01, BH03, BH05 and BH08. The BHs corresponding to the section of the proposed outfall pipeline route (marine section) to be excavated by the dredging operations were BH03, BH05, and BH08.

Analysis of the three identified BH samples to the proposed trenching depth of 5m showed the sediments to range from grey silty sand to grey sandy gravel. The sediments are summarised in Table 8.12, with the particle size distributions at each of the BH depths detailed in Table 8.13 in terms of percentages remaining on standard sieve sizes.

**Table 8.12: Borehole Sediment Characteristics**

| Borehole | Depth | Characteristic |
|---|---|---|
| BH03 | 0m | Grey brown silty sand with shell fragments |
| | 3m | Grey silty sand with shell fragments |
| | 5m | Very stiff grey slightly gravelly sandy silt |
| BH05 | 0m | Grey brown silty sand with shell fragments |
| | 2m | Grey brown silty sand with shell fragments |
| | 6m | Grey sandy gravelly silty clay |
| BH08 | 0m | Grey fine to medium subrounded gravel with shell fragments |
| | 5m | Grey sandy silty gravel |

**Table 8.13: Particle Size Distribution: Percentages Retained**

| Sieve Size (mm) | Borehole Reference | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | BH03_0m | BH03_3m | BH03_5m | BH05_0m | BH05_2m | BH05_6m | BH08_0m | BH08_5m |
| 2.000 | 12% | 2% | 2% | 5% | 55% | 36% | 59% | 67% |
| 0.600 | 4% | 1% | - | 4% | 9% | 3% | 26% | 10% |
| 0.300 | 2% | - | - | 1% | 2% | 2% | 3% | 13% |
| 0.150 | 35% | 10% | 2% | 8% | 7% | 4% | 8% | 9% |
| 0.063 | 42% | 63% | 21% | 71% | 25% | 6% | 3% | - |
| 0.035 | 5% | 24% | 75% | 11% | 2% | 49% | 4% | 1% |

The information from the various samples shows consistently that the material to be dredged is predominantly a grey silty sand. Even though there is an increase in the gravel fraction over depth and towards the offshore end of the trench, only the finer fractions are put into suspension in the water column during dredging, with the heavier fractions settling out within a few metres of the dredger.

Water Quality Standards

The objective of the modelling study was to assess and quantify the potential impacts of siting the proposed outfall pipeline route (marine section) discharge point at a location approximately 1km to the north-east of Ireland's Eye, as previous modelling studies had indicated that the location chosen for the proposed outfall pipeline route (marine section) discharge point was the most environmentally advantageous location (MarCon 2011; MarCon 2013).

Three water quality modelling scenarios were undertaken using the data inputs described above. The three scenarios modelled represented average daily flow conditions, FFT conditions, and a pumping failure scenario. The results from the three simulations were analysed against environmental quality standards and bathing water standards. The standards were discussed previously and are listed in Table 8.14

The location of the proposed outfall pipeline route (marine section) discharge point is within the coastal waters delineated for consideration under the WFD. In all plots, the lowest contour value equates to the Environmental Quality Standard or the Bathing Water Regulation requirements.

Note that in the European Communities Environmental Objectives (Surface Waters) Regulations 2009 (S.I. No. 272 of 2009) there is no standard for MRP in coastal waters. Therefore, the MRP standard for transitional waters has been adopted for this assessment.

**Table 8.14: Water Quality Standards for Reporting**

| Parameter | WFD Classification | Status | Value | Salinity | Standard | Regulation |
|---|---|---|---|---|---|---|
| DIN (mg/l N) | Coastal & Transitional | Good | ≤ 0.25 | 34.5 psu | Median | Environmental Objectives (Surface Waters) Regulations 2009 |
| MRP (mg/l P) | Transitional | - | ≤ 0.04 | 35 psu | Median | |
| BOD (mg/l $O_2$) | Coastal | - | ≤ 4.00 | - | 95% | |
| COLI (/100ml) | Transitional & Coastal | Good<br>Sufficient | 500 | - | 95%<br>90% | Bathing Water Quality Regulations 2008 |

Decay Coefficients

In order to more accurately simulate the behaviour of the nutrients and bacteria in the coastal waters over time, a constant empirical decay rate for each parameter was introduced. The decay rate acted as a proxy for modelling the complex biogeochemical reactions that the nutrient parameters experience.

The decay rates specified to the model for each parameter are detailed in Table 8.15, and were consistent with values used for the Ringsend WwTP Upgrade Project EIAR (Irish Water 2018) so that any in-combination effects between both the Proposed Project and the Ringsend WwTP Upgrade Project could be accurately assessed.

**Table 8.15: Parameter Decay Rates**

| Parameter | Decay Rate |
|---|---|
| Dissolved Inorganic Nitrogen (DIN) | $6.75 \times 10^{-7}$ counts (c)/sec |
| Molybdate Reactive Phosphate (MRP) | $4.05 \times 10^{-7}$ c/sec |
| Biochemical Oxygen Demand (BOD) | $1.16 \times 10^{-6}$ c/sec |
| Escherichia coliform (COLI) | $1.47 \times 10^{-5}$ c/sec |

## 8.3 Baseline Environment

### 8.3.1 Hydrography

The proposed outfall pipeline route (marine section) discharge point will be located approximately 1km to the north-east of Ireland's Eye off the coast of north Dublin. The coastline of north Dublin from Howth Head runs in an east to west direction approximately 4.5km towards Baldoyle Estuary, thereafter continuing in a predominantly south to north direction approximately 21km due north to Skerries. This stretch of coastline features three prominent estuaries: Baldoyle Bay Estuary, Malahide Estuary and Rogerstown Estuary.

Baldoyle Bay extends from just below Portmarnock village to the west pier at Howth, Dublin. It is a tidal estuarine bay protected from the open sea by a large sand dune system. Two small rivers, the Mayne River and the Sluice River, flow into the inner part of the Baldoyle Bay Estuary. Large areas of intertidal flats are exposed at low tide. These are mostly sands but grade to muds in the inner sheltered parts of the estuary.

Malahide Estuary is situated between the towns of Malahide and Swords. The site encompasses the Malahide Estuary, saltmarsh habitats and shallow subtidal areas at the mouth of Malahide Estuary. A railway viaduct, built in the 1800s, crosses the site and has led to the inner estuary becoming lagoonal in character and only partly tidal. Much of the outer part of Malahide Estuary is well-sheltered from the sea by a large sand spit, known as ‘The Island’. This spit is now mostly converted into a golf course. The outer part empties almost completely at low tide and there are extensive intertidal flats exposed.

Rogerstown Estuary is situated about 2km north of Donabate in north Dublin. It is a relatively small, funnel-shaped estuary separated from the sea by a sand and shingle peninsula and extending eastwards beyond the low water mark to include an area of shallow marine water. Rogerstown Estuary receives the waters of the Ballyboghil River and Ballough River, both of which flow through intensive agricultural catchments. Rogerstown Estuary has a wide salinity range, from near full sea water to near full freshwater, and is divided by a causeway and narrow bridge, built in the 1840s to carry the Dublin-Belfast railway line. At low tide, extensive intertidal sand and mud flats are exposed. The intertidal flats of Rogerstown Estuary are mainly sands, with soft muds in the north-west sector and along the southern shore. A salt marsh fringes parts of Rogerstown Estuary, especially its southern shores.

Offshore are a number of islands: Ireland’s Eye approximately 1.5km north of Howth; Lambay Island approximately 4km east of Portrane; Rockabill Islands approximately 7km west to north-west of Skerries; and the cluster of Colt, Shenick and St. Patrick’s Islands located between 0.5km to 1.5km east of Skerries.

Ireland's Eye is an uninhabited island located about 1.5km north of Howth in Dublin and has an area of approximately 24ha above the high tide mark. The underlying geology is Cambrian greywackes and quartzites. These rocks form impressive near-vertical cliffs, reaching 69m, along the northern and eastern sides of the island, with scattered exposures elsewhere on the island and especially in the high northern half. A tall stack, which is completely cut off from the main island at mid to high tide, occurs at the eastern side of the cliffs. A sandy beach, backed by low sand hills, occurs at Carrigeen Bay on the western shore, while a shingle beach extends from Carrigeen to Thulla Rocks. Elsewhere, the island is covered by glacial drift. A low-lying, sparsely vegetated islet, known as Thulla, occurs a little to the south of the island, and an extensive area of bedrock shore (heavily covered by brown seaweeds) is exposed at low tide between Thulla and the main island. There are no watercourses or springs on the island, though two small rainwater ponds form during winter in the north-west and north-east sectors.

Lambay Island lies approximately 4km off the north Dublin coastline and is separated from it by a channel of 10m to 13m in depth. East of Lambay, the water deepens rapidly into the Irish Sea basin. The island has an area of 250ha above high tide mark. The island is well raised above sea level, with about two-thirds above the 50m contour. On the western side of the island, the land rises gently from a bedrock shoreline. Cobble storm beaches are associated with this shore, and at low tide, sandflats are exposed within the harbour and below a section of the rocky shore. The northern, eastern and most of the southern shorelines consist of steep cliffs varying from about 15m to 50m. These are backed by vegetated slopes along most of their length. Several small streams occur.

Rockabill Islands consist of two small, low-lying, granitic islets situated approximately 7km off the Dublin coast. The islands are separated by a narrow channel, although they are connected at low spring tides. The main island is known as the Lighthouse Island, with the smaller island known as the ‘Bill’.

The Skerries Islands are a group of three small uninhabited islands situated between 0.5km and 1.5km off the north Dublin coast. Shenick Island and St. Patrick’s Island are of similar size, with Colt Island being somewhat smaller. All are low-lying islands, with maximum heights from 8m to 13m above sea level. St Patrick’s Island and Colt Island have low cliffs, while Shenick Island has more extensive expanses of intertidal rocky shores and sand flats. Shenick also has a shingle bar and is connected to the mainland at low tides.

The coast of north Dublin slopes gently away from the shoreline out to depths of approximately 10m to 15m below chart datum before rising again towards Lambay Island. Directly to the east of Howth Head, the depth increases to 35m below chart datum before rising again to approximately 15m below chart datum to meet the

Bennet Bank, which runs in a north-south direction from Lambay Island to the Kish Bank off the south coast of Dublin.

### 8.3.2 Hydrographic Monitoring

With the purpose of providing data for calibration and verification of a numerical model, two current measurement campaigns were conducted off the north Dublin coastline. The first survey was undertaken between 12 July 2012 and 23 August 2012. The second survey was undertaken between 20 April 2015 and 19 June 2015. The first survey deployed two tide gauges, one each at Skerries and Howth, with three ADCPs deployed on the seabed: north of Ireland's Eye, west of Lambay Island, and south-east of Skerries. In addition, a series of dye and drogue surveys were undertaken to map the transport pathways. The tide gauges recorded the water surface level at 10-minute intervals throughout the course of the hydrographic survey. The ADCPs recorded the speed and direction of the water currents at different depths in the water column.

The second survey deployed one tide gauge at Howth, and two ADCPs were also deployed on the seabed north and north-west of Ireland's Eye. In addition, a series of dye surveys were undertaken to map the transport pathways. The data from both survey campaigns were used to develop and calibrate the three-dimensional hydrodynamic and transport numerical model which forms part of this study. The locations of the ADCPs and tide gauges deployed during the survey campaigns are displayed in Figure 8.5 Calibration Locations.

The predominant current direction off the coast of Ireland's Eye is in a north-west to south-east direction for both neap and spring tides. Maximum speeds of 0.88m/s were recorded by the drogues during flooding neap tides, having travelled a total distance of just over 3km during their 58-minute float time. Maximum speeds of 0.84m/s were recorded by the drogues during ebbing spring tides, having travelled a total distance of just under 3km during their 55-minute float time.

The predominant current direction off the coast of Skerries is in a north-south direction for both neap and spring tides. Maximum speeds of 0.56m/s were recorded by the drogues during flooding neap tides, having travelled a total distance of just over 2km during their 54-minute float time. Maximum speeds of 0.90m/s were recorded by the drogues during ebbing spring tides, having travelled a total distance of just under 2.5km during their 46-minute float time.

The tidal currents in the Irish Sea offshore of Dublin are north/south caused by the tidal wave propagating northwards during the flood tide and southward during the ebbing tide. The tides at Dublin Port and those along the north Dublin coastline are semi-diurnal; that is, they exhibit two high tides and two low tides each day. The range of mean spring and neap tides at Howth Harbour (low water to high water) is 3.6m and 2m respectively (United Kingdom Hydrographic Office 2008). The time of high and low water varies from place to place as the wave moves along the coast; for the purposes of this study, all times relate to high water at Dublin Port.

### 8.3.3 River Catchments

North Dublin is split between Hydrometric Area No. 09 (Liffey & Dublin Bay) and Hydrometric Area No. 08 (Nanny-Delvin). The principal rivers that discharge to the north Dublin coastline are the above mentioned Mayne River, Sluice River, Ward River, Broadmeadow River, Turvey River, Ballyboghil River, Ballough River and Mill Stream. The catchment areas and long-term average flows in the rivers are detailed above.

### 8.3.4 Water Quality

The water quality of the waters off the coast of north Dublin and the main rivers that discharge to it are discussed in this section, under the following headings:

- WFD Status Classification;
- Bathing Waters; and
- Trophic Status.

Water Framework Directive Status Classification

The status of a water body is determined by combining assessment results for biological, chemical and physicochemical quality elements in the manner prescribed by the WFD. The ecological status of natural surface waters falls into one of five classes: high, good, moderate, poor or bad.

The EPA have completed a WFD classification of transitional and coastal waters for the period 2010 to 2015. The location of the waterbodies and their associated classification is shown in Figure 8.11 Ecological Status.

The coastal waters of HA 09 (Irish Sea-Dublin) from Howth Head to Malahide Bay have a status of “Unassigned”. The coastal waters of Dublin Bay and HA 08 (Northwestern Irish Sea) from Malahide Bay north have a status of “Good”. The coastal waters of Malahide Bay have a status of “Moderate”.

The transitional water body of the Mayne Estuary has a status of “Unassigned”. The transitional waterbody of the Broadmeadow Estuary has a status of “Moderate”, and Rogerstown Estuary has a status of “Bad”.

Bathing Waters

Under the Bathing Water Quality Regulations 2008, eight stretches of beach have been designated as bathing water protected areas along the north Dublin coastline:

- Claremont Beach is a sandy, gently sloping north-facing beach located in the WFD Mayne-Santry Coastal/Coastal Howth catchment area. Claremont Beach is classified as achieving good water quality status based on the assessment of bacteriological results for the period 2013 to 2016. Claremont Beach was also classified as achieving good water quality status during the previous assessment periods 2012 to 2015 and 2011 to 2014 (EPA 2017f);
- Sutton, Burrow Beach is located on the north side of Burrow Road, between Sutton and Howth. Sutton Burrow Beach is a sandy, gently sloping beach facing mainly to the north and is adjacent to Baldoyle Estuary. Sutton, Burrow Beach is classified as achieving excellent water quality status based on the assessment of bacteriological results for the period 2013 to 2016. Sutton, Burrow Beach was also classified as achieving excellent water quality status during the previous assessment periods 2012 to 2015 and 2011 to 2014 (EPA 2017g);
- Portmarnock, Velvet Strand Beach is approximately 1.5km from Portmarnock town centre. Bathing water quality monitoring has been carried out at Portmarnock since 1996. Portmarnock, Velvet Strand Beach is classified as achieving excellent water quality status based on the assessment of bacteriological results for the period 2013 to 2016. Portmarnock, Velvet Strand Beach was also classified as achieving excellent water quality status during the previous assessment periods 2012 to 2015 and 2011 to 2014 (EPA 2017h);
- Donabate, Balcarrick Beach is located in the Delvin/Coastal-Coastal Donabate catchment area. Donabate, Balcarrick Beach is a south-east facing, gently sloping sandy beach consisting of a large sandy dune area. Bathing water quality monitoring has been carried out at Donabate, Balcarrick Beach since 1996. Donabate, Balcarrick Beach is classified as achieving good water quality status based on the assessment of bacteriological results for the period 2013 to 2016. Donabate, Balcarrick Beach was classified as achieving excellent water quality status during the previous assessment periods 2012 to 2015 and 2011 to 2014 (EPA 2017i);

- Portrane, Brook Beach is a gently sloping beach, on the seaward side of the sand and shingle bar that comprises Portrane Peninsula. The Brook Beach extends to the north and becomes the Burrow Beach, which is made up of a series of sand dune ridges running from north to south. Bathing water quality monitoring has been carried out at Portrane, Brook Beach since 1996 and is classified as having poor water quality status based on the assessment of bacteriological results for the period 2013 to 2016. Consequently, an 'advice against bathing' restriction applies at the bathing water for the 2017 season. Portrane, Brook Beach was classified as achieving good water quality status during the previous assessment period 2012 to 2015 and excellent water quality status during the period 2011 to 2014 (EPA 2017j);
- Rush, South Beach is a gently sloping sandy beach located in the Delvin – Coastal/Coastal Skerries WFD catchment area. A local stream discharges occasionally (and generally outside the bathing season) into the identified bathing water. Bathing water quality monitoring has been carried out at Rush, South Beach since 1996. Rush, South Beach is classified as achieving sufficient water quality status based on the assessment of bacteriological results for the period 2013 to 2016. Rush, South Beach was classified as having poor water quality status during the previous assessment periods 2012 to 2015 and 2011 to 2014 (EPA 2017k);
- Rush, North Beach lies to the north-east of Rush town and is a gently sloping sandy beach. Rush, North Beach was newly identified in 2016 as a beach for monitoring, management and assessment under the requirements of the Bathing Water Quality Regulations 2008 (S.I. No. 79 of 2008). Rush, North Beach is assigned 'New' status until monitoring results of at least the minimum number of required samples (16) are available over a four-year period to undertake water quality classification (EPA 2017l); and
- Loughshinny Beach is located in the Delvin – Coastal/Coastal Skerries WFD catchment area and is a small, sandy and sheltered cove-like beach which gently slopes to the sea. Bathing water quality monitoring has been carried out at Loughshinny Beach since 1996. Loughshinny Beach is classified as having poor water quality status based on the assessment of bacteriological results for the period 2013 to 2016. Consequently, an 'advice against bathing' restriction applies at the beach for the 2017 season. Loughshinny Beach was also classified as having poor water quality status during the previous assessment period 2012 to 2015 and sufficient water quality status during the period 2011 to 2014 (EPA 2017m).

Each of the previously mentioned beaches are all located in the coastal waters, and the locations are shown in Figure 8.12 Quality of Bathing Waters which reflects the EPA's monitoring point for each site and compliance status. Bathing waters can be classified as 'Excellent', 'Good', 'Sufficient' and 'Poor' under the Bathing Water Quality Regulations, as described previously.

Blue Flag beaches are selected through strict criteria dealing with water quality, environmental education and information, environmental management, and safety and other services. The only beach in north Dublin awarded Blue Flag status for 2017 was Portmarnock Velvet Strand Beach (EPA 2017h).

Trophic Status

In Ireland, the presence of eutrophication is assessed by the EPA using the Trophic Status Assessment Scheme (EPA 2017n). The scheme compares the compliance of individual parameters against a set of criteria indicative of trophic state. These criteria fall into three different categories which broadly capture the cause-effect relationship of the eutrophication process, namely nutrient enrichment, accelerated plant growth, and disturbance to the level of dissolved oxygen normally present. Based on criteria levels of nutrient enrichment (DIN and MRP), chlorophyll levels and percentage saturation of dissolved oxygen, the trophic status of the water can be classified into 'eutrophic', 'potentially eutrophic', 'intermediate' and 'unpolluted' based on the following:

- Eutrophic water bodies are those in which criteria in each of the categories are breached;

- Potentially eutrophic water bodies are those in which criteria in two of the categories are breached and the third falls within 15% of the relevant threshold value;
- Intermediate status water bodies are those which breach one or two of the criteria; and
- Unpolluted waterbodies are those which do not breach any of the criteria in any category.

The coastal waters of Dublin Bay, HA 09 (Irish Sea-Dublin) from Howth Head to Malahide Bay, and HA 08 (Northwestern Irish Sea) from Malahide Bay north have a status of ‘unpolluted’. The coastal waters of Malahide Bay have a status of ‘intermediate’.

The transitional water bodies of the Mayne Estuary, Broadmeadow Estuary and Rogerstown Estuary have a status of ‘eutrophic’.

The outcome of the most recent Trophic Status Assessment Scheme of estuarine and coastal waters for the period 2010 to 2015 is presented in Figure 8.13 Trophic Status.

## 8.4 Impact of the Proposed Project

### 8.4.1 Construction – Dredging of the Proposed Outfall Pipeline Route (Marine Section) Trench

The dredging of the proposed outfall pipeline route and casting of the spoil within the route corridor was assessed over a 78-day period, from 1 March to 30 April. The simulated placement of dredged material from split-hull hopper barges was defined as a discrete discharge on flood tides (at intervals of approximately 12.25hrs).

The physical processes governing the discharge of dredged spoil material followed a three-step process:

- Convective descent, during which the material falls under the influence of gravity;
- Dynamic collapse, occurring when the descending cloud impacts the bottom; and
- Passive transport-dispersion, commencing when the material transport and spreading are determined more by ambient currents than by the dynamics of the placement operation.

The near instantaneous simulated placement of dredged material in the relatively shallow waters along the proposed pipeline route produces a rapid convective descent of the material. During the convective descent phase, it was found that the bulk of the dredged material fell in a dense jet directly to the bottom with only minor losses to the water column as the released dredged material possessed an initial downward momentum and a density greater than that of the surrounding water.

Diagram 8.3 presents the percentage of time during the dredging operation that suspended sediment concentrations at the water’s surface were predicted to exceed 10mg/l in each of the modelled grid cells. It occurred for a maximum of 0.2% (3.74hrs) of the dredging operation period.

Diagram 8.4 presents the percentage of time during the dredging operation that suspended sediment concentrations in the middle of the water column were predicted to exceed 10mg/l in each of the modelled grid cells, with a maximum of 0.5% (9.36hrs) of the dredging operation period.

Diagram 8.5 presents the percentage of time during the dredging operation that suspended sediment concentrations in the bottom layer were predicted to exceed 10mg/l in each of the modelled grid cells, with a maximum of 0.8% (14.97hrs) of the dredging operation period.

Diagram 8.6 presents the percentage of time during the dredging operation that suspended sediment concentrations at the water’s surface were predicted to exceed 100mg/l in each of the modelled grid cells, in all cases 0% of the time.

Diagram 8.7 presents the percentage of time during the dredging operation that suspended sediment concentrations in the middle of the water column were predicted to exceed 100mg/l in each of the modelled grid cells, with a maximum of 0.3% (5.61hrs) of the dredging operation period.

Diagram 8.8 presents the percentage of time during the dredging operation that suspended sediment concentrations in the bottom layer were predicted to exceed 100mg/l in each of the modelled grid cells, with a maximum of 0.5% (9.36hrs) of the dredging operation period.

Measurements of background total suspended solids made between 2015 and 2017 in the receiving waters were between 15mg/l and 50mg/l for the majority of the time.

The suspended sediments from each individual placement operation were predicted to dissipate to background levels within the 12.25hr period between the placement operations on flooding tides.

The diagrams show that there was predicted to be a brief but recurring effect during the course of the dredging operations but that it would be of negligible impact when compared to the natural variability of total suspended solid concentrations in the receiving waters.

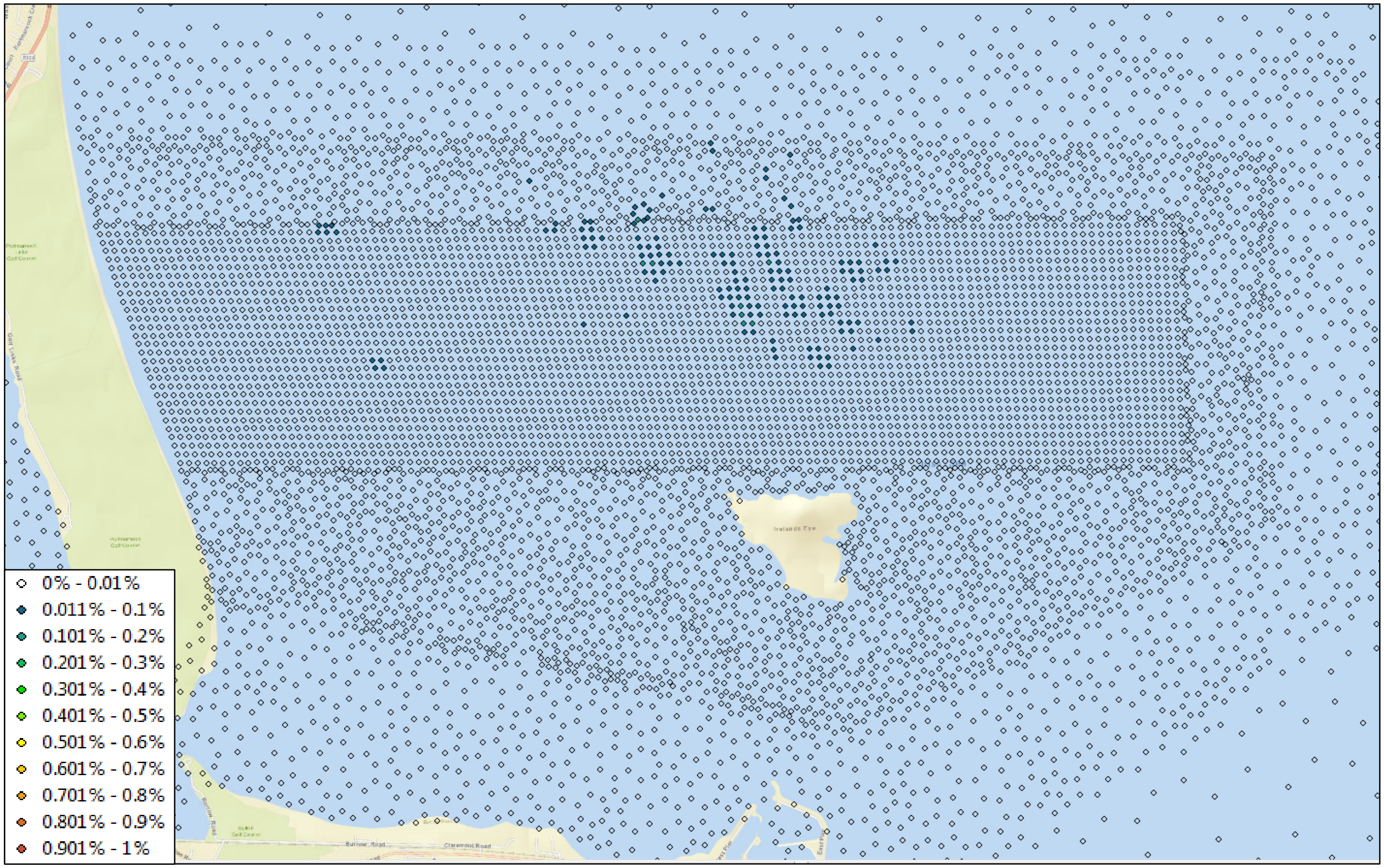



**Diagram 8.3: Percentage of Time During Dredging Operation that Suspended Sediment Concentrations Exceed 10mg/l at Water Surface**

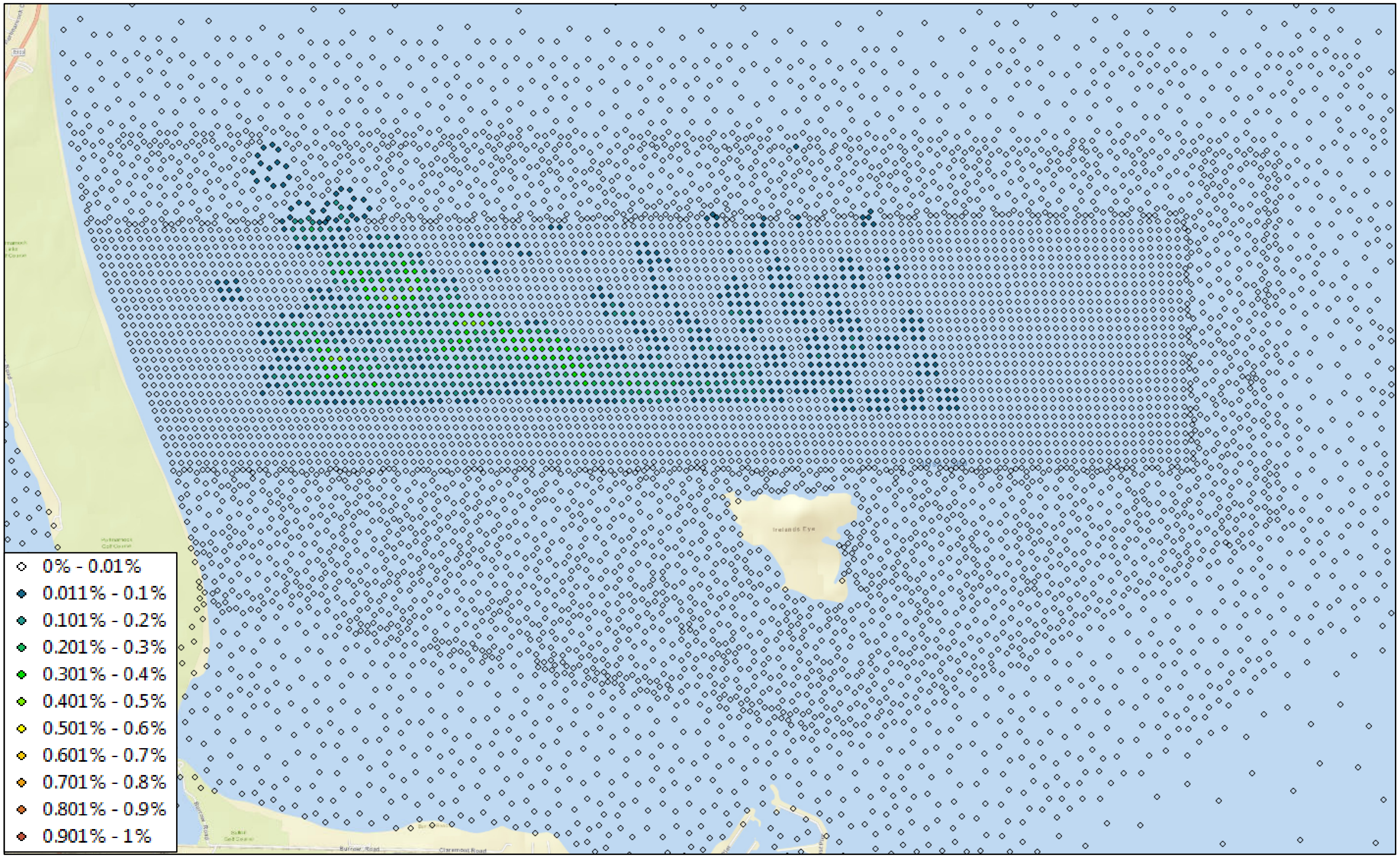



**Diagram 8.4: Percentage of Time During Dredging Operation that Suspended Sediment Concentrations Exceed 10mg/l in Mid Water Column**

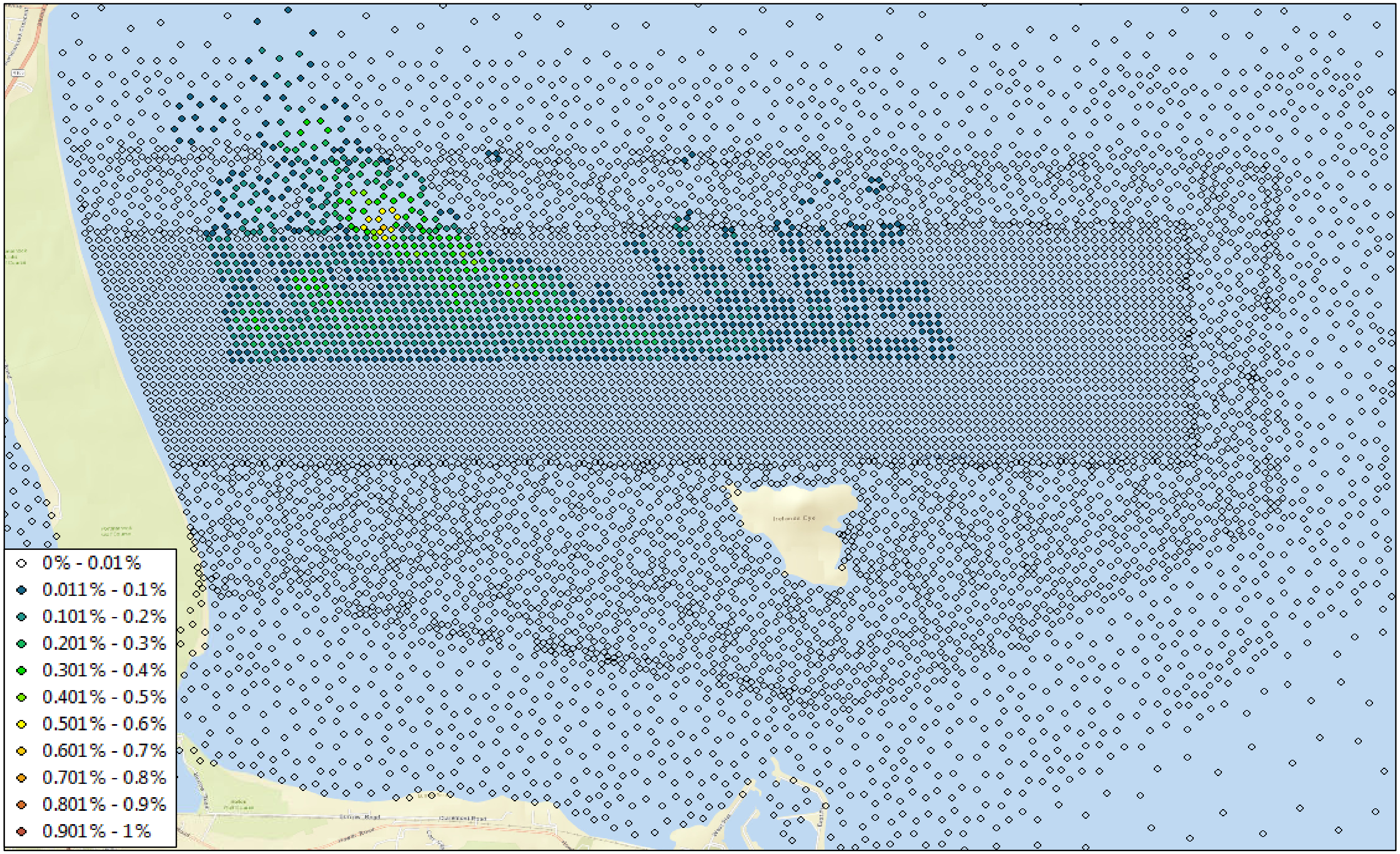



**Diagram 8.5: Percentage of Time During Dredging Operation that Suspended Sediment Concentrations Exceed 10mg/l Near Seabed**

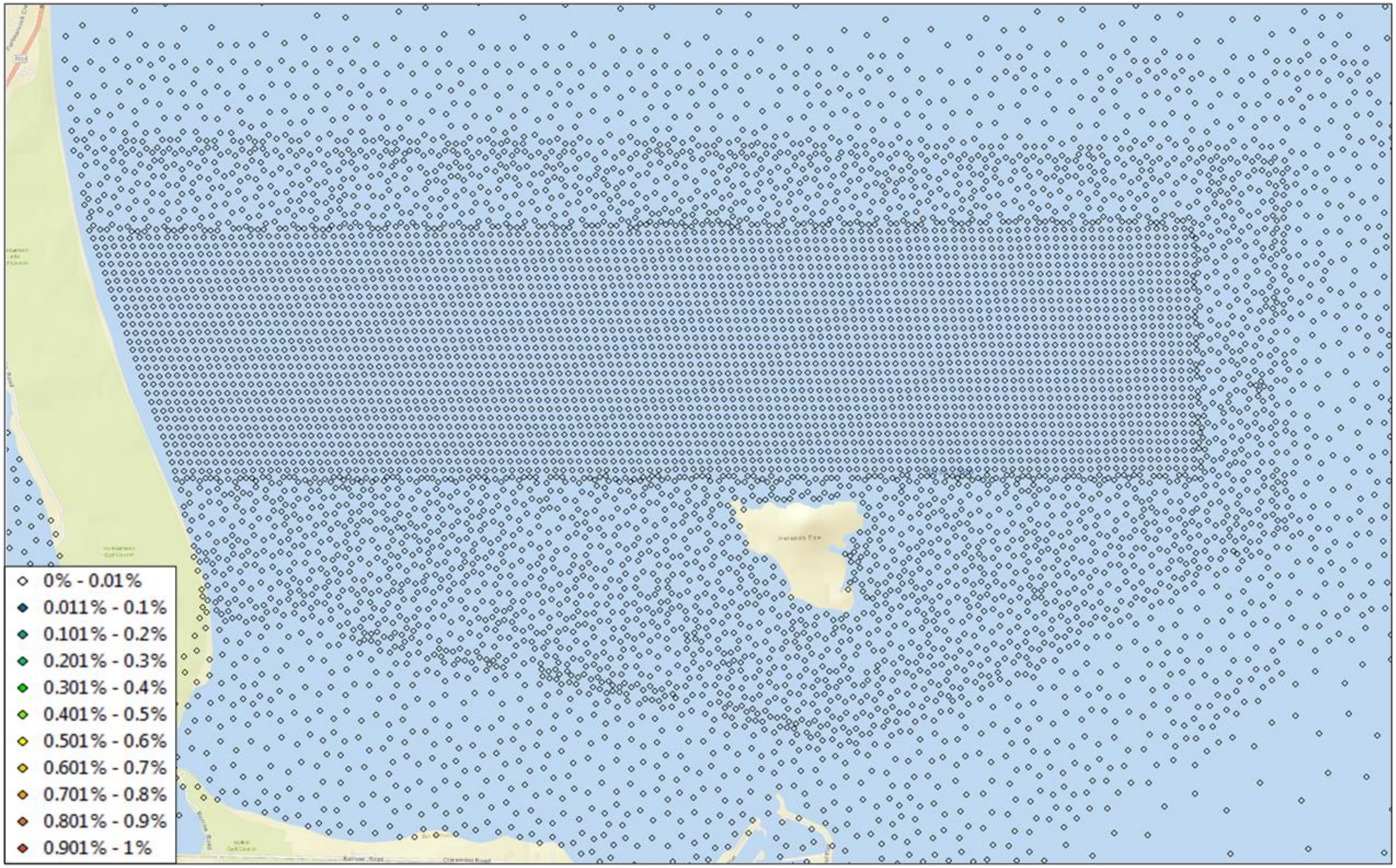



**Diagram 8.6: Percentage of Time During Dredging Operation that Suspended Sediment Concentrations <u>Exceed 100mg/l</u> at the Water Surface**

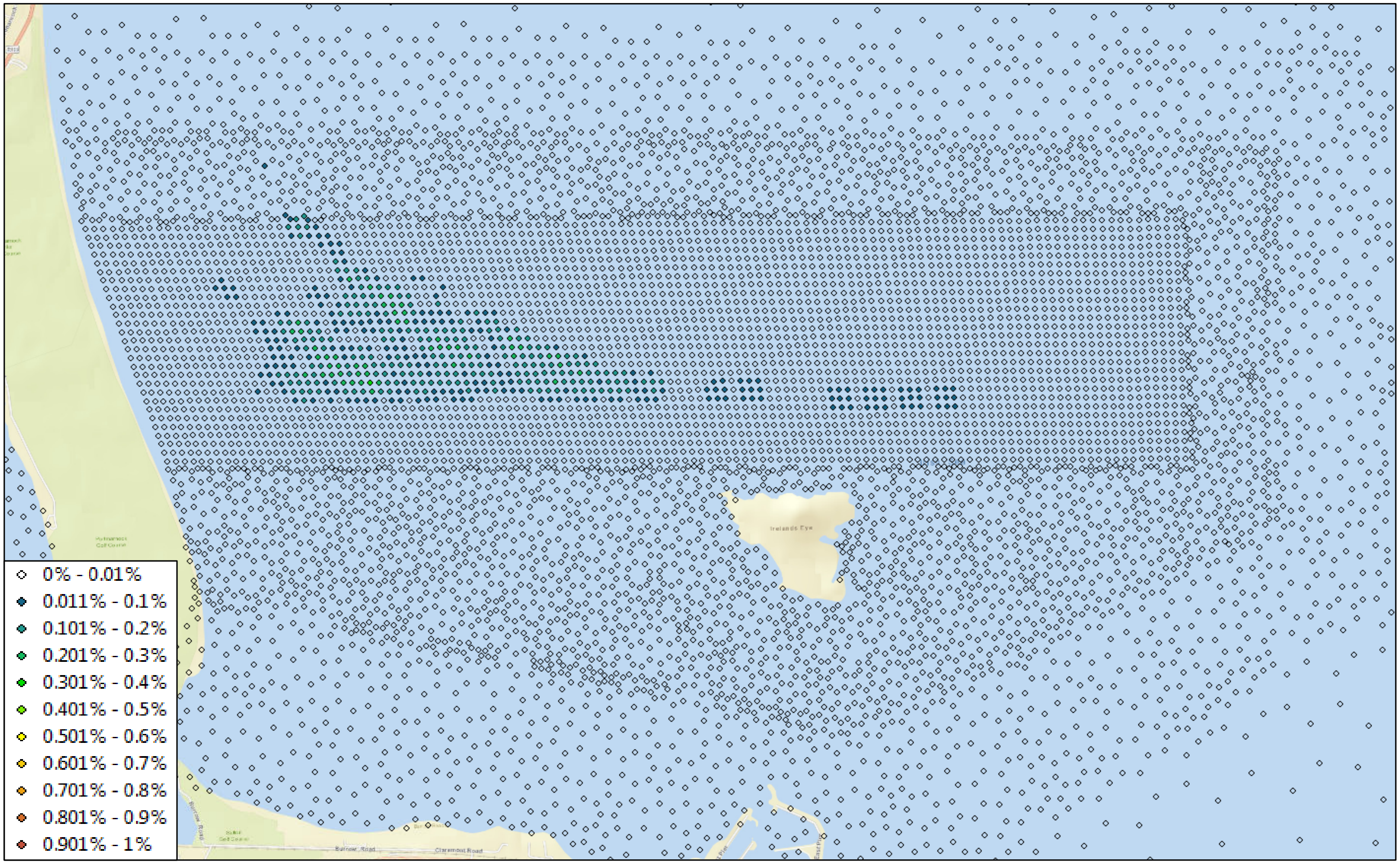



**Diagram 8.7: Percentage of Time During Dredging Operation that Suspended Sediment Concentrations <u>Exceed 100mg/l</u> in Mid Water Column**

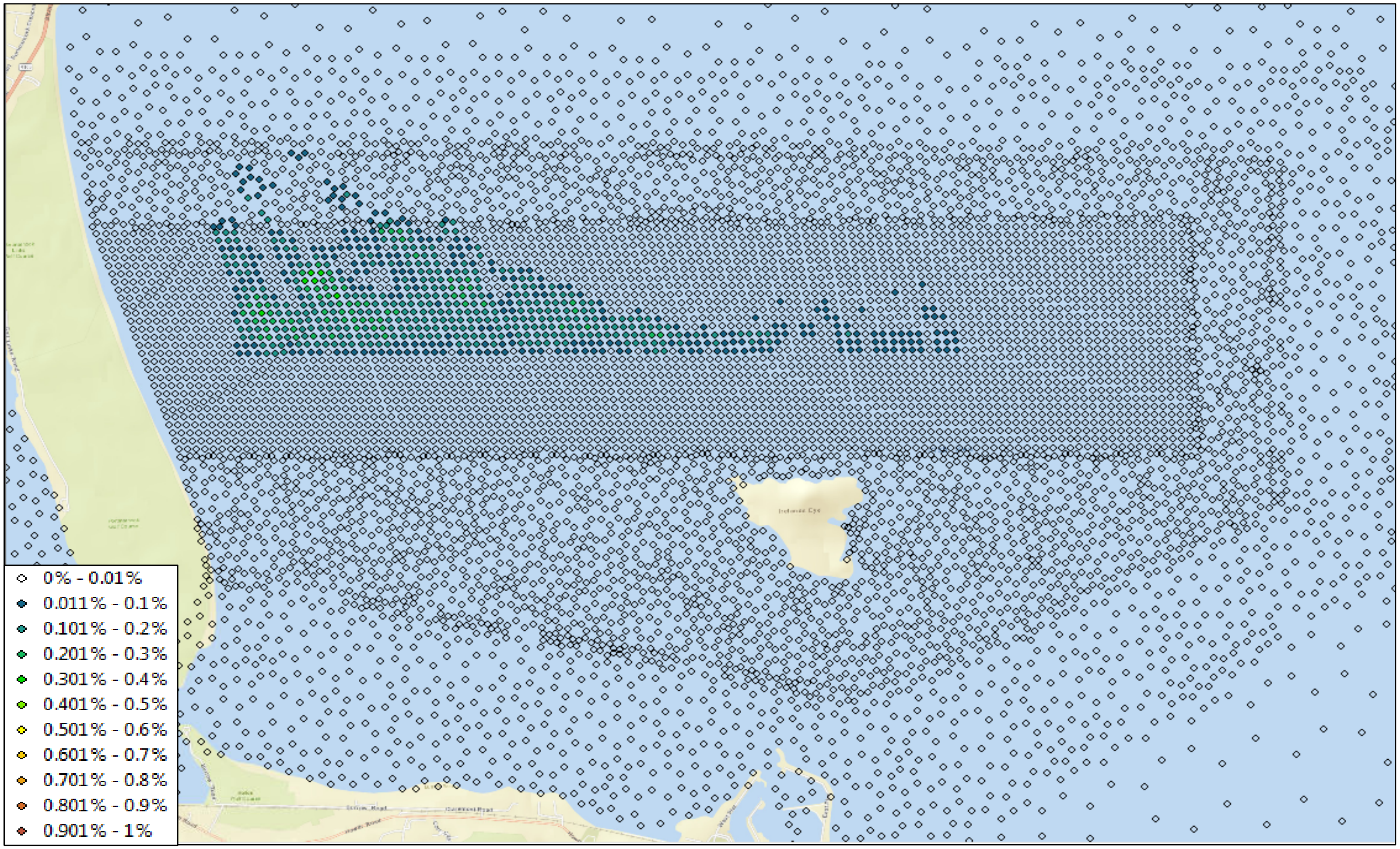



**Diagram 8.8: Percentage of Time During Dredging Operation that Suspended Sediment Concentrations Exceed 100mg/l Near Seabed**

### 8.4.2 Proposed Wastewater Treatment Plant – Operational Phase

Following the construction of the proposed WwTP, the only impact on water quality will be due to the treated wastewater discharge, or the potential discharge of untreated wastewater for a very short duration owing to a pumping failure in the proposed WwTP. The predicted results of the proposed discharge for the average daily flow conditions, FFT conditions and pumping failure scenario are presented in this section.

The modelling results of each parameter (DIN, MRP, BOD and COLI) are presented as the average concentration over the depth of the water column for each scenario at four stages of both a neap tide and spring tide, namely high water, mid ebb, low water and mid flood.

Dissolved Inorganic Nitrogen

The Environmental Objectives Regulations 2009 set a median concentration limit for DIN at ≤0.17mg/l N in coastal and transitional waters to achieve high status.

The Environmental Objectives Regulations 2009 set a median concentration limit for DIN at ≤0.25mg/l N in coastal and transitional waters to achieve good status.

In the diagrams below, all coloured areas correspond to where the DIN concentrations in the water were predicted to exceed the high status limit of ≤0.17mg/l N.

*Average Daily Flow*

The tidal plots showing the maximum extent of the predicted DIN plume from the proposed outfall pipeline route (marine section) discharge point at high water, mid ebb, low water and mid flood on neap tides are presented in Diagram 8.9 to Diagram 8.12 and on spring tides in Diagram 8.13 to Diagram 8.16. None of the diagrams show the DIN plume from the proposed outfall pipeline route (marine section) discharge point exceeding the 0.17mg/l N limit required to achieve high status nor the 0.25mg/l N limit required to achieve good status. Elevated DIN levels in the transitional waters displayed in the diagrams result from other WwTPs or rivers directly discharging to the affected waters. The diagrams show that there was predicted to be no impact on the receiving waters from the proposed operation of the proposed outfall pipeline route (marine section) discharge point for average daily discharge conditions.

*Flow to Full Treatment*

The tidal plots showing the maximum extent of the predicted DIN plume from the proposed outfall pipeline route (marine section) discharge point at high water, mid ebb, low water and mid flood on neap tides are presented in Diagram 8.17 to Diagram 8.20 and on spring tides in Diagram 8.21 to Diagram 8.24. The diagrams show the DIN plume from the proposed outfall pipeline route (marine section) discharge point exceeding the 0.17mg/l N limit required to achieve high status but does not exceed the 0.25mg/l N limit required to achieve good status. Elevated DIN levels in the transitional waters displayed in the diagrams result from other WwTPs or rivers directly discharging to the affected waters. The diagrams show that there was predicted to be a Slight impact on the receiving waters, local to the proposed outfall pipeline route (marine section) discharge point for FFT conditions.

*Process Failure*

The tidal plots showing the maximum extent of the predicted DIN plume from the proposed outfall pipeline route (marine section) discharge point at mid ebb, low water, mid flood and high water on the last tide of the three-day simulated process failure scenario are presented in Diagram 8.25 to Diagram 8.28.

The diagrams show the DIN plume from the proposed outfall pipeline route (marine section) discharge point was predicted to exceed the 0.25mg/l N limit required to achieve good status at two stages of the tide at the proposed outfall pipeline route (marine section) discharge point, during the high and low slack water stages of the tide with least mixing. The 0.25mg/l N limit was not exceeded during mid flood or ebb tides. Elevated DIN levels in the transitional waters displayed in the diagrams result from other WwTPs or rivers directly discharging to the affected waters. The diagrams show that there was predicted to be a Slight impact on the receiving waters, local to the proposed outfall pipeline route (marine section) discharge point, from the proposed operation of the outfall discharge during a simulated process failure in the plant.

None of the scenarios examined predicted the likelihood of any significant impact on the receiving waters from the operation of the proposed outfall pipeline route (marine section).

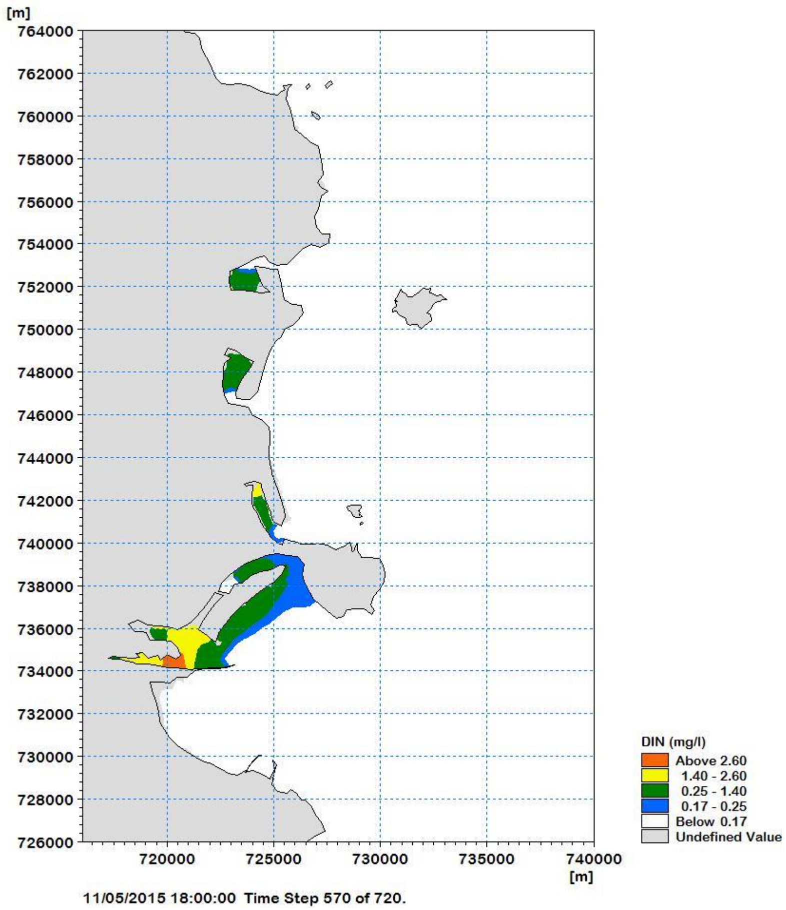



Diagram 8.9: DIN Concentration at High Water on Neap Tide

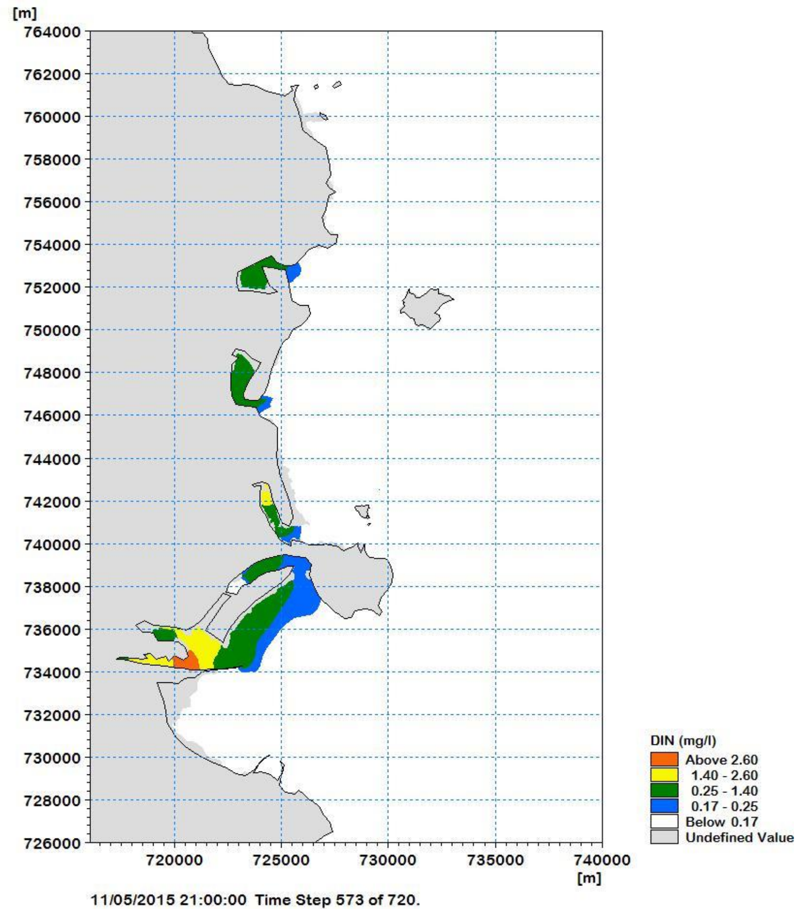



Diagram 8.10: DIN Concentration at Mid Ebb on Neap Tide

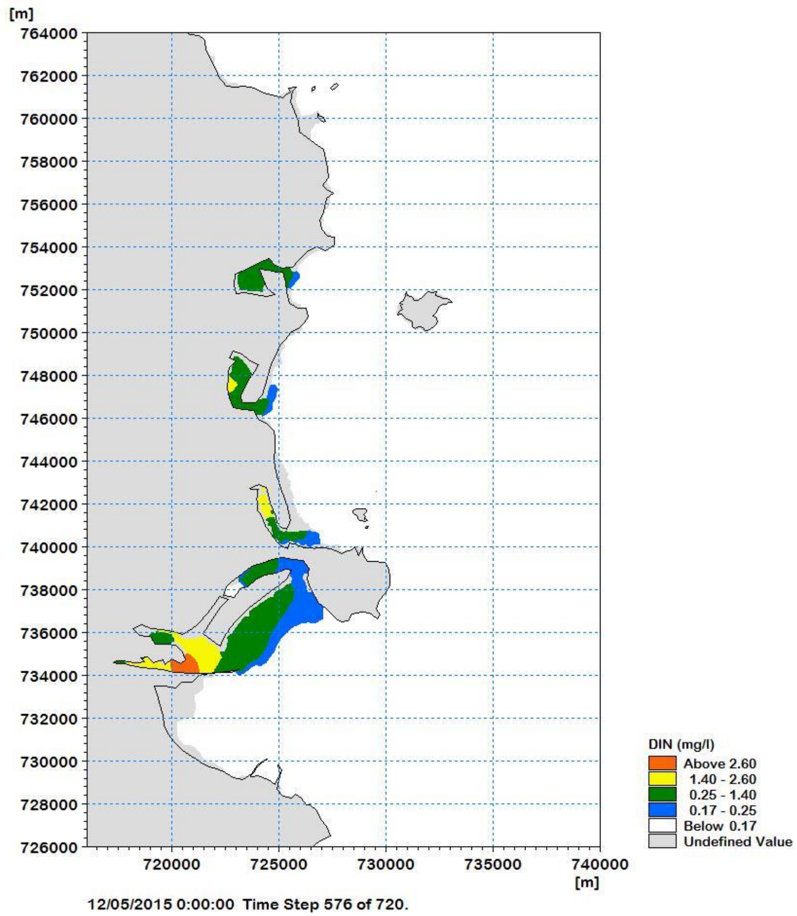



**Diagram 8.11: DIN Concentration at Low Water on Neap Tide**

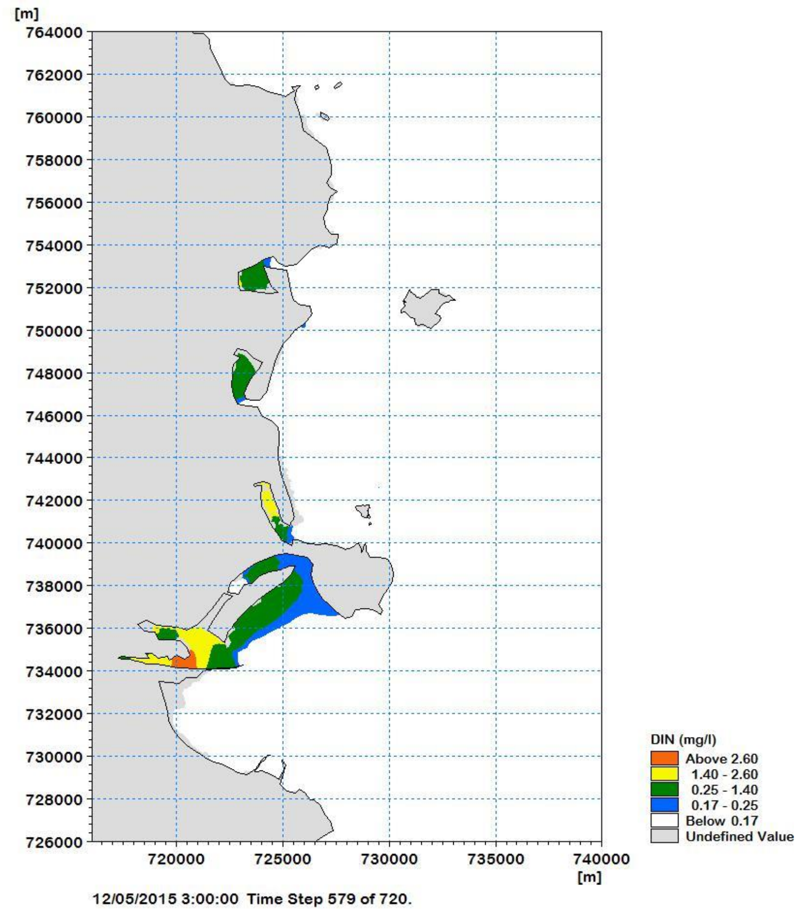



**Diagram 8.12: DIN Concentration at Mid Flood on Neap Tide**

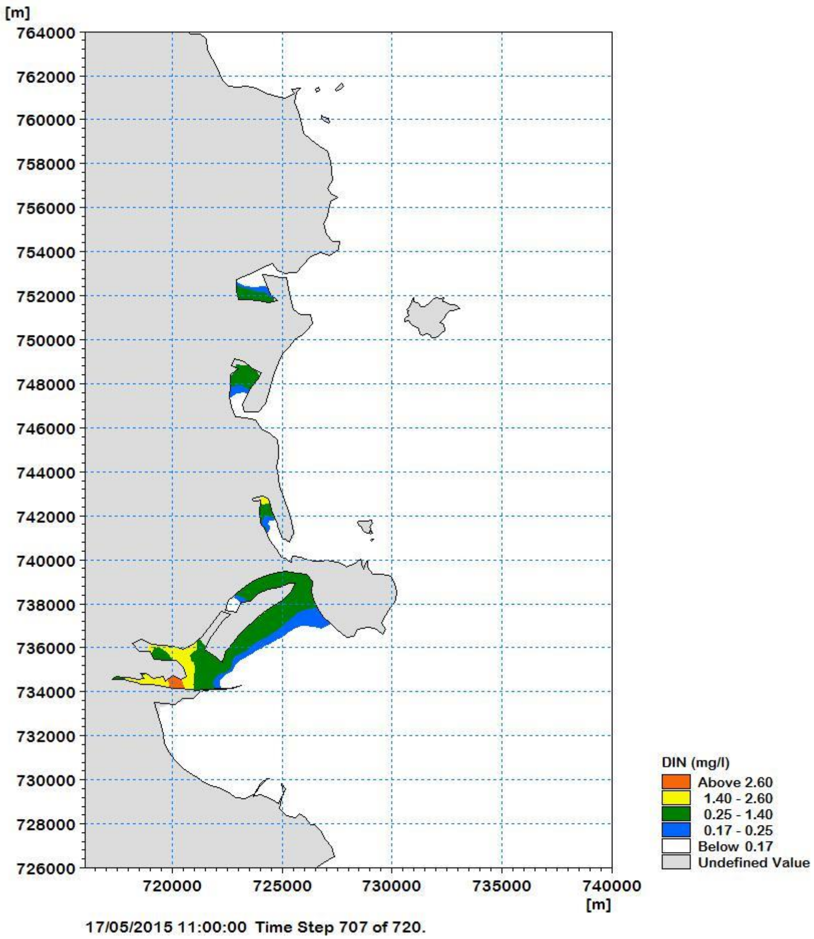



**Diagram 8.13: DIN Concentration at High Water on Spring Tide**

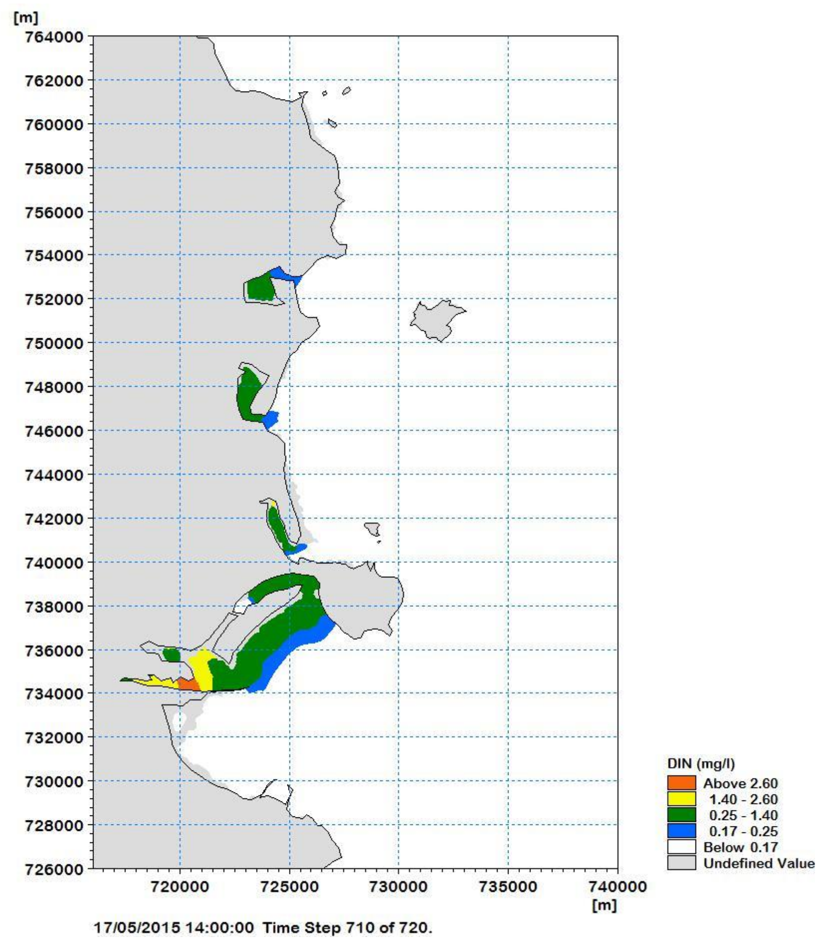



**Diagram 8.14: DIN Concentration at Mid Ebb on Spring Tide**

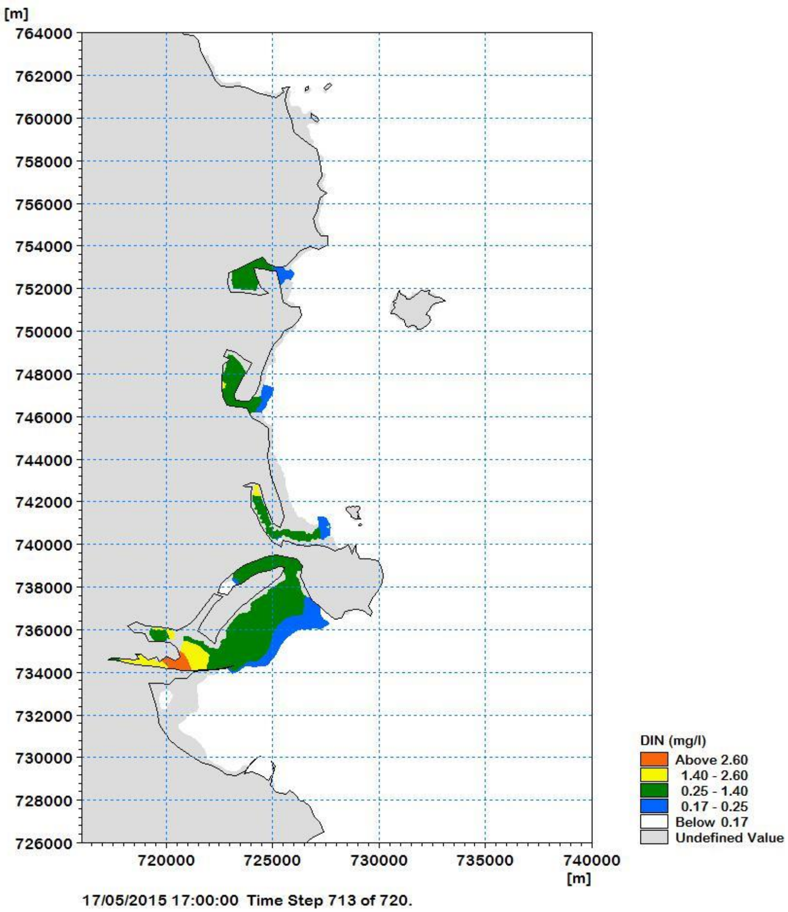



**Diagram 8.15: DIN Concentration at Low Water on Spring Tide**

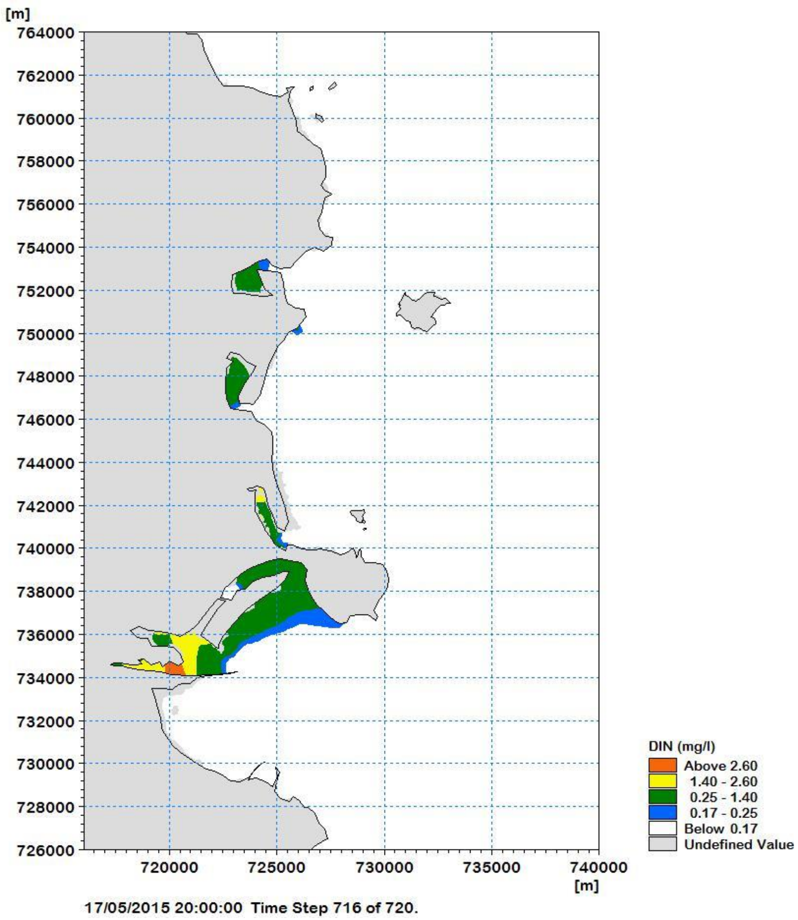



**Diagram 8.16: DIN Concentration at Mid Flood on Spring Tide**

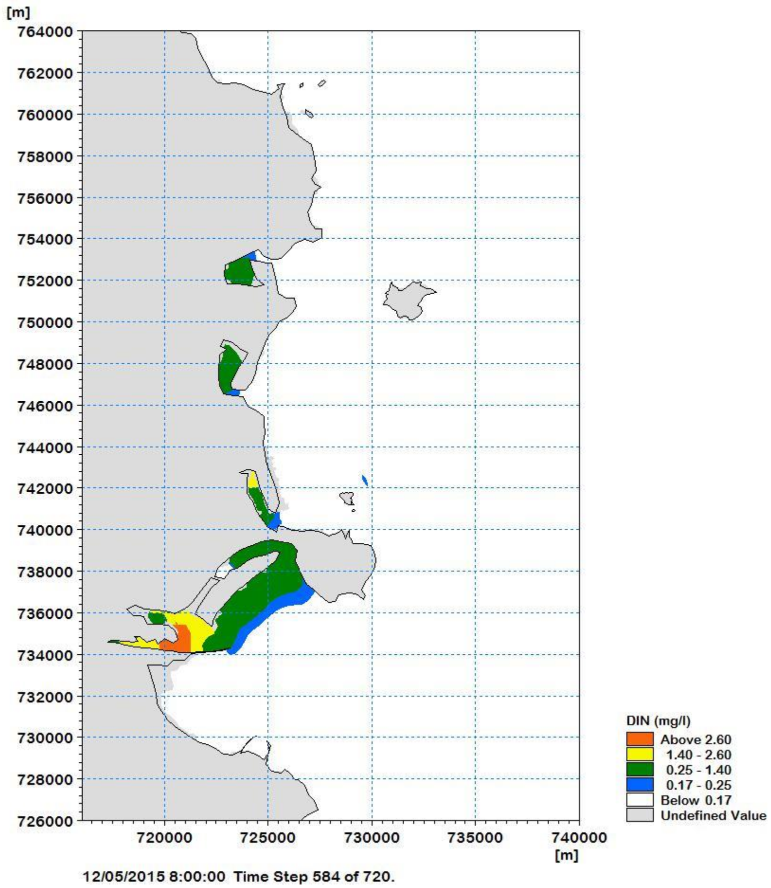



**Diagram 8.17: DIN Concentration at High Water on Neap Tide**

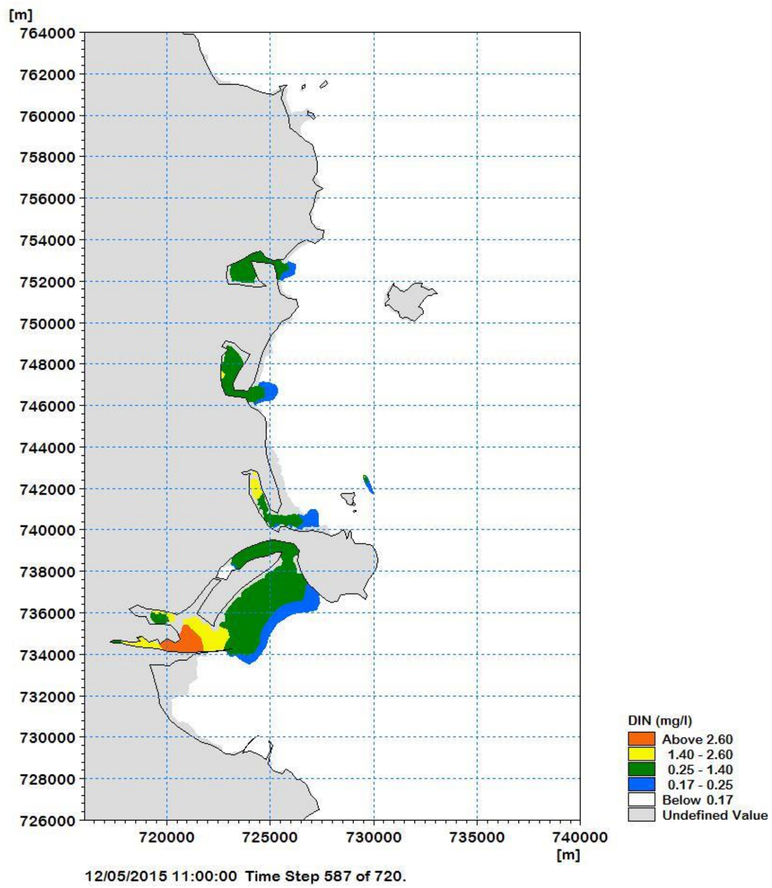



**Diagram 8.18: DIN Concentration at Mid Ebb on Neap Tide**

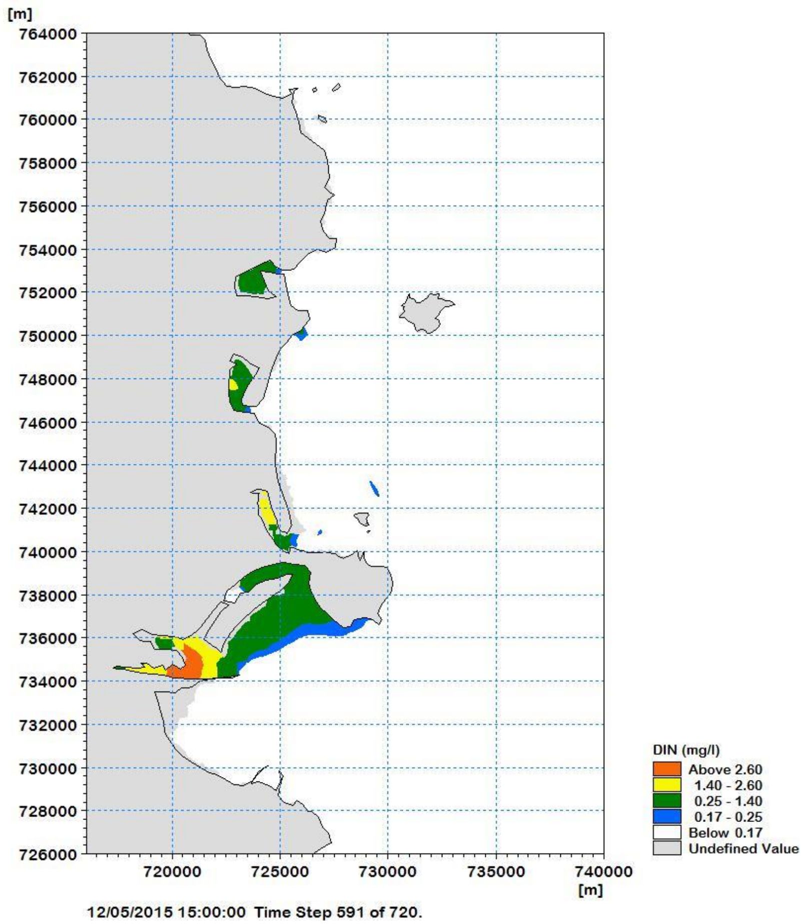



**Diagram 8.19: DIN Concentration at Low Water on Neap Tide**

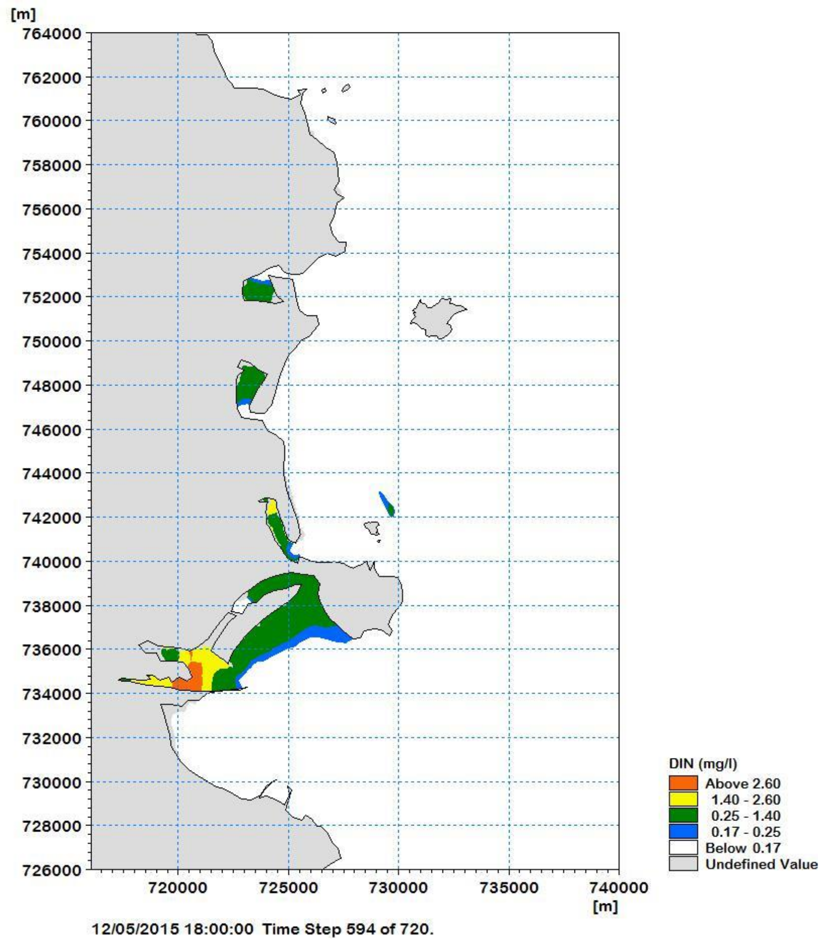



**Diagram 8.20: DIN Concentration at Mid Flood on Neap Tide**

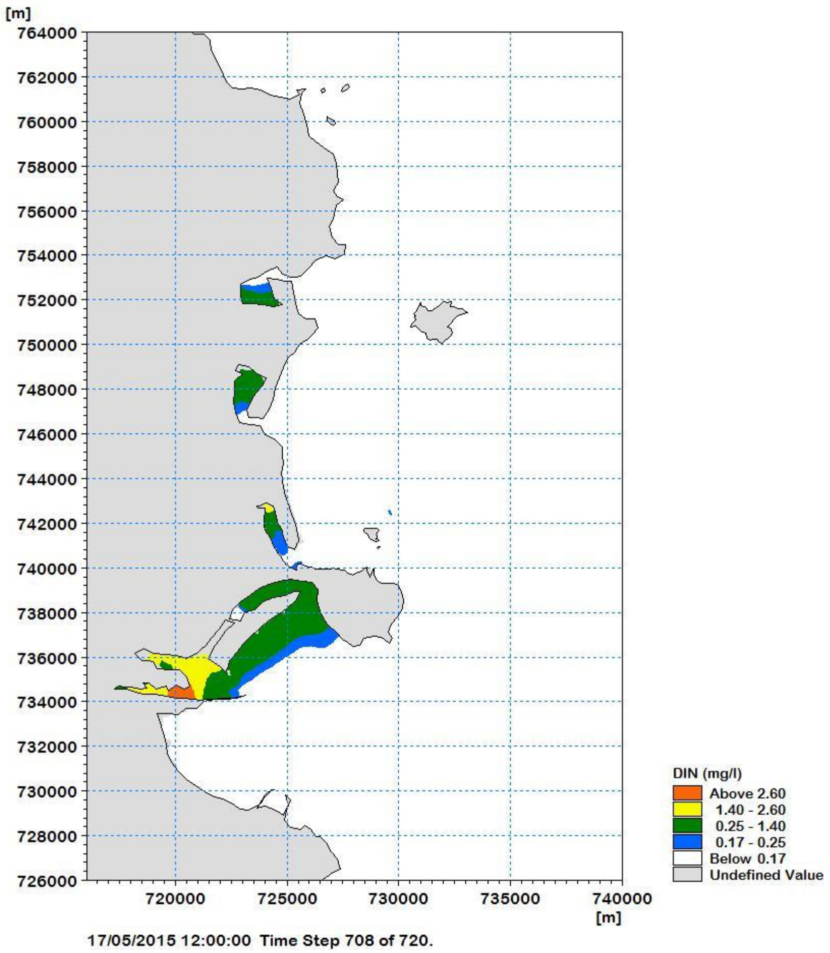



Diagram 8.21: DIN Concentration at High Water on Spring Tide

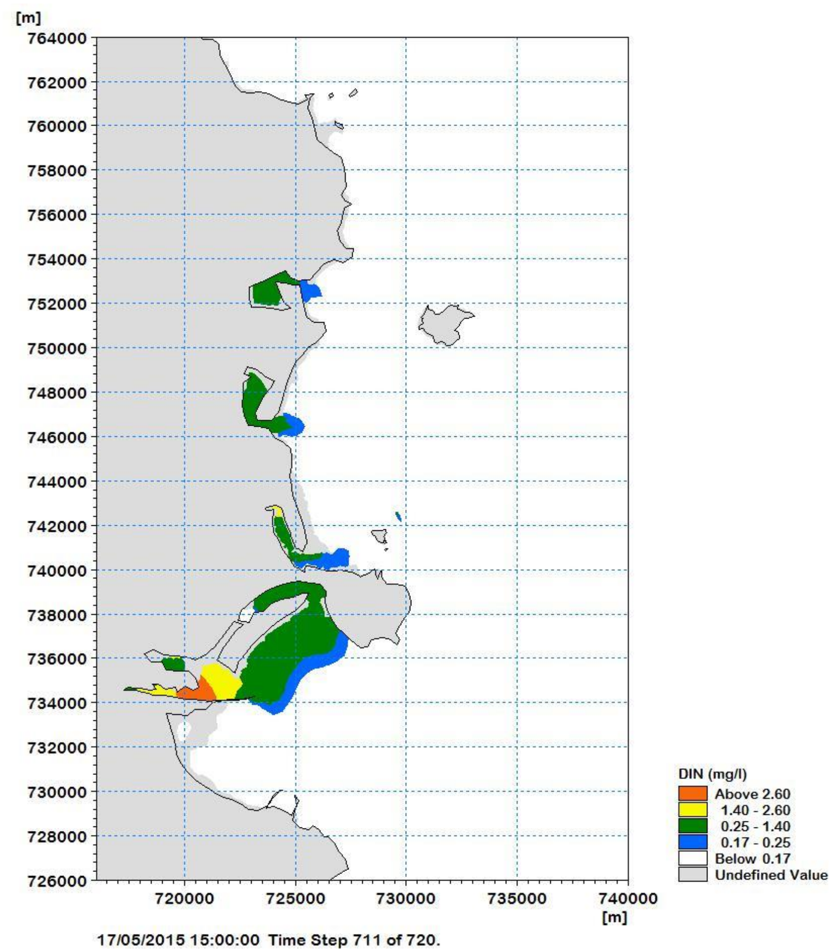



Diagram 8.22: DIN Concentration at Mid Ebb on Spring Tide

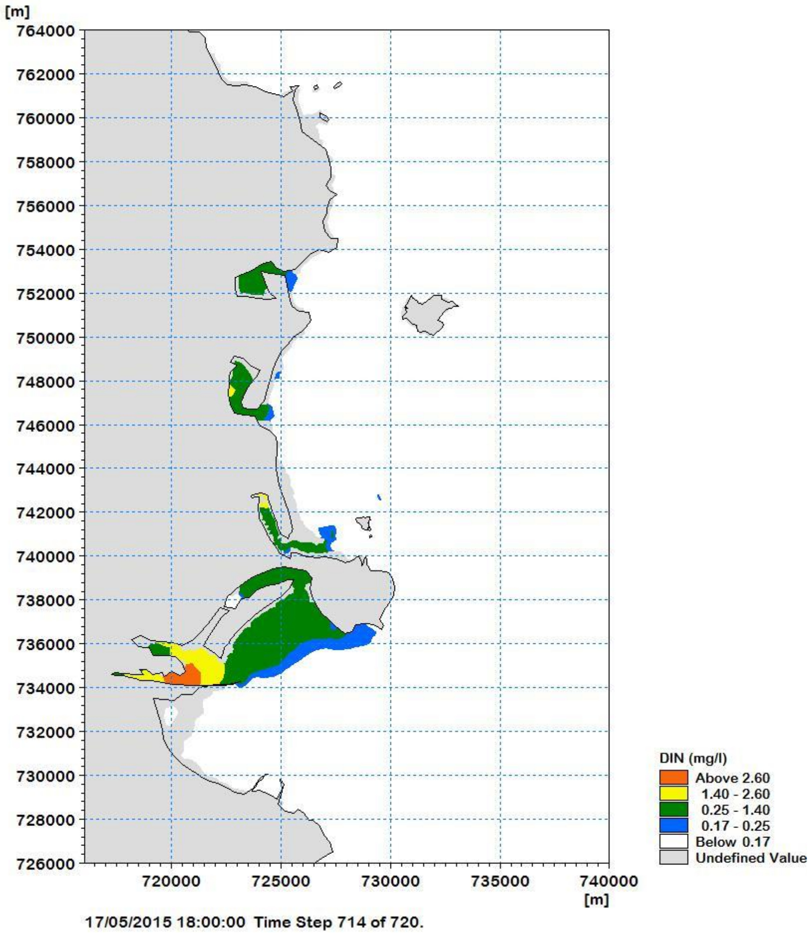



Diagram 8.23: DIN Concentration at Low Water on Spring Tide

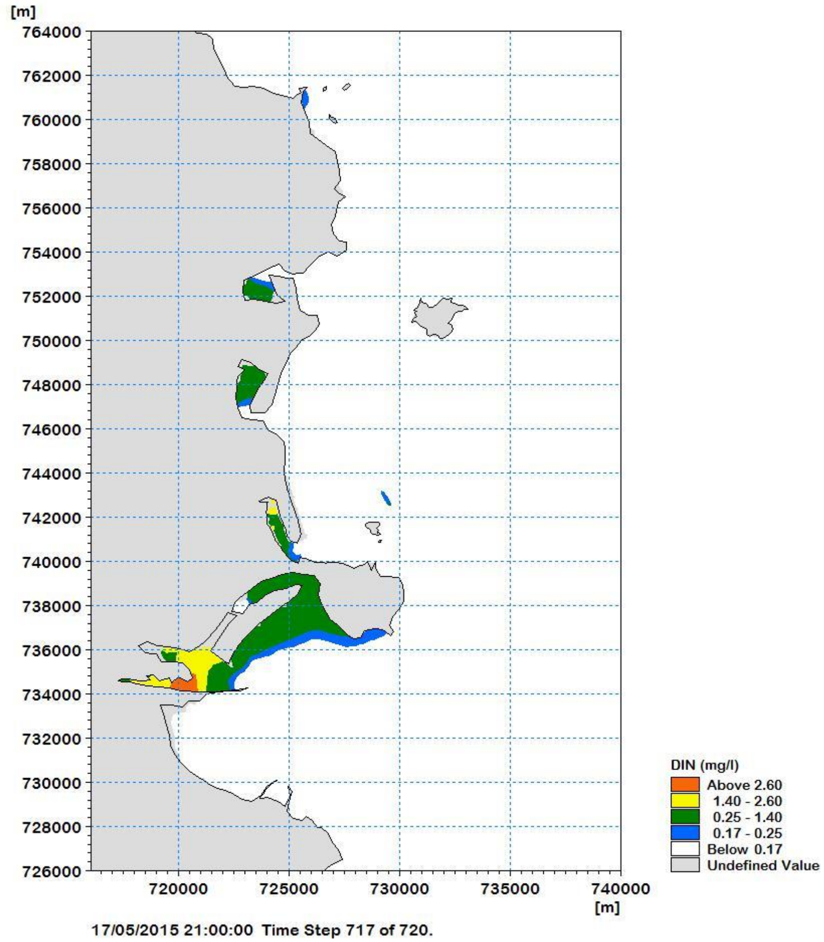



Diagram 8.24: DIN Concentration at Mid Flood on Spring Tide

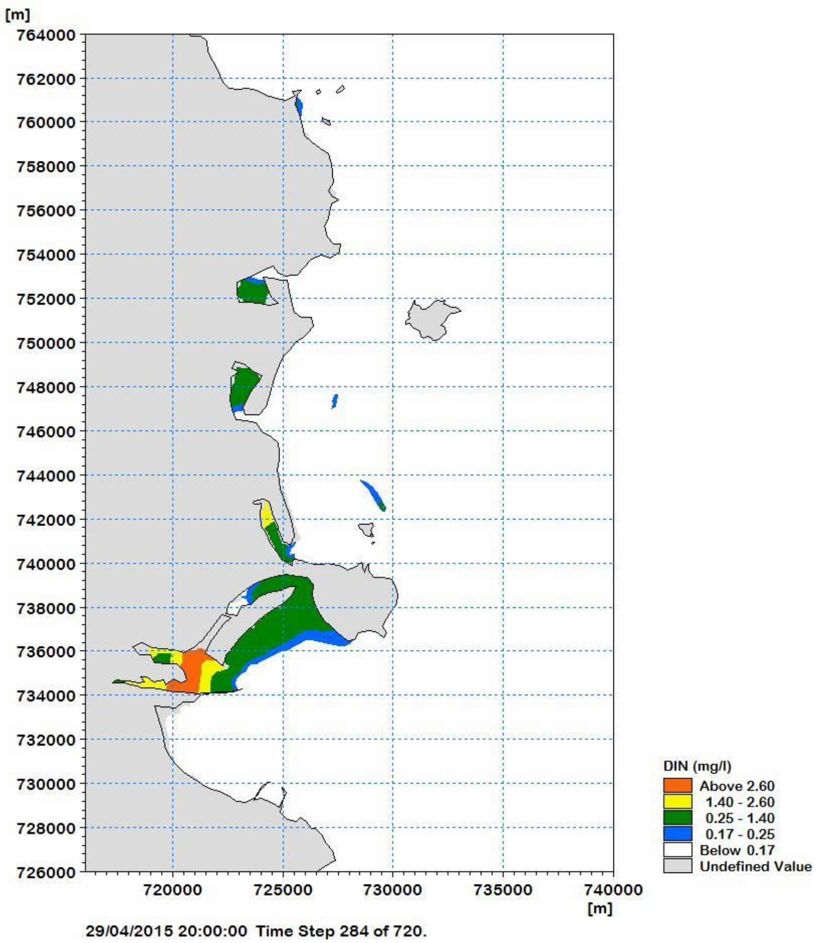



**Diagram 8.25: DIN Concentration at High Water**

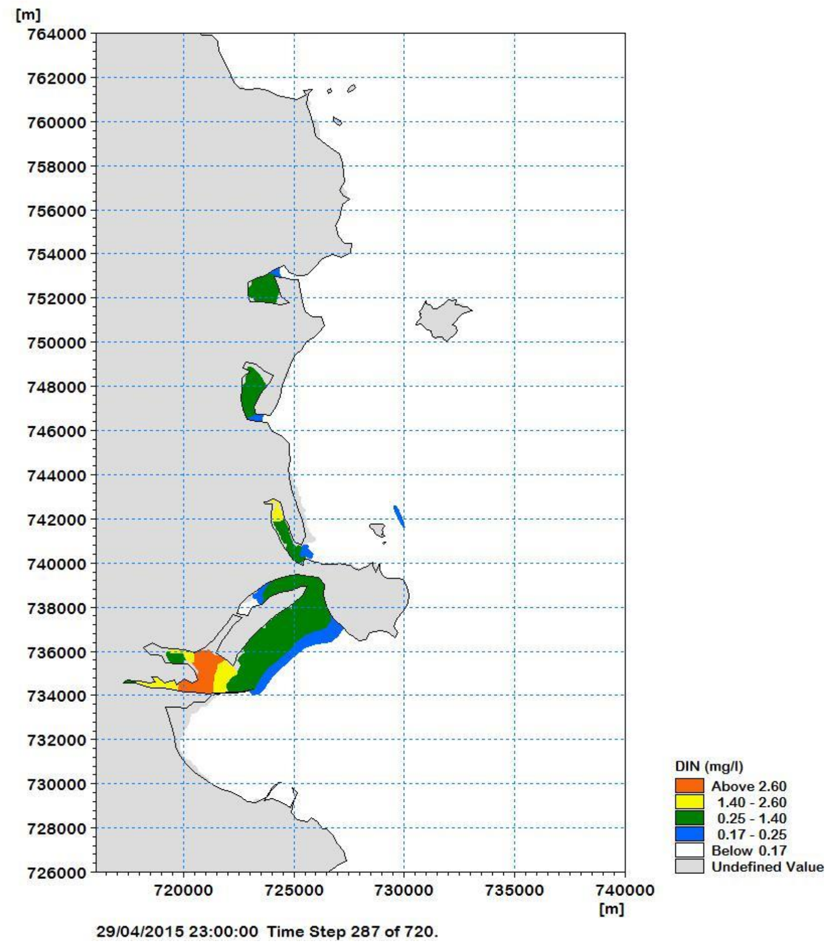



**Diagram 8.26: DIN Concentration at Mid Ebb**

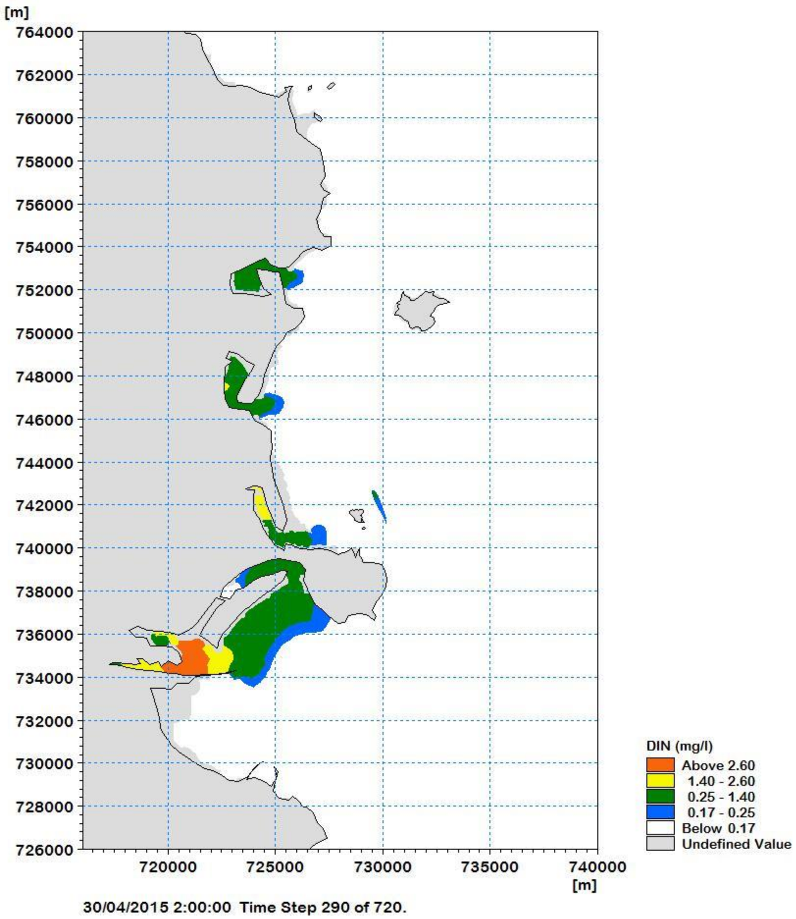



Diagram 8.27: DIN Concentration at Low Water

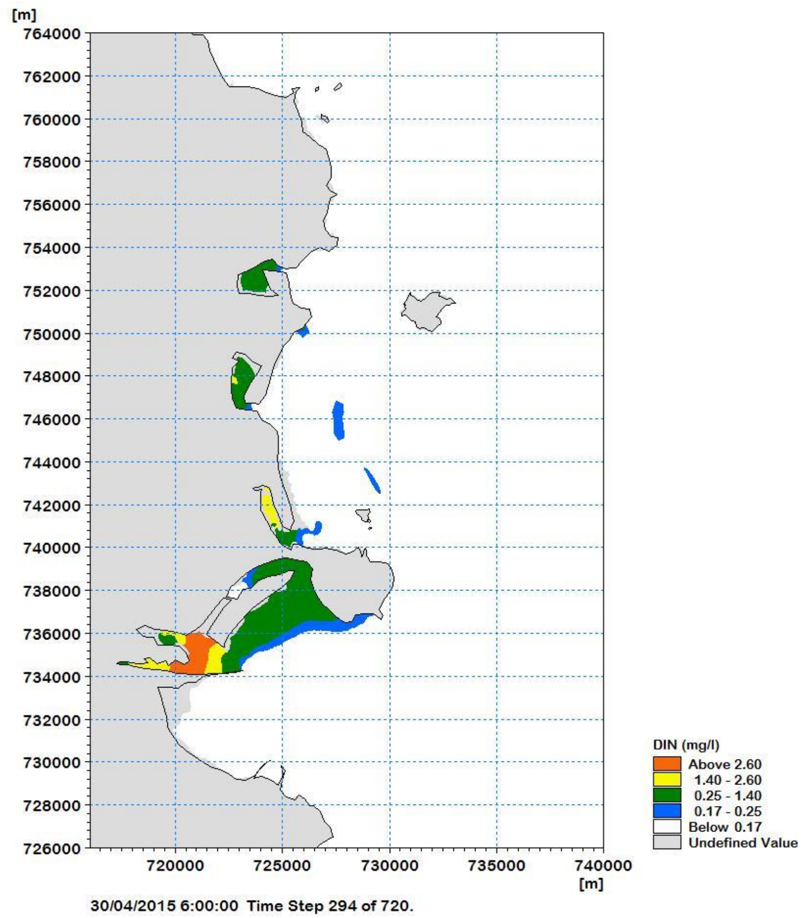



Diagram 8.28: DIN Concentration at Mid Flood

Molybdate Reactive Phosphorus

The Environmental Objectives Regulations 2009 do not set a limit for MRP in coastal waters. The transitional waters' median concentration limit of ≤0.04mg/l P required to achieve good status has been applied in the absence of a coastal waters limit.

In the diagrams below, all coloured areas correspond to where the MRP concentrations in the water were predicted to exceed the good status limit of ≤0.04mg/l P.

*Average Daily Flow*

The tidal plots showing the maximum extent of the predicted MRP plume from the proposed outfall pipeline route (marine section) discharge point at high water, mid ebb, low water and mid flood on neap tides are presented in Diagram 8.29 to Diagram 8.32 and on spring tides in Diagram 8.33 to Diagram 8.36. None of the diagrams show the MRP plume from the proposed outfall pipeline route (marine section) discharge point exceeding the 0.04mg/l P limit required to achieve good status. Elevated MRP levels in the transitional waters displayed in the diagrams result from other WwTPs or rivers directly discharging to the affected waters. The diagrams show that there was predicted to be no impact on the receiving waters from the proposed outfall pipeline route (marine section) discharge point for average daily flow conditions.

*Flow to Full Treatment*

The tidal plots showing the maximum extent of the predicted MRP plume from the proposed outfall pipeline route (marine section) discharge point at high water, mid ebb, low water and mid flood on neap tides are presented in Diagram 8.37 to Diagram 8.40 and on spring tides in Diagram 8.41 to Diagram 8.44. The diagrams show a very small MRP plume from the outfall exceeding the 0.04mg/l P limit required to achieve good status at certain stages of the tide and very localised to the proposed outfall pipeline route (marine section) discharge point. Elevated MRP levels in the transitional waters displayed in the diagrams result from other WwTPs or rivers directly discharging to the affected waters. The diagrams show that there was predicted to be a very Slight localised impact on the receiving waters from the proposed operation of the proposed outfall pipeline route (marine section) discharge point.

*Process Failure*

The tidal plots showing the maximum extent of the predicted MRP plume from the proposed outfall pipeline route (marine section) discharge point at mid ebb, low water, mid flood, high water on the last tide of the three-day simulated process failure scenario are presented in Diagram 8.45 to Diagram 8.48. The diagrams show a very small MRP plume from the proposed outfall pipeline route (marine section) discharge point exceeding the 0.04mg/l P limit required to achieve good status very localised to the proposed outfall pipeline route (marine section) discharge point. Elevated MRP levels in the transitional waters displayed in the diagrams result from other WwTPs or rivers directly discharging to the affected waters. The diagrams show that there was predicted to be a Slight localised impact on the receiving waters from the proposed operation of the proposed outfall pipeline route (marine section) discharge point.

None of the scenarios examined predicted the likelihood of any significant impact on the receiving waters from the proposed outfall pipeline route (marine section) discharge point.

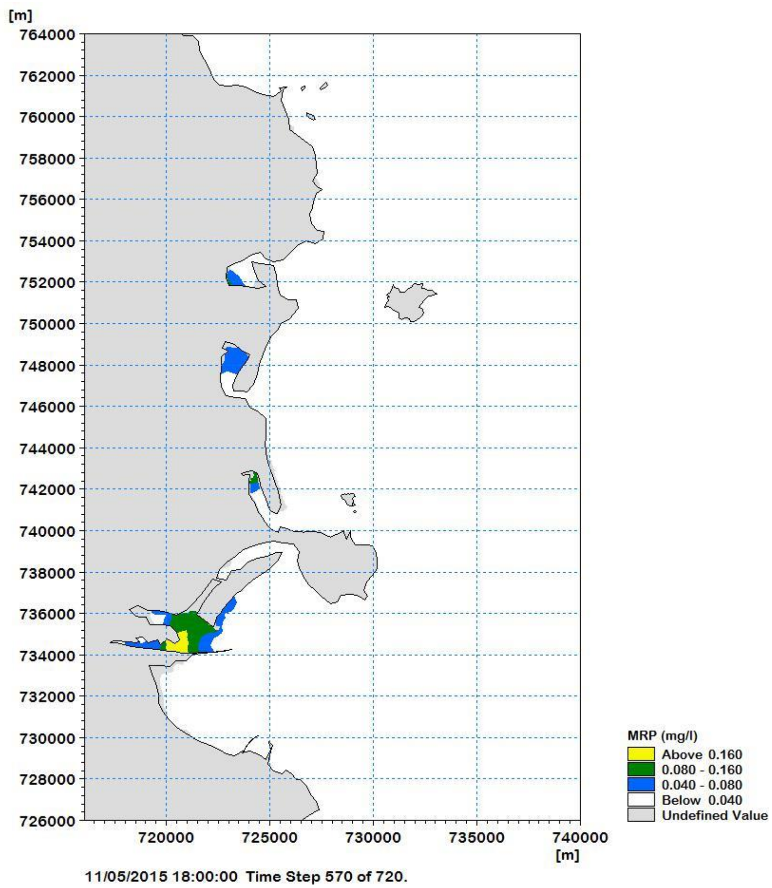



Diagram 8.29: MRP Concentration at High Water on Neap Tide

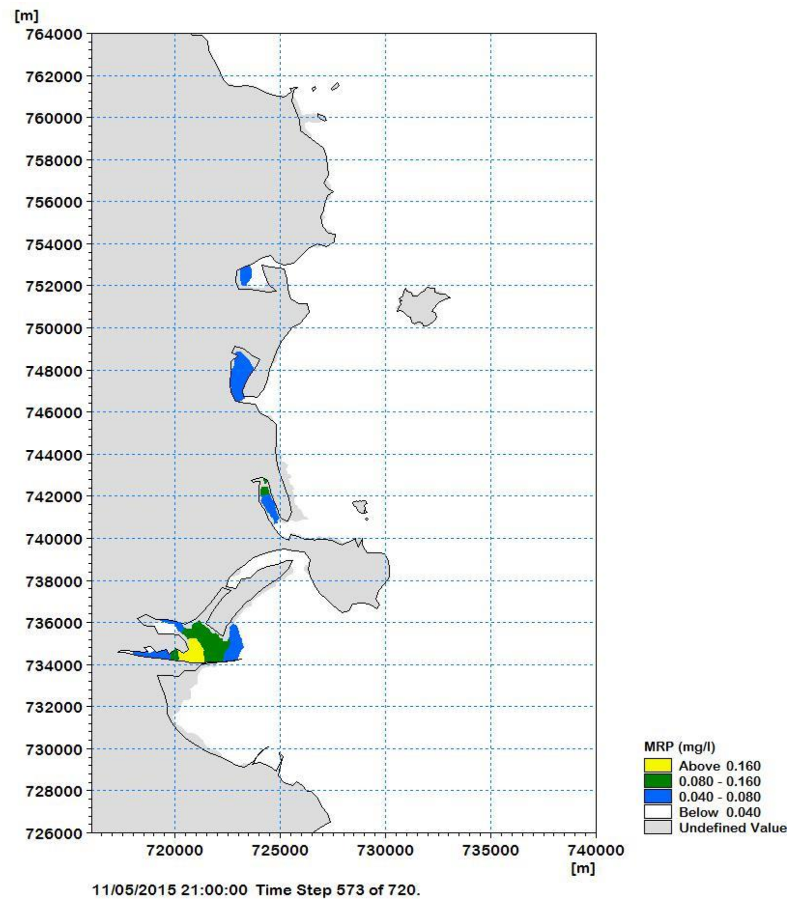



Diagram 8.30: MRP Concentration at Mid Ebb on Neap Tide

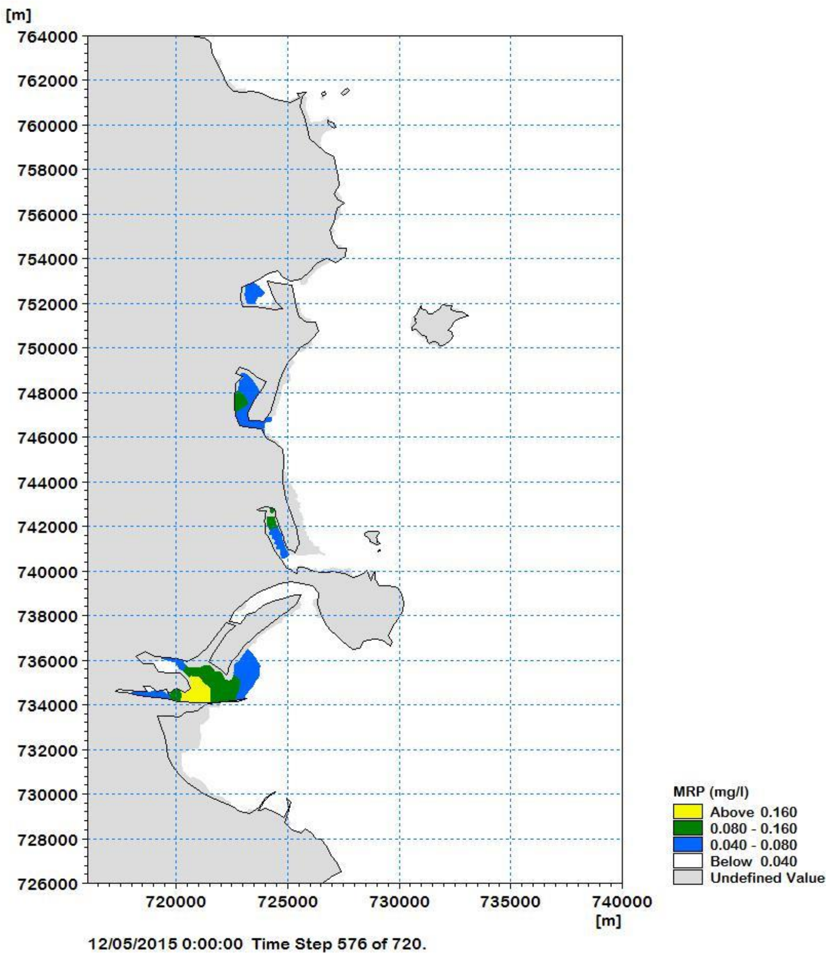



Diagram 8.31: MRP Concentration at Low Water on Neap Tide

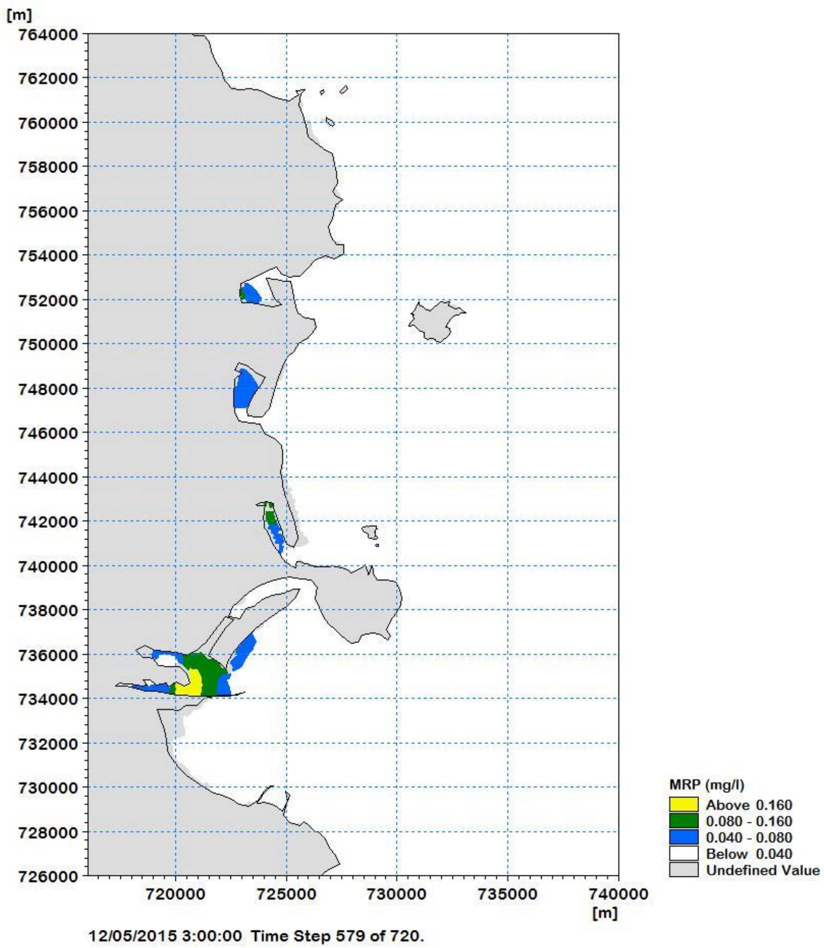



Diagram 8.32: MRP Concentration at Mid Flood on Neapt Tide

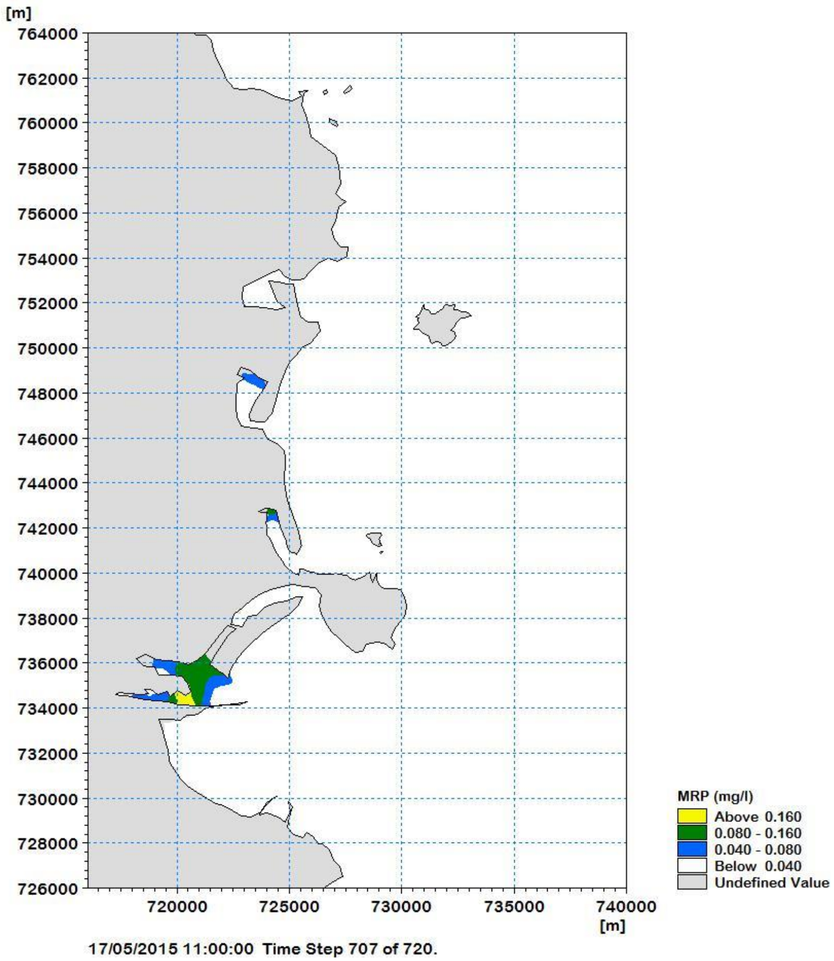



**Diagram 8.33: MRP Concentration at High Water on Spring Tide**

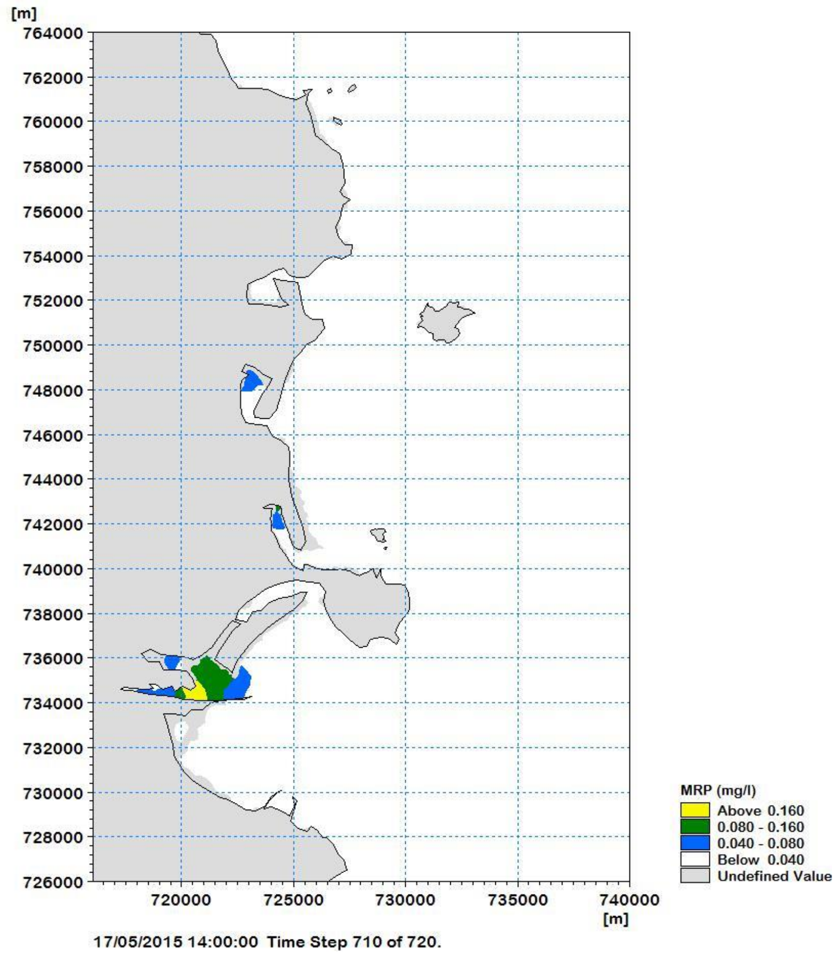



**Diagram 8.34: MRP Concentration at Mid Ebb on Spring Tide**

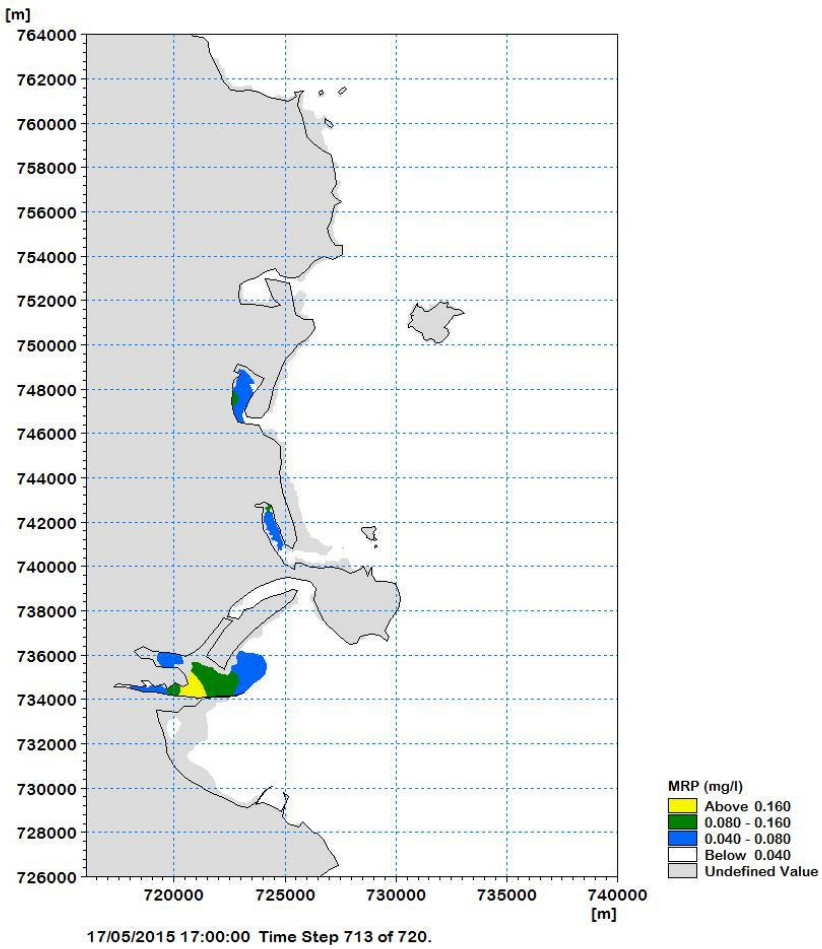



**Diagram 8.35: MRP Concentration at Low Water on Spring Tide**

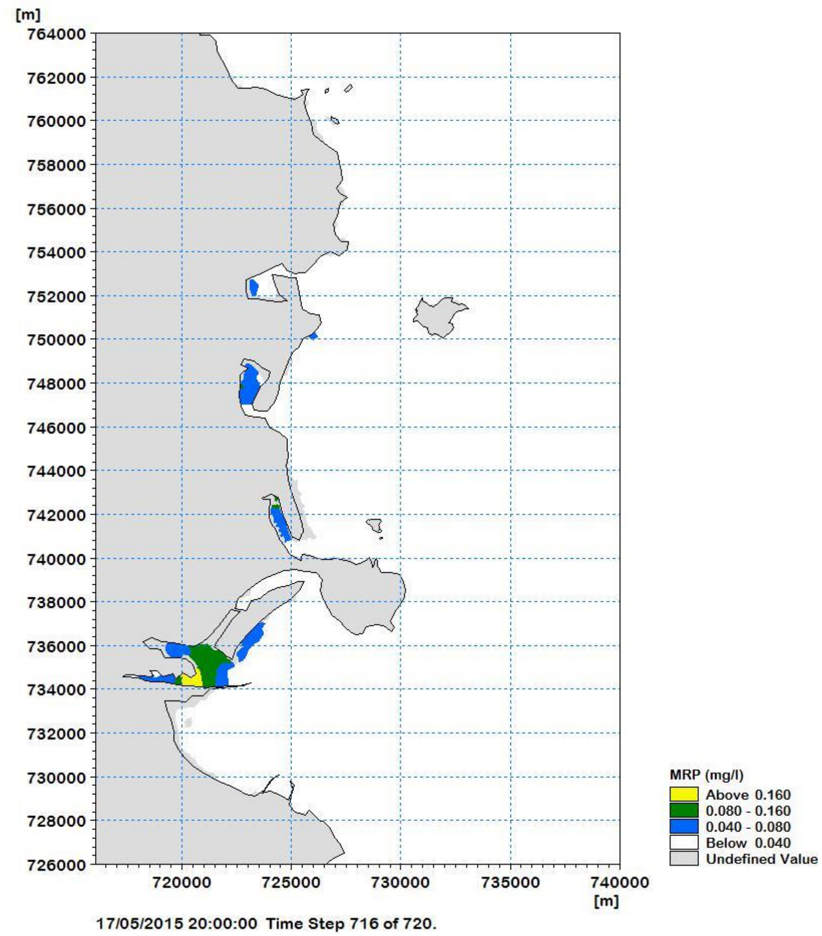



**Diagram 8.36: MRP Concentration at Mid Flood on Spring Tide**

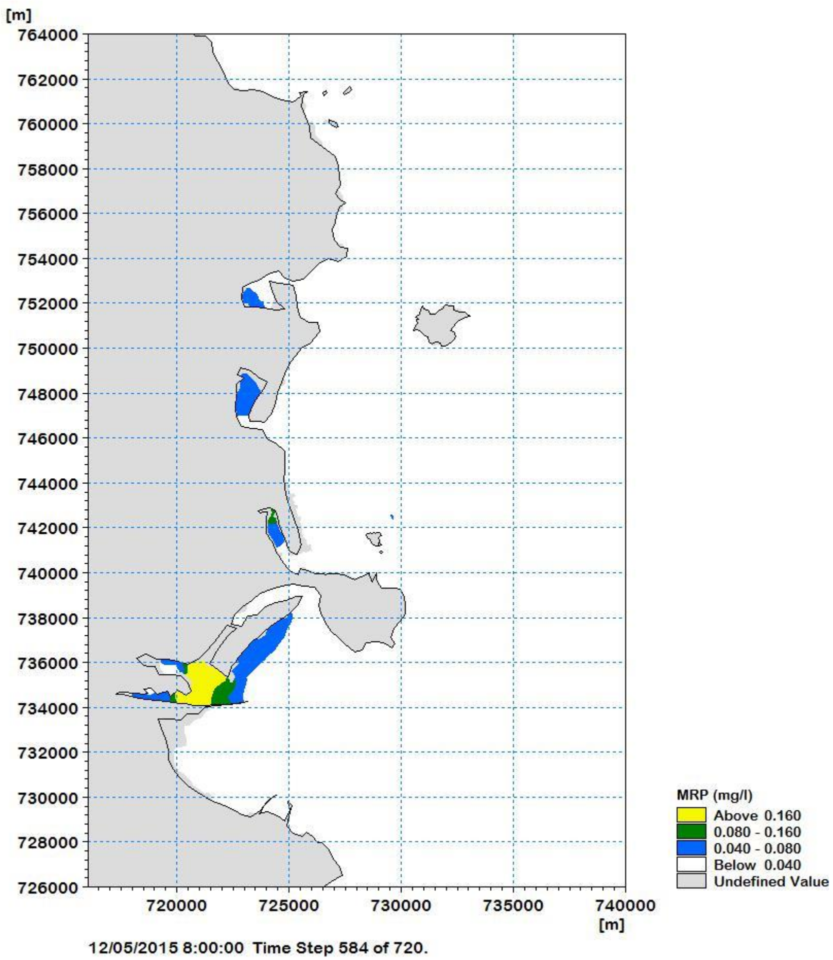



Diagram 8.37: MRP Concentration at High Water on Neap Tide

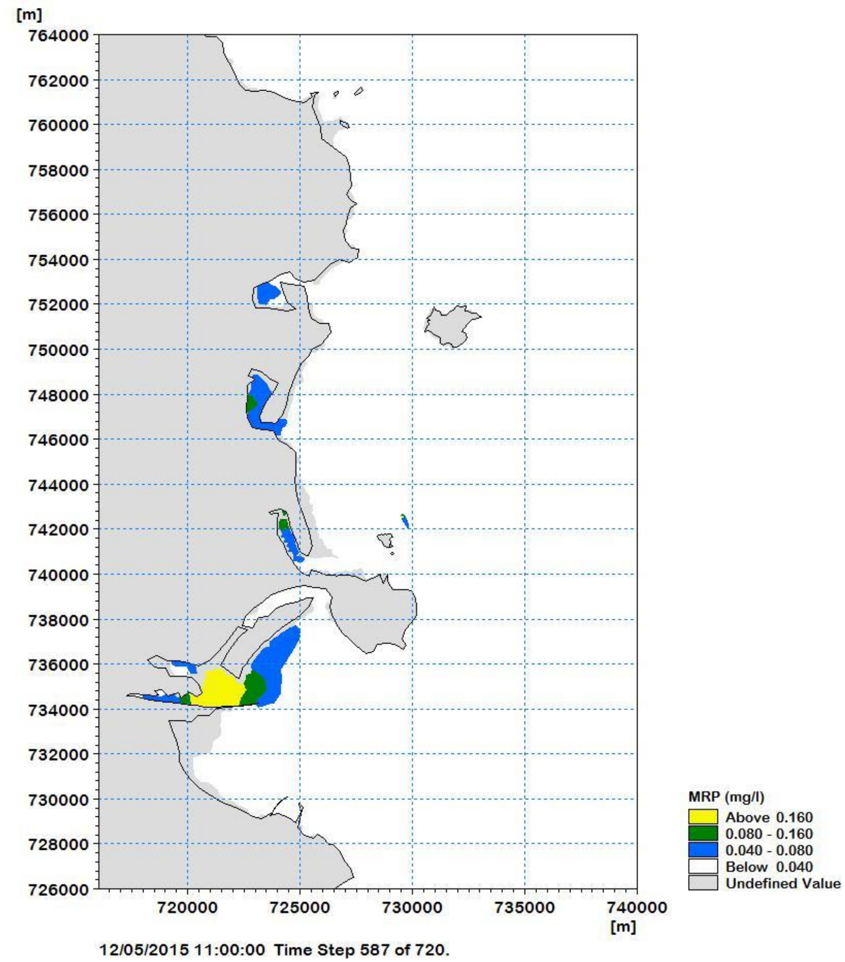



Diagram 8.38: MRP Concentration at Mid Ebb on Neap Tide

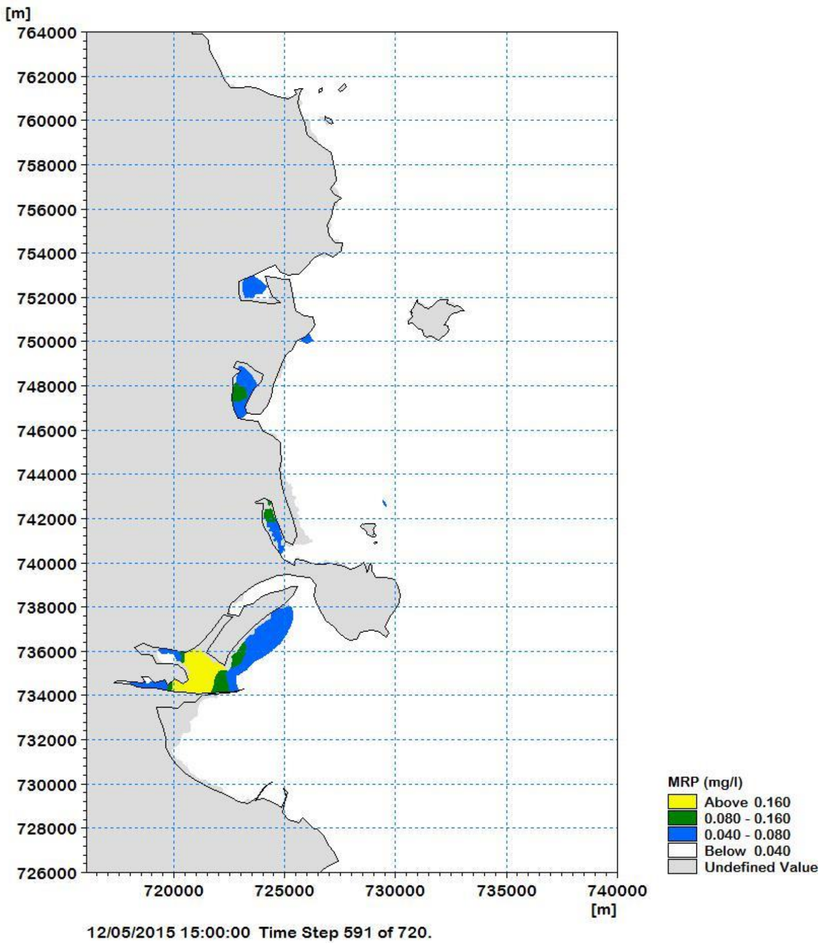



Diagram 8.39: MRP Concentration at Low Water on Neap Tide

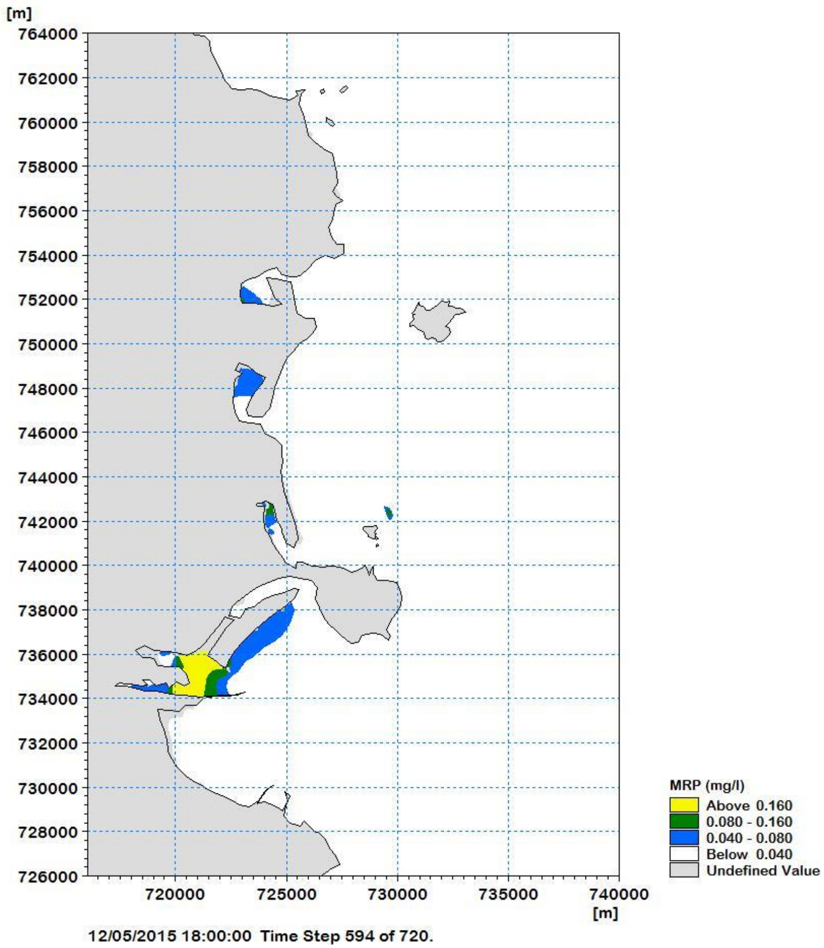



Diagram 8.40: MRP Concentration at Mid Flood on Neap Tide

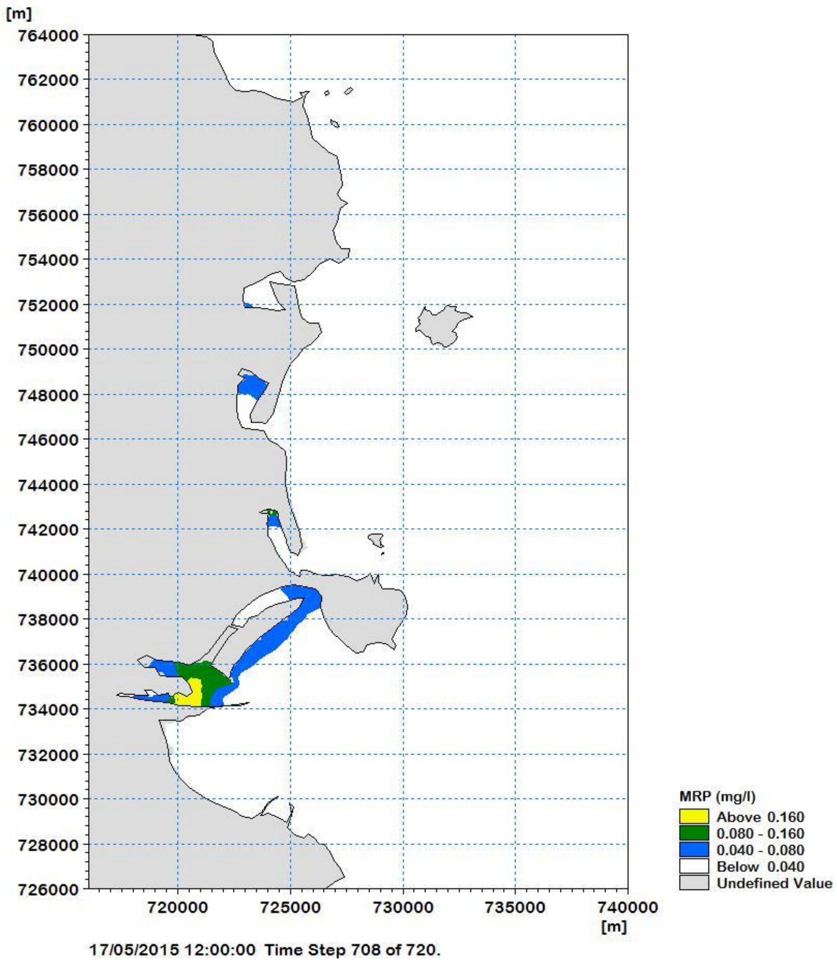



**Diagram 8.41: MRP Concentration at High Water on Spring Tide**

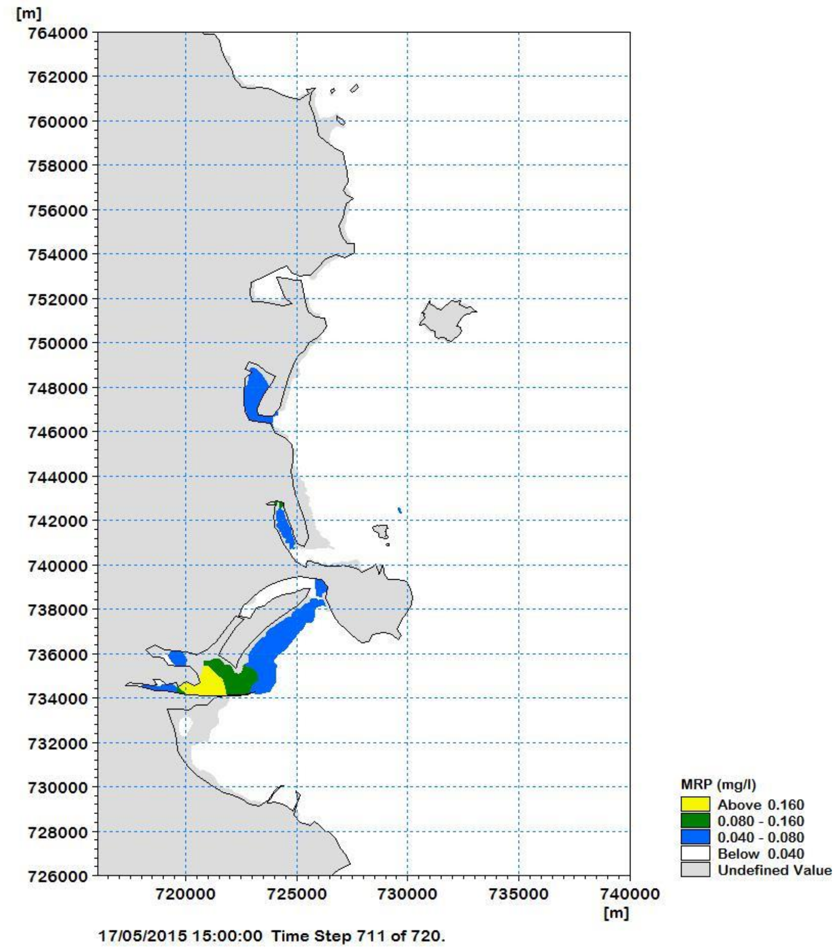



**Diagram 8.42: MRP Concentration at Mid Ebb on Spring Tide**

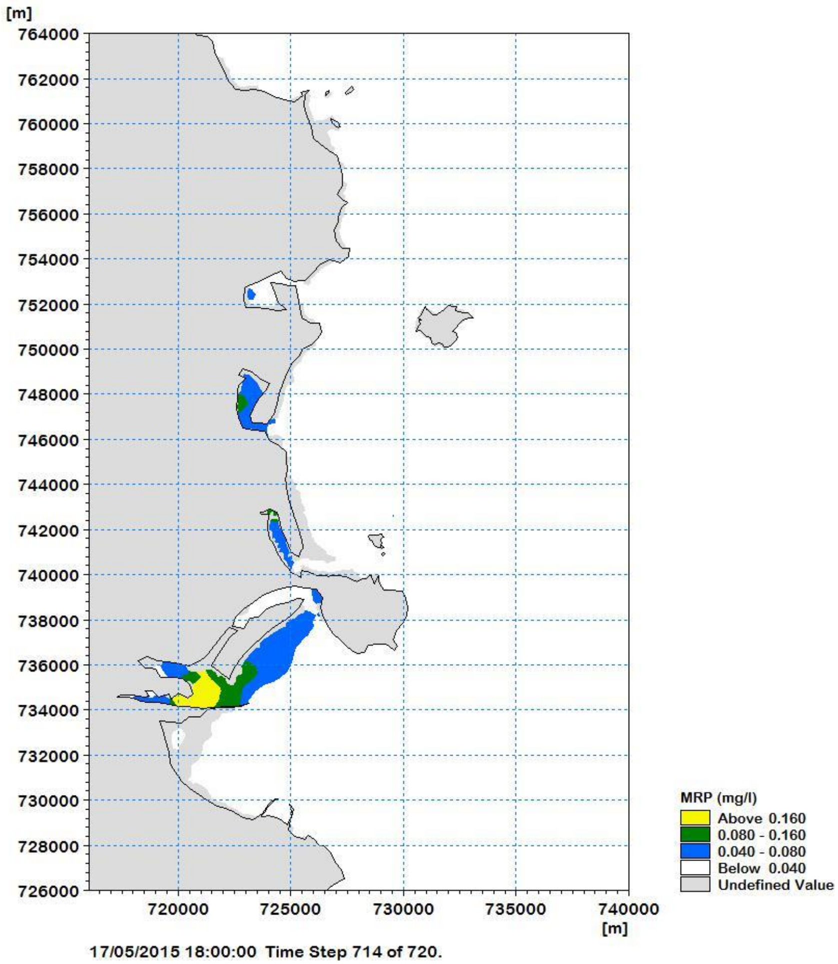



**Diagram 8.43: MRP Concentration at Low Water on Spring Tide**

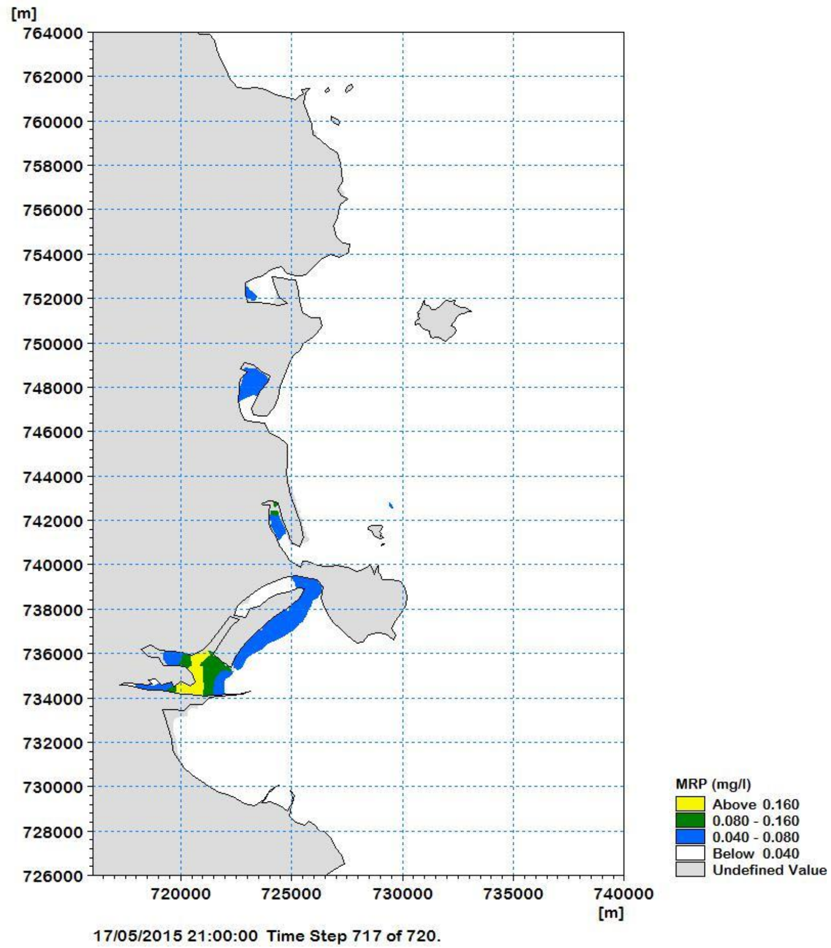



**Diagram 8.44: MRP Concentration at Mid Flood on Spring Tide**

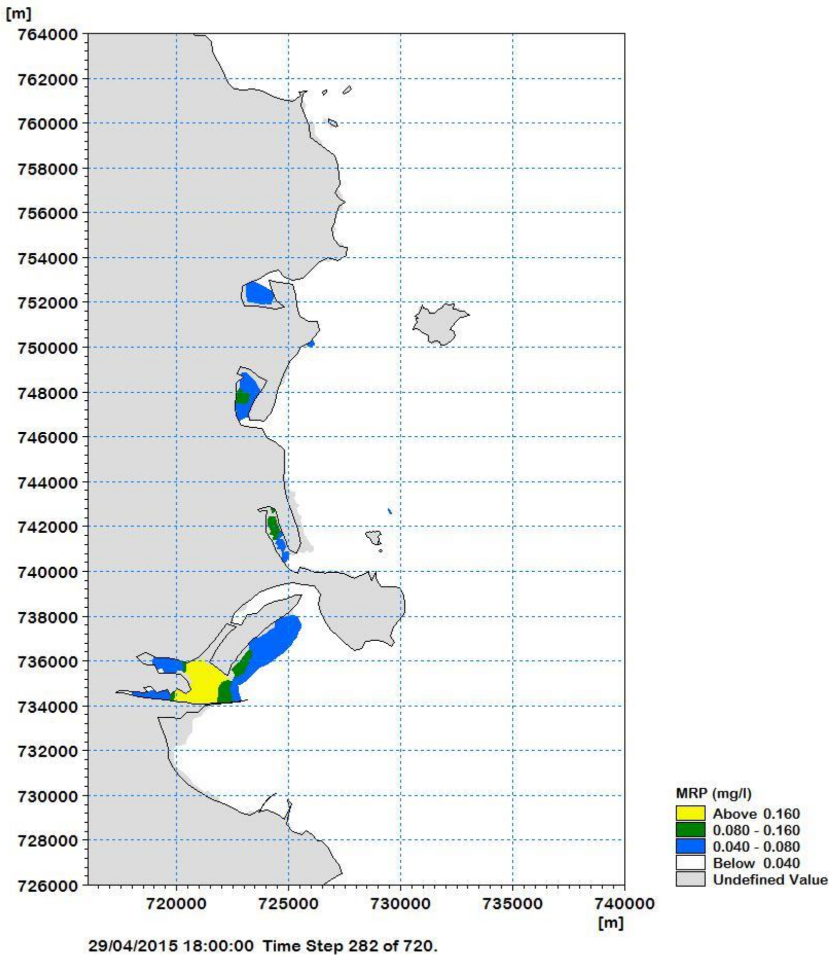



**Diagram 8.45: MRP Concentration at High Water**

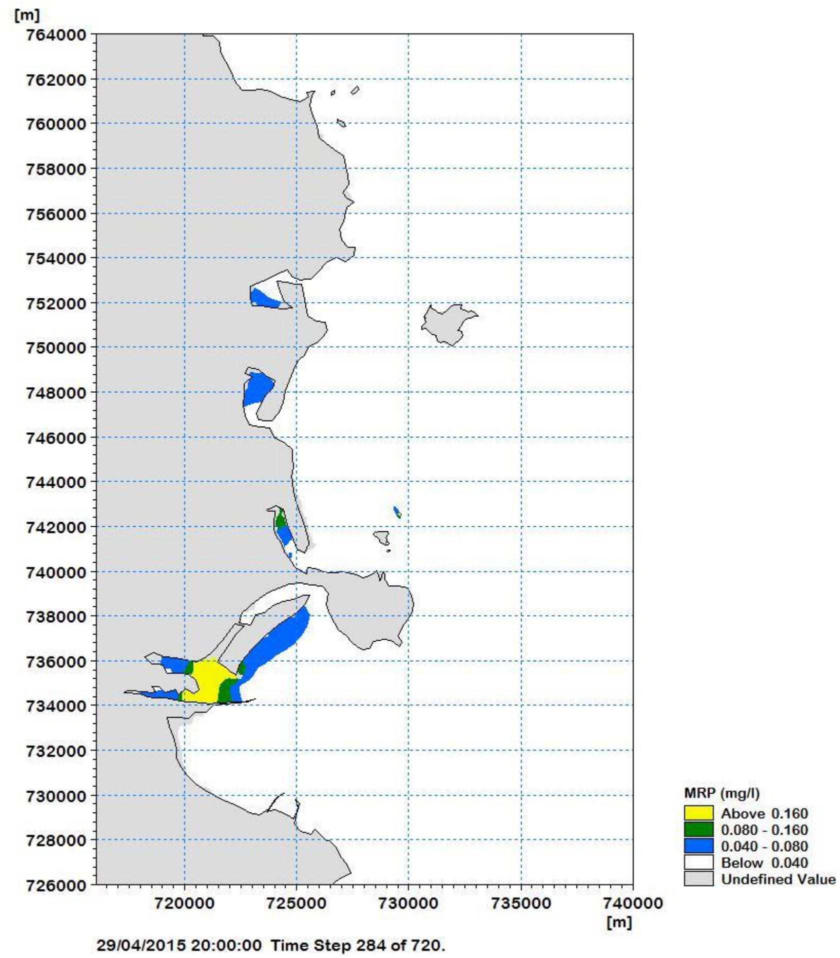



**Diagram 8.46: MRP Concentration at Mid Ebb**

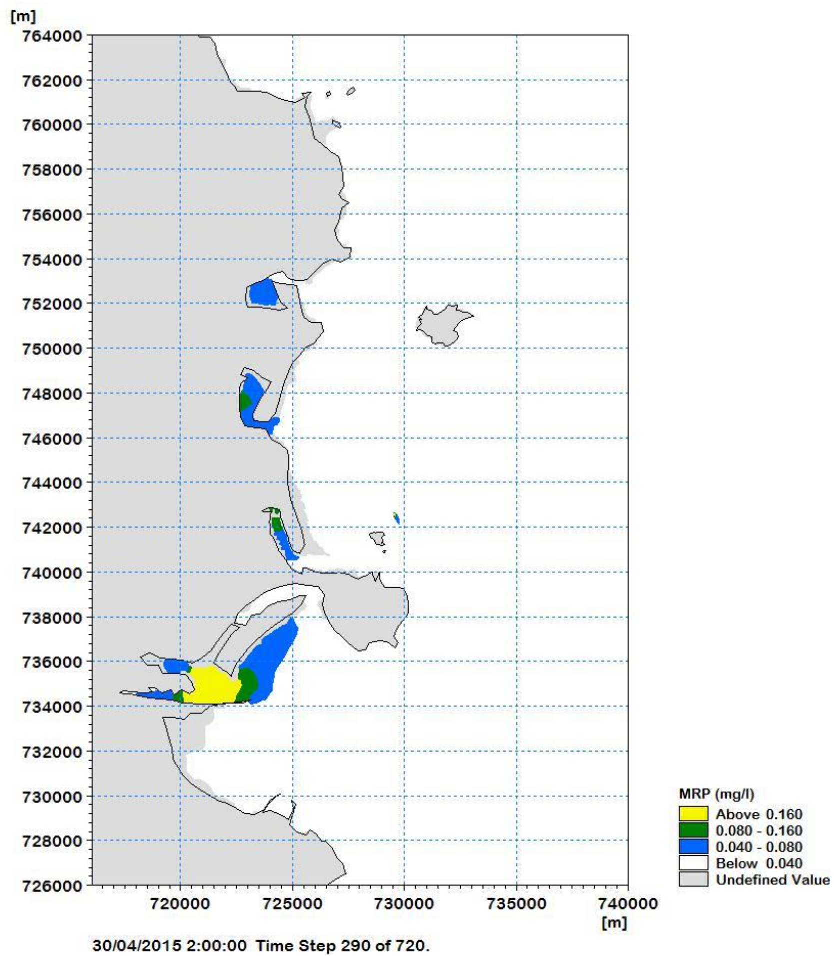



Diagram 8.47: MRP Concentration at Low Water

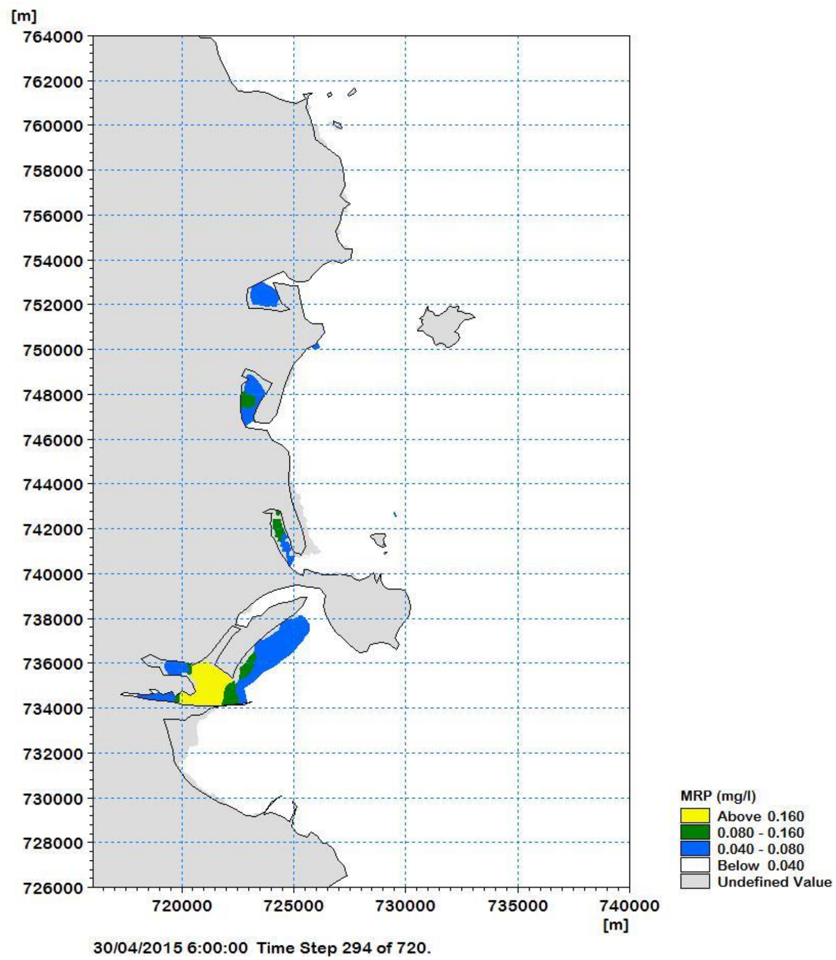



Diagram 8.48: MRP Concentration at Mid Flood

Biochemical Oxygen Demand

The Environmental Objectives Regulations 2009 sets a 95th percentile concentration limit for BOD at ≤4.0mg/l $O_2$ in coastal waters to achieve good status.

In the diagrams below, all coloured areas correspond to where the BOD concentrations in the water were predicted to exceed the good status limit of ≤4.0mg/l $O_2$.

*Average Daily Flow*

The tidal plots showing the maximum extent of the predicted BOD plume from the proposed outfall pipeline route (marine section) discharge point at high water, mid ebb, low water and mid flood on neap tides are presented in Diagram 8.49 to Diagram 8.52 and on spring tides in Diagram 8.53 to Diagram 8.56. None of the diagrams show the BOD plume from the proposed outfall pipeline route (marine section) discharge point exceeding the 4.0mg/l $O_2$ limit required to achieve good status. Elevated BOD levels in the transitional waters displayed in the diagrams result from other WwTPs or rivers directly discharging to the affected waters. The diagrams show that there was predicted to be no impact on the receiving waters from the proposed operation of the proposed outfall pipeline route (marine section) discharge point.

*Flow to Full Treatment*

The tidal plots showing the maximum extent of the predicted BOD plume from the proposed outfall pipeline route (marine section) discharge point at high water, mid ebb, low water and mid flood on neap tides are presented in Diagram 8.57 to Diagram 8.60 and on spring tides in Diagram 8.61 to Diagram 8.64. None of the diagrams show the BOD plume from the proposed outfall pipeline route (marine section) discharge point exceeding the 4.0mg/l $O_2$ limit required to achieve good status. Elevated BOD levels in the transitional waters displayed in the diagrams result from other WwTPs or rivers directly discharging to the affected waters. The diagrams show that there was predicted to be no impact on the receiving waters from the proposed operation of the proposed outfall pipeline route (marine section) discharge point.

*Process Failure*

The tidal plots showing the maximum extent of the predicted BOD plume from the proposed outfall pipeline route (marine section) discharge point at mid ebb, low water, mid flood, high water on the last tide of the three-day simulated process failure scenario are presented in Diagram 8.65 to Diagram 8.68. None of the diagrams show the BOD plume from the proposed outfall pipeline route (marine section) discharge point exceeding the 4.0mg/l $O_2$ limit required to achieve good status. Elevated BOD levels in the transitional waters displayed in the diagrams result from other WwTPs or rivers directly discharging to the affected waters. The diagrams show that there was predicted to be no impact on the receiving waters from the proposed operation of the proposed outfall pipeline route (marine section) discharge point.

None of the scenarios examined predicted the likelihood of any significant impact on the receiving waters from the proposed operation of the proposed outfall pipeline route (marine section) discharge point.

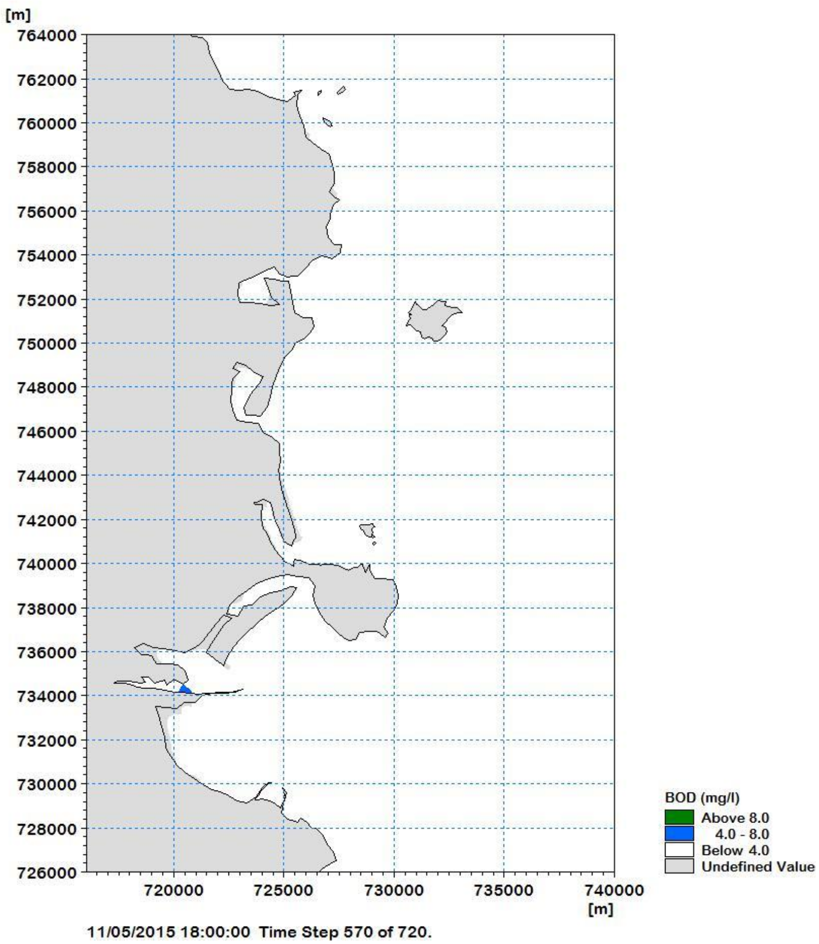



**Diagram 8.49: BOD Concentration at High Water on Neap Tide**

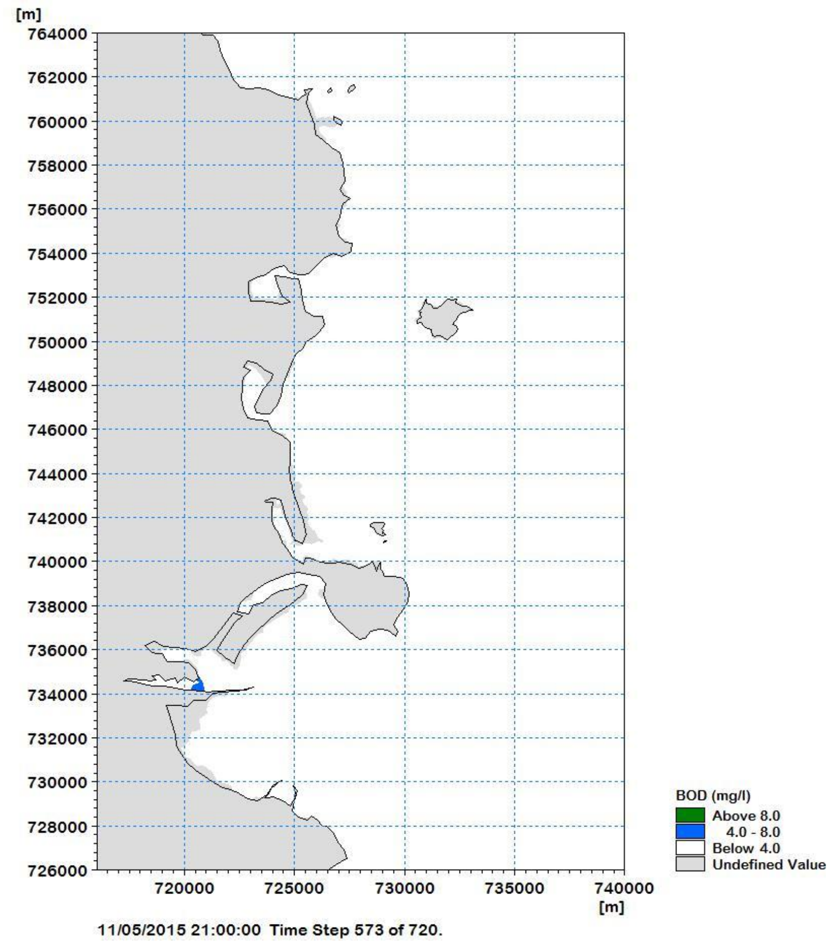



**Diagram 8.50: BOD Concentration at Mid Ebb on Neap Tide**

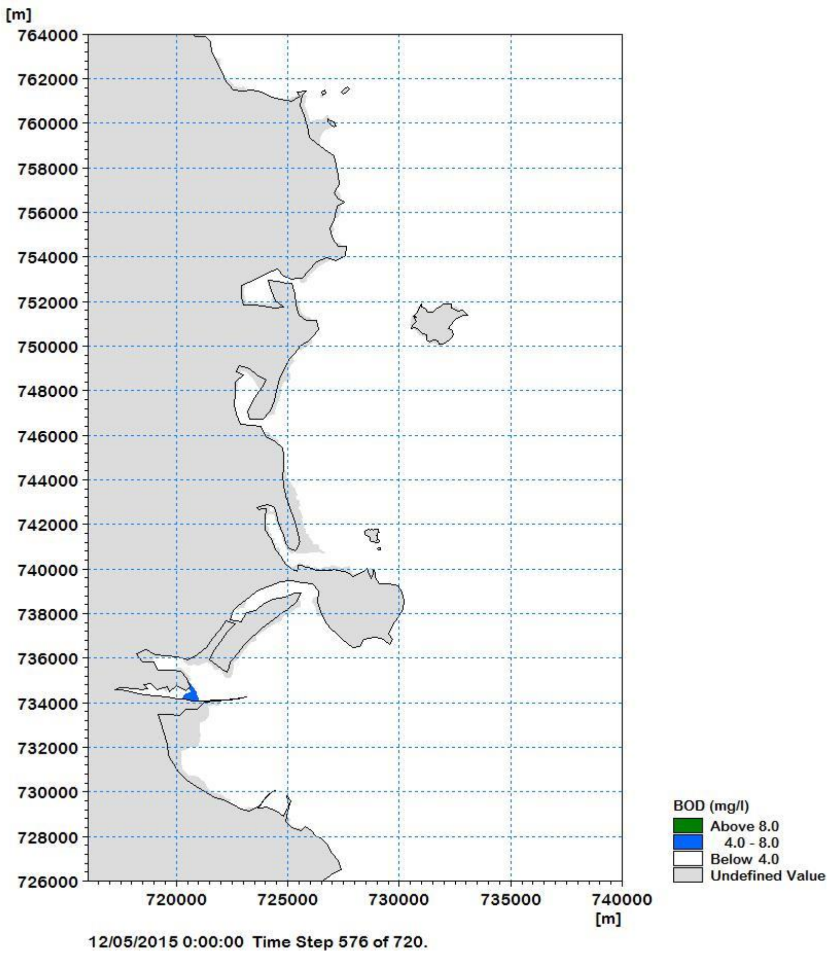



**Diagram 8.51: BOD Concentration at Low Water on Neap Tide**

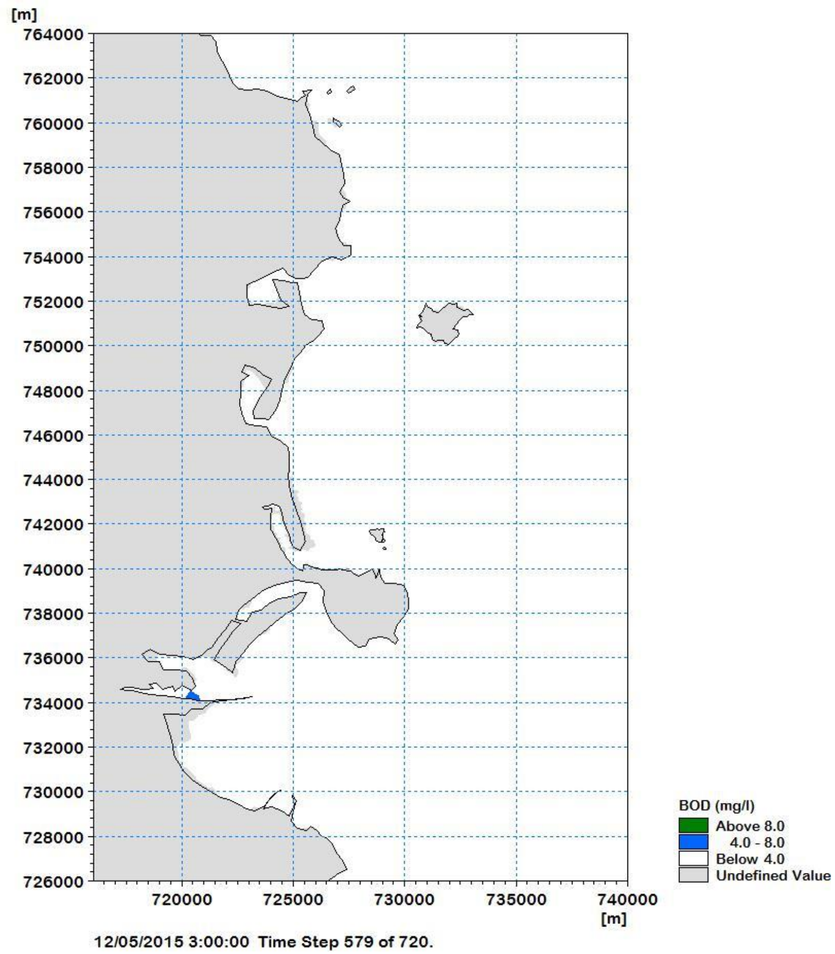



**Diagram 8.52: BOD Concentration at Mid Flood on Neap Tide**

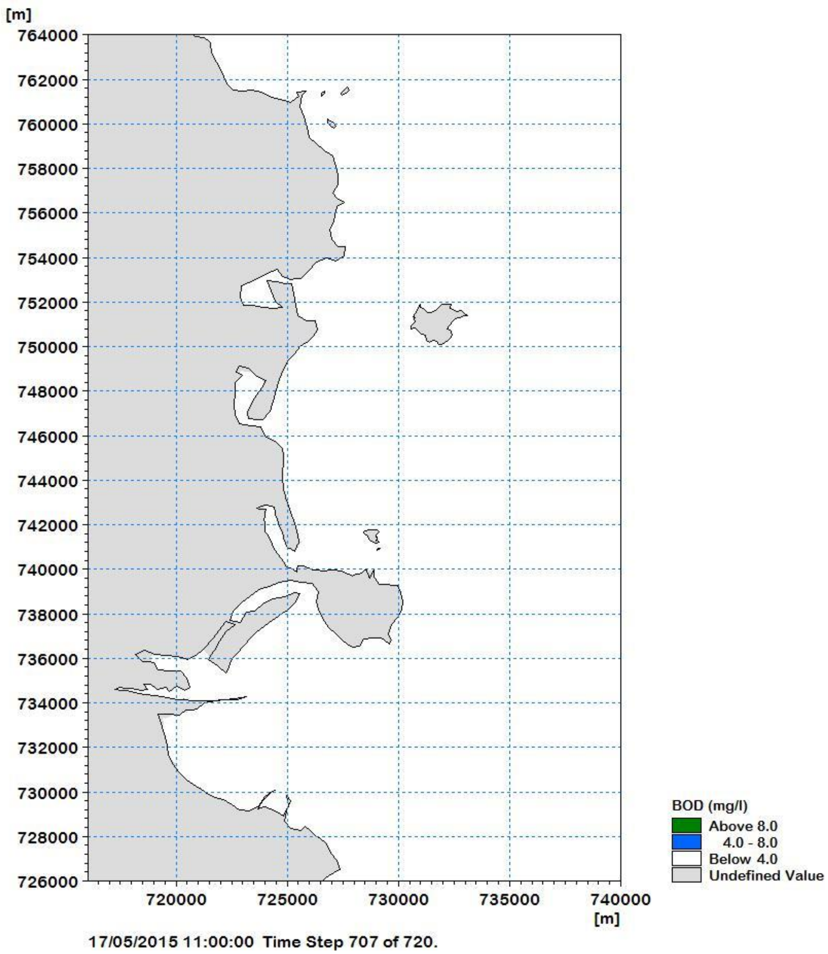



Diagram 8.53: BOD Concentration at High Water on Spring Tide

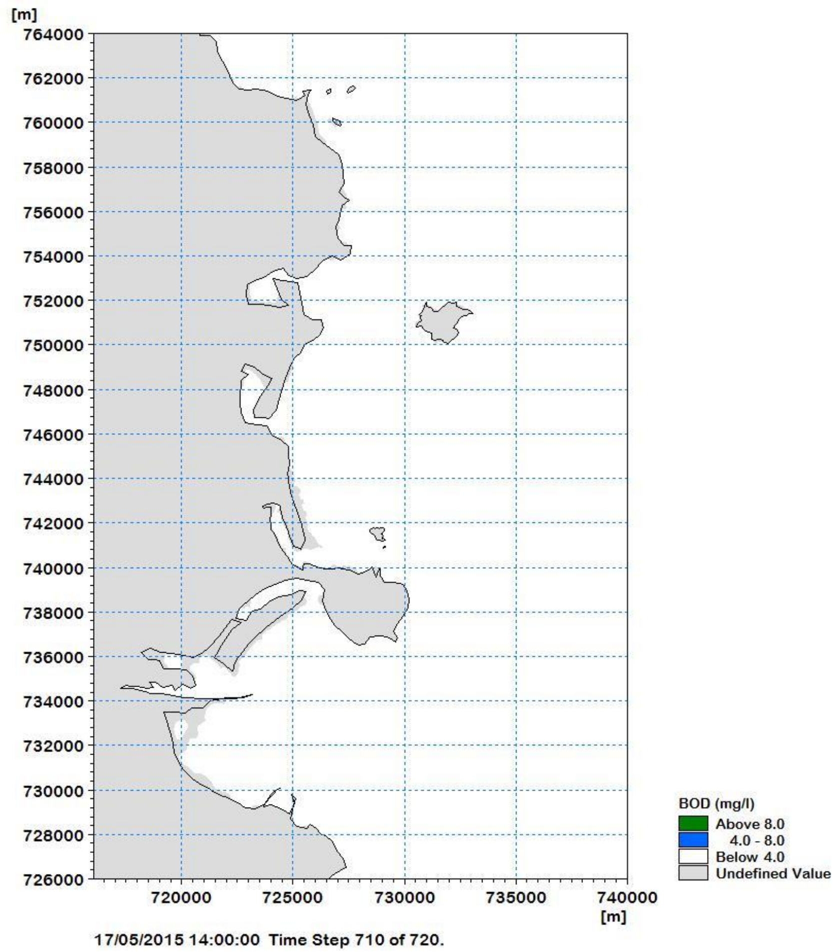



Diagram 8.54: BOD Concentration at Mid Ebb on Spring Tide

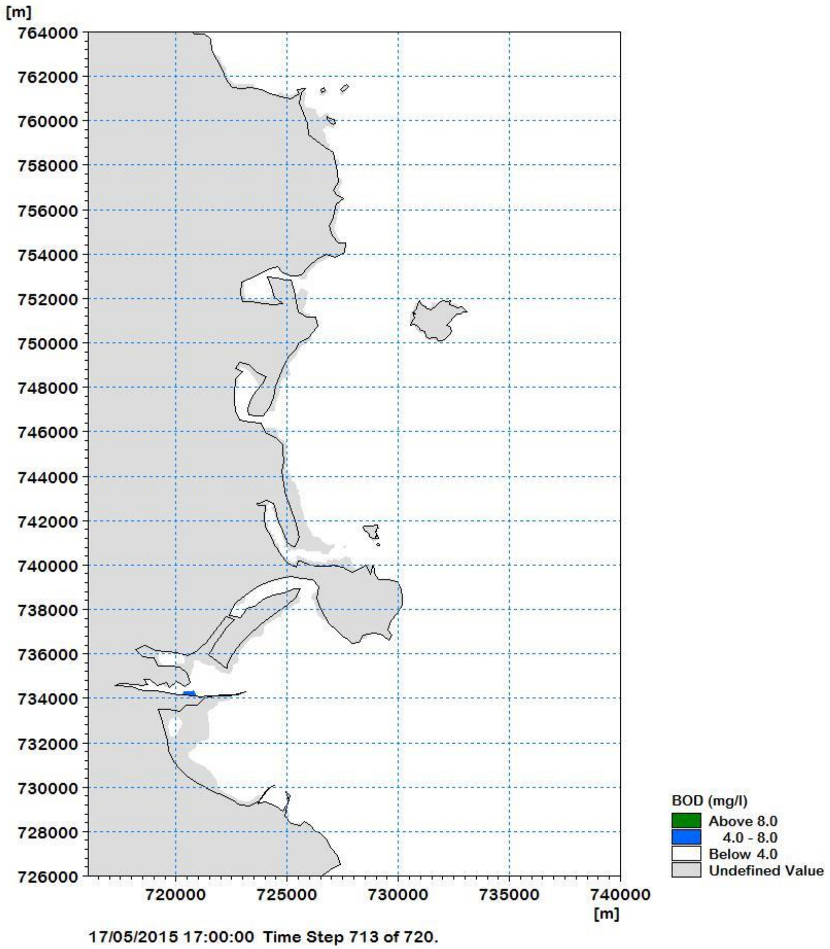



Diagram 8.55: BOD Concentration at Low Water on Spring Tide

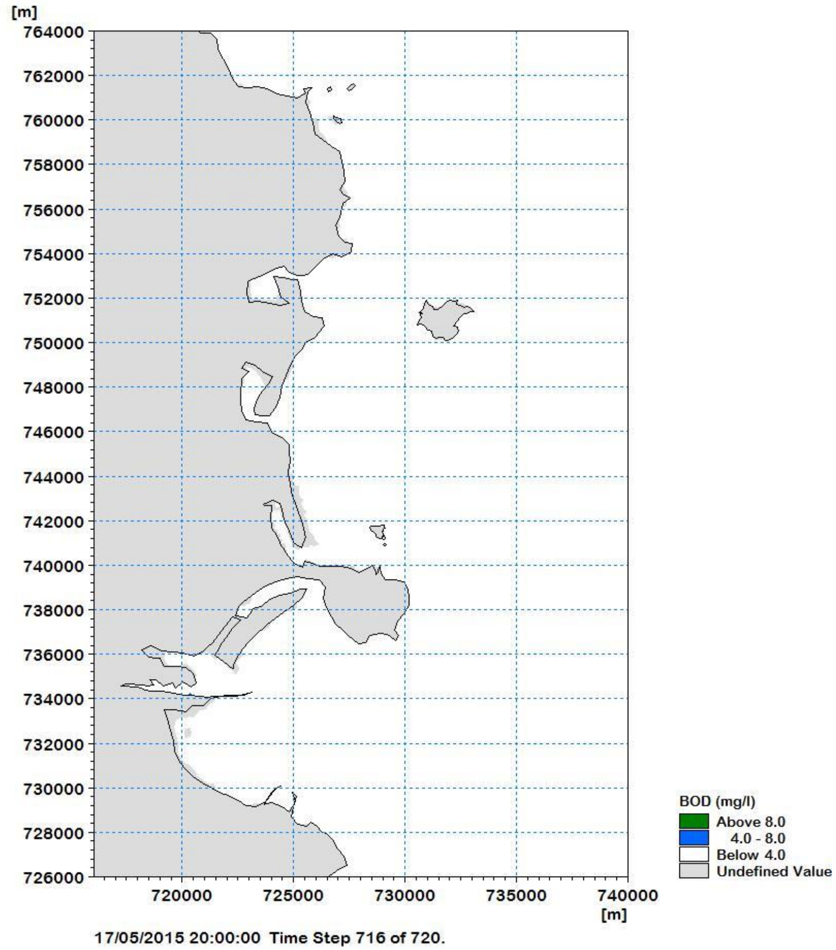



Diagram 8.56: BOD Concentration at Mid Flood on Spring Tide

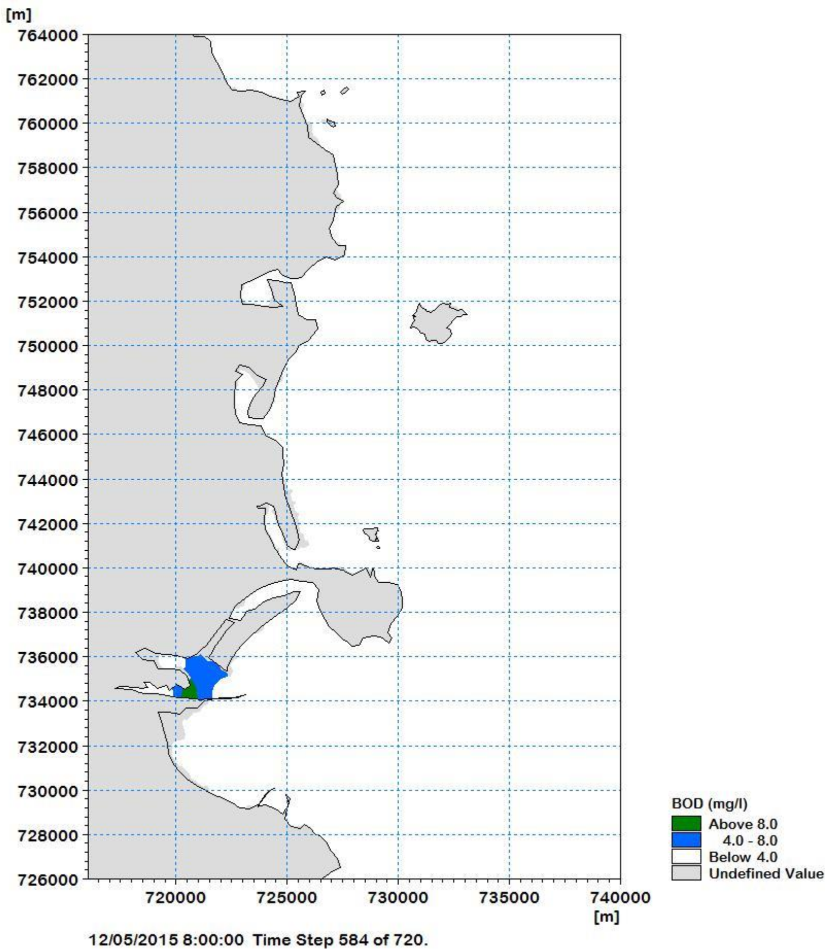



**Diagram 8.57: BOD Concentration at High Water on Neap Tide**

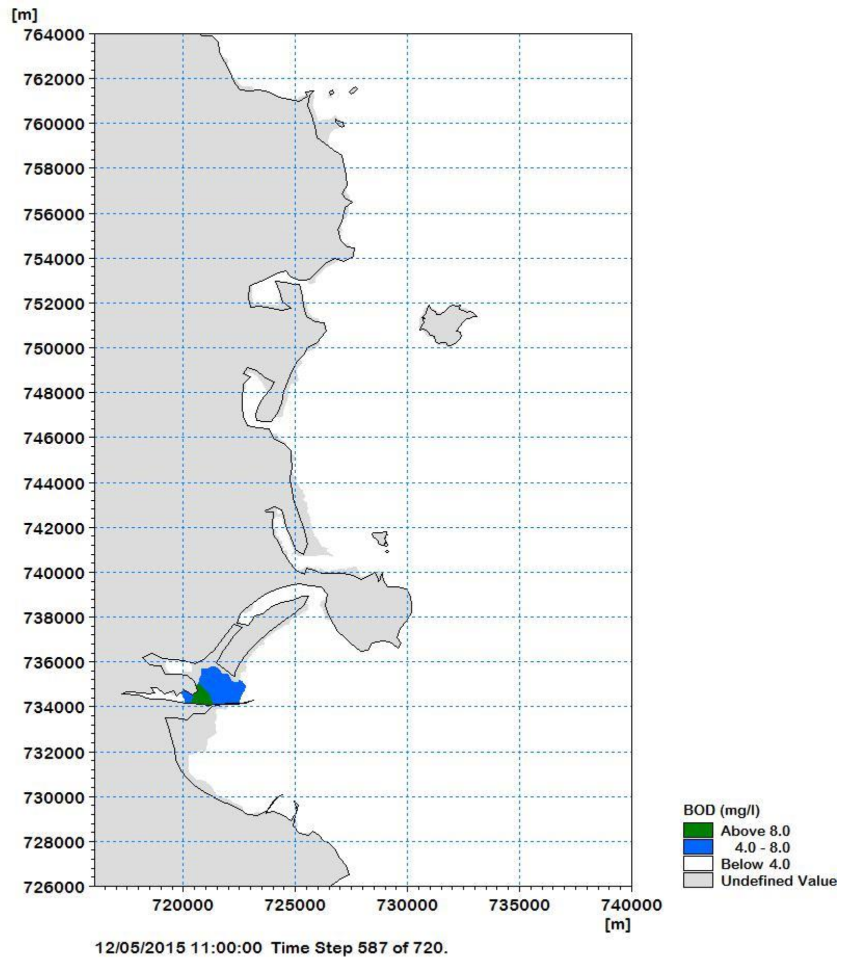



**Diagram 8.58: BOD Concentration at Mid Ebb on Neap Tide**

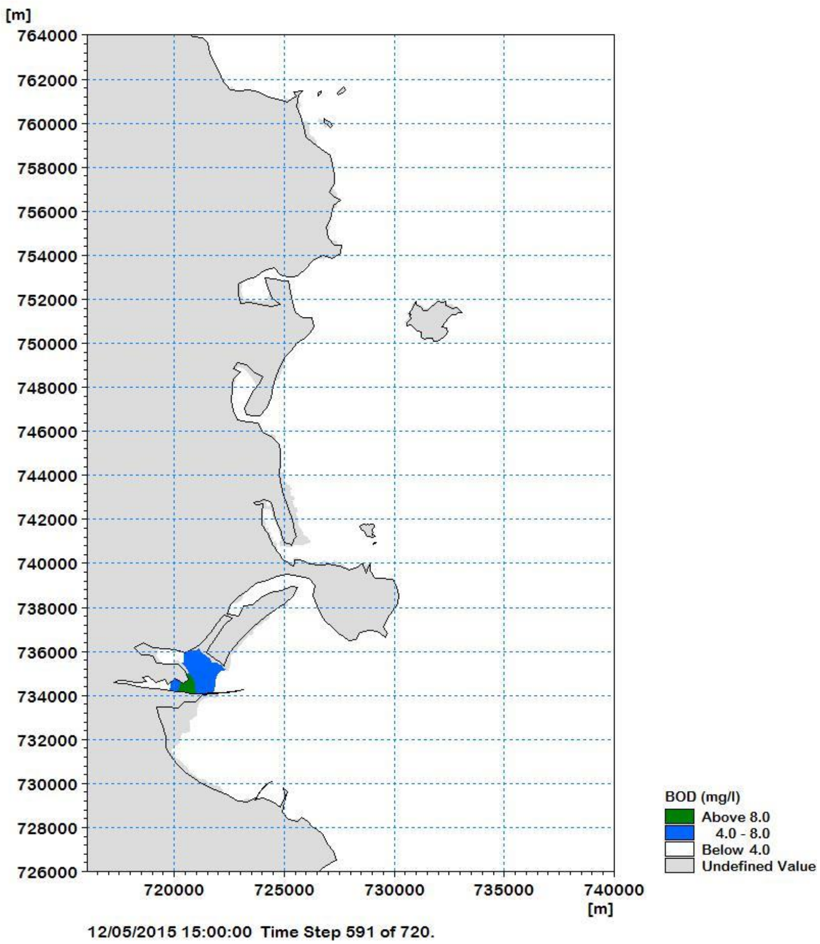



**Diagram 8.59: BOD Concentration at Low Water on Neap Tide**

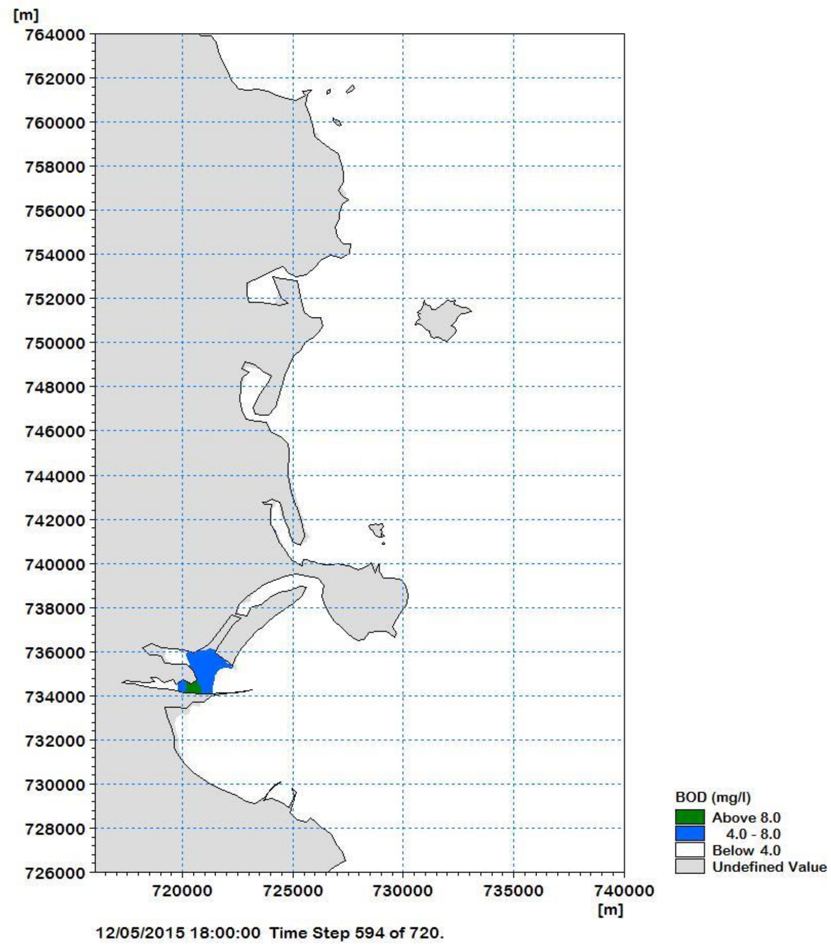



**Diagram 8.60: BOD Concentration at Mid Flood on Neap Tide**

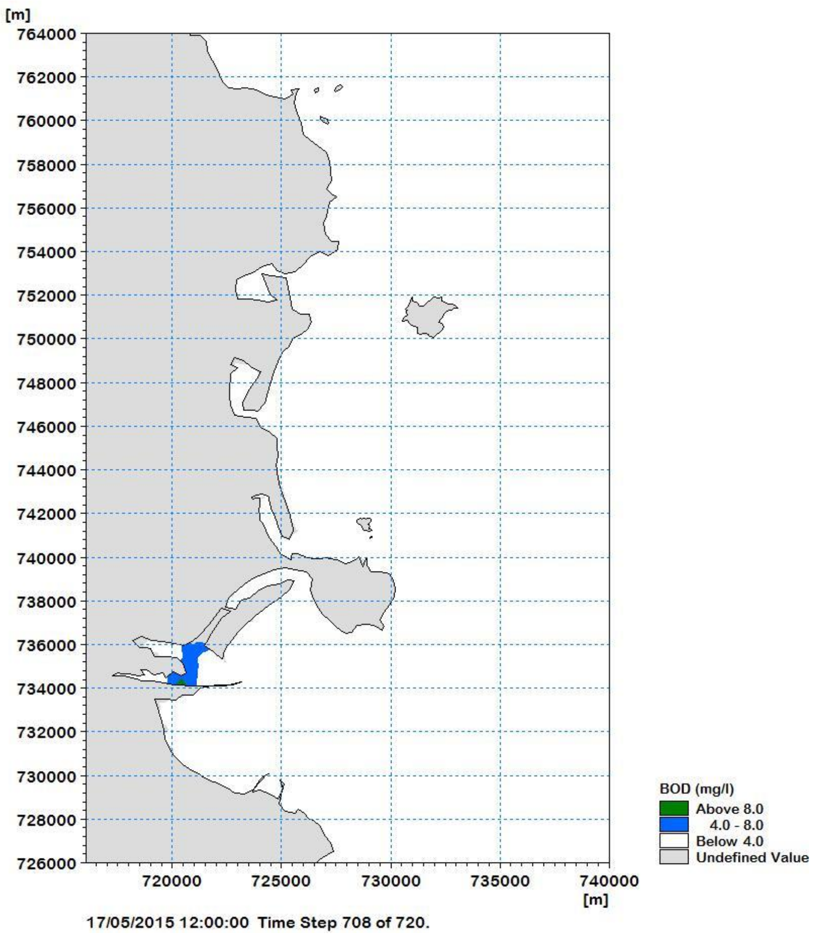



**Diagram 8.61: BOD Concentration at High Water on Spring Tide**

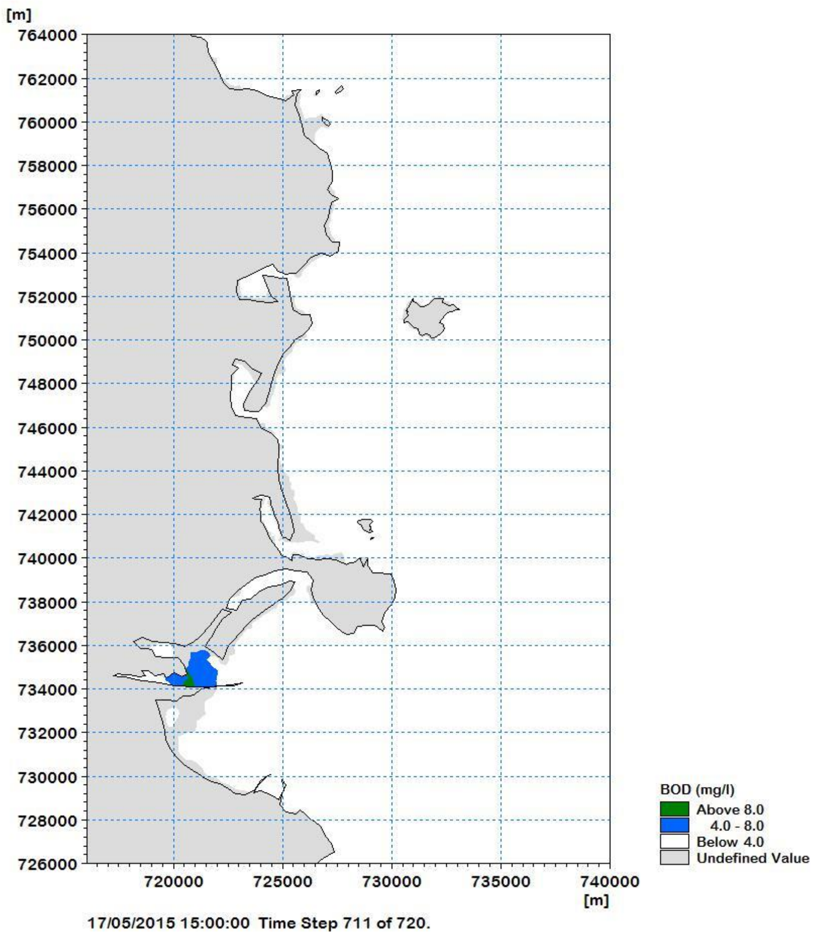



**Diagram 8.62: BOD Concentration at Mid Ebb on Spring Tide**

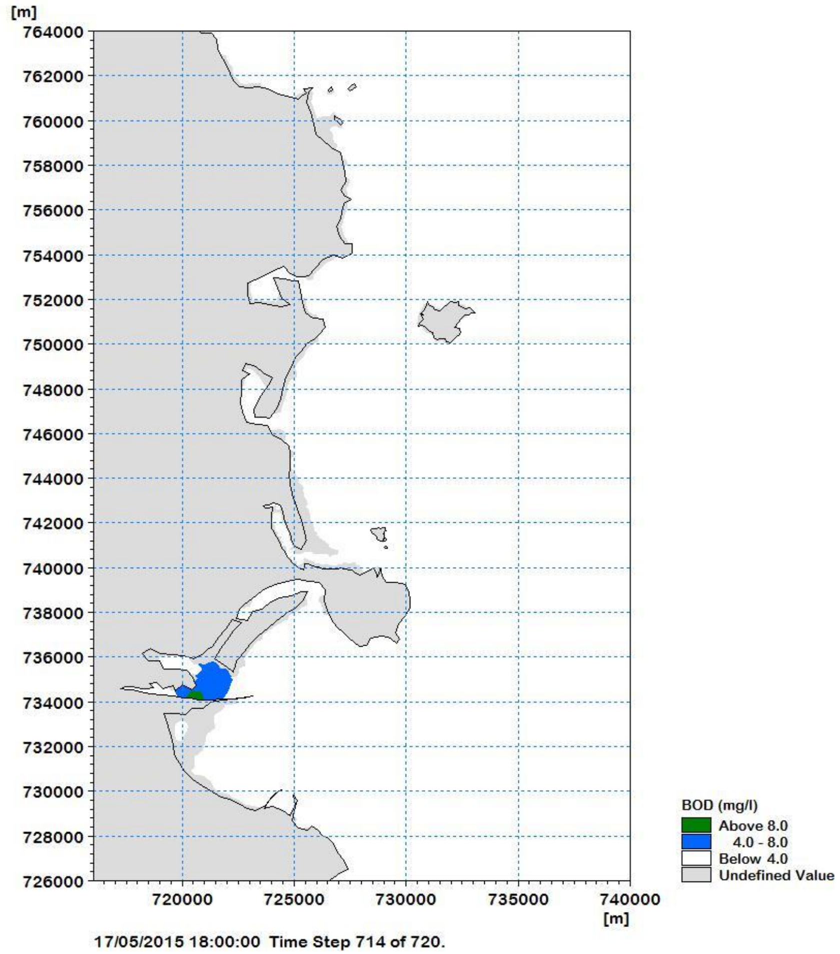



**Diagram 8.63: BOD Concentration at Low Water on Spring Tide**

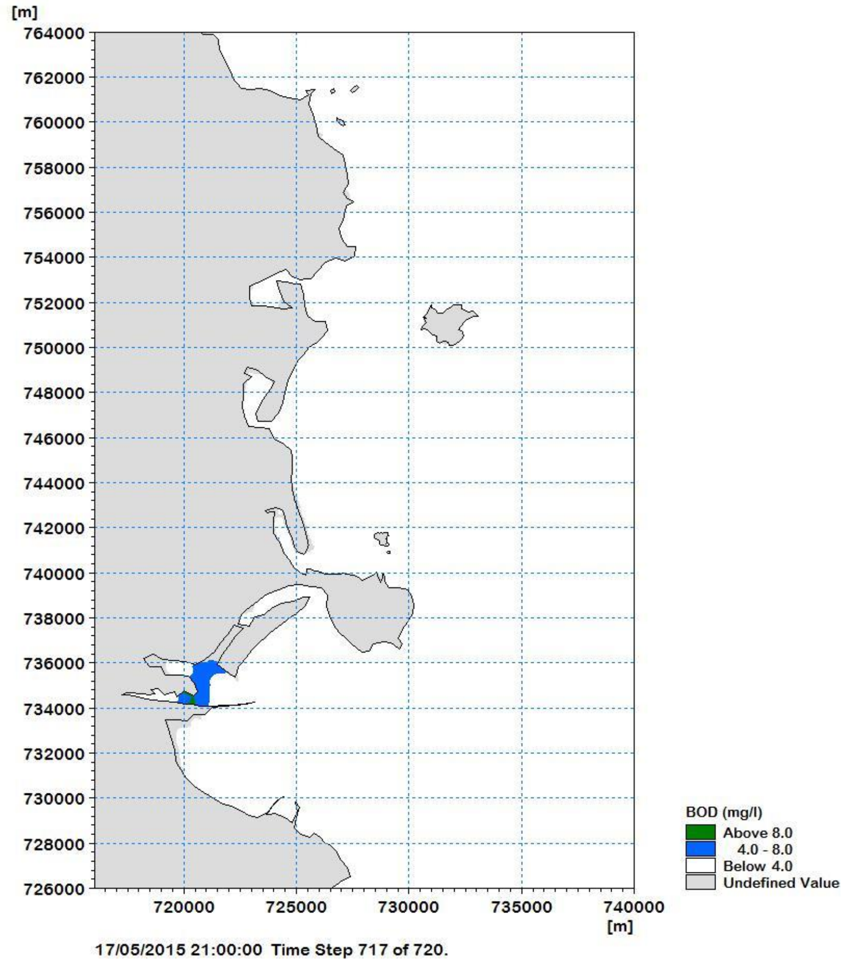
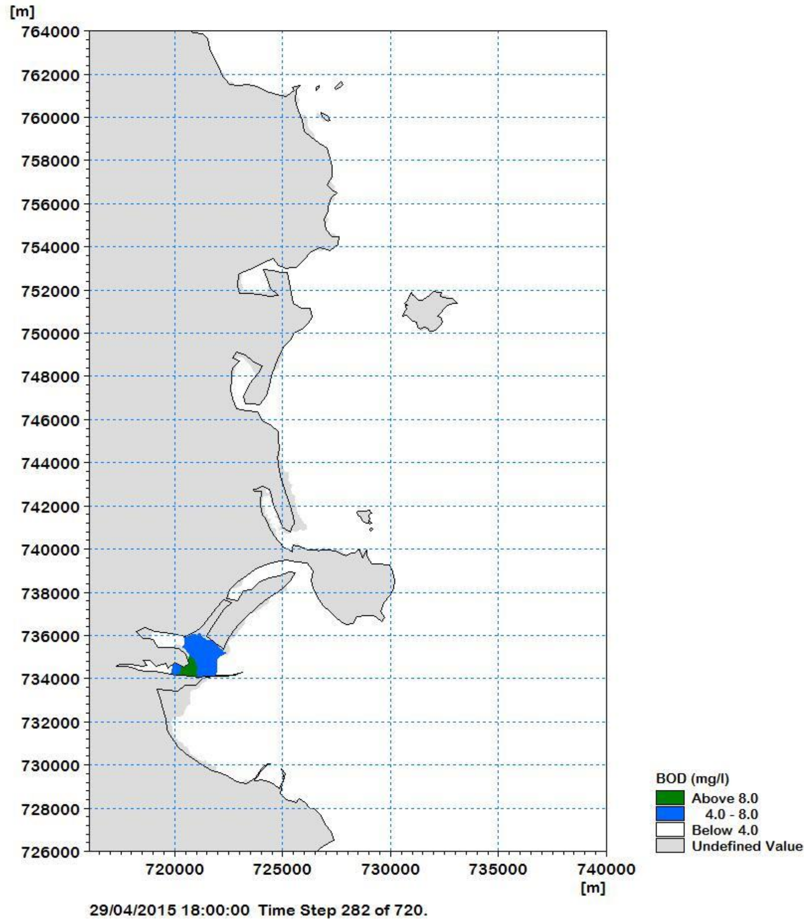
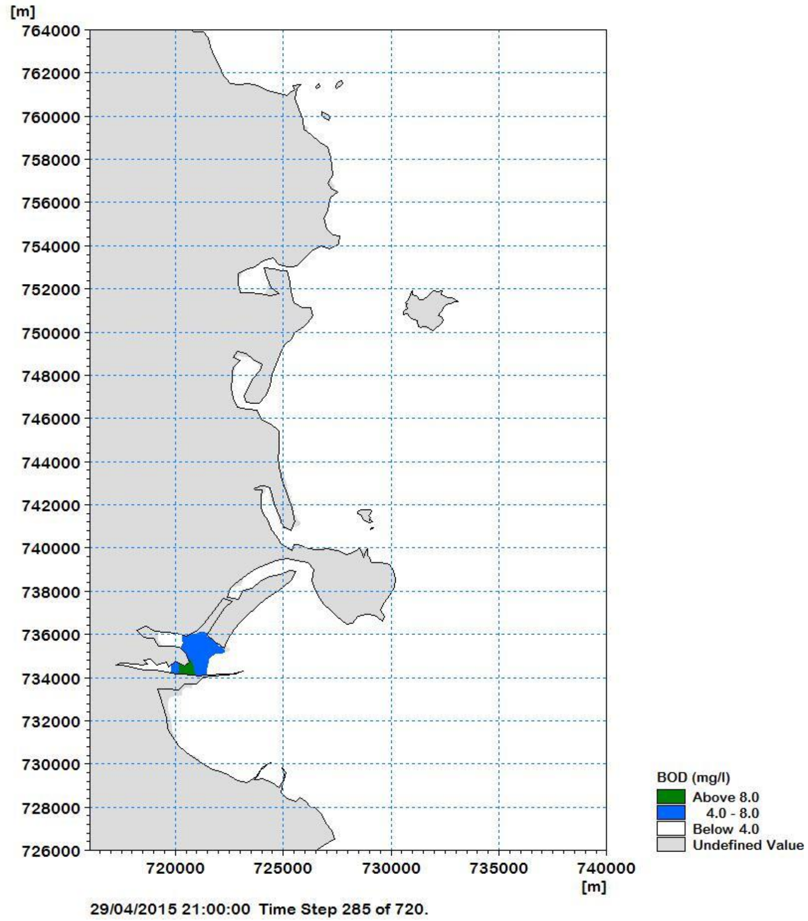
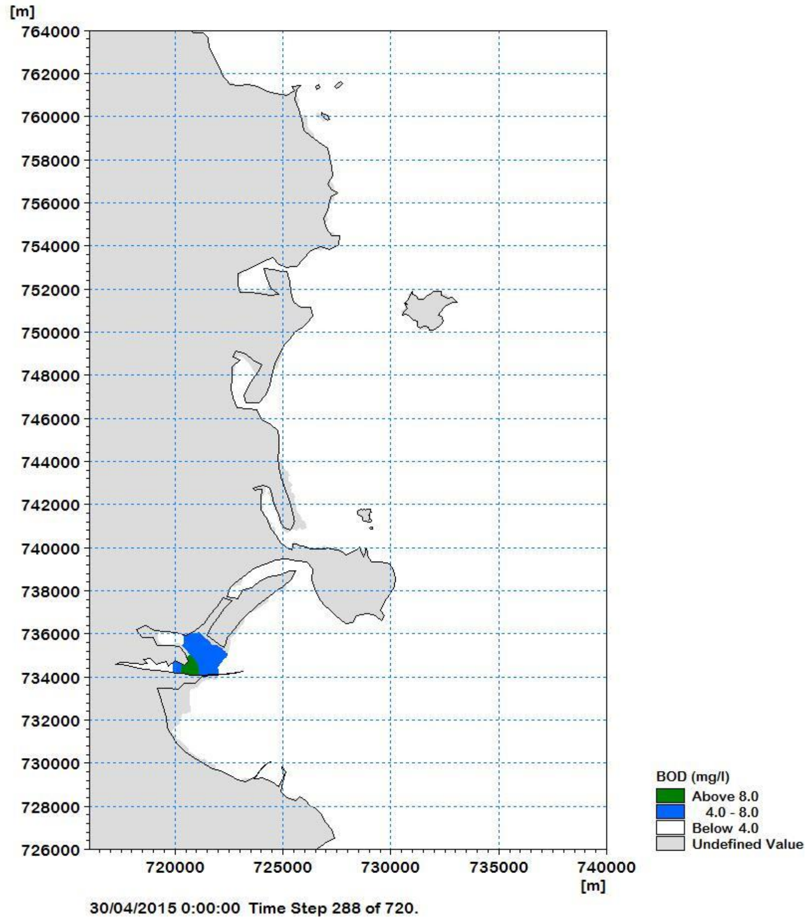



**Diagram 8.64: BOD Concentration at Mid Flood on Spring Tide**




| | |
|---|---|
| **Diagram 8.65: BOD Concentration at High Water** | **Diagram 8.66: BOD Concentration at Mid Ebb** |



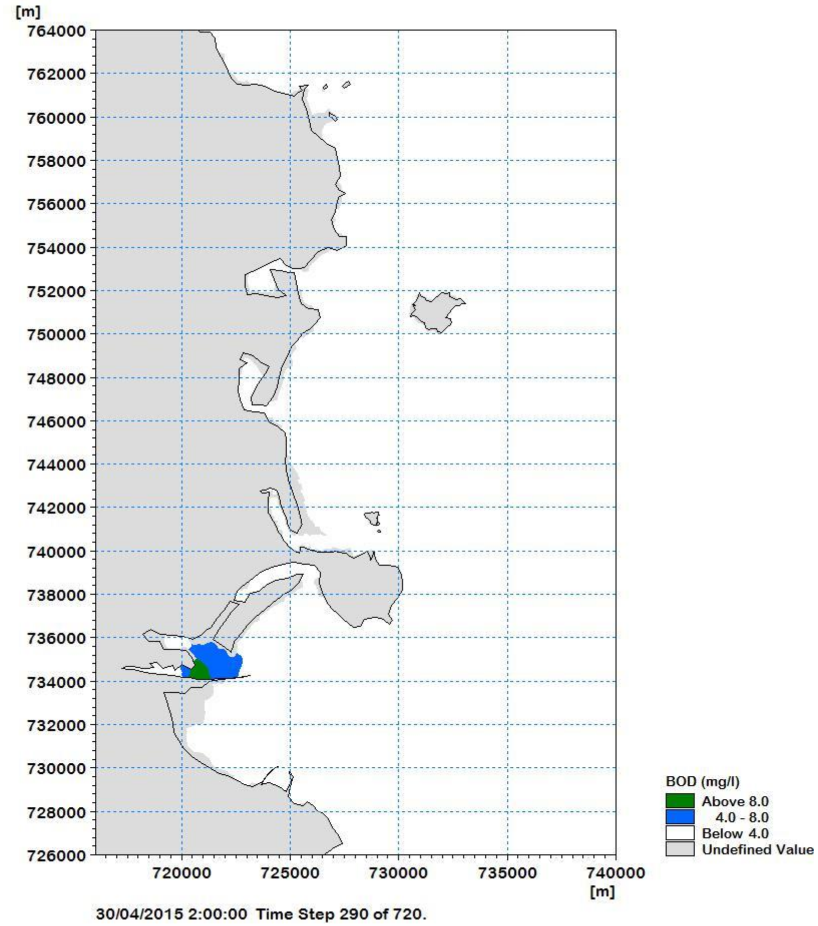




**Diagram 8.67: BOD Concentration at Low Water**

**Diagram 8.68: BOD Concentration at Mid Flood**

Escherichia coli (COLI)

The Bathing Water Quality Regulations 2008 (S.I. No. 79 of 2008) require that the maximum values of Escherichia coliforms should not exceed the mandatory value of 500/100ml in 95% or more of the samples taken in the season to ensure a 'good' classification of bathing water beaches.

*Average Daily Flow*

The tidal plots showing the maximum extent of the predicted COLI plume from the proposed outfall pipeline route (marine section) discharge point at high water, mid ebb, low water and mid flood on neap tides are presented in Diagram 8.69 to Diagram 8.72 and on spring tides in Diagram 8.73 to Diagram 8.76. None of the diagrams show the COLI plume from the proposed outfall pipeline route (marine section) discharge point exceeding the 500/100ml limit required to achieve good status. Elevated COLI levels in the transitional waters displayed in the diagrams result from other WwTPs or rivers directly discharging to the affected waters. The diagrams show that there was predicted to be no impact on the receiving waters from the proposed operation of the proposed outfall pipeline route (marine section) discharge point.

*Flow to Full Treatment*

The tidal plots showing the maximum extent of the predicted COLI plume from the proposed outfall pipeline route (marine section) discharge point at high water, mid ebb, low water and mid flood on neap tides are presented in Diagram 8.77 to Diagram 8.80 and on spring tides in Diagram 8.81 to Diagram 8.84. Only one diagram shows the COLI plume from the outfall exceeding the 500/100ml limit required to achieve good status in a very localised area to the proposed outfall pipeline route (marine section) discharge point. Elevated COLI levels in the transitional waters displayed in the diagrams result from other WwTPs or rivers directly discharging to the affected waters. The diagrams show that there was predicted to be an Imperceptible on the receiving waters from the proposed operation of the proposed outfall pipeline route (marine section) discharge point.

*Process Failure*

The tidal plots showing the maximum extent of the predicted COLI plume from the proposed outfall pipeline route (marine section) discharge point at mid ebb, low water, mid flood, high water on the last tide of the three-day simulated process failure scenario are presented in Diagram 8.85 to Diagram 8.88. None of the diagrams show the COLI plume from the proposed outfall pipeline route (marine section) discharge point exceeding the 500/100ml limit required to achieve good status. Elevated COLI levels in the transitional waters displayed in the diagrams result from other WwTPs or rivers directly discharging to the affected waters. The diagrams show that there was predicted to be no impact on the receiving waters from the proposed operation of the proposed outfall pipeline route (marine section) discharge point.

There are no compliance failures predicted at any of the designated bathing water beaches or Blue Flag beaches arising from the proposed discharge of treated wastewater.

None of the scenarios examined predicted the likelihood of any significant impact on the receiving waters from the proposed operation of the proposed outfall pipeline route (marine section) discharge point.