

7.0 Coastal Processes

Introduction

- 7.1 This chapter of the Environmental Impact Assessment Report (EIAR) presents the assessment of the potential impact of the proposed development on coastal processes. Specifically, this chapter considers the potential impact of the proposed development seaward of Mean High Water Springs (MHWS) during the construction and operational phases.
- 7.2 The assessment presented also informs and is informed by the following technical chapters:
- **Chapter 10.0: Flood Risk**
 - **Chapter 11.0: Water Quality**
 - **Chapter 12.0: Benthic Ecology**
 - **Chapter 21.0: Soils, Geology and Contamination**
- 7.3 In this chapter coastal processes are considered to encompass both receptors which are designated for coastal features and those which form pathways for other designated features. Further supporting information in addition to that provided within this chapter, relating to coastal modelling methodology, calibration and supplementary model output, is provided in **Appendix 7.1 (Volume 2 of EIAR)**.

Competency Statement

- 7.4 The author, Dr Naomi Shannon, is a Principal Engineer for the Water Environment and Flood Risk Management Team at RPS. Naomi has a BEng (Hons) in Civil Engineering, an MSc in Engineering Computation and a Doctorate in Computational Fluid Dynamics from Queen's University, Belfast. Naomi has 25 years' post-doctoral experience in coastal modelling and has been involved in undertaking environmental assessments for 20 years.
- 7.5 The co-author, Kristopher Calder, is a Technical Director within RPS and holds a BSc (Hons) in Marine Biology and an MSc (Distinction) in Physical Oceanography and has over ten years of experience in the field of coastal processes and numerical modelling. Kristopher is Chartered Scientist (CSci) and Water and Environment Manager (CWEM) and a full member of the Chartered Institute of Water and Environmental Management (CIWEM) an Associate Member of the Institute of Civil Engineers (AMICE).
- 7.6 The reviewer, Mr Adrian Bell, is a Senior Director within RPS' Coastal Engineering and Environment team and has more than 40 years' experience in the field of coastal engineering. Adrian holds a BSc Civil Engineering (1st Class Hons) and is a Chartered Engineer (CEng), a Fellow of the Institution of Engineers of Ireland (FIEI), a Fellow of the Irish Academy of Engineering (FIAE), a Member of the Institute of Civil Engineers (MICE), a Member of the Institution of Structural Engineers (MIStructE) and a Member of the Permanent International Association of Navigation Congress.

Legislation, Guidance and Policy

Introduction

- 7.7 The policy context for the proposed development is set out in **Chapter 4.0: Legislative and Planning Context of the EIAR**.
- 7.8 Policy and legislation relating specifically to coastal processes is contained in the National Planning Framework (NPF4)¹, Scottish National Marine Plan (NMP)² and the United Kingdom (UK) Marine Policy Statement (MPS)³. A summary of the policy statements relevant to coastal processes are provided below.

National Planning Policy Context

National Planning Framework 4 (NPF4)

- 7.9 Overarching planning policies for Scotland are contained within the NPF4. Policy 10 states that coastal development should not result in the need for further coastal protection or increase the risk to people from coastal erosion. The assessment of coastal processes in this chapter will outline any potential changes and mitigation measures required to minimise impacts from the proposed development.

Scottish National Marine Plan (NMP)

- 7.10 The general policies (GEN 8) included in the NMP state that developments and activities in the marine environment should be resilient to coastal change, and not have unacceptable impact on coastal processes. This assessment outlines potential changes caused by the proposed development and includes mitigation measures to minimise the impact, in line with section 4.36 of the NMP, where applicable.

United Kingdom (UK) Marine Policy Statement (MPS)

- 7.11 In concert with the aforementioned policies, the UK MPS primarily references coastal processes in relation to coastal change/erosion, coastal protection and climate change. The purpose of this chapter is to assess any potential changes to the coastal processes due to the proposed development, which will include changes that would impact coastal change. Mitigation measures to minimise any potential impacts are contained within this assessment.

¹ Scottish Government: National Planning Framework 4: February 2023

² Scottish Government: Scottish National Marine Plan (2015)

³ HM Government: United Kingdom (UK) Marine Policy Statement (2011)

Local Policy and Guidance

Dumfries and Galloway Council Local Development Plan 2 (LDP2)

- 7.12 Policy NE10 of the LDP2⁴ relates to erosion and coastal protection and confirms that Dumfries and Galloway Council are in favour of maintaining the natural sediment processes of the coastline. This chapter includes an assessment of the potential impact to sediment transport from the proposed development and any mitigation measure required to minimise potential changes.

⁴ Dumfries and Galloway Council: Local Development Plan 2: October 2019

Methodology Used For Assessment

Introduction

- 7.13 For the purposes of this EIAR chapter, coastal processes are defined as encompassing the following elements:
- tidal elevations and currents;
 - waves;
 - seabed sediments;
 - suspended sediments; and
 - sediment transport.
- 7.14 This chapter is supported by numerical modelling and presents the existing environmental baseline established from desk studies, site-specific surveys, numerical modelling studies, and consultation with Stakeholders. For the purposes of identifying significant impacts a comparative study was undertaken which assessed potential changes in coastal process drivers (i.e. tidal currents and waves) using numerical modelling techniques.
- 7.15 Coastal processes are not merely considered as receptors in themselves; they may be a pathway by which coastal features may be impacted or form a pathway for indirect impacts on other receptors. For example, increases in suspended sediments during the construction phase may lead to the deposition of sediments and smothering of benthic habitats. In this case, the magnitude of the potential changes has been assessed, with the sensitivity of the receptors to these changes and the significance of effects assessed within the relevant chapter (i.e., **Chapter 12.0: Benthic Ecology**).
- 7.16 Similarly, there are currently no areas designated specifically for coastal processes attributes in the vicinity of the proposed development, however changes to coastal processes and suspended sediment concentration (SSC) may influence a range of designations in terms of supporting habitats. The modelling study outcomes reported within this chapter therefore quantifies potential changes to coastal processes and this information is used to assess the impact on any designated receptors in the relevant sections of this EIAR.
- 7.17 The assessment is therefore undertaken with regards to both receptors relating to coastal features and those which form pathways for other designated features. The assessment highlights any necessary monitoring and/or mitigation measures which are recommended to prevent, minimise, reduce or offset the likely significant effects of the proposed development on coastal processes.
-

Consultation

- 7.18 During the pre-application phase of the proposed development Stakeholder engagement was undertaken. With regards to coastal processes, this principally focussed on obtaining a scoping opinion through Marine Scotland - Licensing Operations Team (MS-LOT) and agreeing the impacts and receptors to be included in the assessment. The emphasis of the EIA submission documents is on likely significant environmental effects as required by the EIA Regulations⁵.
- 7.19 A summary of the key issues raised during consultation activities undertaken to date and specific to coastal processes for the proposed development is presented in Table 7-1. This table includes a summary of the response or where this issue is considered within this chapter, as appropriate.

Table 7-1: Summary of Key Consultation of Relevance to Coastal Processes

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or where Considered in this Chapter
February 2023	MS-LOT Scoping Report response: Marine Scotland Science (MSS)	MSS advise that the dispersion and fate of sediment plumes from the dredging and reclamation aspects of the construction phase should be investigated irrespective of whether or not pollutants exist in the sediment.	Dredging plume modelling was scoped into the study and applied within the assessment. Further details are provided in Appendix 7.1 (Volume 2 of EIAR) .
February 2023	MS-LOT Scoping Report response: MSS	On-going maintenance dredging, and this needs to be properly evaluated and disposal options being discussed. What happens if not all dredged material during the construction phase can be used in the reclamation works, is a back-up plan in place?	The project description includes excess dredging material being deposited in Beaufort's Dyke Licenced site. The operational phase assessment includes Maintenance Dredging .
February 2023	MS-LOT Scoping Report response: MSS	MSS advise that if possible, once the breakwater design has been finalised, further hydrodynamic modelling should be undertaken to compare current existing conditions with conditions once the new breakwater development is in place.	A full modelling study was undertaken for the final breakwater design. Further details are provided in Appendix 7.1 (Volume 2 of EIAR) .
February 2023	MS-LOT Scoping Report response: MSS	MSS advise that the model should get validated appropriately. If field studies are possible to collect data for model validation this is strongly encouraged, but historical data might also exist in the region that could get utilised. The model needs to get validated appropriately and details of the model,	Gap analysis was undertaken. A modelling methodology was circulated to Stakeholders. This is presented along with model calibration data in Appendix 7.1 (Volume 2 of EIAR) .

⁵ Environmental Impact Assessment (EIA) Directive (2014/52/EU)

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or where Considered in this Chapter
		boundary conditions and forcing, including sensitivity analysis, provided.	
February 2023	MS-LOT Scoping Report response: Scottish Environment Protection Agency (SEPA)	SEPA advise that the potential for the Proposed Works to cause changes to coastal and sediment transport processes in the adjacent water body upon completion of the works should be assessed.	Operational Phase assessment includes tidal regime, wave climate and sediment transport.
February 2023	MS-LOT Scoping Report response: SEPA	SEPA advise that the Applicant must consider implications with respect to shoreline and seabed morphology, and wider ecosystem health in line with SEPA's River Basin Management Plan objectives.	Operational Phase assessment includes tidal regime, wave climate and sediment transport.
January 2025	MSS Modelling methodology response	Marine Directorate - Licensing Operations Team (MD-LOT) stated that Marine Directorate - Science, Evidence Data and Digital (MD-SEDD) do not provide direct advice to applicants.	Assessments were carried out on the basis of the scoping opinion received.
January 2025	NatureScot Modelling methodology response	Broad agreement with the modelling methodology proposed. Modelling would be required to establish wave climate within the harbour for the purposes of design.	Modelling for environmental assessment was undertaken in line with the methodology proposed. Design of breakwater extension and new breakwater established following wave modelling Appendix 1.3 (Volume 2 of EIAR) .
January 2025	SEPA Modelling methodology response	Since provided scoping comments SEPA have stepped back from providing bespoke input on marine consultations as such this application now falls below the thresholds for which SEPA provide site specific advice and SEPA Standing Advice should be applied.	Modelling was undertaken in line with an approach previously agreed with SEPA with regards to an earlier study undertaken at Stranraer.
March 2025	NatureScot Modelling methodology response	Request for further information regarding modelling strategies applied for Loch Ryan associated with previous projects.	Additional information was provided and is presented in Appendix 7.1 (Volume 2 of EIAR) .

Study Area

- 7.20 The coastal processes study area (henceforth “*the study area*”) is illustrated in **Figure 7-1** and encompasses the following:
- Stranraer Marina Expansion Scheme offshore development extent (i.e. the area within which the increased dredging and breakwaters to accommodate the new marina layout will be located)
 - Seabed and shoreline extent that may be influenced by changes to coastal processes due to the proposed development
- 7.21 Generally the study area may be defined as one spring tidal excursion. This is the distance suspended sediment could be transported prior to being carried back on the returning tide. A preliminary study was undertaken to determine this extent, as documented in **Appendix 7.1 (Volume 2 of EIAR)**. It was however observed that some material mobilised in the inner harbour settles in the harbour mouth at slack water and, given the increased current speed at this location, may be resuspended on the subsequent tide. Therefore to ensure that a conservative approach was applied a second tide was considered and the greatest distance observed was applied at the project boundary to define the potential Zone of Influence (Zol).
- 7.22 It is however noted that although the study area forms the focus for the assessment, that the numerical modelling study undertaken to support the assessment is not limited to this region, as detailed in [Modelling Methodology](#) and illustrated in **Figure 7-2**. The coastal processes modelling study therefore also identifies any potential impacts that may arise beyond the coastal processes study area.
-

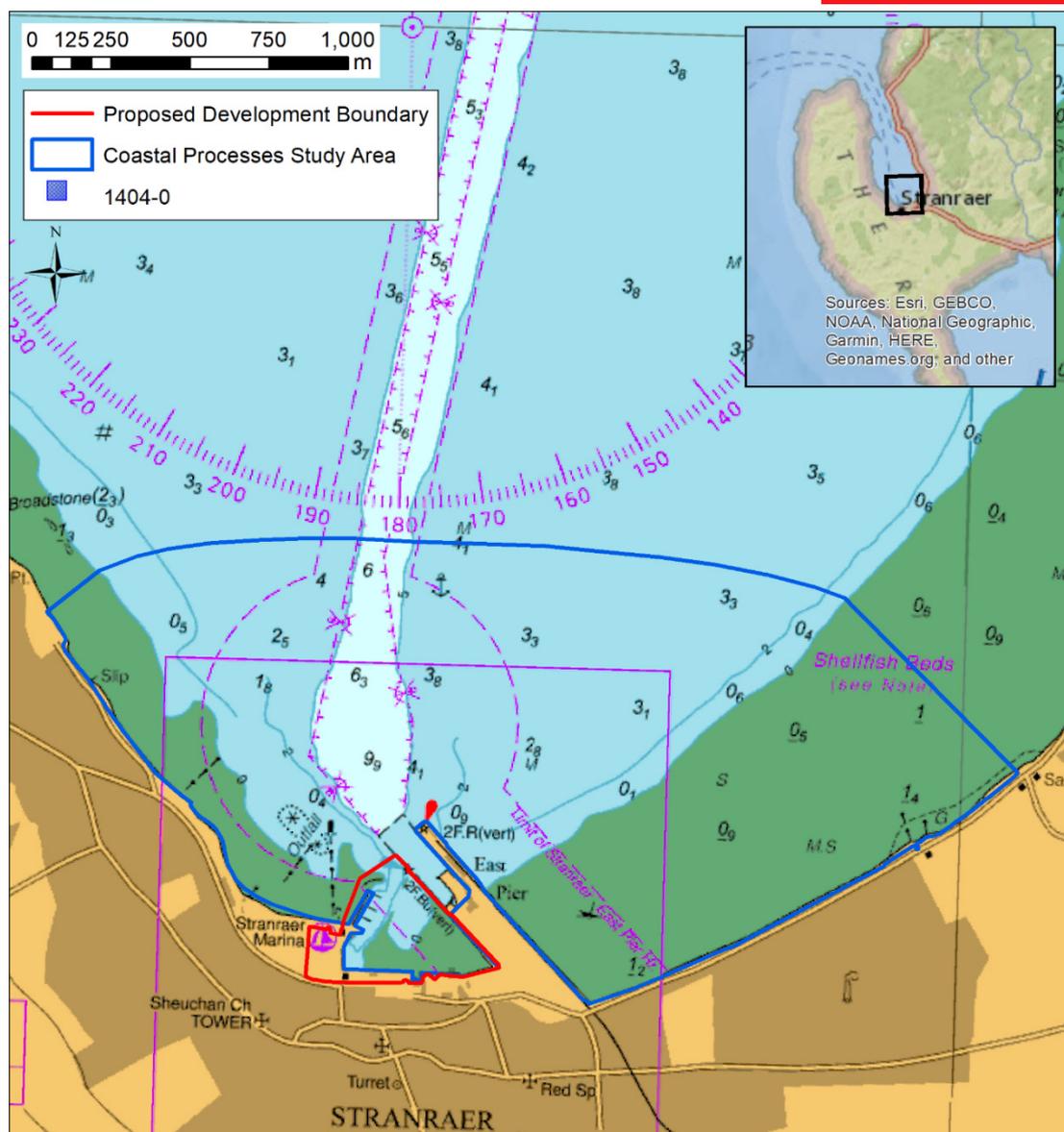


Figure 7-1: Coastal Processes Study Area (Admiralty chart 1404)

Receptors and Pathways within the Study Area

7.23 Any designated sites or qualifying interest features within the study area that could be affected by the construction and operation phases of the proposed development were identified using a number of sources. These included:

- SEPA register of protected areas (https://www.sepa.org.uk/media/0t0bowmf/protected_area_register.xlsx)
- Marine Scotland website (<http://marine.gov.scot/>)
- NatureScot website (<https://sitelink.nature.scot/map>)
- Atlas of Marine Protection website (<https://mpatlas.org/>)

- Joint Nature Conservation Committee (JNCC) resources (<https://jncc.gov.uk/mpa-mapper/>)

7.24 There are no areas designated for coastal process features or bathing waters located within the study area. Loch Ryan is however a SEPA Shellfish Water Protected Area which is assessed in **Chapter 11.0: Water Quality** and **Chapter 13.0: Fish Ecology**. Therefore the coastal processes assessment focusses on quantifying the magnitude of changes to coastal processes and on the consideration of pathways for effects on related disciplines i.e. SSC and subsequent deposition in addition to potential changes to sediment transport regimes.

Baseline Conditions

7.25 The coastal processes study used the MIKE 21 hydrodynamic numerical modelling software package developed by the Danish Hydraulic Institute (DHI), to quantify coastal processes. This was achieved by developing a range of two-dimensional numerical models to represent the baseline conditions. These models were used in conjunction with site specific hydrographic survey and sediment data to determine the baseline condition associated with the following coastal processes:

- The tidal regime;
- The inshore wave climate; and
- Sediment dynamics under both calm (pure tides) and meteorological conditions (storm activity).

Coastal Process Modelling Software

7.26 A suite of coastal process models, based on the MIKE software developed by DHI, was used to establish the coastal processes within Stranraer Harbour, along the adjacent shoreline and in the south of Loch Ryan. The MIKE software is an industry-standard, modelling system, utilising a flexible mesh approach and is approved by numerous statutory bodies including SEPA. This software was specifically developed for applications within oceanographic, coastal and estuarine environments.

7.27 A brief synopsis of the MIKE system and specific modules used for this assessment is outlined below:

- **MIKE 21 FM system** - Using these flexible mesh modelling systems, it is possible to simulate the mutual interaction between currents, waves and sediment transport by dynamically coupling the relevant modules.
- **The Hydrodynamic module** - This module simulates water level variations and flows in response to various forcing functions in lakes, estuaries and coastal regions. The Hydrodynamic module is a fundamental computational component of the systems, providing the hydrodynamic basis for the Sediment Transport module. The Hydrodynamic module solves the two dimensional incompressible Reynolds

averaged Navier-Stokes equations subject to the assumptions of Boussinesq and hydrostatic pressure.

- **The Spectral Wave module** - This module simulates the growth, decay and transformation of wind-generated waves and swell in offshore and coastal areas and accounts for key physical phenomena including wave growth by wave action, dissipation, refraction, shoaling and wave-current interaction where appropriate.
- **The Sediment Transport module** - The Sediment Transport Module was used to simulate the erosion, transport, settling and deposition of non-cohesive sediment in marine and estuarine environments and includes key physical processes such as forcing by waves. The module can be used to assess the impact of marine developments on erosion and sedimentation patterns by including common structures such as jetties, piles or dikes. Related transport modules enable point sources to be introduced to represent localised increases in current flows with associated sediment loading as a result of various coastal activities such as re-nourishment or dredging operations.

Modelling Methodology

- 7.28 The modelling study undertaken utilised the full scope of the MIKE integrated modelling system, whereby a single base model was used to determine both baseline and post-construction coastal processes, i.e. tidal flow, wave climate and sediment transport regimes. The approach was in line with the modelling methodology developed in scoping and detailed in the briefing document circulated during consultation (**Appendix 7.1 (Volume 2 of EIAR)**).
- 7.29 The coastal processes model domain extended to cover Loch Ryan and the Stranraer shoreline as illustrated in **Figure 7-2**. The triangular element mesh varied in resolution throughout the domain in order to represent the bathymetry with the detail required to simulate variation in tidal flow and wave climate across the domain. The mesh was also tailored to enable the same arrangement of cells to be implemented for the post-construction scenario and for use in dispersion modelling associated with dredging plumes.
- 7.30 The bathymetry and mesh resolution in the south of Loch Ryan is shown in **Figure 7-3**. The cell sizes within Stranraer Harbour and marina are *circa* 5m, whilst in the immediate vicinity they increase to *circa* 8m. Along the adjacent shoreline and within the navigation channel cell sizes ranged between 15m to 20m whilst cell sizes in the remainder of the lower Loch did not generally exceed *circa* 50m.
-

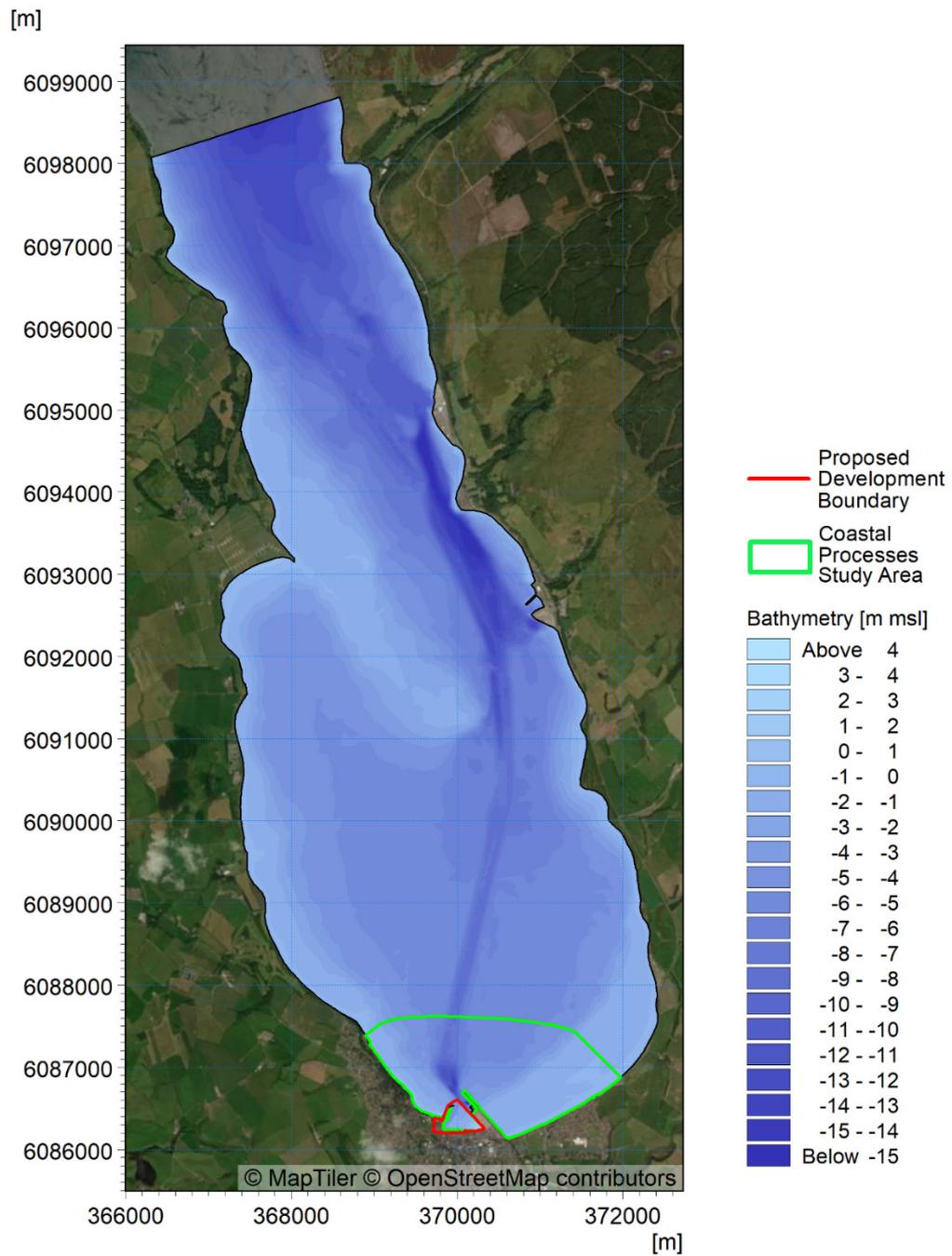


Figure 7-2: Coastal Processes Model Domain

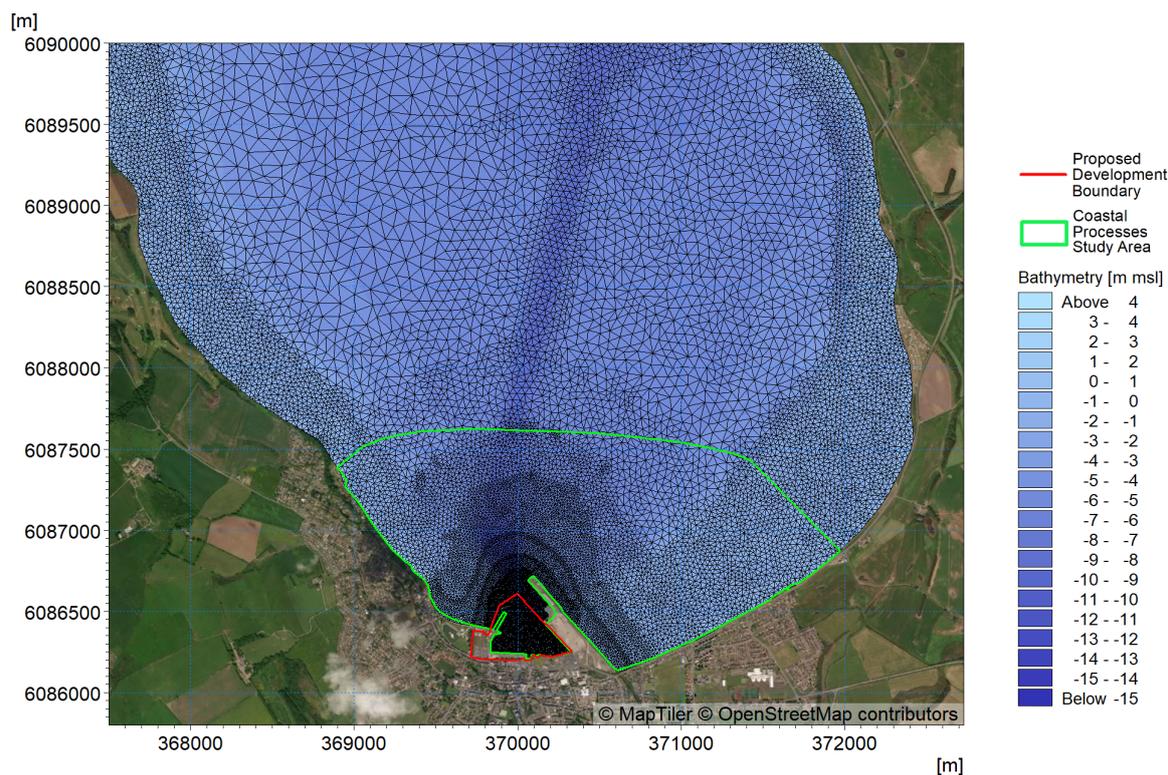


Figure 7-3: Mesh Resolution in South of Loch Ryan

7.31 The bathymetry of the model was developed from a range of data sources including project specific and local surveys with a resolution of between 1m to 4m within Stranraer marina and the navigation channel. Data sources used to develop the Loch Ryan wider model included:

- Project specific surveys undertaken by Six West of Stranraer harbour and approaches (2023);
- Surveys relating to other projects undertaken in the vicinity e.g. to the east of the harbour (2013);
- Detailed Lidar along the Stranraer coastline sourced from Scottish Remote Sensing Portal (2011-2012);
- UK Hydrographic Office (UKHO) Bathymetric survey data – Marine Environmental Data and Information Network (Medin) (1998, 1999); and
- Admiralty chart data (various).

7.32 The modelling undertaken to determine baseline conditions used a range of forcing parameters to drive the models depending on the coastal process being investigated. The hydrodynamic modelling implemented a 'flather' boundary at the northern extent of the Loch Ryan model; whereby both surface elevation and current flows are prescribed. These boundary conditions were provided from RPS's inhouse model covering the northern section of the Irish Sea and southern Inner Hebrides, as shown in **Figure 7-4**. Where the model was used to simulate a combination of both tidal and meteorological conditions. The pressure and wind field was applied using data from the European Centre for Medium-Range Weather Forecasts (ECMWF)

operation model. This is an industry standard dataset which is used by many organisations to force regional models, including the “Atlantic- European North West Shelf - Ocean Physics Analysis and Forecast” model as developed by the UK Met Office.

- 7.33 It was also recognised that due to the geography and enclosed nature of Loch Ryan, the application of water levels generated from harmonic analysis also provided effective boundary conditions for simulating tidal flow throughout the Loch under calm conditions (i.e. tide only).

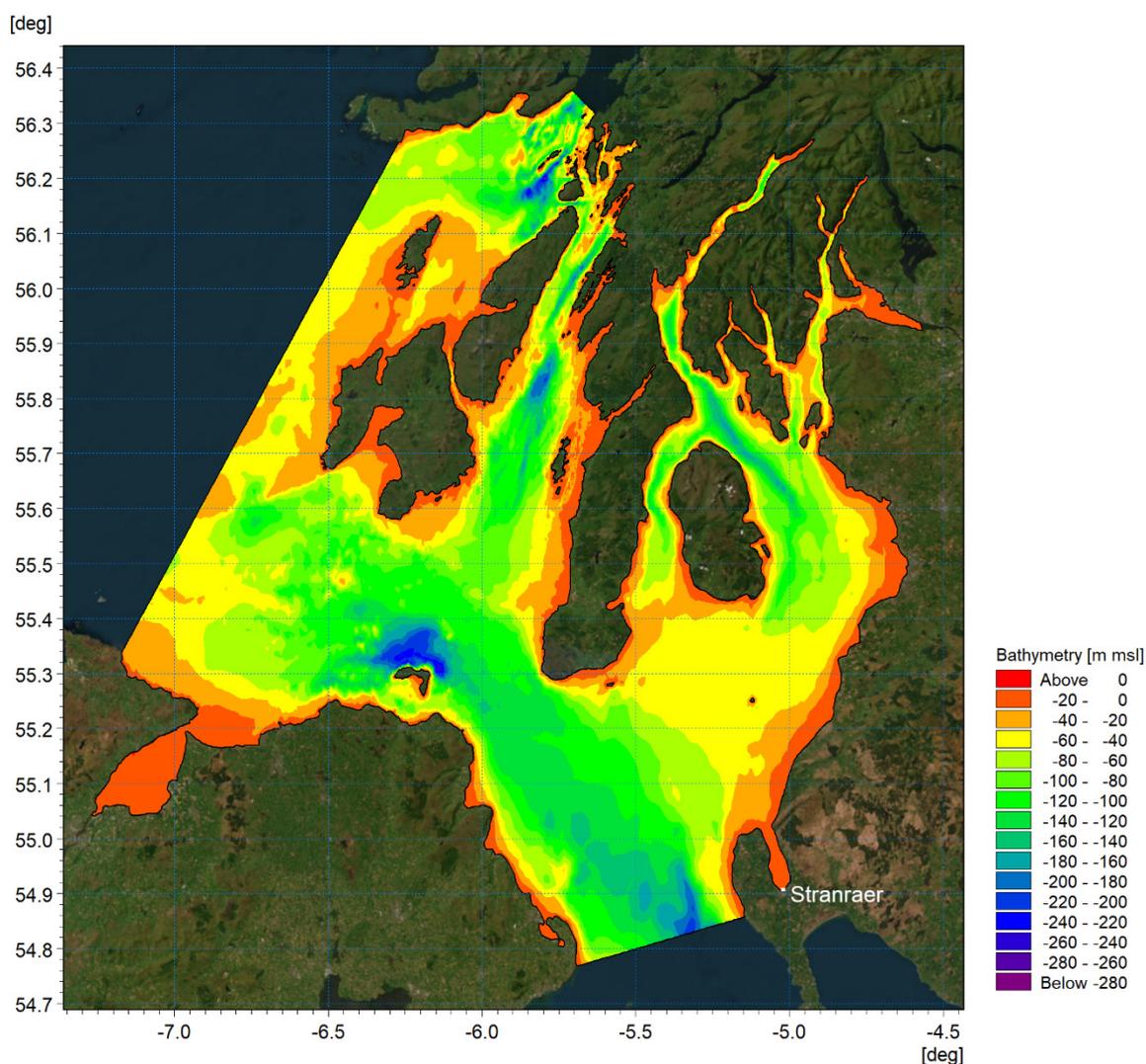


Figure 7-4: Extent of the Tidal Boundary Forcing Model

- 7.34 The baseline wave climate was established using a two stage process. First the waves were generated and transformed over the Firth of Clyde and the North Channel. The wave generation and transformation was then modelled in Loch Ryan itself using the offshore model forcing data on the boundary of the Loch Ryan model in addition to the wind data applied across the model domain.

- 7.35 The extent of the outer wave model of the North Channel, the Firth of Clyde and the approaches to Loch Ryan is shown in **Figure 7-5**. The wind data for wave generation was based on the

analysis of long term wind data (>30 years) from the ECMWF Atmospheric model and data from extreme winds developed by the UK Met Office for BS EN 1991:2005. Extreme value analysis (EVA) was undertaken for each 30° directional sector for the wind data from the ECMWF to establish the return period wind speeds for wave generation.

- 7.36 The results of the EVA analysis were compared with data from BS EN1991:2005 with the wind speeds for wave generation over the offshore fetches and the fetches within Loch Ryan being adjusted to take account of over water wind speeds and the length of time required to fully develop the waves over the appropriate fetch. The wave climate was then simulated for the outer model for a range of typical and extreme events (e.g. 1 in 1 year return period and 1 in 50 year return period).
- 7.37 The wave transformation modelling was then undertaken using the Loch Ryan model with wave climate at the boundary taken from the results of the offshore wave model simulations coupled with the wind for wind-wave generation within the Loch.

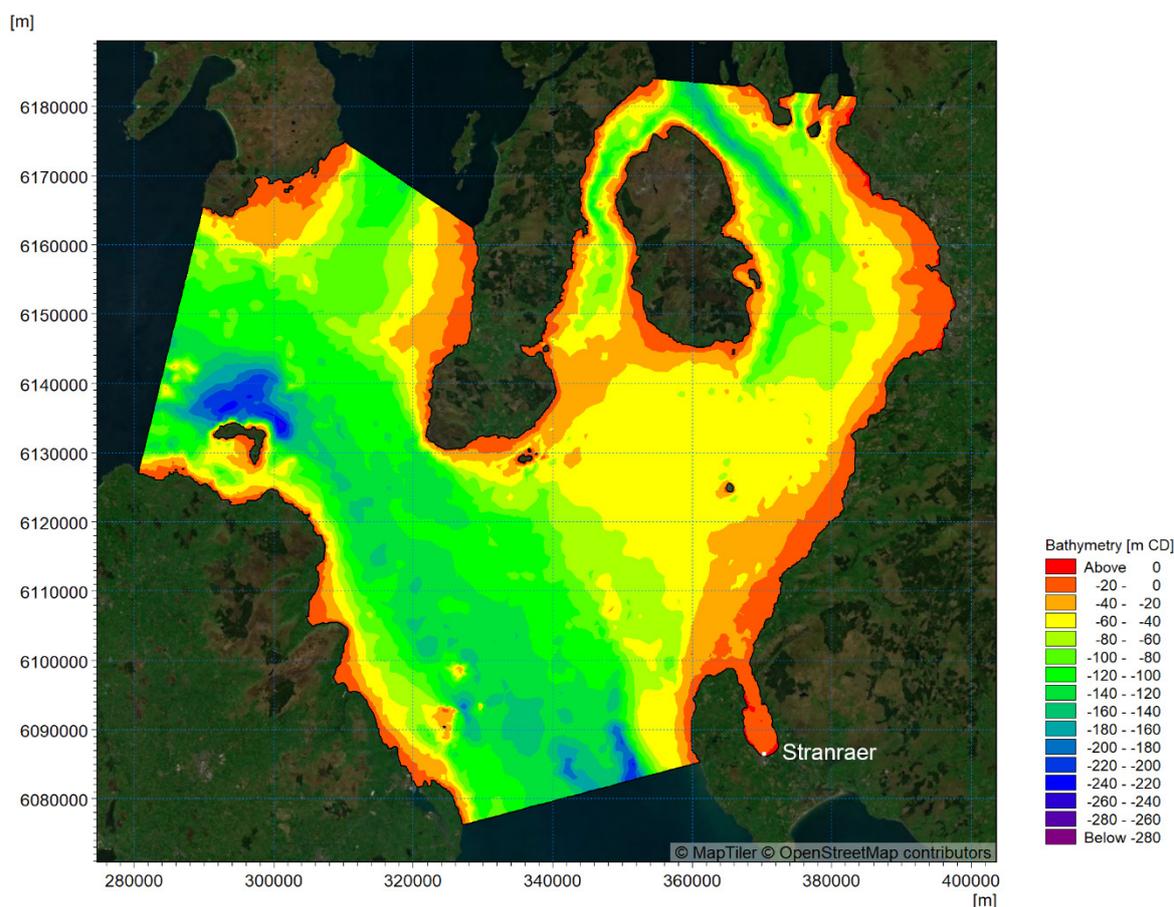


Figure 7-5: Extent of the Wave Climate Boundary Forcing Model

- 7.38 To undertake baseline sediment transport modelling, information was required to characterise the seabed substrate in both Stranraer Harbour and the wider extent of Loch Ryan. To this end, site specific ground investigation surveys were undertaken as part of the proposed development

and included boreholes and particle sieve analysis (PSA). This information was supplemented with data sourced from British Geological Survey (BGS) which provides generalised seabed sediment types. It was recognised that there is somewhat less data available in the shallow and intertidal areas. The nature of the seabed in these areas was therefore based on information in published Admiralty charts and a visual assessment of historic satellite data.

- 7.39 The hydrodynamic model was calibrated for a range of tidal conditions using SEPA tide gauge data, tidal harmonics published in the Admiralty Tide Tables⁶ and tidal streams published on Admiralty chart 1404, as illustrated in **Figure 7-6**. The range of conditions included spring and neap tides in addition to a range of meteorological conditions to ensure the model simulated the full range of tidal flow experienced within Loch Ryan. Further model calibration data is provided in **Appendix 7.1 (Volume 2 of EIAR)**.

⁶ The United Kingdom Hydrographic Office (UKHO) Volume 1 of the 2025 Admiralty Tide Tables for United Kingdom and Ireland.

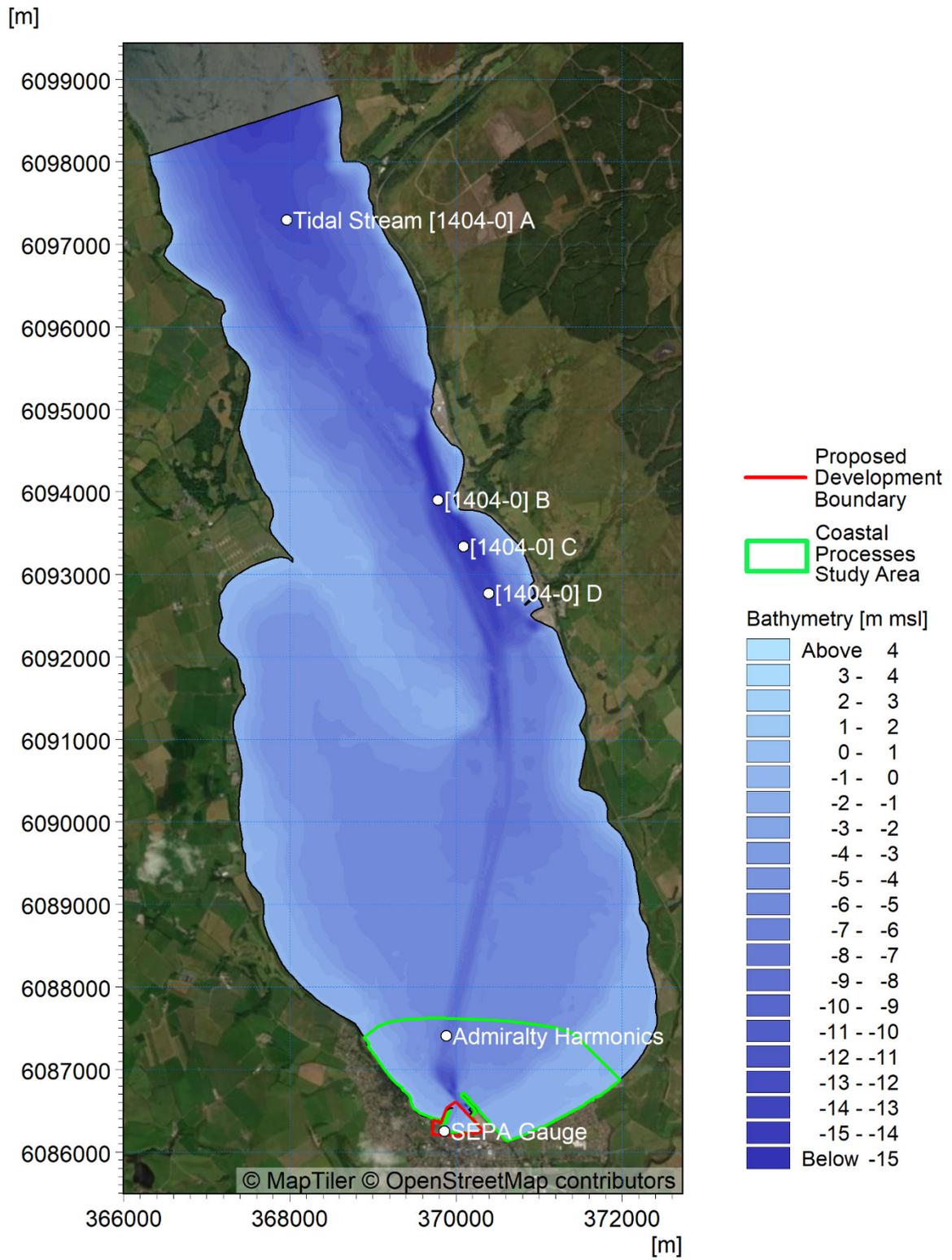


Figure 7-6: Location of Tidal Data used in Model Calibration

Impact Assessment Methodology

- 7.40 The scope of this EIAR has been developed in consultation with relevant statutory and non-statutory consultees as detailed in **Table 7-1**. The potential effects scoped into the coastal processes assessment can largely be broken down into two main groups:
- The installation of the marine infrastructure and associated dredging which are accompanied with increased SSC
 - The presence of the marine infrastructure which have the potential to change coastal processes, (i.e. tides, waves and sediment transport).
- 7.41 In terms of the physical presence of infrastructure and associated changes in bathymetry influencing tides, waves and sediment transport, impacts will escalate from the baseline condition (no infrastructure or impact) to the completed development though the course of the construction phase. Therefore, as a worst case scenario, these impacts will be the same as the operational phase and have been assessed on this basis. Therefore for succinctness the activities and potential impacts on receptor pathways are assessed during the two project phases as follows.

Construction Phase (Temporary)

- 7.42 The proposed marine based development principally relates to increased dredging and provision of breakwaters to accommodate a new marina layout. Therefore the construction phase activities which are assessed will be related to dredging activities. The assessment considers increased SSC due to the sediment spill during dredging operations and the extent of sediment plumes and subsequent deposition of this material. Increases in SSC due to construction dredging activities are temporary and, on cessation of dredging, the contribution to SSC will conclude following settlement.
- 7.43 A proportion of the material extracted to accommodate the new marina layout will be used for in land reclamation, specifically to provide new car parking and community space as part of the proposed development. Excess material (and subsequent maintenance dredging material) will be disposed in the Beaufort's Dyke. This is a licenced disposal site and located outside of Loch Ryan and will therefore not result in cumulative impacts and on this basis has not been considered further in the context of the coastal processes assessment.

Operational Phase (Permanent)

- 7.44 The proposed development includes permanent changes to the marine environment relating to infrastructure, i.e. the extension of the existing breakwater and provision of a floating breakwater. Additionally, dredging to accommodate the new marina layout will result in changes in bathymetry which will give rise to changes in tidal flow. By design, the provision of infrastructure will alter the wave climate within the harbour to facilitate berthing, therefore the

assessment focuses on potential impacts beyond those intended changes to coastal processes.

- 7.45 The coastal process pathway to receptors are interlinked; i.e. an ecologically sensitive receptor may be impacted by changes to sediment transport regime however this process is influenced by both tidal flow and wave climate. Therefore in the context of this assessment a holistic approach is applied whereby changes to the driving forces of sediment transport, i.e. tidal flow and wave climate, are also examined.

Sensitivity of Receptor

- 7.46 As outlined in previously in Receptors and Pathways within the Study Area, there are no areas designated specifically for coastal processes attributes in the vicinity of the proposed development. However the changes to coastal processes, coastal features and suspended sediment concentration may influence a range of designations in terms of supporting habitats. The assessment is therefore undertaken with regards to both receptors relating to coastal features and those which form pathways for other designated features.
- 7.47 In accordance with the appropriate EIA Regulations, potential impacts are considered on the basis of their magnitude, nature, probability, duration, and reversibility. The significance of an effect is evaluated based on the scale (magnitude) of the impact, and the importance or sensitivity of the receptor(s). **Table 7-2** provides the definition of terms relating to the classification of the sensitivity of coastal process receptors.

Table 7-2: Definition of Terms Relating to the Sensitivity of the Receptor

Sensitivity of the Receptor	Description
High	Coastal feature forms part of a wider scale system and is non-recoverable.
Medium	Coastal feature has limited potential for recovery.
Low	Coastal features of local scale and recoverable i.e. coastal feature adaptable to changes in physical processes.

- 7.48 It may also be appropriate to consider the value which may be associated with a receptor. This is particularly useful in cases where the assigned sensitivity, magnitude or significance falls close to a classification boundary and when expert judgment is applied. **Table 7-3** provides the definition of terms relating to the classification of the value of coastal process receptors.

Table 7-3: Definition of Terms Relating to the Value of the Receptor

Value of the Receptor	Description
High	Receptor is designated and/or of national or international importance for marine geology, oceanography or physical processes. Likely to be rare with minimal potential for substitution. May also be of significant wider-scale, functional or strategic importance.
Medium	Receptor is not designated but is of local to regional importance for marine geology, oceanography or physical processes.
Low	Receptor is not designated but is of local importance for marine geology, oceanography or physical processes.
Negligible	Receptor is not designated and is not deemed of importance for marine geology, oceanography or physical processes.

Magnitude of Impact

7.49 The numerical modelling study outlined in Modelling Methodology was used to quantify the potential construction and operational impacts of the proposed development in the context of the following coastal processes:

- The dispersion of and settlement of material spilled during dredging operations.
- The tidal regime.
- The inshore wave climate.
- Sediment transport within the surrounding area.

7.50 The modelling study took advantage of the integrated modelling system, whereby a single base model was used to determine both baseline and post-construction coastal processes, i.e. tidal flow, wave climate and sediment transport regimes. The mesh was also tailored to enable the same arrangement of cells to be implemented for the post-construction scenario and for use in dispersion modelling. The post construction bathymetry utilised in the modelling is illustrated in **Figure 7-7**.

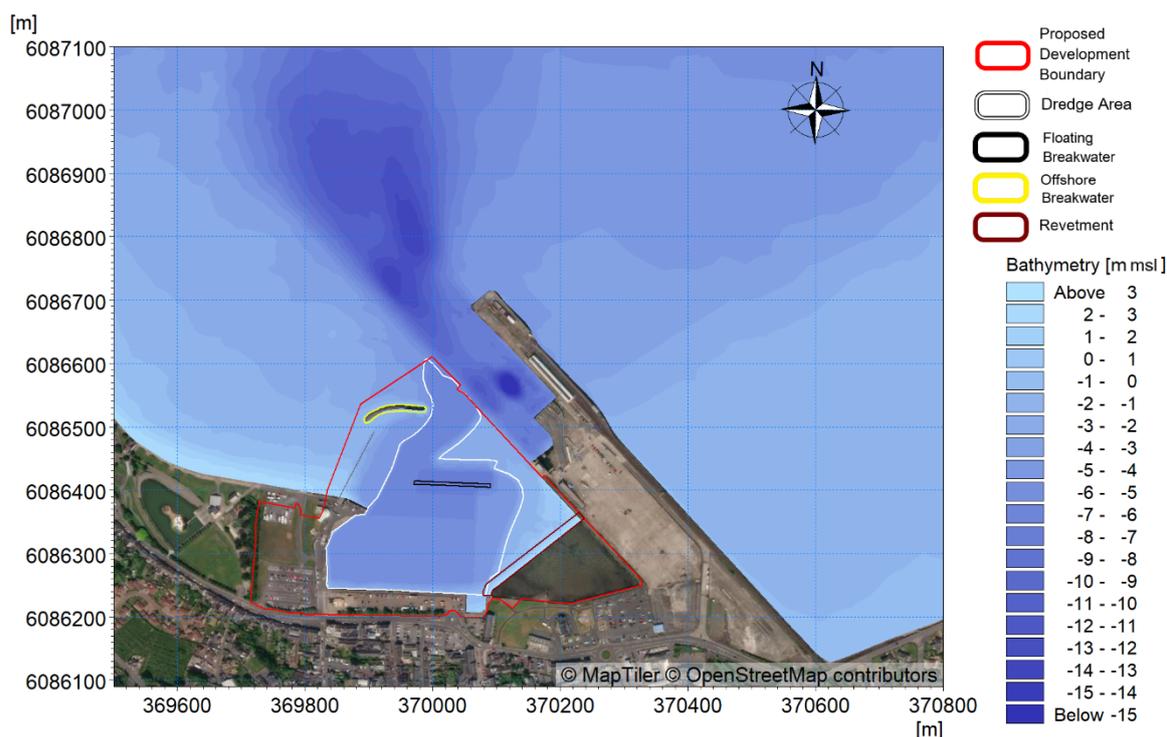


Figure 7-7: Post-construction model bathymetry in the vicinity of Stranraer

- 7.51 Sediment plume modelling was undertaken by simulating the dispersion and fate of sediment released into the water column in line with the dredging plan and operations. The sediment plumes relating to the proposed sediment dredging and reclamation were informed by site specific ground investigation surveys which have been undertaken as part of the proposed development. This included boreholes and particle sieve analysis (PSA) to provide the sediment grading information implemented within the modelling.
- 7.52 In terms of the coastal processes assessment, dredging rate and percentage spill was set at an upper bound to cover the range of dredging techniques applicable for capital dredging and reclamation works, i.e. cutter suction, backhoe, grab bucket etc. The assessment therefore applied to the maximum design scenario; this type of assessment where a maximum design scenario for each impact is selected from the range of possible design or construction parameters within the project description is the Project Design Envelope approach aka Rochdale Envelope approach.
- 7.53 This gives flexibility to the contractor and mitigation measures to be developed and applied should likely significant impacts be identified. Such mitigation may include the prescribed use of specific dredging techniques like the use of environmental lidded buckets (which have lower spill percentages and dredging rates are slower) or tidal restrictions to limit plume excursion.
- 7.54 The magnitude of SSC is characterised using two separate parameters. The first relating to the maximum SSC which occurs in each cell at any time during the simulation and is thus an

envelope covering the maximum sediment plume excursion. It is important to note that these values may have only occurred for a short period of time or even a single timestep in the simulation. The second SSC relates to the mean SSC over the course of the dredging campaign, which provides a context for the maximum SSC values. The dredging plume model output is provided in full in **Appendix 7.1 (Volume 2 of EIAR)**, with further information outlined in [Suspended Sediment Concentration and Deposition](#).

- 7.55 The mesh was also tailored to enable the same arrangement of cells to be implemented for the post-construction scenario. Whereby, in order to quantify the magnitude of changes to wave climate, tidal flow and sediment transport, the model bathymetry was adjusted to reflect the post-construction scenario. The models used to determine baseline were then re-run with the adjusted bathymetry. Following completion of the modelling phase, minor alterations were made to the proposed development. This includes the infilling of the area surrounding the existing slipway within the harbour and provision of a new 40m slipway into the dredged area. The infilling of this area, *circa* 30m wide with the upper slipway currently remaining dry, would result in *de minimis* changes to coastal processes within the main marina basin and have no impact beyond the harbour; therefore re-modelling was not deemed appropriate for such minor changes.
- 7.56 The impact of the proposed development on the coastal processes was quantified using difference plots throughout this chapter, i.e., post-construction phase minus baseline conditions. As such, the extent and magnitude of potential impacts as a result of the proposed development were identified and compared against baseline conditions.
- 7.57 Following the modelling study, the dredging plan was optimised and extended to incorporate a limited amount of maintenance dredging at the location of the southern berths on the West Pier in the existing marina, as illustrated by the dashed outline in **Figure 7-8**. The total dredging volume was maintained from the modelled scenarios. Due to the limited nature of the modification from the bathymetry utilised in the post-construction scenario within the modelling study, the characteristics of the dredging plumes and the coastal processes associated with the slightly adjusted dredging area were considered to be representative of those modelled.
-

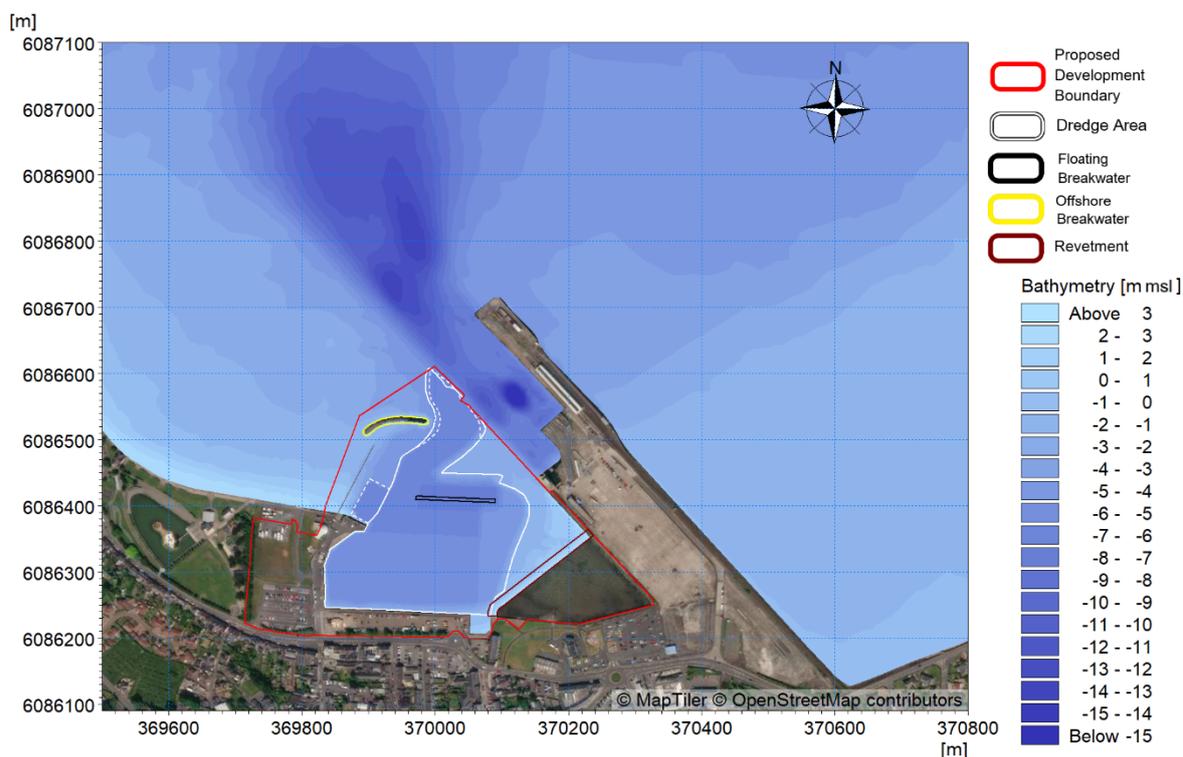


Figure 7-8: Post-construction bathymetry for proposed development application

7.58 **Table 7-4** provides the definition of terms relating to the classification of the magnitude of the impacts relating to coastal process receptors. It takes account of both the scale of the change and also the duration, and reversibility.

Table 7-4: Definition of Terms Relating to the Magnitude of the Impact

Magnitude of Impact		Definition
High	Adverse	Change in physical processes which results in the loss of a coastal feature (e.g. blockage of sediment pathway resulting in loss of spit). Persists for a long-term duration i.e. more than five years and is irreversible.
	Beneficial	Change in physical processes which results in the creation of a coastal feature (e.g., reduction in wave climate giving rise to dune formation). Persists for a long-term duration i.e. more than five years and is irreversible.
Medium	Adverse	Alteration of physical processes which effects the rate at which a coastal feature is maintained (e.g., reduction in accretion rate). Persists for a long-term duration i.e. more than five years.
	Beneficial	Alteration of physical processes which effects the rate at which a coastal feature is developing (e.g., reduction in erosion rate). Persists for a long-term duration i.e. more than five years.

Magnitude of Impact		Definition
Low	Adverse	Some measurable change in physical processes but does not affect the rate at which a coastal feature is maintained. Persists for a medium-term duration i.e. one to five years.
	Beneficial	Some measurable change in physical processes but does not affect the rate at which a coastal feature is developing. Persists for a medium-term duration i.e. one to five years.
Negligible	Adverse	Imperceptible loss to a coastal feature, or alteration to physical processes of short-term duration i.e. less than one year.
	Beneficial	Imperceptible gain to a coastal feature, or alteration to physical processes of short-term duration i.e. less than one year.
No change		No loss or alteration of characteristics, features or elements; no observable impact in either adverse or beneficial.

Significance of Effect

7.59 The purpose an EIA is to identify potential significant effects and, should potential significant environmental effects be determined, standard and additional mitigation and/or compensation measures should be identified and evaluated. The significance of an effect is evaluated on the basis of the magnitude of the impact and the sensitivity of the receptor(s). The overall significance of effects was assigned as detailed in **Table 7-5**.

Table 7-5: EIA Matrix - Assigning significance of Effect

Sensitivity	Magnitude of Impact			
	High	Medium	Low	Negligible
High	Substantial	Moderate/ Substantial	Slight/ Moderate	Slight
Medium	Moderate/ Substantial	Moderate	Slight	Negligible/ Slight
Low	Moderate	Slight/ Moderate	Negligible/ Slight	Negligible

Limitations to Assessment

7.60 It is noted that various developments have been undertaken in Loch Ryan including the development of the Port of Cairnryan, the installation of the marine outfall at Stranraer and works relating to the development and use of the Stranraer harbour and marina which included maintenance dredging of the approaches and harbour basin. Indeed the harbour has been through many stages of development since it was first built in the mid-18th century. The proposed development is focused on reducing the wave climate and enhancing berthing facilities within the confines of the harbour and therefore would have limited influence beyond

the development area, as has been the case for previous developments and dredging campaigns.

- 7.61 Modelling studies have been undertaken for previous projects including the modelling to support the Stranraer Gasworks Remediation work on behalf of Dumfries and Galloway Council in consultation with SEPA. In this case, modelling was undertaken to investigate the potential dispersion and dilution of pollutants egressing from the seawall into the harbour. The modelling undertaken to support these studies was verified using similar data sources as the current study for the proposed development and was accepted by the Statutory Authorities in each case. Further information regarding undertaking of modelling studies in Stranraer Harbour and Loch Ryan is presented in **Appendix 7.1 (Volume 2 of EIAR)**, and in response to Stakeholder request.
- 7.62 For the assessment of the proposed development the existing data sources have been supplemented with significant data collection campaigns undertaken by the Applicant. This includes detailed bathymetric surveys, geophysical surveys, boreholes and grab sampling. Although some physical processes are complex and inter-related, there is a significant amount of data available. It is therefore considered that the data used in this assessment are robust and sufficient for the purposes of the impact assessment presented.
-

Baseline Conditions

7.63 The following coastal processes were evaluated based on a baseline scenario:

- **Tidal regime:** Current speeds and direction;
- **Wave patterns:** Significant wave heights and directions; and
- **Sediment transport:** Magnitude of sediment transport rates under pure tides and wave induced conditions.

7.64 This assessment was undertaken with reference to both the simulated model data and, where applicable, measured gauge data. It should be noted that **Chapter 10** considers the potential impact of the proposed development on coastal flood risk.

Tidal Regime

Tidal Water Level

7.65 The United Kingdom Hydrographic Office (UKHO) indicates that the mean tidal range at the Standard Port of Stranraer is approximately 2.3m. The tidal characteristics are shown in **Table 7-6** referenced both to Chart Datum (CD) and Mean Sea Level (MSL). These tidal levels have been derived using the Admiralty Tide Tables⁷.

Table 7-6: Tidal Levels at Standard Port of Stranraer

	Mean Sea Level (MSL) [m]	Chart Datum (CD) [m]
Highest Astronomical Tide	1.8	3.7
Mean High Water Spring	1.3	3.2
Mean High Water Neap	0.8	2.7
Mean Sea Level	0	1.9
Mean Low Water Neap	-0.9	1.0
Mean Low Water Spring	-1.5	0.4
Lowest Astronomical Tide	-2	-0.1

7.66 Tidal levels are also recorded by the SEPA gauge⁸ located at Stranraer as illustrated in **Figure 7-6**. An example of recorded gauge data is shown in **Figure 7-9** which illustrates the variation in tidal range between neap and spring tides. The recorded period, October 2024, also shows

⁷ Volume 1 of the 2025 Admiralty Tide Tables for United Kingdom and Ireland.

⁸ <https://timeseriesdoc.sepa.org.uk/>

how the tidal elevation at Stranraer was affected by storm Ashley. This was the first named storm of the season with winds from the north west gusting to 60 knots at Stranraer.

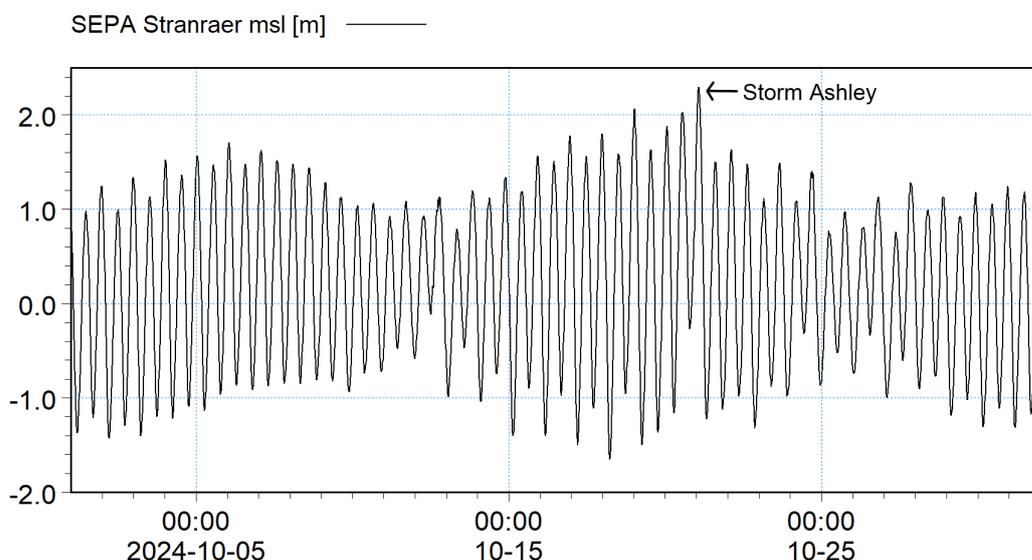


Figure 7-9: Recorded tidal levels at SEPA Stranraer gauge

Tidal Model Baseline

7.67 The MIKE 21 module described in [Modelling Methodology](#) was used in conjunction with the baseline scenario model to derive baseline tidal regime information at Stranraer. The model included bathymetric data collected for the proposed development at 1m to 4m resolution throughout the harbour and approaches. Additionally pier structures were included within the model to represent the piled structures associated with both east and west piers. The hydrodynamic modelling took account of the location, shape and orientation of each structure and updated the tidal flux to account for the obstruction to the flow. The bathymetry in the vicinity of Stranraer Harbour is shown in **Figure 7-10**.

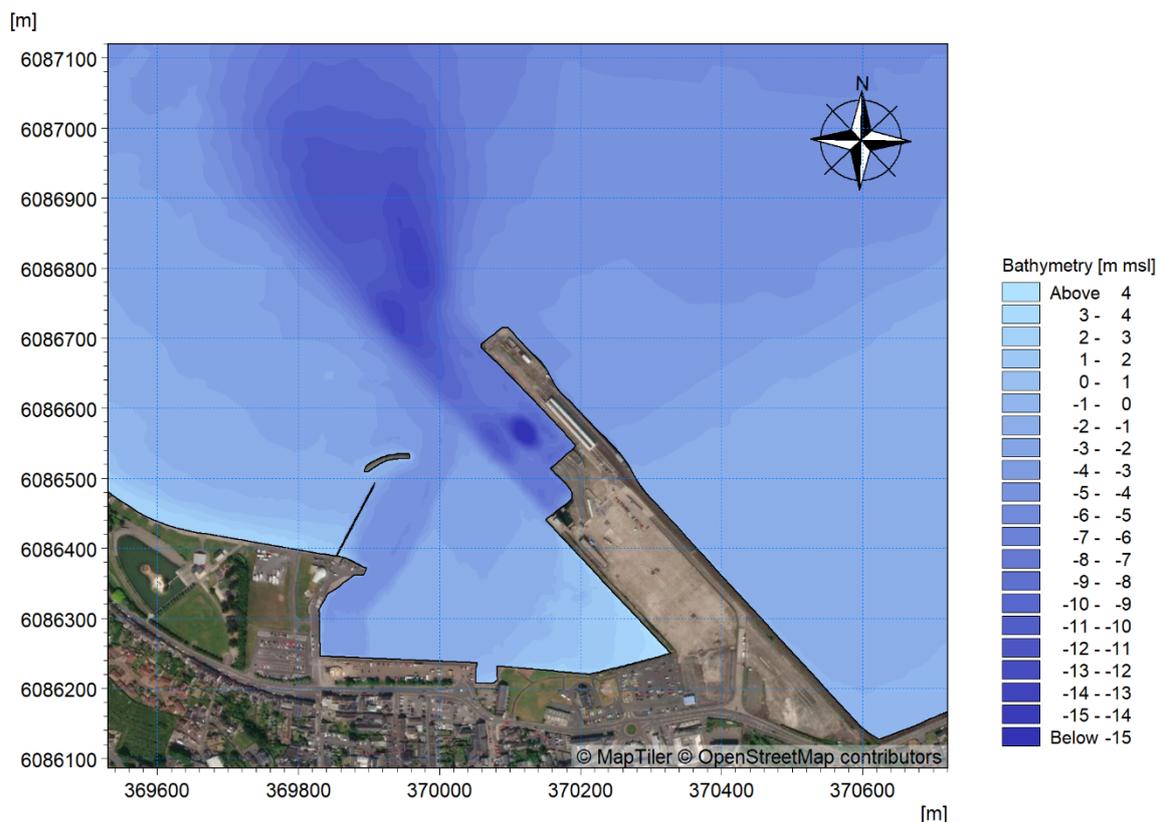


Figure 7-10: Baseline model bathymetry in the vicinity of Stranraer

- 7.68 The results presented in the following figures illustrate typical tidal flow during spring and neap tides, i.e. the models were run without the influence of wind or pressure systems. Typical spring mid-flood and mid-ebb are illustrated in **Figure 7-11** and **Figure 7-12** respectively, whilst typical neap mid-flood and mid-ebb are shown in **Figure 7-13** and **Figure 7-14**. Whilst the plots use a common contour palette to indicate current speed, the vectors are plotted with an exaggerated scale to allow current direction to be indicated.
- 7.69 Although there is accelerated flow through the harbour entrance, the current speeds within Stranraer Marina do not typically exceed 0.05m/s as it enters and exits during mid-flood and mid-ebb tides. During neap conditions currents speed are even less. Along adjacent shorelines to the west, tidal currents are of limited magnitude whilst to the east flows are accelerated over shallow areas in the intertidal region as the flow circulates within the lower Loch.

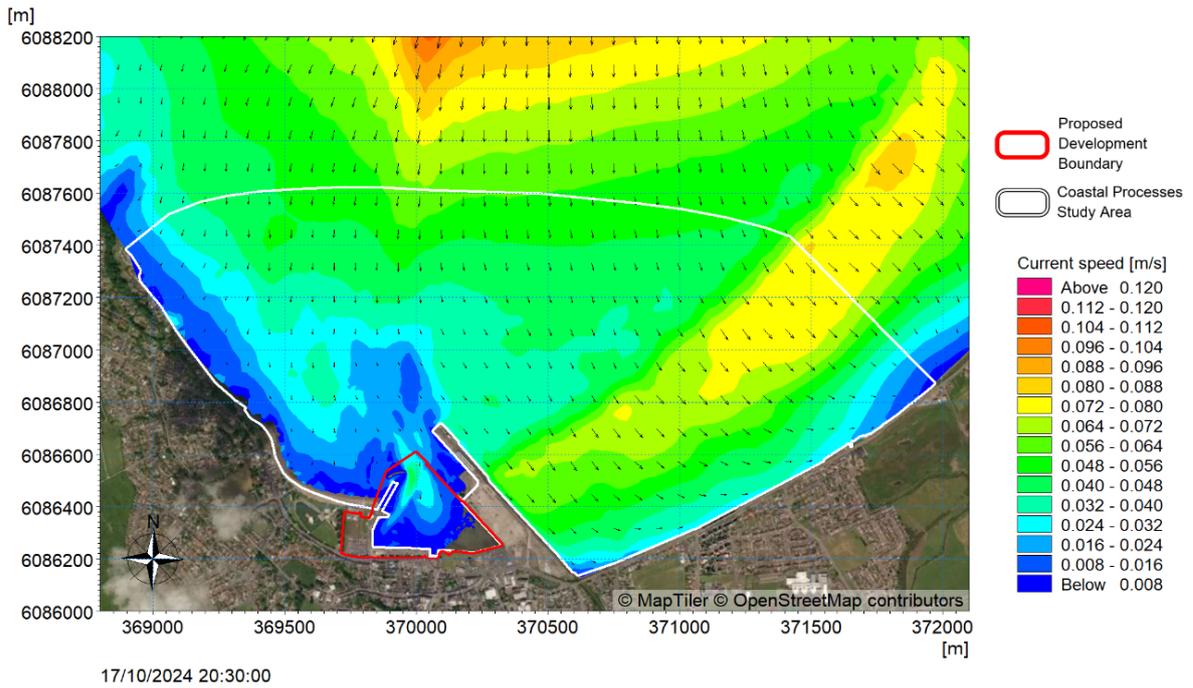


Figure 7-11: Typical spring mid-flood tidal patterns - baseline conditions

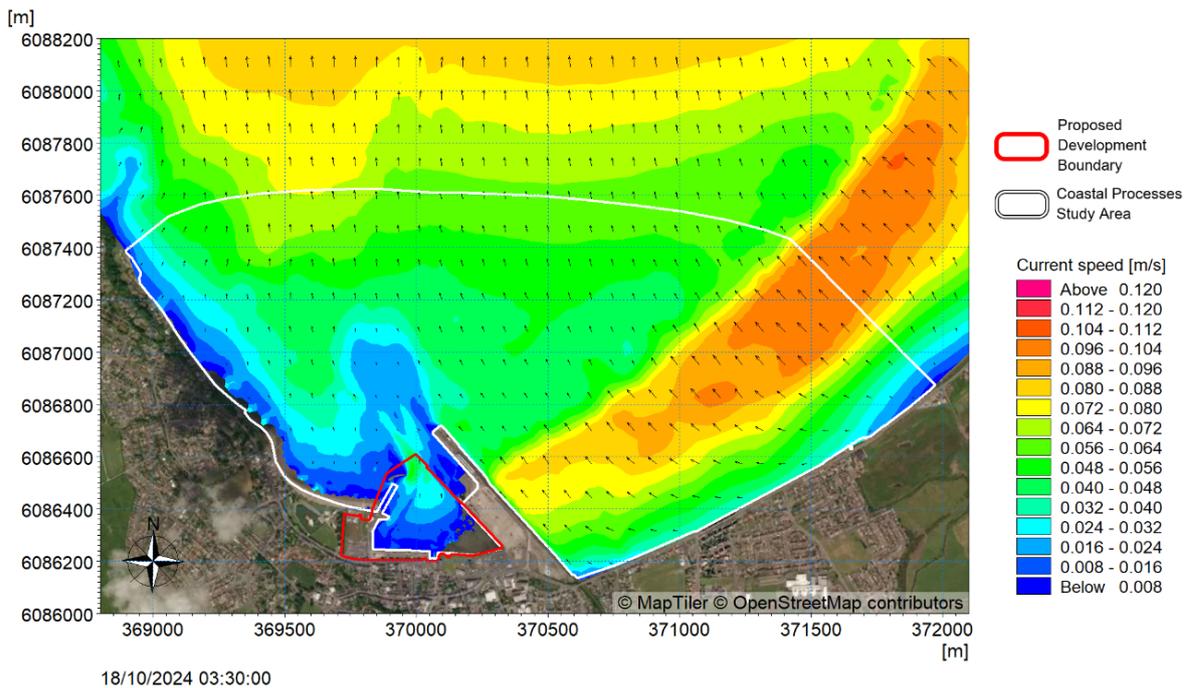


Figure 7-12: Typical spring mid-ebb tidal patterns - baseline conditions

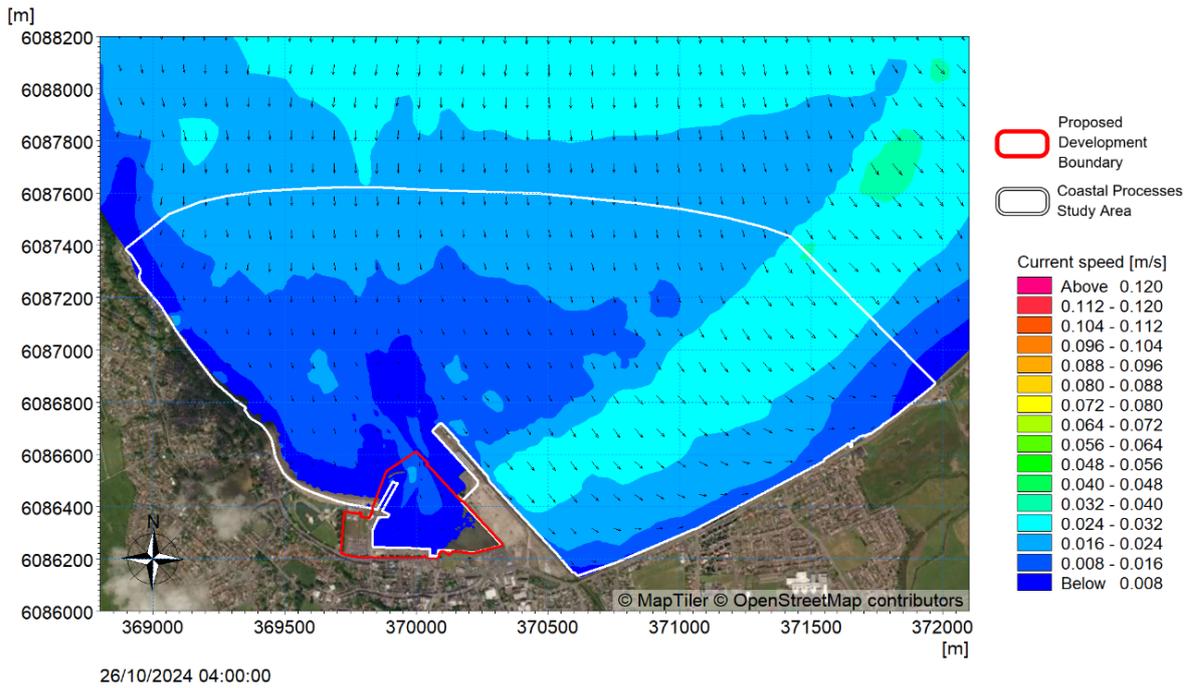


Figure 7-13: Typical neap mid-flood tidal patterns - baseline conditions

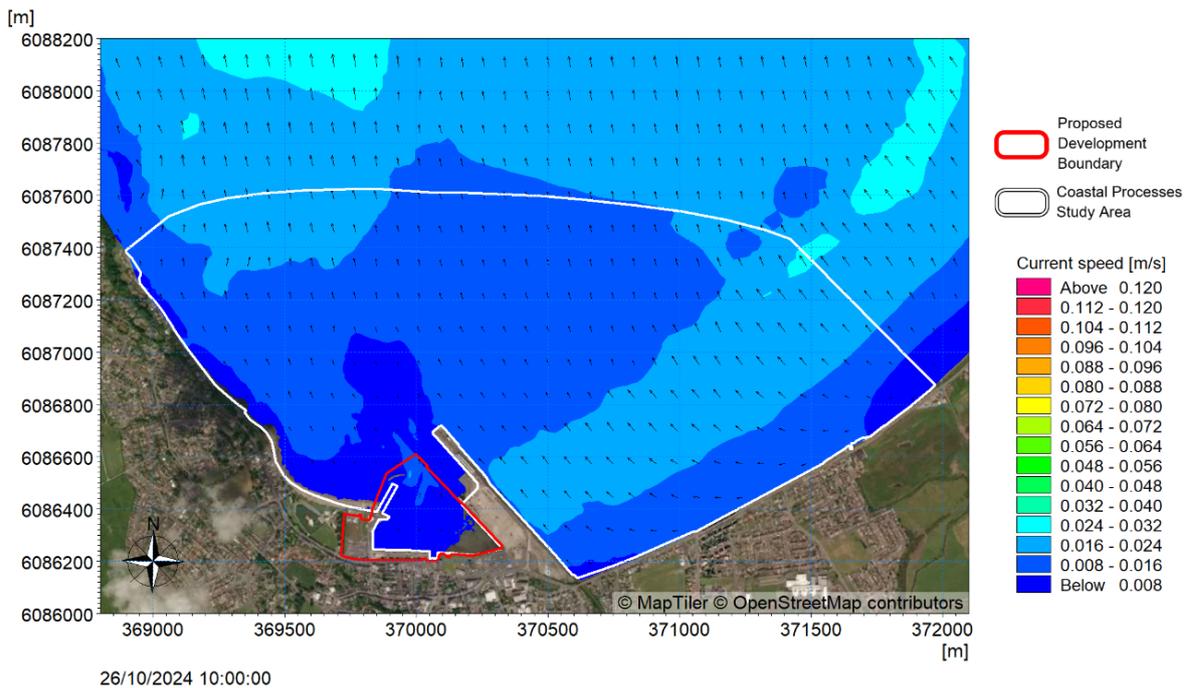


Figure 7-14: Typical neap mid-ebb tidal patterns - baseline conditions

Wave Regime

7.70 Stranraer harbour is exposed to waves generated during storms from the west of north-west to the northeast directions. The baseline wave climate for waves approaching the harbour was established by initially modelling the storms approaching Loch Ryan from offshore and then by simulating how these waves are transformed within Loch Ryan to the approaches to Stranraer

and within the harbour, as detailed in Modelling Methodology. As outlined, during the feasibility stage of the proposed development, a detailed analysis was undertaken to derive both extreme wind speeds for wave generation over the offshore fetches and within Loch Ryan.

7.71 The wave climate at the boundary of the Loch Ryan model was taken from the results of the offshore wave model simulations with the derived wind for wind-wave generation within the Loch, as shown in **Table 7-7**, applied across the model domain. The wave simulations were undertaken with a water level of 1 in 1 year return period.

Table 7-7: Extreme wind speeds for wave generation over the Loch Ryan fetches

Storm Direction °N	1 in 1 year return period (m/s)	1 in 50 year return period (m/s)
300	20.26	28.63
315	20.72	29.24
330	19.87	28.08
345	19.32	27.043
0	18.87	26.80
15	17.96	25.38
30	17.07	24.07
45	16.82	23.74

7.72 The following figures show the wave climate from a sample of directions which affect Stranraer, namely 315°, 345° and 15°. The first three figures (**Figure 7-15** to **Figure 7-17**) relate to a relatively common occurrence, i.e. 1 in 1 year return period which would typically be expected on an annual basis. The second set of three figures (**Figure 7-18** to **Figure 7-20**) relate to a more extreme event, i.e. 1 in 50 year return period. In common with the tidal data presented in the previous section, a single palette has been used to indicate significant wave height, whilst the vectors have been exaggerated so that wave direction can be discerned from the figures.

7.73 Due to the alignment of the mouth of the Loch and the shape of Loch Ryan itself, the largest waves to reach Stranraer harbour approach from 315°, owing to the influence of offshore waves, locally generated wind waves and high wind speeds associated this direction. During a 1 in 1 year storm event significant wave heights within the study area are 1.1m to 1.2m with a reduction to just under 1m for storms approaching from 15°. During a 1 in 50 year storm significant wave heights may reach 1.8m within the study area. Wave transformation in lower Loch Ryan is affected by the variation in bed level, particularly those associated with the navigation channel.

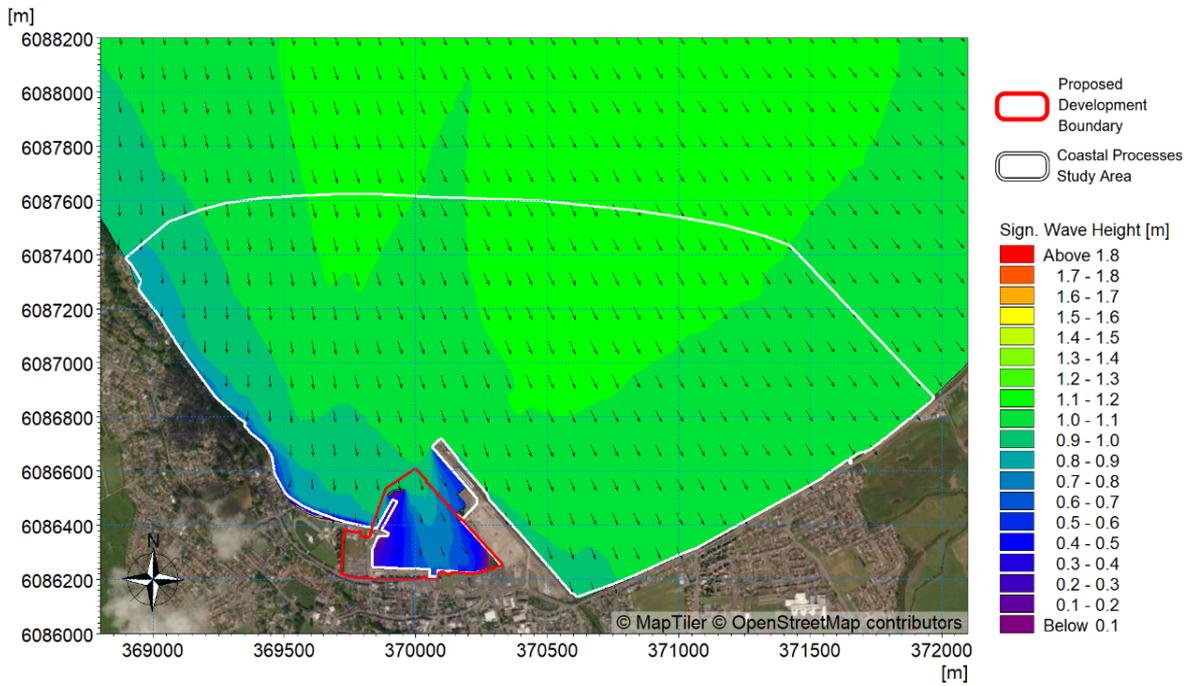


Figure 7-15: Wave climate 1 in 1 year storm from 315° - baseline conditions

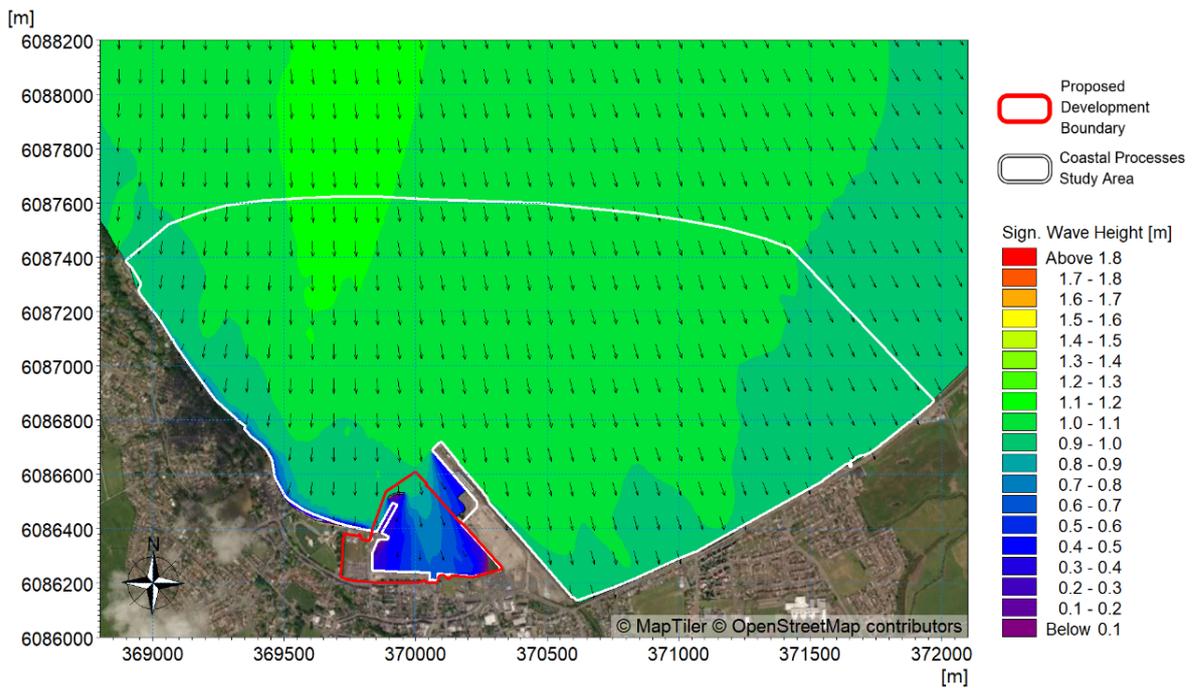


Figure 7-16: Wave climate 1 in 1 year storm from 345° - baseline conditions

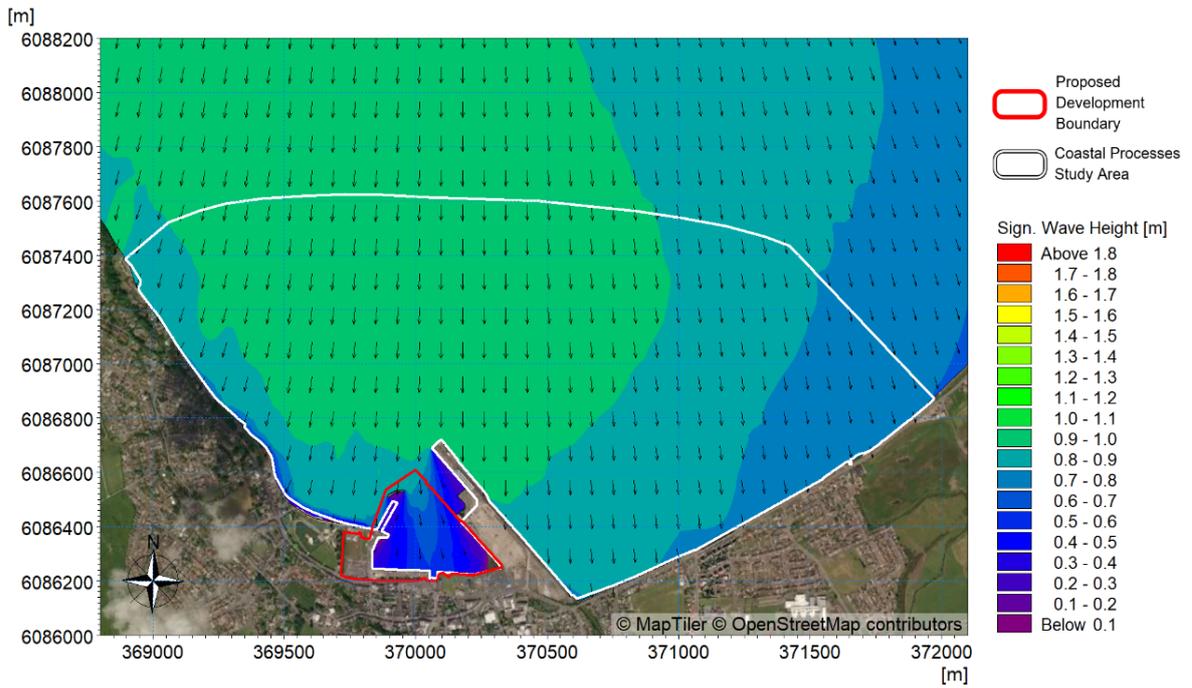


Figure 7-17: Wave climate 1 in 1 year storm from 015° - baseline conditions

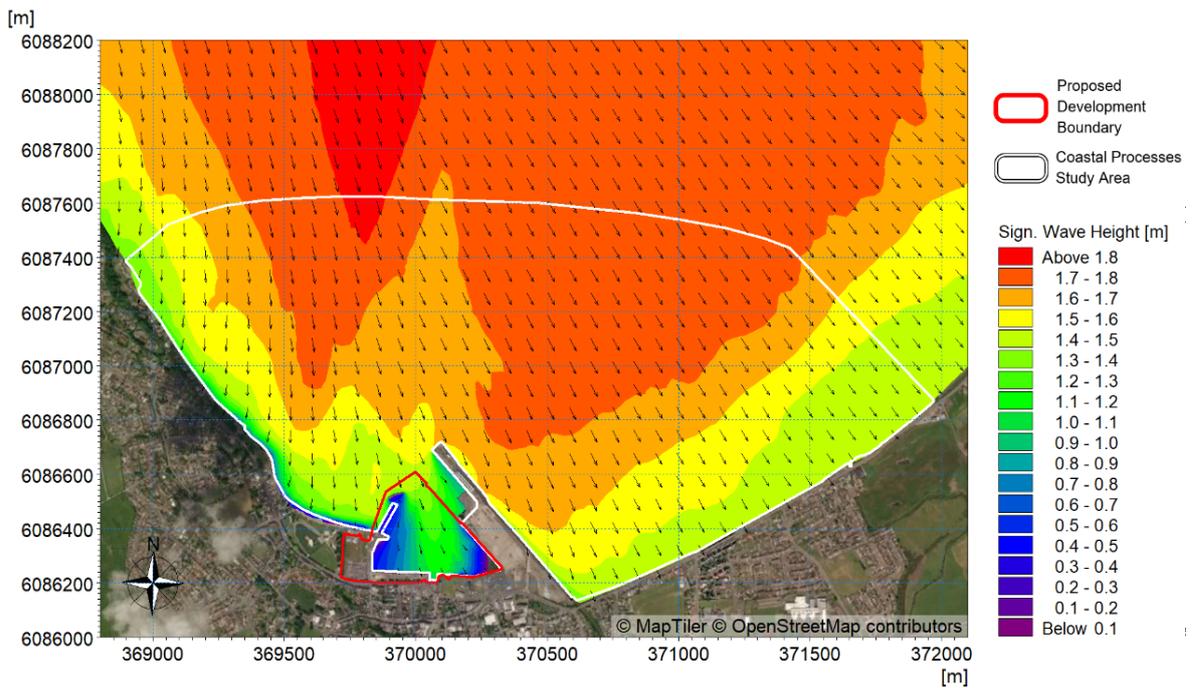


Figure 7-18: Wave climate 1 in 50 year storm from 315° - baseline conditions

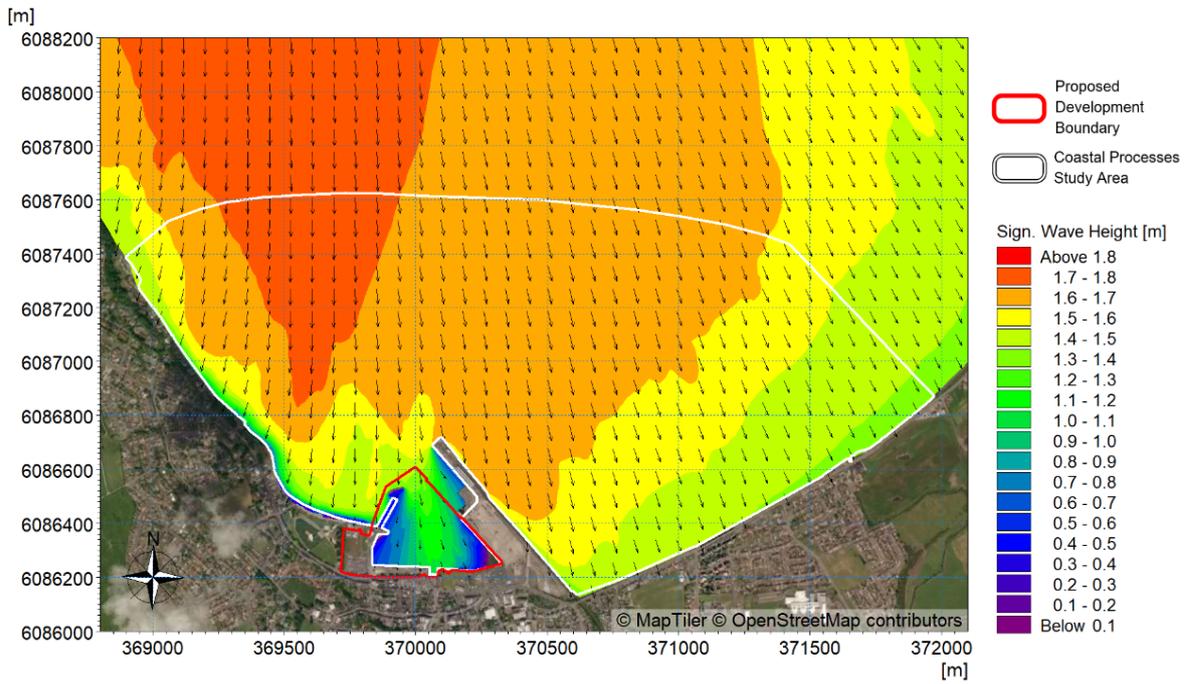


Figure 7-19: Wave climate 1 in 50 year storm from 345° - baseline conditions

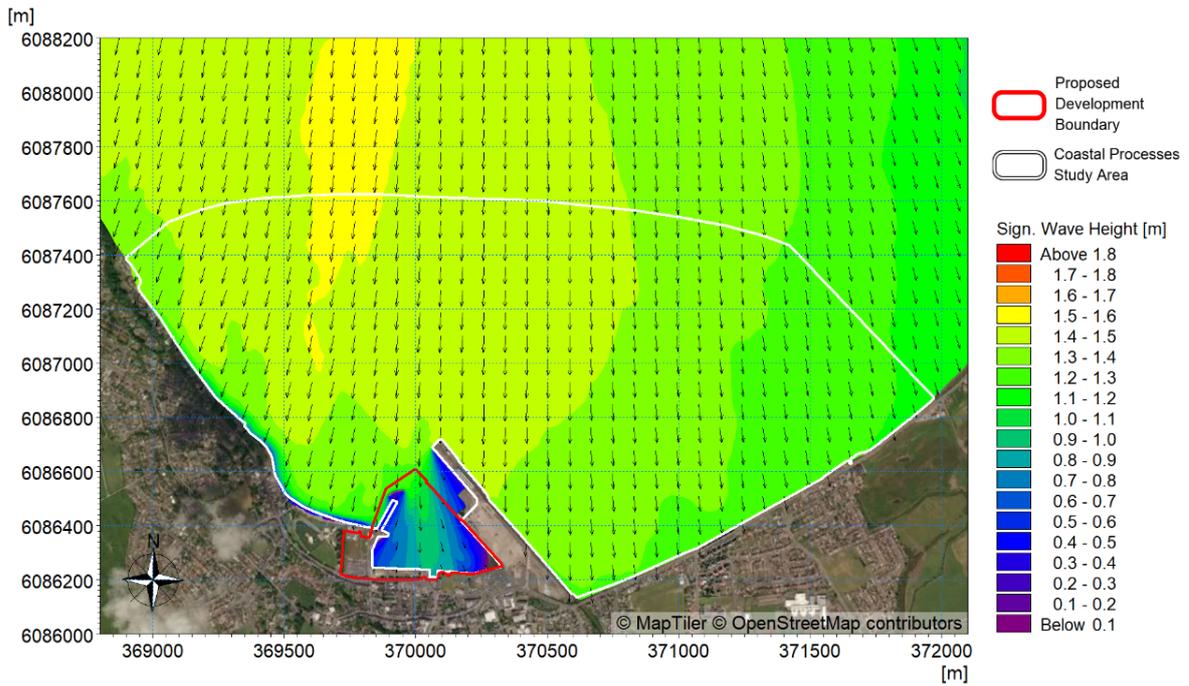


Figure 7-20: Wave climate 1 in 50 year storm from 15° - baseline conditions

Sediment Transport

- 7.74 Sediment transport regimes are characterised by a variety of interdependent parameters. In addition to the driving factors, i.e. tidal currents and wave climate discussed in the previous section, the composition of the seabed is an important factor.

Seabed Substrate

- 7.75 The seabed substrate within Loch Ryan is comprised of Gravel, muddy Gravel and gravelly Mud, as illustrated in **Figure 7-21**. Generally, in the lower Loch, seabed sediments become finer as the current speeds are reduced and the sediment transport potential is reduced. Whilst there is a limited amount of sampling data available in the lower Loch outside Stranraer Harbour, information from Admiralty charts was used to characterise seabed substrate as illustrated, **Figure 7-23**. The limited borehole data from SEPA resources⁹ also indicated raised beach material in the lower Loch. Additionally the distribution of the seabed sediments were examined from an Acoustic Benthic Survey of Loch Ryan undertaken by Agri-Food and Biosciences Institute (AFBI) in November 2000¹⁰ as part of an investigation into the coastal processes of Loch Ryan, as shown in **Figure 7-22**.

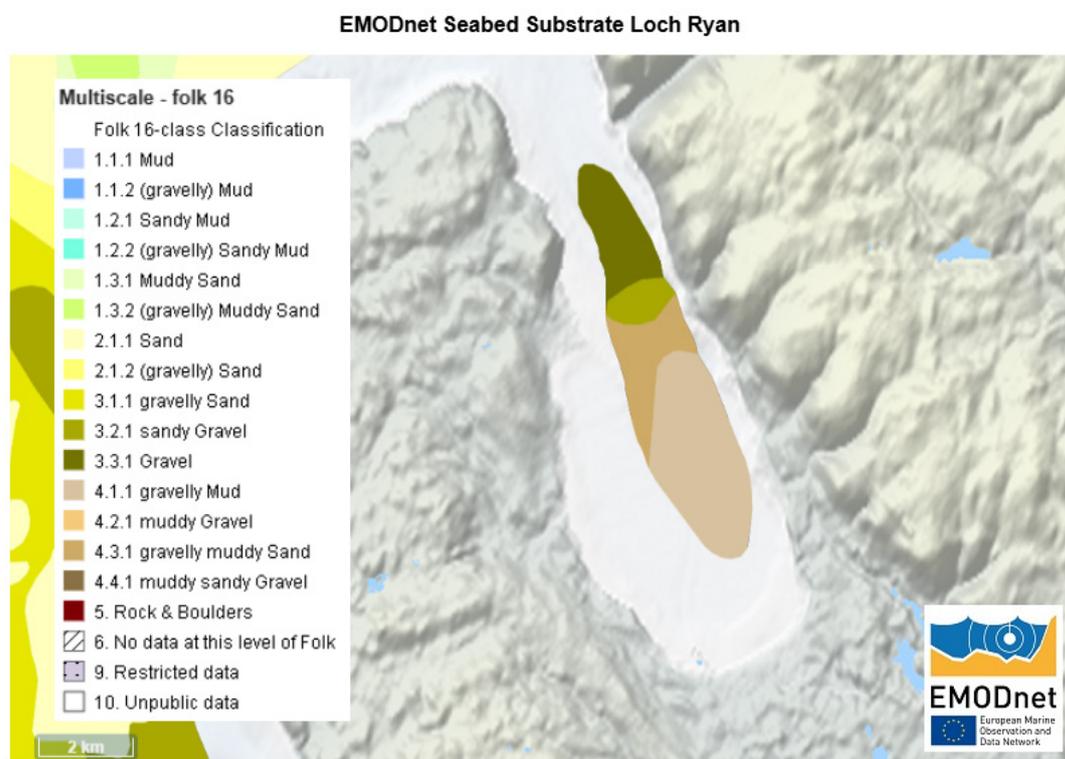


Figure 7-21: Seabed substrate Folk Classification, EMODnet¹¹

⁹ <https://map.environment.gov.scot/sewebmap/>

¹⁰ https://files.emodnet-seabedhabitats.eu/data/EMODnetSBHsurvey_GB000484.zip

¹¹ <https://emodnet.ec.europa.eu/geoviewer/>

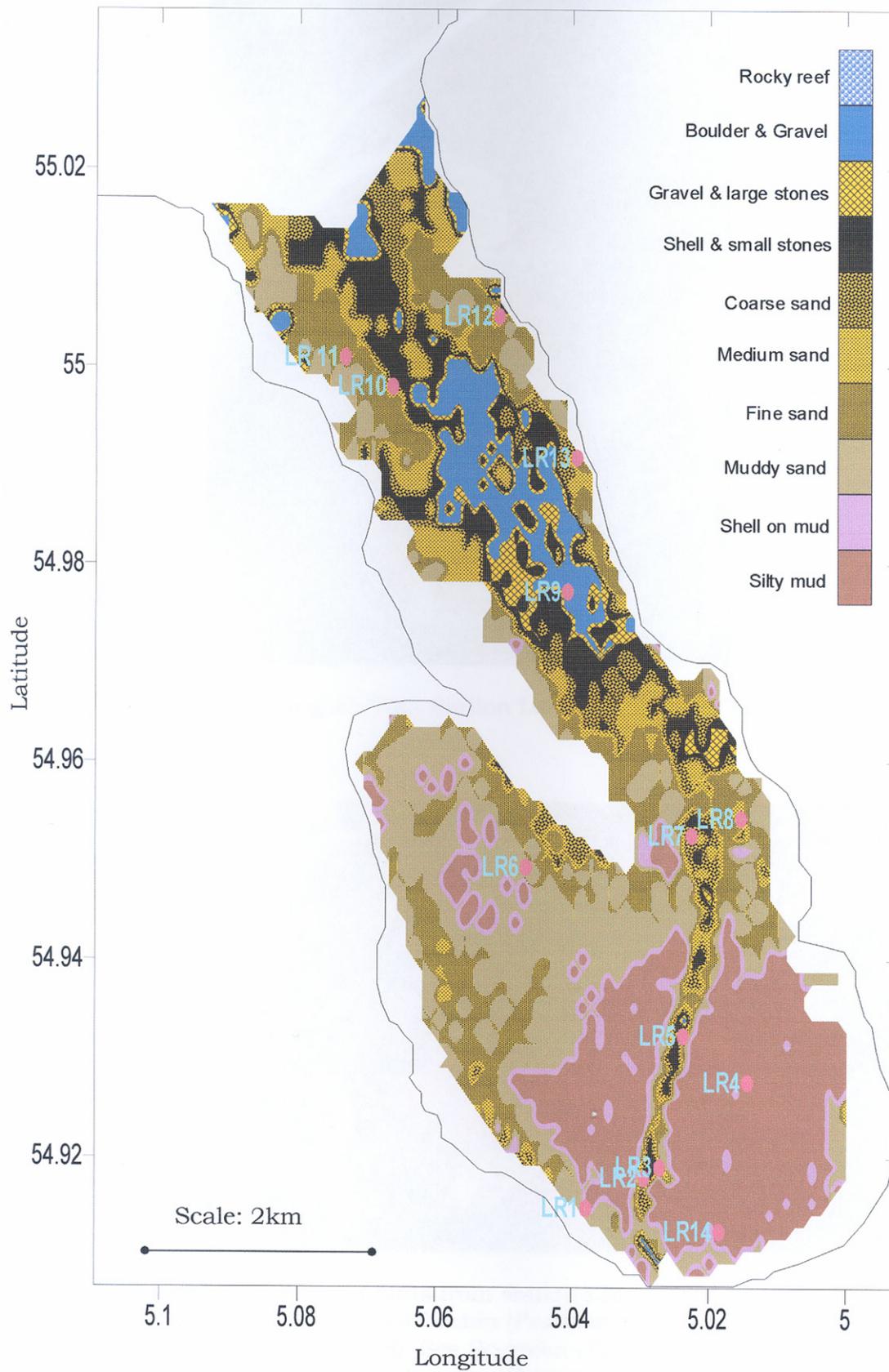


Figure 7-22: Distribution of seabed sediments in Loch Ryan

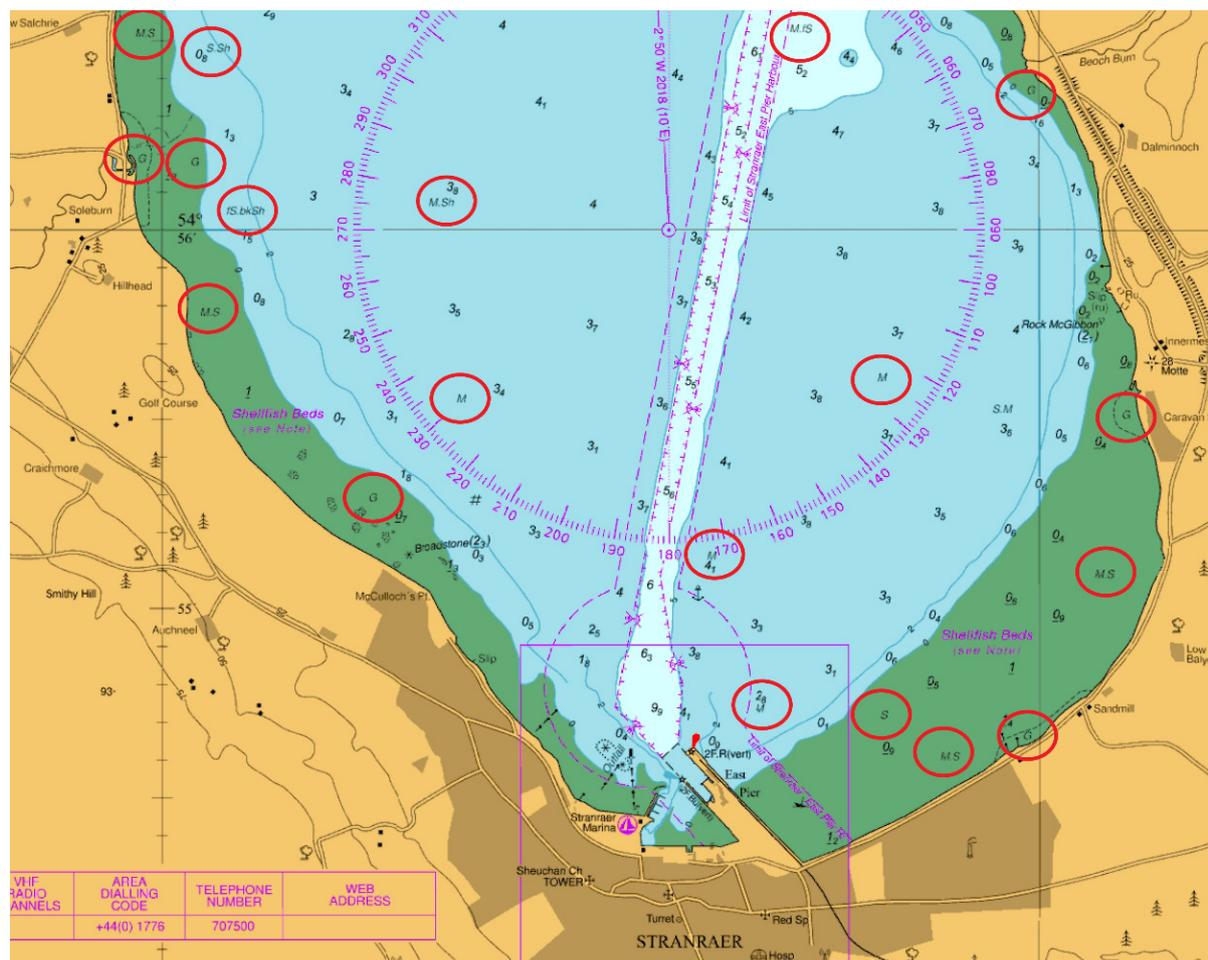


Figure 7-23: Admiralty chart 1404-0 with sediment characteristics (red outline)

- 7.76 As part of the proposed developed, project specific geotechnical surveys were undertaken¹² and provided a detailed description of seabed characteristics within the harbour. The sample locations are illustrated in **Figure 7-24** and included offshore vibro-core (VC) and borehole (BH) sampling. Granular marine deposits were encountered widely in the offshore exploratory positions at the bed and extended to a depth of 3m. Where the granular marine deposits, i.e. sand and gravel, were not encountered at the seabed, these deposits have been recorded to underlie the cohesive marine deposits.
- 7.77 Cohesive marine deposits comprising silt and clay were encountered in almost all of the offshore sample locations, between the seabed and a depth of 0.70m. Where the cohesive marine deposits were not encountered at the seabed level, these deposits were found to underlie the granular marine deposits. Cohesive glacial deposits, typically clay, were also

¹² Fairhurst, Geo-environmental and Geotechnical Interpretative Report, 136625/GL/G/01, December 2021

recorded in the majority of the offshore exploratory boreholes below the surface layers often in multiple layers interbedded with the granular glacial deposits.

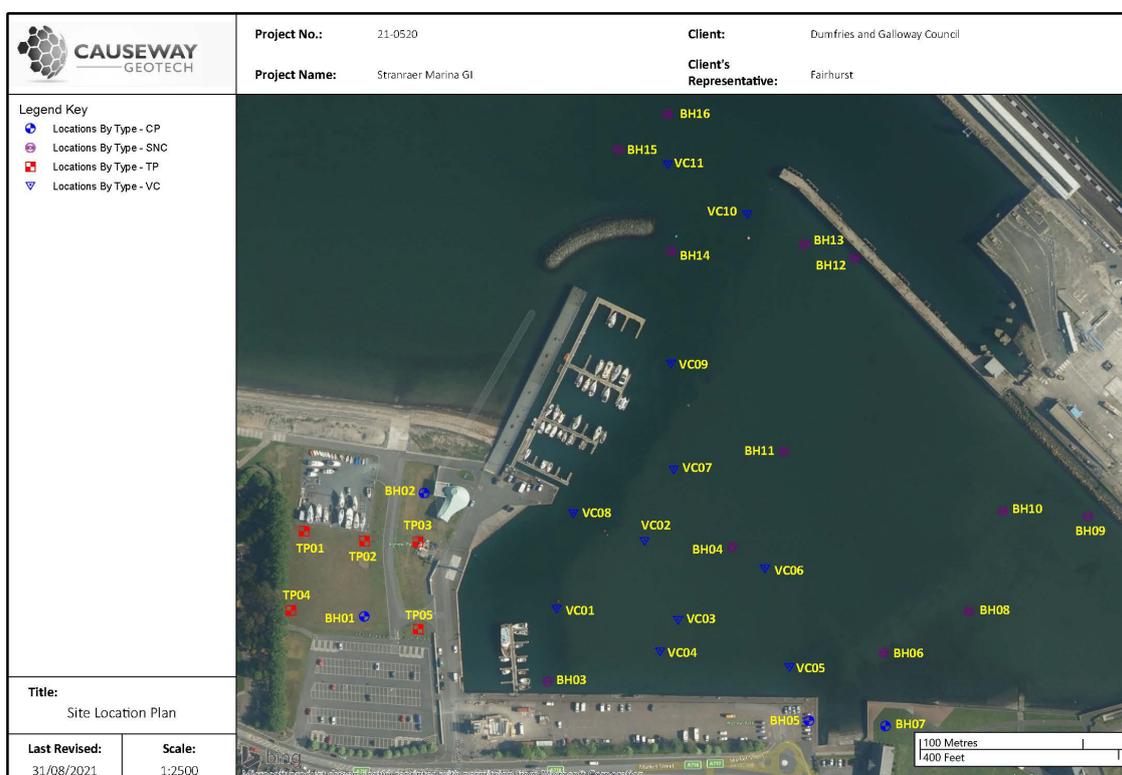


Figure 7-24: Ground Investigation sample locations, Causeway Geotech 2021

- 7.78 Within the main navigation channel in Loch Ryan and the approaches to Stranraer harbour tidal current speeds tend to be higher. This, coupled with historic ferry traffic, has depleted any loose finer material and, although the seabed sediments are comprised of mud in some of these areas, sediment transport is limited due to the cohesive nature of the seabed sediment.
- 7.79 Although there is limited sample data in the foreshore immediately to the east and west of Stranraer harbour, visual evidence in the intertidal areas can be used to describe the seabed sediment. **Figure 7-25** and **Figure 7-26** show images from Google Street View¹³ captured from the west of looking east towards Stranraer and east looking west towards Stranraer respectively. In both cases the foreshore is characterised by relatively coarse surface material. Historically, beach levels in the areas close to Stranraer have changed little due to the sheltered nature of the lower Loch, low current speeds and self-armoured beach; whereby the coarse surface sediment anchors the finer sediment below.

¹³ <https://www.google.com/streetview/>



Figure 7-25: View from the west of Stranraer looking east, Google Streetview

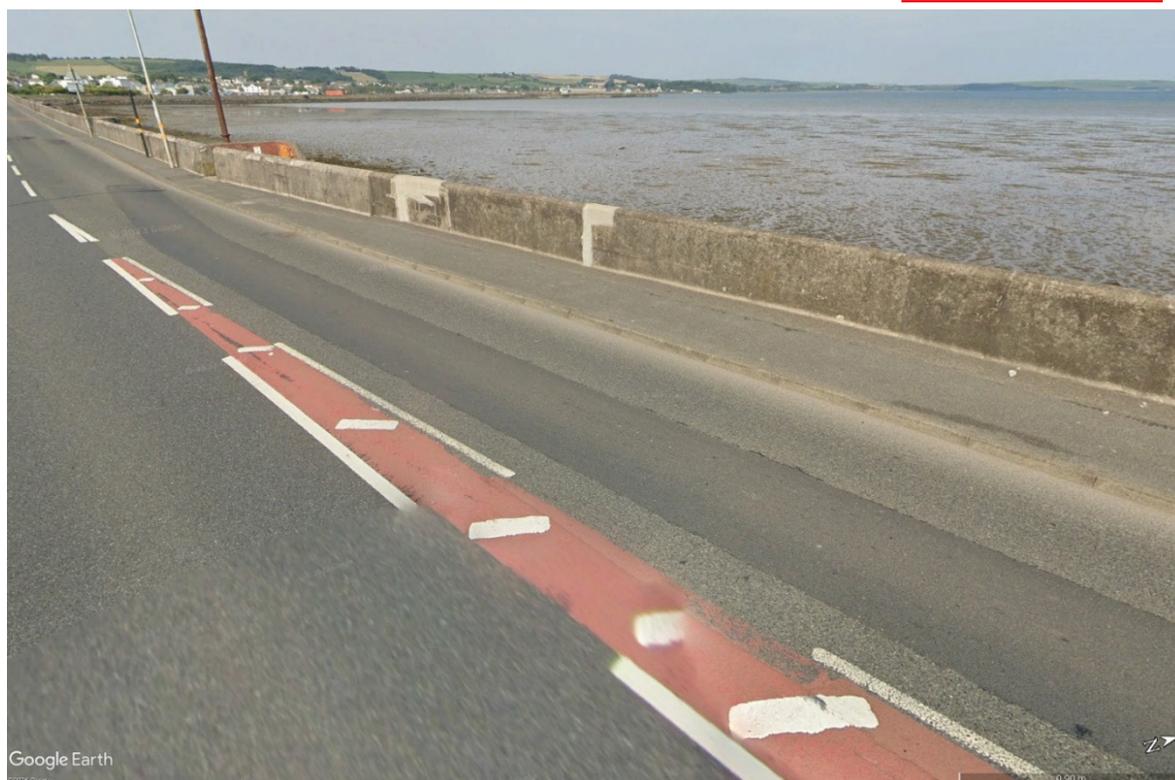


Figure 7-26: View from the east of Stranraer looking west, Google Streetview

Sediment Transport Model Baseline

7.80 Since construction, Stranraer Harbour has periodically undergone dredging to maintain the required levels within the harbour basin. The build-up of material in the harbour basin occurs due to longshore drift where natural beach material is moved in an easterly direction and carried around the West Pier and inside the breakwater into the harbour and prevented from being moved further along the shore by the East Pier. This material is supplied from the areas on the western side of the Loch which are more vulnerable to coastal erosion where the coastal edge is made up of very soft raised marine deposits¹⁴. Satellite imagery captured by Google Earth¹⁵ presented in **Figure 7-27** illustrates this process with increased turbidity on the outer wall of the West Pier and western side of the harbour.

¹⁴ The SCAPE Trust, Coastal Zone Assessment Survey – Loch Ryan, 2023. Available at: <https://scapetrust.org/wp-content/uploads/reports/Loch-Ryan-Report.pdf>

¹⁵ <https://earth.google.com/web/>

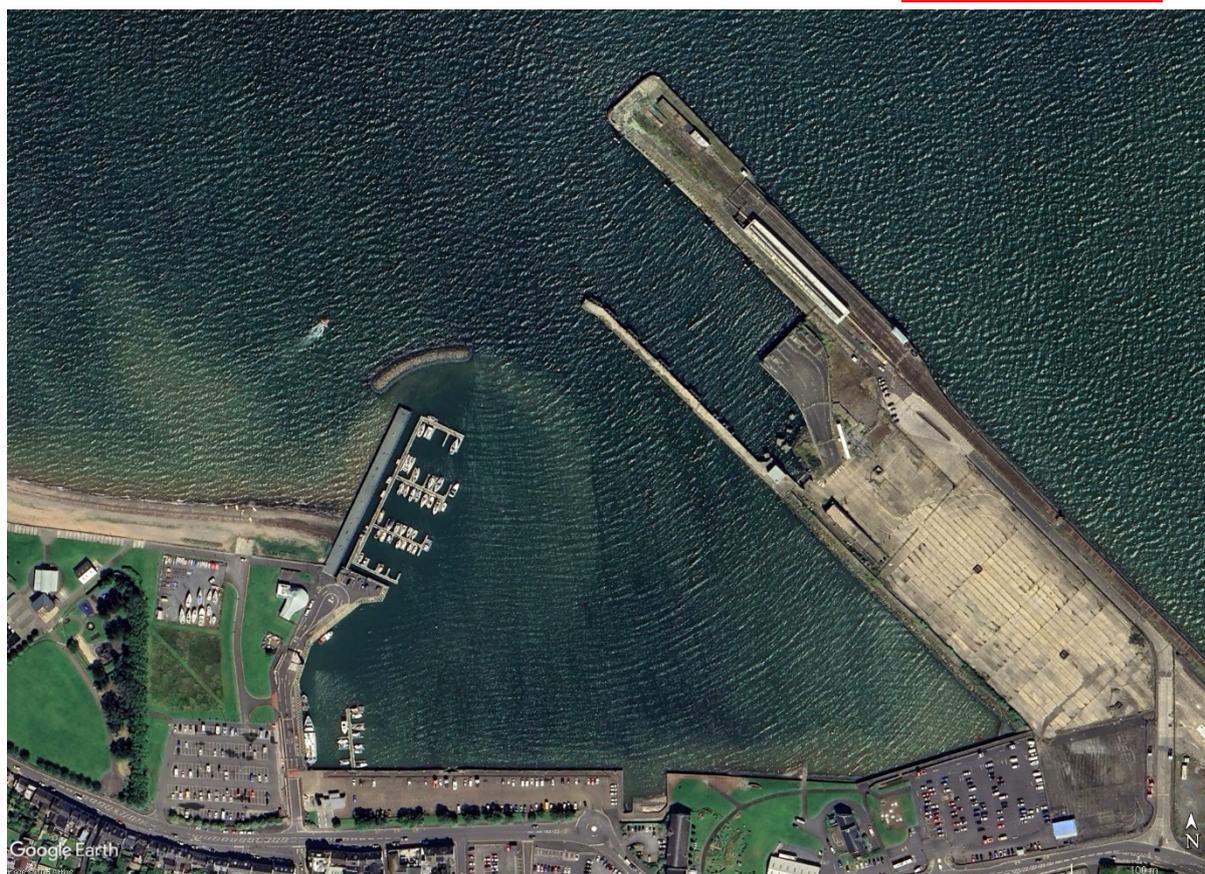


Figure 7-27: Satellite view of Stranraer, Google Earth

7.81 On the eastern side of the harbour longshore drift is to the west and therefore also towards Stranraer. Similarly to the western side, beach deposits originate from further up to Loch. Those from the eastern side of Loch Ryan are carried along the east pier where they coalesce with increased turbidity from the inner harbour on the ebb tide. This process is captured in the satellite imagery from ESRI¹⁶ shown in **Figure 7-28**.

¹⁶ Esri, Maxar, Earthstar Geographics, and the GIS User Community
http://goto.arcgisonline.com/maps/World_Imagery

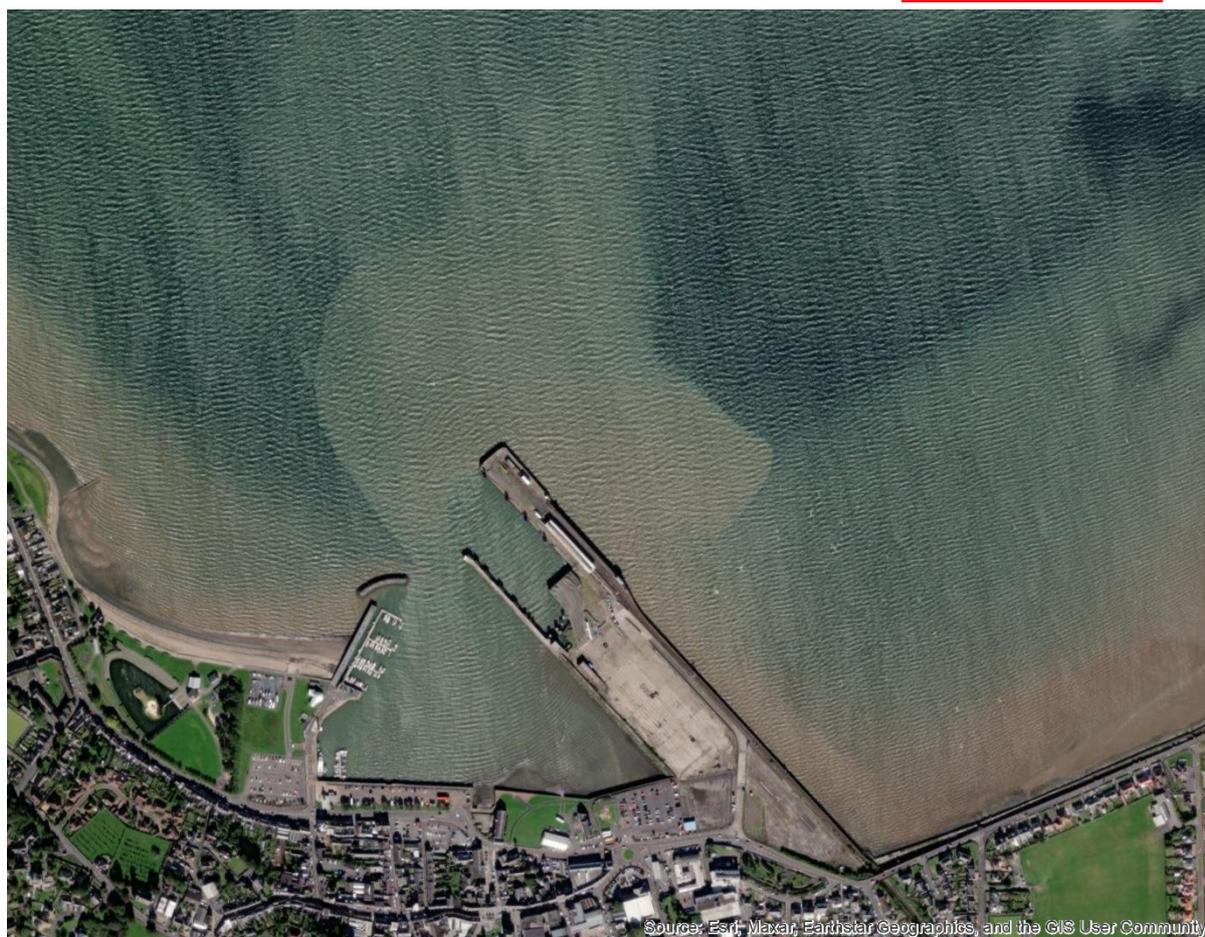


Figure 7-28: Satellite view of Stranraer, Bing Maps

- 7.82 In order to assess the potential changes in sediment transport due to the proposed development these processes were quantified. Two scenarios were selected to form baseline ‘snap-shots’ against which the post construction scenario could be assessed. A typical spring tide and a 1 in 1 year event were selected to be representative of baseline conditions. For the calm scenario the same period was modelled as the baseline tidal flow presented in [Tidal Regime](#) but with the inclusion of the sediment transport module. For the annual event, the ECMWF records discussed in Modelling Methodology were analysed to identify an event with the characteristics associated with wind speed and direction for the 1 in 1 year return event from 315° as discussed in Wave Regime. In each case the same initial bed sediment map was used at the beginning of the simulation. The seabed characteristics were derived from the information presented in the previous section.
- 7.83 In common with the previous model output, a shared colour palette has been used for the magnitude of sediment transport rate whilst the vectors illustrating direction have been exaggerated. It should also be noted that it was necessary to apply a logarithmic scale, whereby each contour interval is *circa* double the preceding lower interval, in order to illustrate the full range of transport rates.

7.84 **Figure 7-29** and **Figure 7-30** present the sediment transport rates at mid-flood and mid-ebb respectively for a typical spring tide under calm conditions. As anticipated, sediment transport is negligible and it is clear that any significant sediment transport within the lower Loch or increases in turbidity levels would occur as a result of meteorological conditions, i.e. is wave induced.

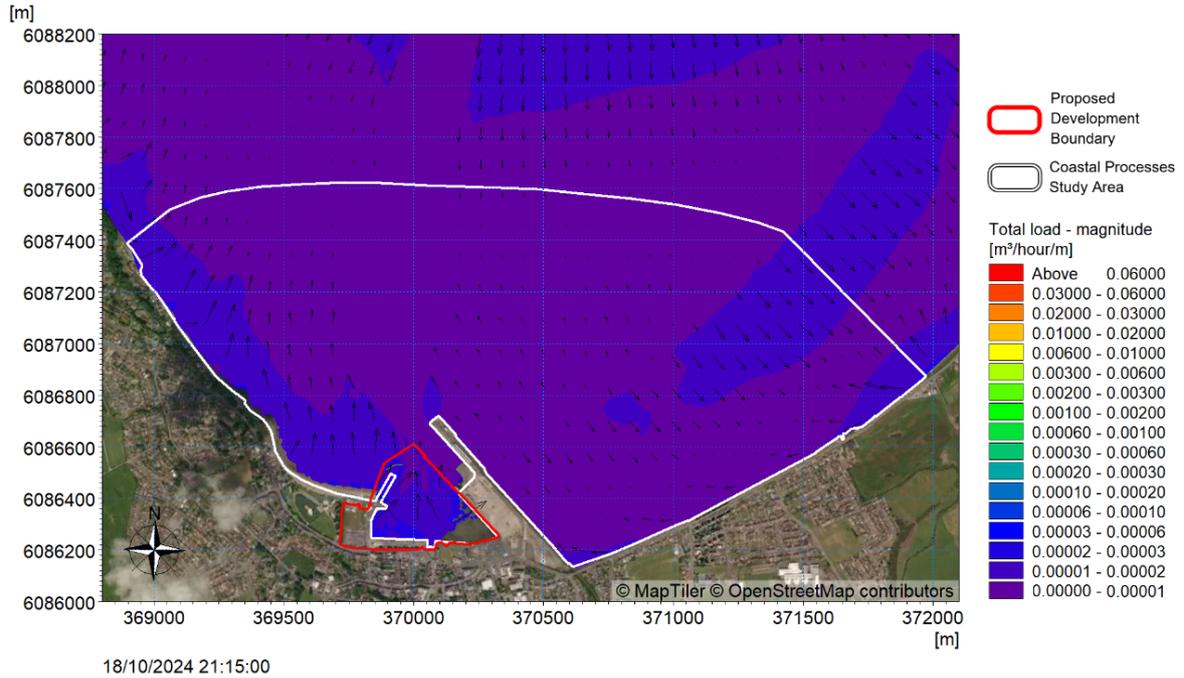


Figure 7-29: Sediment transport spring tide flood tide - baseline conditions

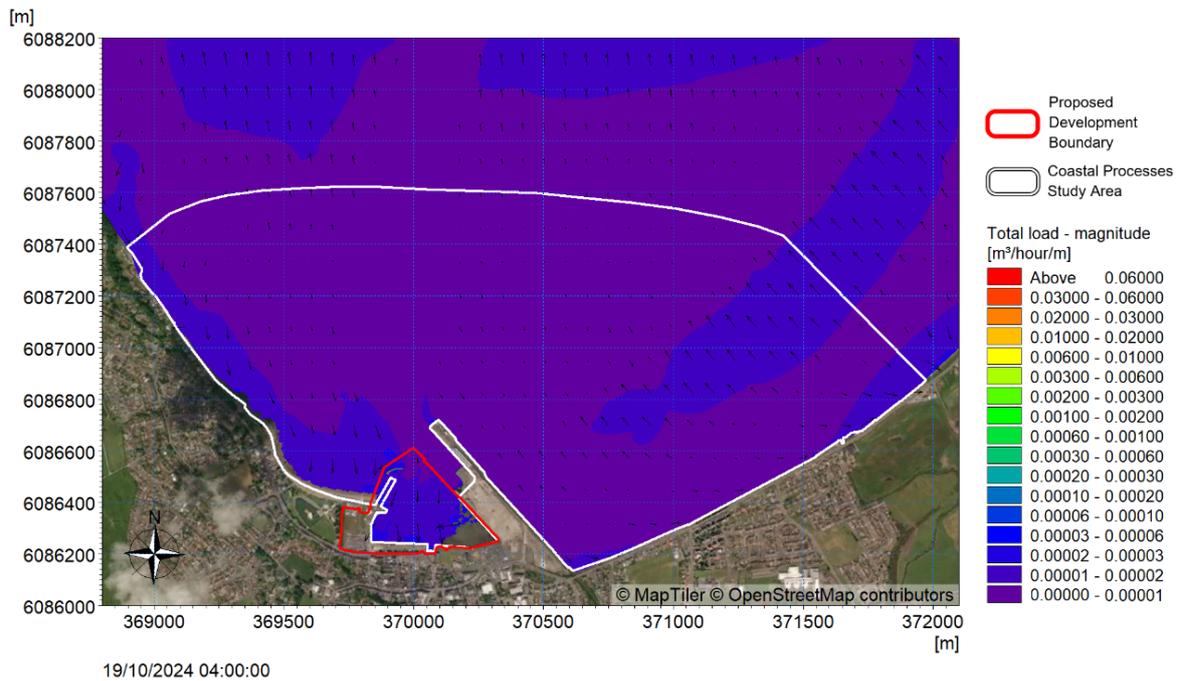


Figure 7-30: Sediment transport spring tide ebb tide - baseline conditions

- 7.85 The following figures present the baseline conditions for a 1 in 1 year event from the north-west. For this scenario five plots are presented; they relate to littoral currents during mid-flood and mid-ebb (**Figure 7-31** and **Figure 7-33**), i.e. currents which are comprised of both the contributions of tidal current and wave climate which drive sediment transport. Sediment transport at these two points in the tidal cycle are also presented (**Figure 7-32** and **Figure 7-34** using the same palette as the calm scenario) and the change in bed level over the course of the storm event is also presented in **Figure 7-35**.
- 7.86 During both the flood tide shown in **Figure 7-32** and ebb tide shown in **Figure 7-34** sediment transport is carried along the coast towards the harbour on either side and along the piers. This corroborates with the anecdotal evidence and also demonstrates how the influence of the wave climate is greater than the tidal flow; with both littoral current (**Figure 7-33**) and, more markedly sediment transport, running counter to the ebb tide, i.e. continuing in a southerly direction.
- 7.87 The change in bed levels shown in **Figure 7-35** support these transport mechanisms further. There is accretion on material on the outer West Pier (shown in brown) whilst to the east of Stranraer, material is eroded from the lower beach and deposited along the upper shoreline. It should however be recognised that, although strongly contrasting colour palettes have been used to accentuate the sediment transport regime and changes in bed levels to illustrate these processes, the magnitudes are limited; with changes in bed level in the order of a few millimetres even during a 1 in 1 year return period storm from the most arduous of directions.
-

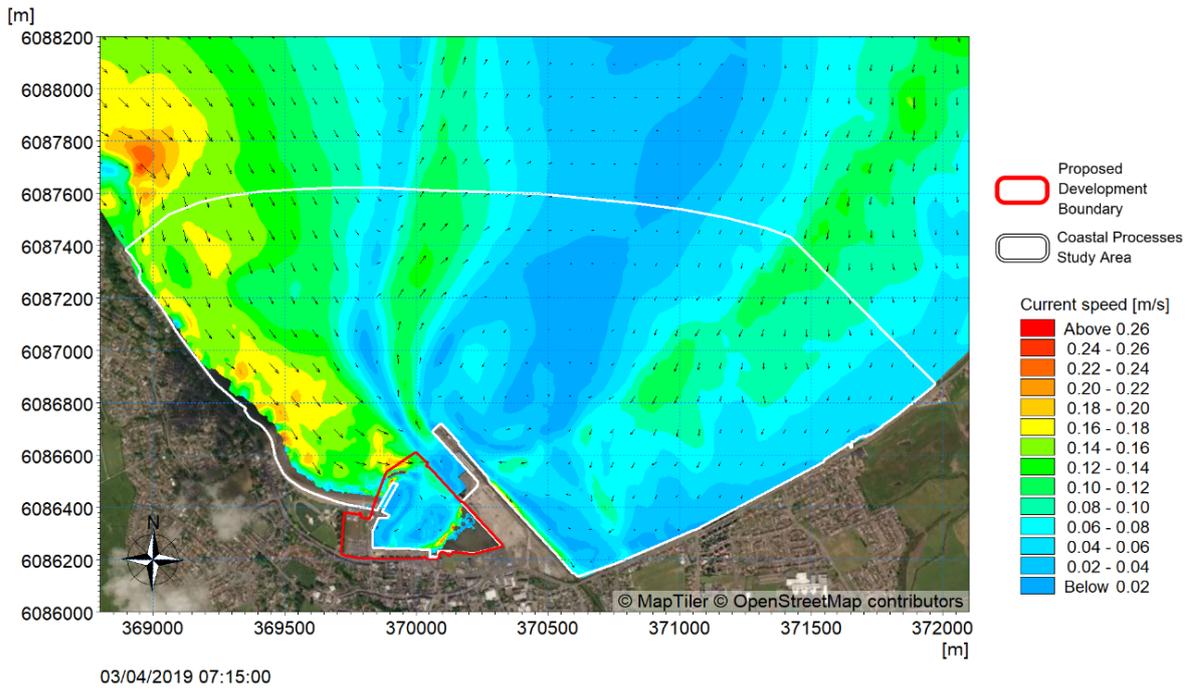


Figure 7-31: Littoral currents 1 in 1 year event flood tide - baseline conditions

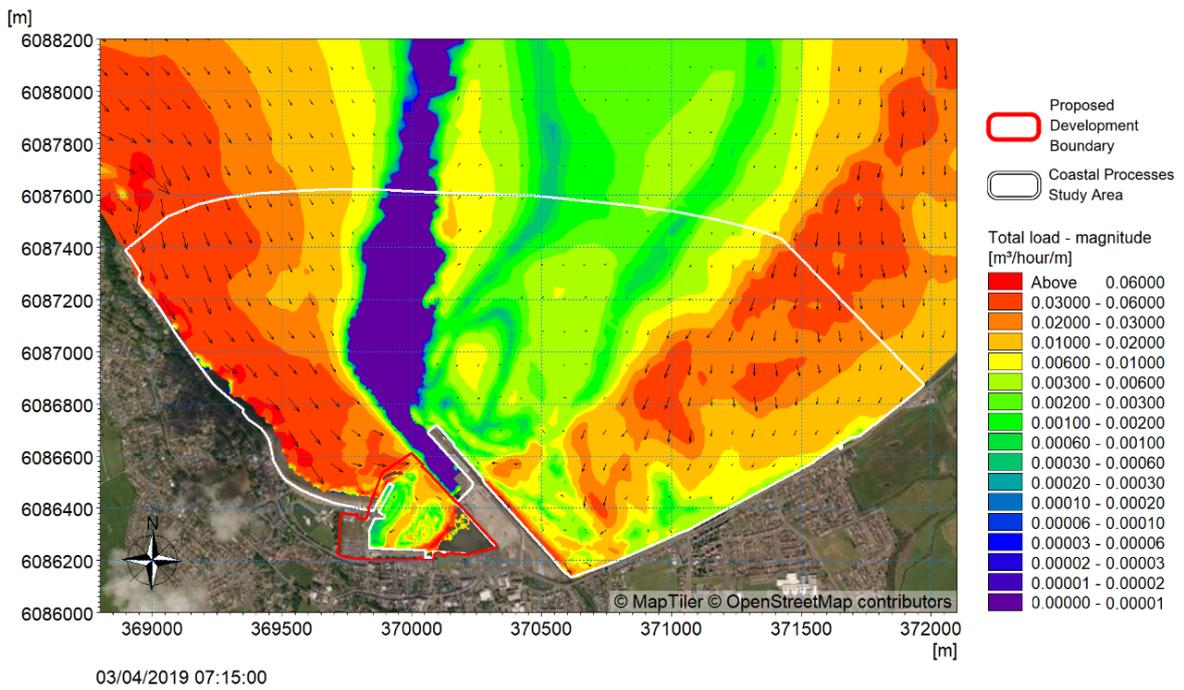


Figure 7-32: Sediment transport 1 in 1 year event flood tide - baseline conditions

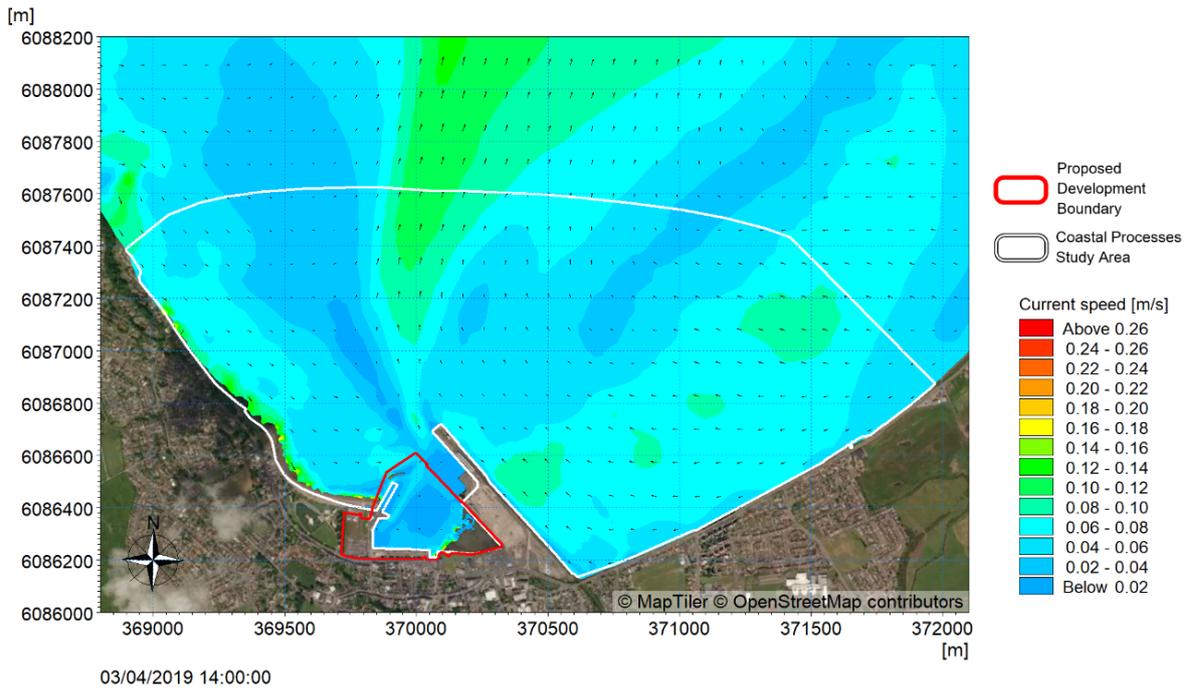


Figure 7-33: Littoral currents 1 in 1 year event ebb tide - baseline conditions

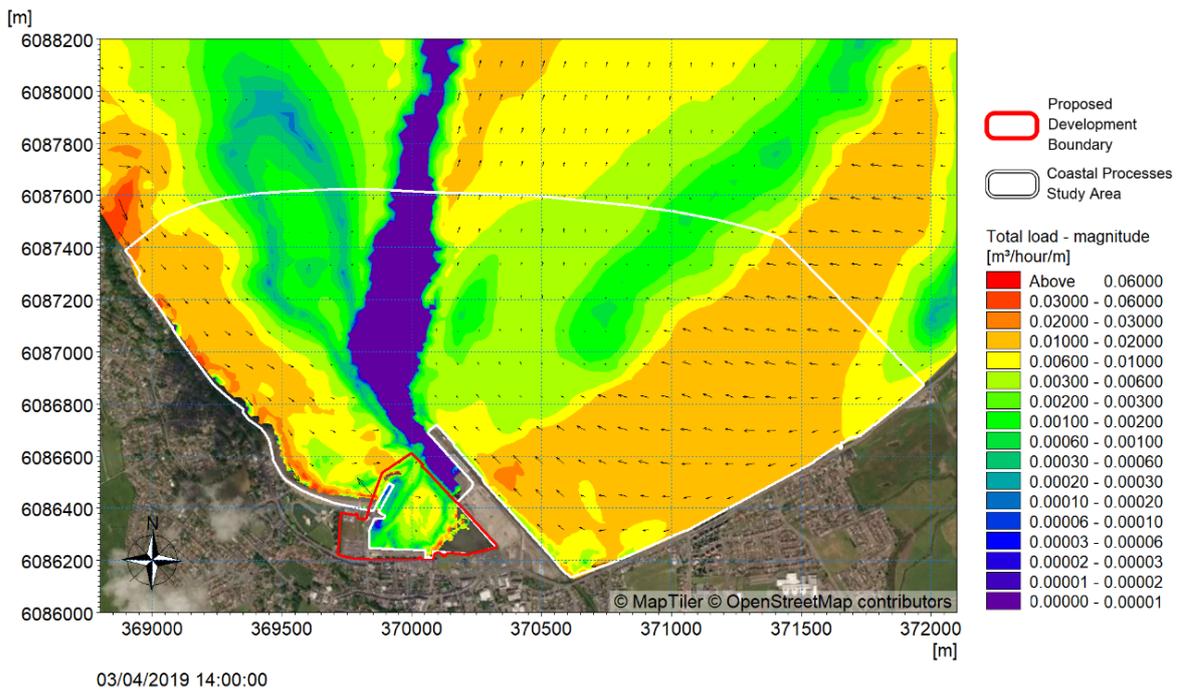


Figure 7-34: Sediment transport 1 in 1 year event ebb tide - baseline conditions

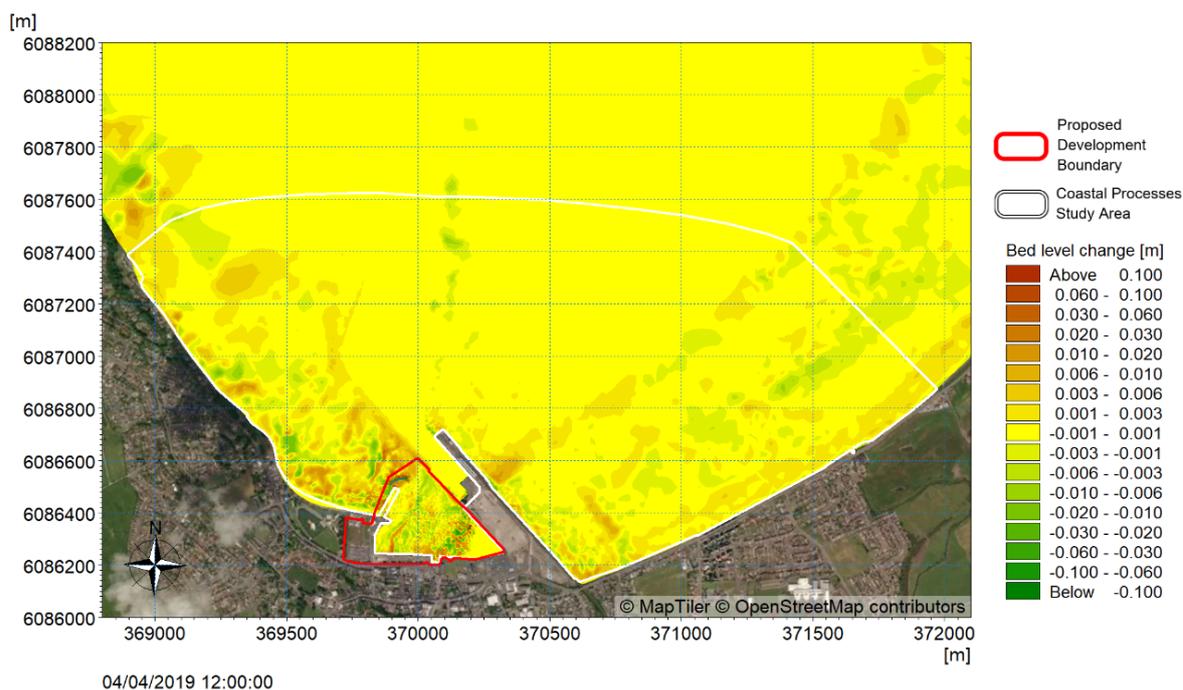


Figure 7-35: Change in bed thickness 1 in 1 year event - baseline conditions

Future Baseline

- 7.88 The baseline environment for coastal processes is not static and will exhibit a degree of natural change over time. Such changes will occur with or without the proposed development in place due to natural variability. Future baseline conditions would be altered by climate change resulting in sea level rise and increased storminess.
- 7.89 Much of the coastline in the vicinity of Stranraer is protected by artificial sea defences. It is predicted that sea level within the south of Loch Ryan will increase 0.29m from the 1990 levels by 2025 under the high emissions scenario, and by 0.93m by 2100¹⁷. Under these circumstances the defences extending to Bishop Burn to the east of Stranraer and to the west, just north of the West End would not be breached. Similarly, over this extent, the artificial sea defences will protect against coastal erosion.
- 7.90 Coastal erosion and flooding are however anticipated along undefended coastal regions where the coastal edge is made up of very soft raised marine deposits¹⁸, along both east and western sides of the Loch. The changes in water level and storminess are unlikely to have the effect of significantly altering tidal patterns and sediment transport regimes offshore. However, in the near-shore or inter-tidal areas increased frequency of storm events may have the potential to alter existing sediment transport regimes. Increased rates of erosion in the areas of soft marine

¹⁷ <https://www.dynamiccoast.com/webmaps>

¹⁸ The SCAPE Trust, Coastal Zone Assessment Survey – Loch Ryan, 2023. Available at: <https://scapetrust.org/wp-content/uploads/reports/Loch-Ryan-Report.pdf>

deposits could fuel sediment supply to the lower loch and potentially heighten maintenance dredging requirements in the longer term.

- 7.91 The return period of the wave climates would also be altered by climate change (e.g. what is defined as a 1 in 50 year event may become a 1 in 20 year event) as deeper water would allow larger waves to develop. There is, however, a notable degree of uncertainty regarding how future climate change will impact prevailing wave climates within the enclosed confines of Loch Ryan.

Impact Assessment

Embedded Mitigation

- 7.92 The provision of offshore infrastructure integral to the proposed development is designed to reduce the wave climate and enhance berthing facilities within the confines of the harbour and therefore would have limited influence beyond the development area, as has been the case for previous developments and dredging campaigns.
- 7.93 The design and final arrangement of the extension to the existing breakwater and the provision of an additional new floating breakwater was established following completion of wave modelling and detailed design works. This focussed the potential changes in wave climate to within the harbour basin by utilising a floating breakwater within the existing harbour. The floating breakwater will have a dual purpose as it is designed for berthing super yachts during calm conditions. This reduces the requirement for additional infrastructure with the associated impacts and therefore provides embedded mitigation.
- 7.94 With regards to the new reclaimed land, a natural profile will be retained that will silt up/dry out at times of low tide as it currently does with an option to reuse dredged material in reclaimed land area, rather than having to dispose and move it off site.
- 7.95 The piles proposed for use in the construction of the new marina berthing and floating breakwater/superyacht berth will be comprised of circular hollow section piles with a diameter of 813mm and 1016mm respectively. This diameter and shape, coupled with the diminutive nature of the flow within the marina, means the piles will have very limited impact on tidal flow.
- 7.96 Ground conditions are such that piles will be driven and will therefore not give rise to significant increases in SSC as material is consolidated within the seabed, rather than mobilised into the water column as is the case for augured or drilled piles. Additionally, the sheet pile wall which forms the new Quay Wall will be installed in close proximity and following the alignment of the existing sea wall. The infrastructure will therefore not change tidal flows within the harbour or give rise to significantly increased SSC during the construction phase. This new wall will be located as close to the existing quay as the foundations will allow and will have the advantage of providing a wider coastal pathway as part of the overall benefit to the users of the new marina area.

Construction Phase

- 7.97 The proposed marine based development principally relates to increased dredging and provision of breakwaters to accommodate the new marina layout. Therefore the construction phase activities which are assessed relate primarily to dredging activities. The assessment considers increased SSC due to the sediment spill during dredging operations and the extent of sediment plumes and subsequent deposition of this material. Increases in SSC due to

construction dredging activities are temporary and, on cessation of dredging, the contribution to SSC will conclude following settlement.

Suspended Sediment Concentration and Deposition

Capital Dredging Activities

- 7.98 Dredging plume modelling was undertaken for the proposed development to quantify increases in SSC, the extent of sediment plumes and subsequent deposition which forms the sensitive receptor/pathway for assessment. The modelling examined the MDS for sediment plume modelling for dredging operations. A realistic worst case was applied to ensure any appropriate dredging method which is proposed by the contractor at a later stage would be within the envelope of effects and have been assessed in terms of SSC.
- 7.99 The worst case for elevated SSC and deposition will be when dredging rates, and hence spill rates, are highest and/or where sediment can exit the harbour. A simplified approach was required to cover probable scenarios and determine likely plume excursion to identify zone of influence.
- 7.100 The important dredging parameters in terms of SSC relate to the rate of dredging, e.g. the cutter suction equipment capacity, the associated spill rate and the hopper size which determines the operational cycle for offshore deposits at the disposal site. The specification was initially based on plant typically used for this size of project¹⁹, it was subsequently noted that limited water depth, particularly at the commencement of dredging activities, would necessitate the use of a small cutter dredger. In this case the dredging plant is mounted on a barge and pipes are used to transport the dredged material to the hopper barges or to the reclamation area. The smaller plant would not dredge any faster or use a hopper any larger than initially specified. Indeed, potentially the spill rate may be less, i.e. a reduction from worst case spill rate.
- 7.101 In terms of providing a realistic and flexible MDS, the modelling was based on the data initially specified as outlined above, as this small cutter dredging method would fall within the envelope of effects. It also means that the assessments remain valid if an alternate contractor/supplier has a suitable plant of a size between the two options or, having undertaken some of the dredging, it is determined that sufficient draft is available, and it may be beneficial (for operational or economic reasons), to switch operations to larger plant.
- 7.102 The project description for the proposed development provided details for of the dredging parameters which were used within the plume modelling. This was supported by a Best Practicable Environmental Option²⁰ (BPEO) assessment undertaken to inform proposed capital dredging at Stranraer Marina. Following the modelling study, the dredging plan was optimised and extended to incorporate maintenance dredging at the location of the southern berths on

¹⁹ Sospan Dau Trailing Suction Hopper Dredger (TSHD)

²⁰ Stranraer Marina Best Practicable Environmental Option (BPEO) Report, EnviroCentre, July 2025

the West Pier in the existing marina, as illustrated in **Figure 7-8**. The total dredging volume was maintained with a slightly larger proportion of material being disposed at Beaufort's Dyke. The characteristics of the dredging plumes from the two types of activities (i.e. offshore and inshore disposal) and slightly adjusted dredging area were considered to be representative of those modelled. The modelling indicated that the slight differences in the settlement footprints, and depths of deposition were associated with the construction of the breakwater extension and would not be sufficient to change the results to any discernible degree by altering the proportion of the type of dredging activities. Furthermore, the breakwater extension is likely to be in place for a proportion of the dredging utilising disposal at Beaufort's Dyke. **Table 7-8** provides an overview of the modelled and optimised dredging volumes.

Table 7-8: Modelled and Optimised Dredging Volumes

Dredge Volume	Modelled m ³	Optimised m ³
Total dredging volume	132,891	132,616
Use in reclamation	52,203	48,340
Disposal at Beaufort's Dyke	80,688	84,276

7.103 The change in seabed level due to the proposed development and dredging activities modelled is shown in **Figure 7-36** and indicates the proportion of the dredging programme and associated areas in which dredging activities will take place.

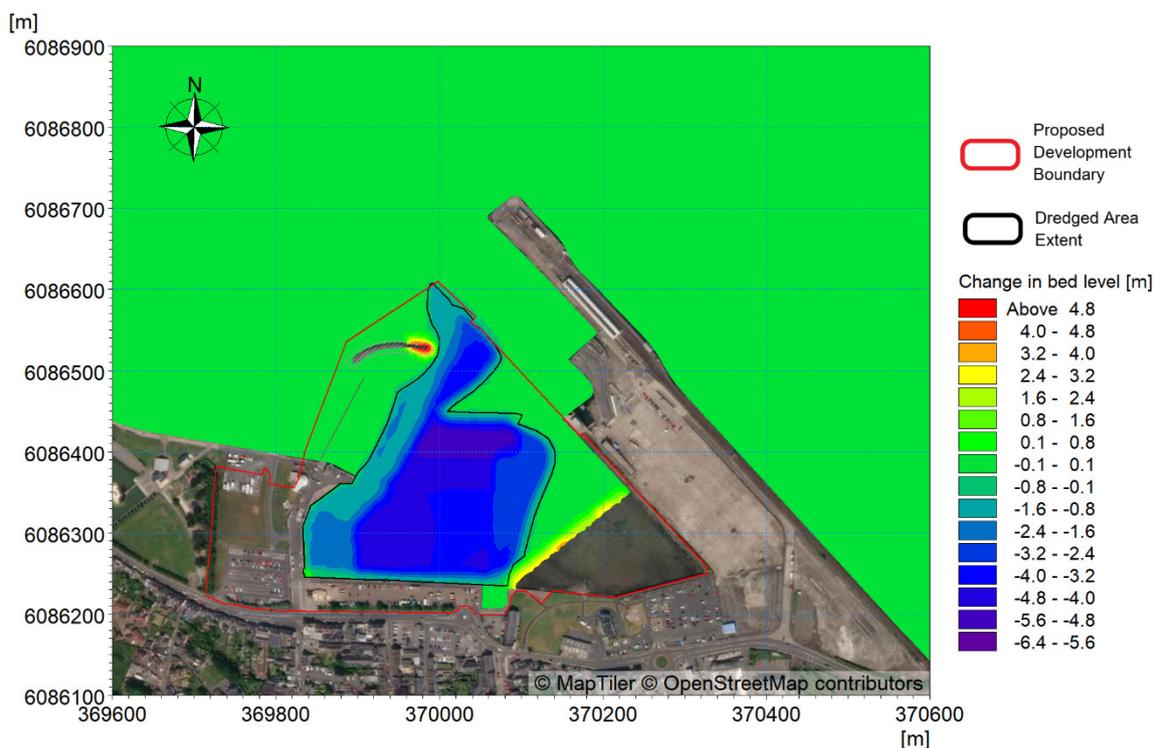


Figure 7-36: Modelled change in bed level due to the proposed development

7.104 The project description describes the main points of the construction sequence, whereby the seawall and revetment will be in place prior to dredging and the breakwater extension will be built part way through dredging programme. Site working is prescribed as 12 hours per day Monday to Friday with half day working on Saturday.

7.105 As previously noted, the modelling methodology was designed to implement a simplified approach to cover probable scenarios and determine likely the plume excursion to identify the zone of influence. It was also designed to apply a MDS which allowed for potential variations in plant and programme in order not to constrain the project in the later detailed planning stage. The following general assumptions were made for the dredging plume modelling based on the project description, site conditions and proposed operations:

- The range of dredging methods proposed all result in spill rate less than 5% - therefore this spill rate was applied for conservativeness and flexibility
- Dredging for sea disposal undertaken with marine plant of limited draft due to initial restricted depth
- Primarily capital dredging - therefore use of the greatest dredging rates associated with very large plant, soft sediments and maintenance dredging would be unrealistic
- Sea disposal anticipated to be undertaken in earlier phases due to
 - better access (prior to breakwater extension being constructed)

- removal surface layers/silt to potentially expose material better suited to reclamation
- 7.106 The modelling examined two scenarios designed to encompass the proposed dredging activities, i.e. dredging for disposal offshore and reclamation. The worst case for elevated SSC occurs when dredging rates, and hence spill rates, are highest and when dredging programmes are most condensed; whereby material has more limited opportunity for settlement and amalgamation into the underlying sediment transport regimes. For this reason, the modelling assumed 7 day working, with a 12 hour day. Whilst it is unlikely that Sunday working would be undertaken, as it requires special permitting, it has been included in this assessment should there be an operational reason to do so (i.e., weather constraints etc).
- 7.107 The modelled spill included the release of sediment across the dredging areas proportional to the depth of dredging undertaken, as illustrated in **Figure 7-36**. It is recognised that the source of sediment release traverses across this area more quickly in the model than may occur in field operations, particularly if a barge with spud legs is used. However, the model simulation was designed to ensure that material is released over the entire coverage of the area, at all stages of the tide, to ensure the full extent of the likely elevated SSC and plume excursion is captured.
- 7.108 The dredging operations are anticipated to be undertaken over a period of 190 days, i.e. *circa* 6 months, which takes account of a 5.5 day working week and a contingency. The application of the MDS and condensed 7 day working reduces this considerably, *circa* 54 days for sea disposal and *circa* 52 days for reclamation (based on modelling parameters outlined in the following section [Dredging Plume Modelling Scenarios](#)). For computational efficiency the modelling was undertaken for half of each of these operations. The spill release over 26 days ensured that discharge occurred at all tidal states; ebb tide, flood tide and slack water and during spring, mean and neap tidal ranges. Thus the suspended sediment plumes encompassed all phases; including neap tide where SSC may be increased but dispersion is more limited i.e. the plume extent is reduced in comparison to spring tides. The modelling simulated calm conditions, i.e. under pure tides without wind action. Therefore, in reality, plumes may extend further but would be more widely dispersed giving much smaller increases in SSC and lower levels of sedimentation.
- 7.109 The models also incorporate any material resuspended on subsequent tides and were extended for five days beyond the dredging period to examine the potential for re-suspension and assimilation of spilled material into the underlying sediment transport regime. The total sedimentation was therefore calculated by doubling the settled material at the end of each simulation and summation of the two scenarios. This provides a conservative value as, in reality, some of this material is incorporated into the baseline sediment transport regimes and, where material settles in the dredging area, it will be removed on subsequent dredger passes.
-

Dredging Plume Modelling Scenarios

7.110 Two dredging scenarios were modelled. The first related to the offshore disposal of material associated with conditions at the start of the dredging programme and a second relating to reclamation of material associated with conditions at the latter part of the dredging programme. In each case the dredging parameters are specific to the operations and site conditions in each scenario.

7.111 The first scenario (Scenario 1) modelled plumes representative of conditions at the start of the programme are associated with the following:

- Seawall and revetment in place;
- Existing (pre-dredge) bathymetry;
- Existing outer breakwater; and
- Utilising deposition offshore at Beaufort's Dyke.

7.112 A typical hopper capacity of 1,500 m³ was assumed, in line with the largest suitable plant, which takes *circa* 4 hours to fill. To facilitate pumping of slurry, it was assumed to have a water content of 50%. This gives rise to a dredging rate of 187.5 m³/h with a 5% conservative spill being applied. It is dependent on availability, but it is assumed for MDS that two hoppers are operational. The round trip to Beaufort's Dyke takes approximately 6 hours (vessel speed *circa* 7.5 knots) therefore a maximum of two cycles may be undertaken per day. The dredging cycle and tidal excursion during the Scenario 1 simulation period is presented in **Figure 7-37**.

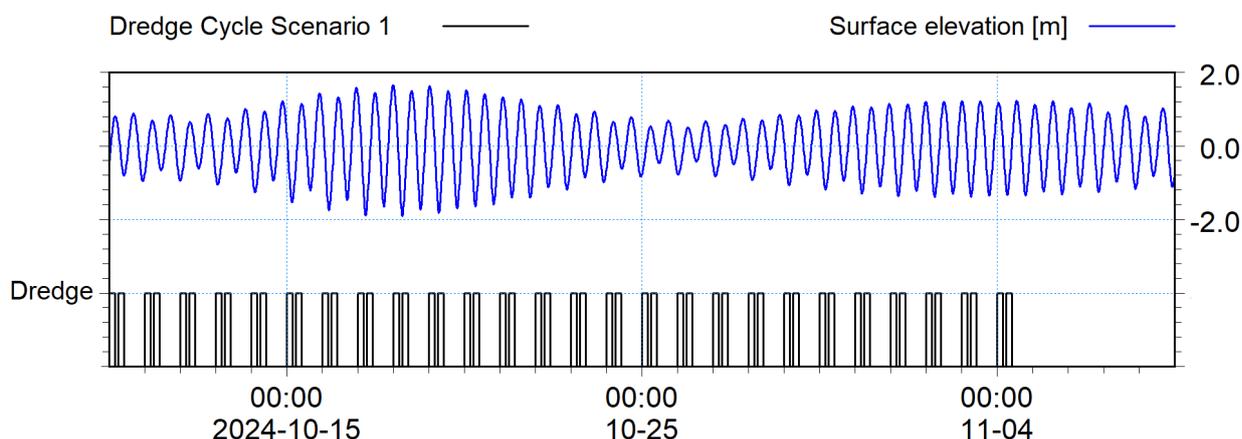


Figure 7-37: Dredging Cycle and Tidal Excursion during Scenario 1 Simulation Period

7.113 The sediment characteristics were derived from Ground Investigations (GI)²¹ utilising analysis of borehole logs and vibro-core samples at a depth of 1 to 2m along with seabed samples sited

²¹ Fairhurst, Geo-environmental and Geotechnical Interpretative Report, 136625/GL/G/01, December 2021

within the dredging area. The typical characteristics were described by first defining intervals for which representative sediment grading was determined, this is outlined in **Table 7-9**.

Table 7-9: Typical Sediment Grading Dredging Area (0 – 2 m)

Sediment Type	Average Grain Diameter (D ₅₀) mm	Proportion %
Coarse material / gravel	>2mm	4
Med / coarse sand	0.9	13
Coarse silt / fine sand	0.11	32
Fine/med silt	0.028	23
Very fine/fine silt	0.006	18
Clay	<0.004	10

7.114 It was noted that the very coarse material, such as gravel, will settle at the cutter head and be removed subsequently by further dredging. It was also seen from the core samples that the clay fraction is highly cohesive and during dredging any spilled material would be deposited as 'clumps' and behave much in the manner of the very coarse material. The material spilled within the model simulation was therefore comprised of the four remaining classifications. The 5% spill was defined as being comprised of very fine silt to coarse sand fractions, rather than excluding 14% of the volume to account for clay and gravel, therefore incorporating a further degree of conservatism, as outlined in **Table 7-10**.

Table 7-10: Sediment Grading Utilised in Scenario 1 Modelling

Sediment Type	Average Grain Diameter (D ₅₀) mm	Proportion %
Med / coarse sand	0.9	15
Coarse silt / fine sand	0.11	37
Fine/med silt	0.028	27
Very fine/fine silt	0.006	21

7.115 The GI also indicated that cohesive marine and glacial sediments were present. As such, some of the finer silt fractions may behave similarly to clay and be deposited in clumps or flocculate

and settle more quickly than non-cohesive silt particles when released. To provide a worst case scenario it was specified in the modelling that all sediment spilled was non-cohesive. The model simulations also accounted for resuspension of settled material should the critical shear stress be exceeded with increasing current speeds due to tidal flow conditions. However, to simulate realistic behaviour, it was assumed that the medium silt and sand (which constitute the greatest proportion of the sediment composition) provides some degree of armouring, trapping the fine silt when disposition occurs.

- 7.116 The plume modelling results relate to SSC and sedimentation with modelling output presented as;
- Statistical plume/sedimentation envelopes;
 - 'Snapshots' indicating magnitude at moment in time during simulation; and
 - Timeseries graphs.
- 7.117 For the purposes of the coastal processes assessment the statistical model output and final sedimentation level output was applied. However the full range of model output was generated to support related disciplines including **Chapter 11.0: Water Quality**, **Chapter 12.0: Benthic Ecology** and **Chapter 13.0: Fish Ecology** and is provided in **Appendix 7.1 (Volume 2 of EIAR)**.
- 7.118 The purpose of the statistical plume/sedimentation envelopes is to convey the dispersion and fate of material which varies over a period of time on a single figure. The maximum plume and sedimentation envelopes show the maximum value that each parameter reaches at each cell location in any time step during the entire course of each simulation. It is most important for the observer to appreciate that, whilst the resulting figure is of use in showing the maximum values that can be reached at any point throughout the area covered and throughout the simulation, it does not represent a real situation in space or time because there is little likelihood, particularly in the case of SSC, of the maximum values recorded occurring simultaneously. Additionally, whilst the time for which the maximum value persists in any given mesh cell will vary and, overall, the percentage frequency of occurrence will be reduced due to tidal oscillation.
- 7.119 Similarly, the average concentration is generated by averaging all the values recorded in all time steps in each cell over the course of the period in question. Once again, the resulting figure is not related to a given point in time, but it is useful when used in conjunction with the maximum plume envelope for gauging the 'typical' values in any area and to indicate how often the maximum values occur. For example, a high concentration may be recorded at one location and presented on the maximum envelope, but when the average plot is interrogated, the value is much lower at this location. This indicates that the maximum value obtained was only experienced for a short period of time. The average values were also calculated for the period of the dredging operations, rather than the entire simulation, to provide a conservative value rather than including the period after the cessation of dredging activities when no further sediment is being released.

- 7.120 A consistent colour palette and associated scale has been applied across all the figures illustrating SSC, and similarly for sedimentation a single pallet has been applied, to enable results to be visually compared. It should be noted that all plotted figures utilise a log scale to cover the range of values whilst also providing clarity for smaller magnitudes. The range of values which are presented also extend much lower than would be discernible from natural variation in background levels and are designed to convey the potential impacts within the study area.
- 7.121 The maximum and average SSC plumes for Scenario 1 are presented in **Figure 7-38** and **Figure 7-39** respectively. As anticipated, the SSC levels within the dredging area are elevated; this is associated with the sediment source being located in very shallow “pre-dredged” bathymetry conditions. High SSCs are observed as the sediment settles through the water column. The finer fractions are subsequently dispersed into Loch Ryan on the ebb tide. The maximum values within the vicinity of the development are circa 500 mg/l whilst average levels are typically one tenth of this value for Scenario 1. This demonstrates how significantly elevated levels do not persist as spilled material is dispersed and settles out.
- 7.122 **Figure 7-40** illustrates sedimentation levels, in millimetres, at the end of the dredging period within the Scenario 1 simulation using a logarithmic scale. Within the harbour, where the sediment source originates and the water is shallow, sedimentation levels may be up to 100mm. However, much of this material would be removed during later stages of the dredging activities. At the harbour entrance, just beyond the proposed development area, sedimentation is reduced to circa 2mm and is a fraction of a millimetre within 250m from the dredging footprint.
-

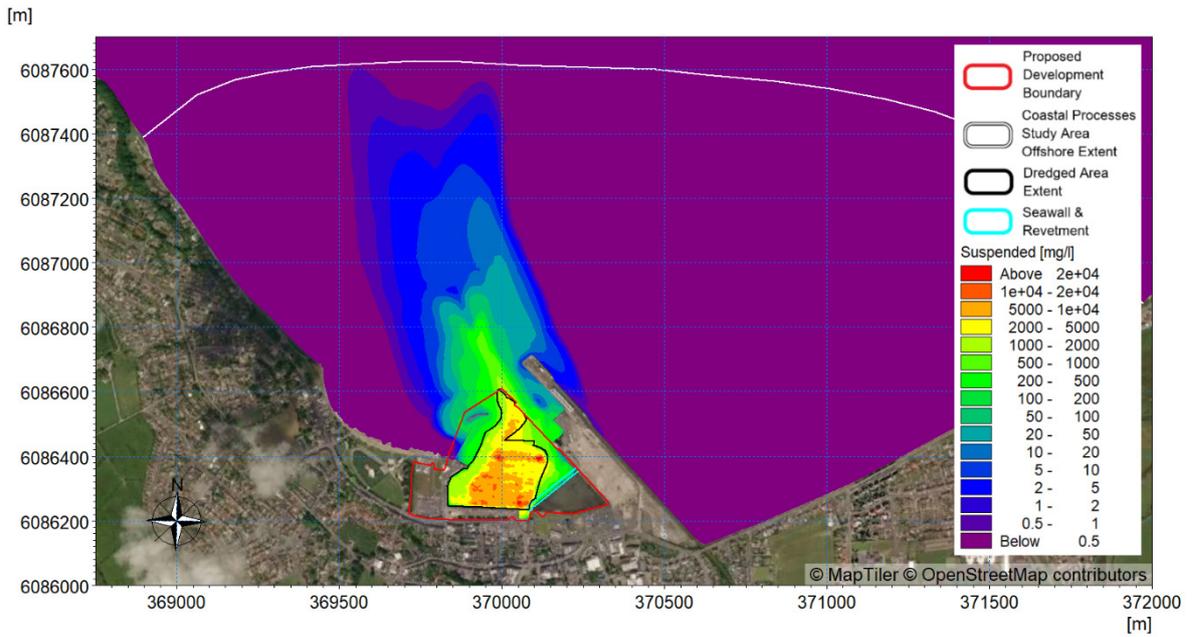


Figure 7-38: Scenario 1 - Maximum Plume Envelope of SSC during Dredging Simulation

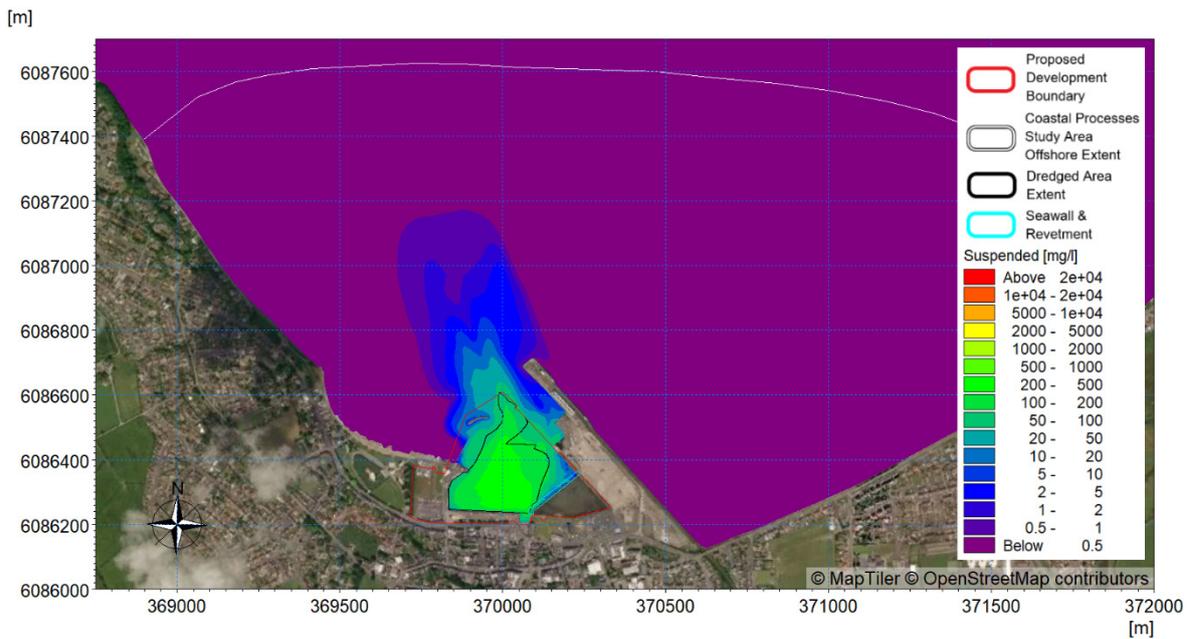


Figure 7-39: Scenario 1 - Average Plume Envelope of SSC during Dredging Operations

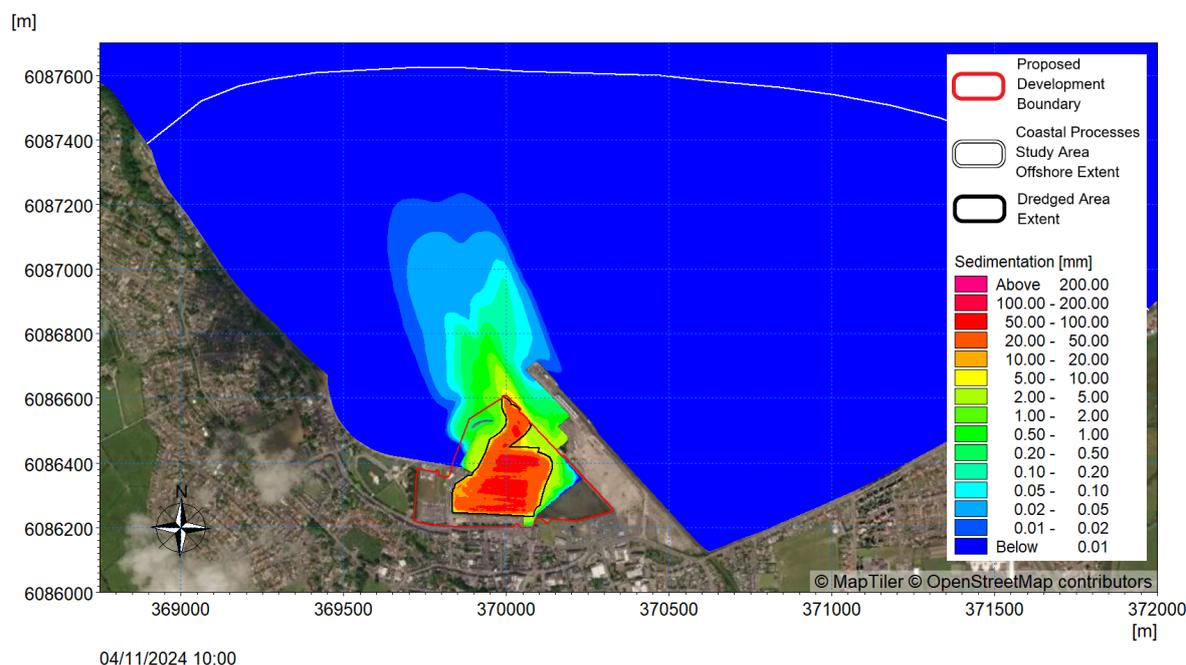


Figure 7-40: Scenario 1 - Sedimentation on Cessation of Dredging Operations

7.123 The second scenario (Scenario 2) modelled plumes representative of conditions near end of the programme are associated with the following:

- Seawall and revetment in place;
- Revised (dredged) bathymetry;
- Extended outer breakwater; and
- Utilising onshore reclamation

7.124 In this scenario pumping is undertaken directly to the reclamation area. The onshore stabilisation / dewatering would be undertaken by a specialist contractor and is limited to an upper bound of *circa* 1000m³/d to produce a firm Class 7 or Class 9 material i.e. suitable for general fill purposes. In reality, reclamation dredging may be more intermittent or slower depending on the method to prepare sand for re-use as infill material. Therefore this daily rate represents the MDS.

7.125 It was assumed that the dredging operation was continuous for the 12 hour working day which equates to a rate of 83.3m³/h, with a conservative spill of 5% applied. The dredging cycle and tidal excursion during the Scenario 2 simulation period is presented in **Figure 7-41**.

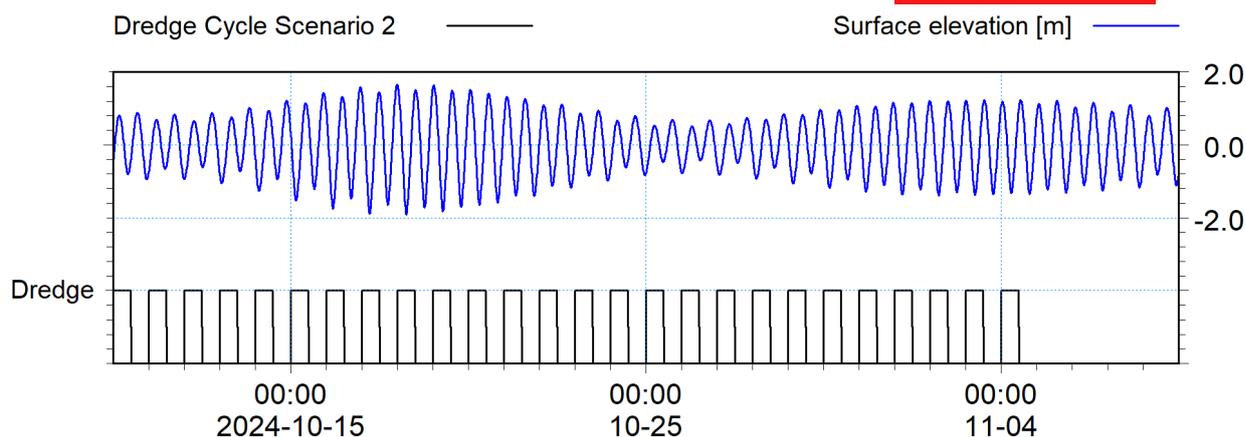


Figure 7-41: Dredging Cycle and Tidal Excursion during Scenario 2 Simulation Period

7.126 The sediment characteristics were derived from GI²² data utilising analysis of borehole logs and vibrocore samples at 2 to 5m depth in line with the dredging requirements. The typical characteristics were described by first defining intervals for which representative sediment grading was determined, this is outlined in **Table 7-11**. As anticipated sediment comprised slightly coarser sediment than the shallower layers used for Scenario 1.

Table 7-11: Typical Sediment Grading Dredging Area (2 – 5 m)

Sediment Type	Average Grain Diameter (D ₅₀) mm	Proportion %
Coarse material / gravel	>2mm	4
Med / coarse sand	0.9	18
Coarse silt / fine sand	0.11	48
Fine/med silt	0.028	14
Very fine/fine silt	0.006	9
Clay	<0.004	7

7.127 As noted previously the very coarse material, such as gravel, will settle at the cutter head and be removed subsequently by further dredging. It was also seen from the core samples that the clay fraction is highly cohesive and during dredging any spilled material would be deposited as ‘clumps’ and behave much in the manner of the very coarse material. As with Scenario 1, the material spilled within the model simulation was therefore comprised of the four remaining classifications. The 5% spill was defined as being comprised of very fine silt to coarse sand

²² Fairhurst, Geo-environmental and Geotechnical Interpretative Report, 136625/GL/G/01, December 2021

fractions, rather than excluding 11% of the volume to account for clay and gravel, therefore incorporating a further degree of conservatism, as outlined in **Table 7-12**.

Table 7-12: Sediment Grading Utilised in Scenario 2 Modelling

Sediment Type	Average Grain Diameter (D ₅₀) mm	Proportion %
Med / coarse sand	0.9	20
Coarse silt / fine sand	0.11	54
Fine/med silt	0.028	16
Very fine/fine silt	0.006	10

7.128 The GI also indicated that, like Scenario 1, cohesive marine and glacial sediments were present therefore some of the finer silt fractions may behave similarly to clay and be deposited in clumps or flocculate and settle more quickly than non-cohesive silt particles when released. As in Scenario 1, to provide a worst case scenario all sediment spilled was defined as non-cohesive in the modelling. The model simulations also accounted for resuspension of settled material should the critical shear stress be exceeded with increasing current speeds due to tidal flow. However, to simulate realistic behaviour, it was assumed that the medium silt and sand (which constitute the greatest proportion of the sediment composition) provides some degree of armouring, trapping the fine silt when disposition occurs.

7.129 The maximum and average SSC plumes for Scenario 2 are presented in **Figure 7-42** and **Figure 7-43** respectively. As with the Scenario 1, the SSC levels within the dredging area are elevated; being associated with the sediment source located in shallow water and high concentrations are observed as the sediment settles through the water column. It is however apparent that for Scenario 2 these values are somewhat lower than previously in Scenario 1, which can be attributed to the reduced rate of spill coupled with the increased depth due to the dredged bathymetry providing greater dilution at the sediment source. The maximum values within the vicinity of the development, just beyond the dredging area, are circa 200mg/l whilst average levels are again typically one tenth of this value.

7.130 The sedimentation levels at the end of the dredging period of the Scenario 2 simulation are presented in **Figure 7-44**. Within the harbour, where the sediment source originates and the water is shallower, sedimentation levels may be up to 50mm. However, as with Scenario 1, much of this material would be removed during later stages of the dredging activities. At the harbour entrance, just beyond the proposed development area, sedimentation is reduced to circa 2mm and is a fraction of a millimetre at a distance of 250m.

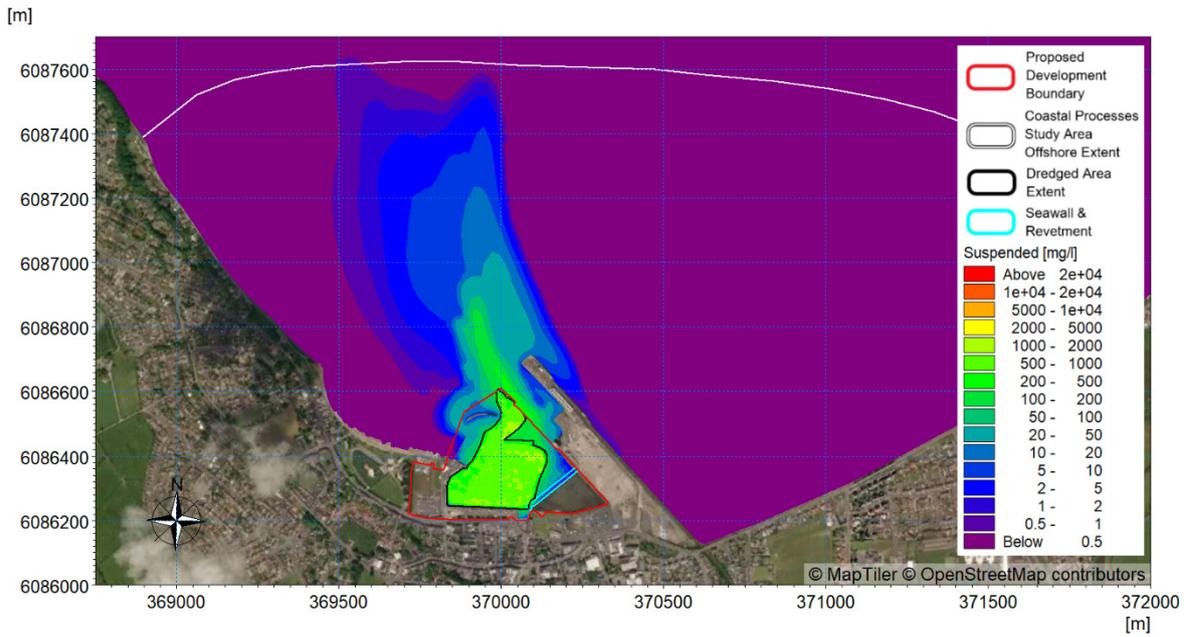


Figure 7-42: Scenario 2 - Maximum Plume Envelope of SSC during Dredging Simulation

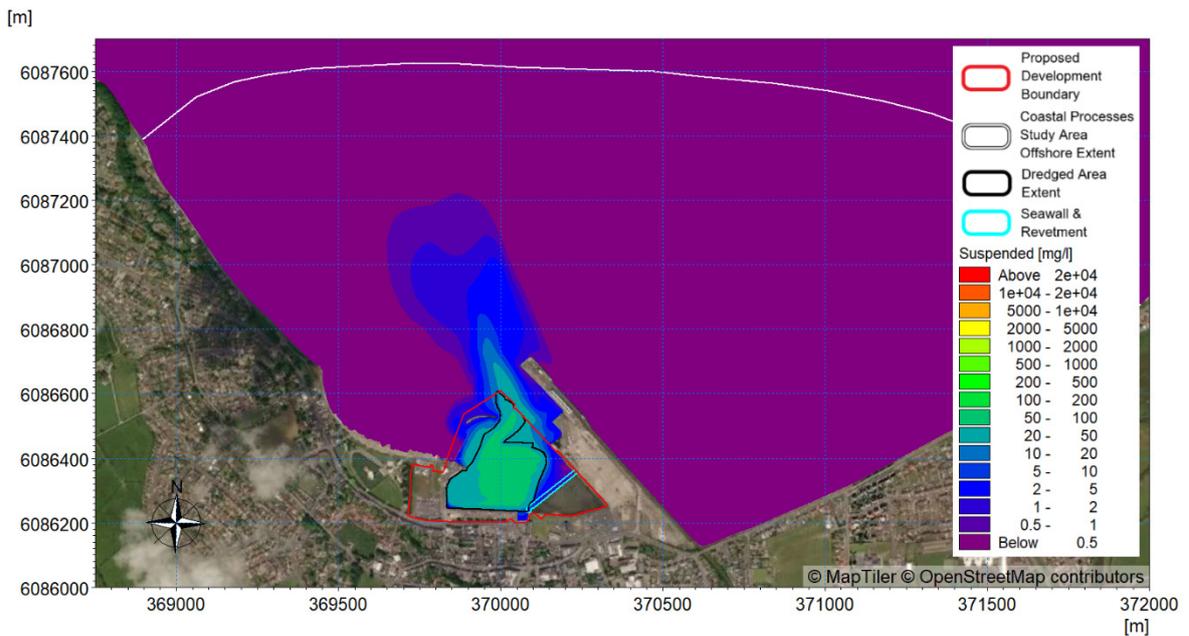


Figure 7-43: Scenario 2 - Average Plume Envelope of SSC during Dredging Operations

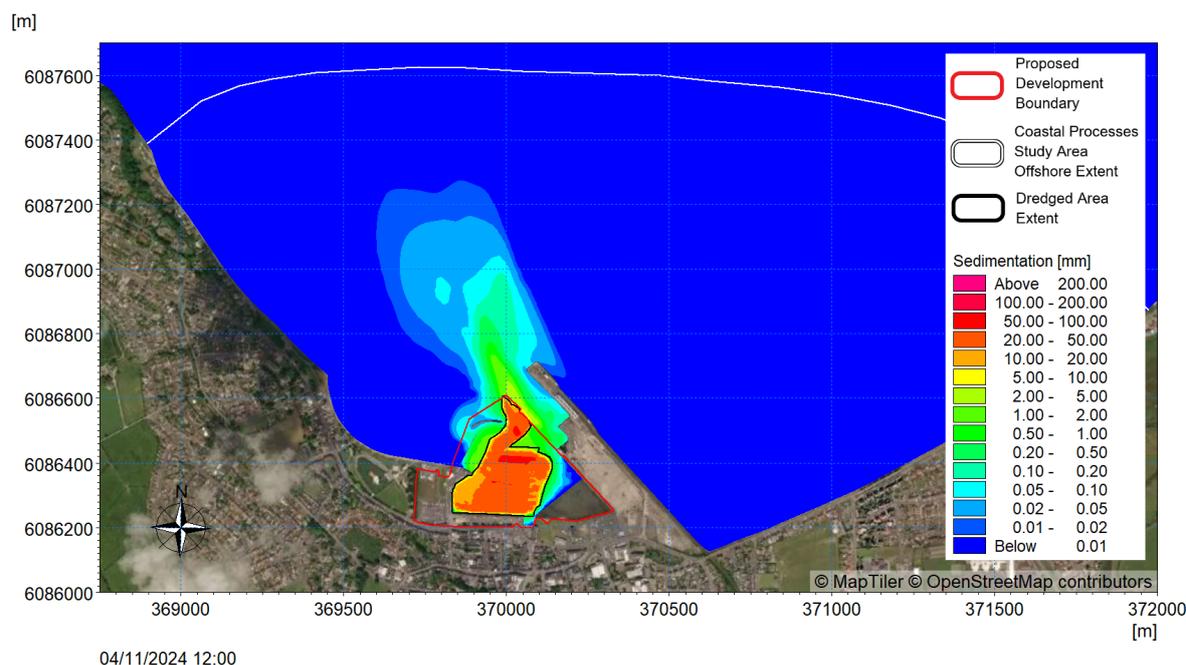


Figure 7-44: Scenario 2 - Sedimentation on Cessation of Dredging Operations

7.131 The model output presented in **Figure 7-45** relates to the total sediment depth due to the capital dredging operations. It was determined by adding the sedimentation at the end of dredging period for the Scenario 1 and Scenario 2 simulations and then doubling as; each of scenario comprised half the dredging volume over a condensed work cycle. It is evident that the greatest sedimentation levels occur within the dredging area extent. Beyond the confines of the harbour levels are significantly lower. Within 200m of the harbour mouth sediment depths are below 5mm, and below 0.5mm at a distance of 400m. The sedimentation is characterised by lozenge shapes associated with tidal excursions. These are aligned slightly differently between the two scenarios due to the influence of the breakwater extension in Scenario 2. The modelling was undertaken during pure tide / calm conditions where spreading is limited; it is noted that wind induced dispersion would give rise to lower levels of sedimentation.

7.132 The wave climate is mainly governed by wind wave generation within the Loch and the winds in Loch Ryan will be influenced by topography; whereby the winds are funnelled from directions that are approximately aligned to the axis of the Loch. The application of meteorological conditions in the model simulations may increase the extent of the sediment plume but in turn reduce SSC and deposition levels. It is also observed that wind approaching from the northern sectors, with the potential to bring sedimentation onto the intertidal areas in the south of the Loch, would also simultaneously reduce the spill from within the harbour confines by opposing tidal flow. Winds from the southern sectors would act to enhance the tidal mixing and significantly reduce SSC with the Loch. Given the limited levels of sedimentation beyond the proposed area of development it was concluded that the use of the calm condition was

appropriate for determination of SSC and sedimentation depths for application in the environmental assessment.

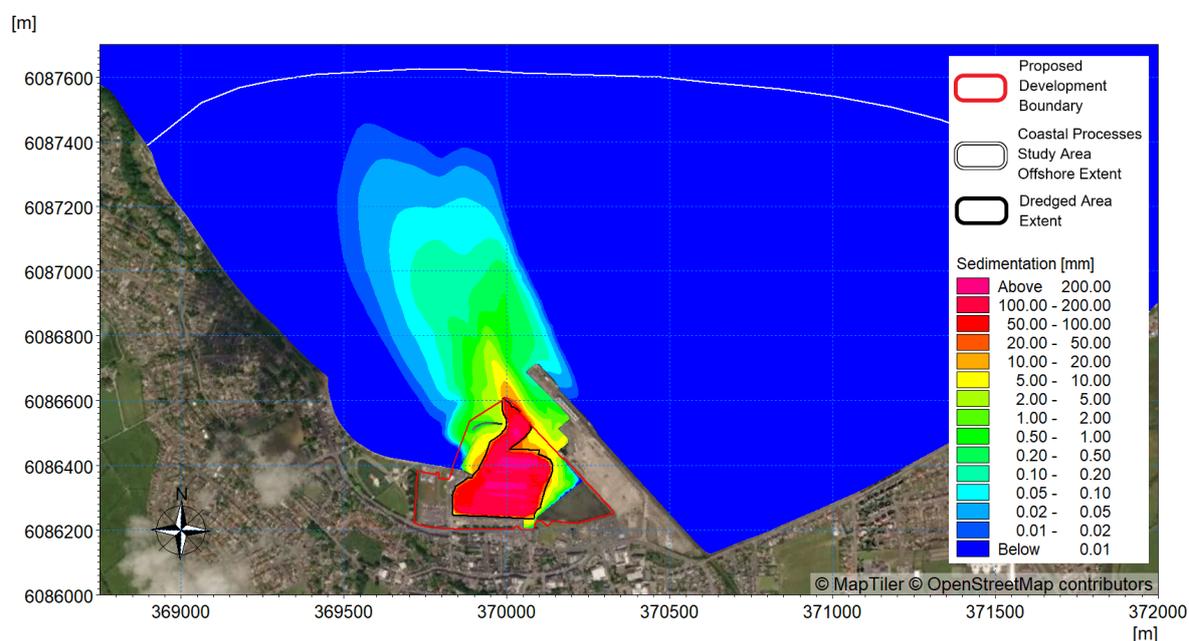


Figure 7-45: Sedimentation Depth due to Dredging Operations

- 7.133 There are no areas designated for coastal process features or bathing waters located within the coastal processes study area. Loch Ryan is however a SEPA Shellfish Water Protected Area which is assessed in **Chapter 11.0: Water Quality** and **Chapter 13.0: Fish Ecology**.
- 7.134 Coastal processes have low sensitivity to changes in SSC, i.e. increased SSC would not change the viscosity of the receiving water such that tidal currents would be altered. Sedimentation levels due dredging activities are of the order of fractions of a millimetre within a water depth of several metres and represent values within the range of natural variation and would therefore not impact on hydrodynamic conditions. Modelling indicated that settled material is resuspended on subsequent tides and it drawn into the underlying sediment transport regime which exhibits high levels of turbidity and variation in SSC, as illustrated in [Baseline Conditions](#).
- 7.135 Given the low sensitivity of coastal processes to changes in SCC and the low magnitude of sedimentation, the impact of dredging activities is therefore considered to be of negligible significance of effect and not significant in EIA terms.

Operational Phase

- 7.136 The proposed development includes permanent changes to the marine environment relating to infrastructure, i.e. the extension of the existing breakwater and provision of a floating breakwater. Additionally, dredging to accommodate the new marina layout will result in changes in bathymetry which will give rise to changes in tidal flow. The provision of infrastructure is designed to alter the wave climate within the harbour to facilitate berthing, therefore the assessment focuses on potential impacts beyond those intended changes in coastal processes. It was noted that following completion of the modelling phase, minor alterations were made to the proposed development. This includes the infilling of the area surrounding the existing slipway within the harbour and provision of a new 40m slipway into the dredged area. Re-modelling was not deemed appropriate for these minor changes which would not influence coastal processes.
- 7.137 The coastal process pathway to receptors are interlinked; i.e. an ecologically sensitive receptor may be impacted by changes to sediment transport regime however this process is influenced by both tidal flow and wave climate. Therefore in the context of the assessment a holistic approach is applied whereby changes to the driving forces of sediment transport, i.e. tidal flow and wave climate, are examined.

Potential Changes to Baseline Tidal Regime

- 7.138 The numerical modelling study outlined in [Modelling Methodology](#) was used to quantify the potential operational impacts of the proposed development with respect to tidal regime which forms the sensitive receptor/pathway for assessment. The baseline model was updated to incorporate the proposed development including the revetment with the reclaimed area, floating breakwater and breakwater extension and capital dredging, as illustrated in **Figure 7-7**. The model simulations were then re-run for the post-construction scenario and a calculation of the magnitude of changes undertaken. It can be difficult to illustrate differences in parameters such as tidal currents as these are vector parameters, i.e. currents are associated with both magnitude (current speed) and direction. Within this assessment the arithmetic change in current speed is presented. The post-construction current speed is subtracted from the baseline scenario; therefore increases in current speed are positive values and vice versa. It should also be recognised that increases and decreases of a similar order of magnitude occur in adjacent locations generally indicates a change in direction, i.e. an alteration of flow path rather than necessarily a significant change in the hydrodynamic regime.
- 7.139 In each of the figures presented the same timestep is shown and the same palette is implemented as in the baseline condition. In the figures the location of floating breakwater is illustrated but this does not impede tidal flow. The outline of the revetment at the limit of the reclamation is also shown.

7.140 The post-construction tidal regime for mid-flood and mid-ebb during the typical spring tides are shown in **Figure 7-46** and **Figure 7-47** respectively; these correspond with **Figure 7-11** and **Figure 7-12** for the baseline condition. The corresponding differences in magnitude for flood and ebb tides are shown in **Figure 7-48** and **Figure 7-49** respectively. The minimum change presented is $\pm 0.001\text{m/s}$ or 1mm/s which would be an indiscernible change from baseline conditions. Changes are most marked within the harbour, but this would be anticipated due to the dredging undertaken as part of the proposed development and change in bed profile. Changes in tidal currents are limited to circa 500m of the proposed development area, at which point they represent a maximum change of *circa* 10%.

7.141 During the flood tide, the flow approaching the harbour is reduced as the outer breakwater extension is reached and is redirected either side with the associated increase in current speed. A similar pattern is also apparent on the ebb tide, where flow is increased at the location of the new navigation channel and flow is obstructed by the breakwater extension.

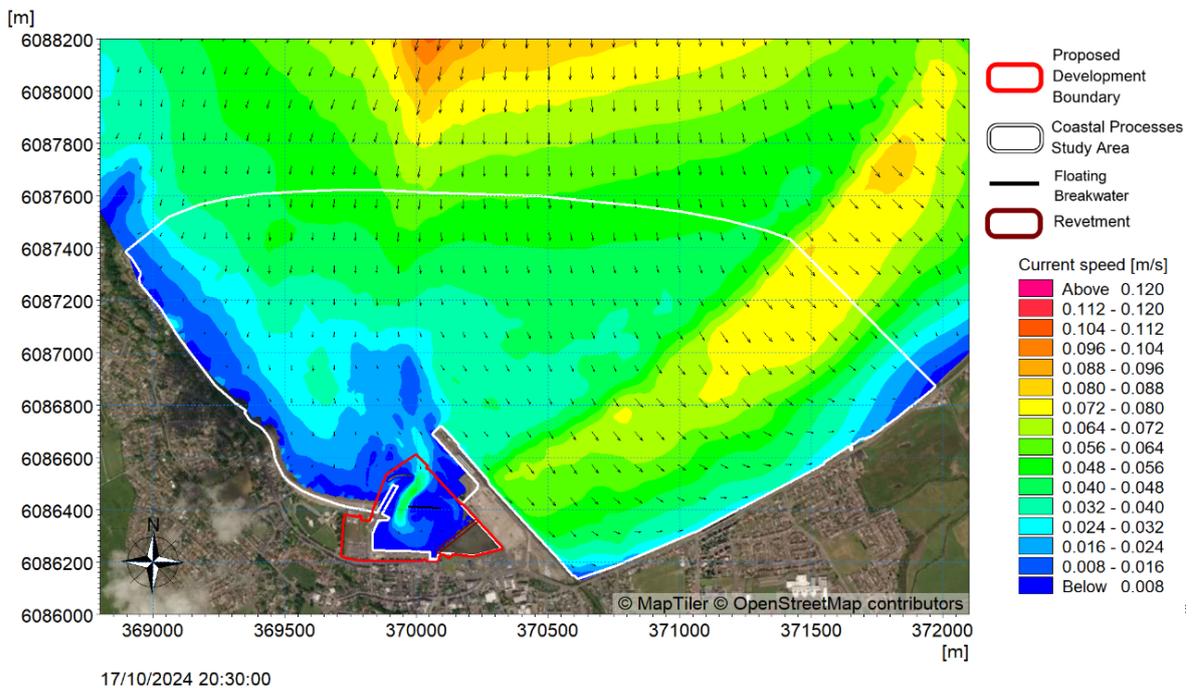


Figure 7-46: Typical spring mid-flood tidal patterns – post-construction

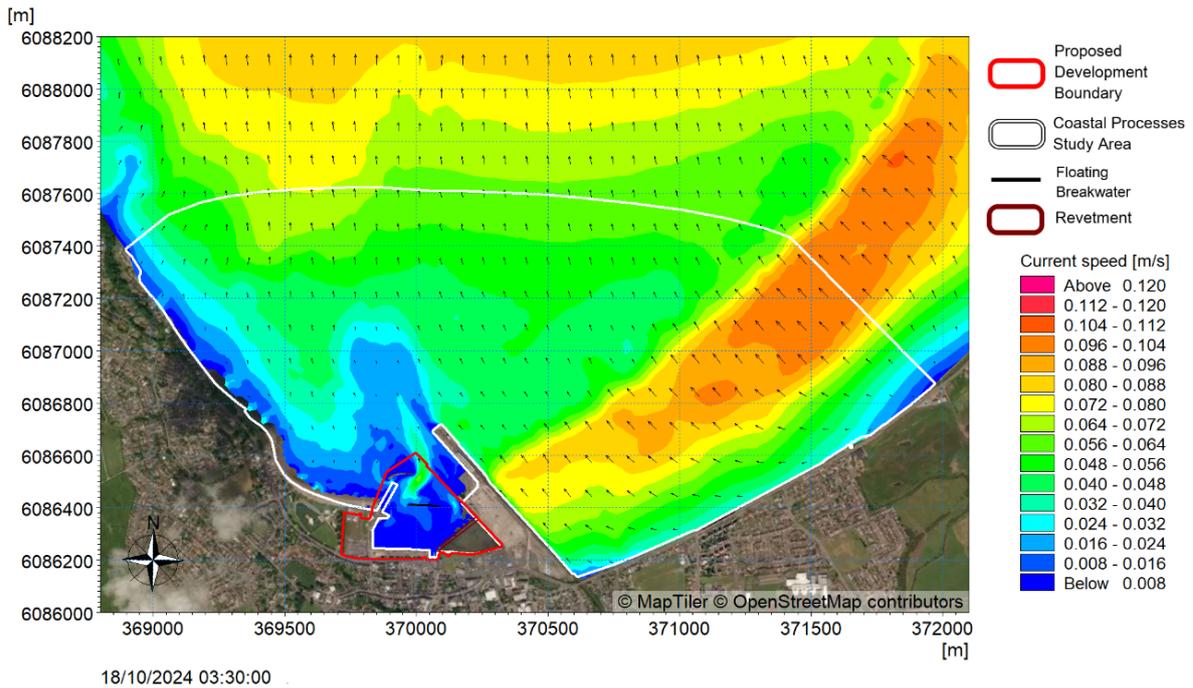


Figure 7-47: Typical spring mid-ebb tidal patterns – post-construction

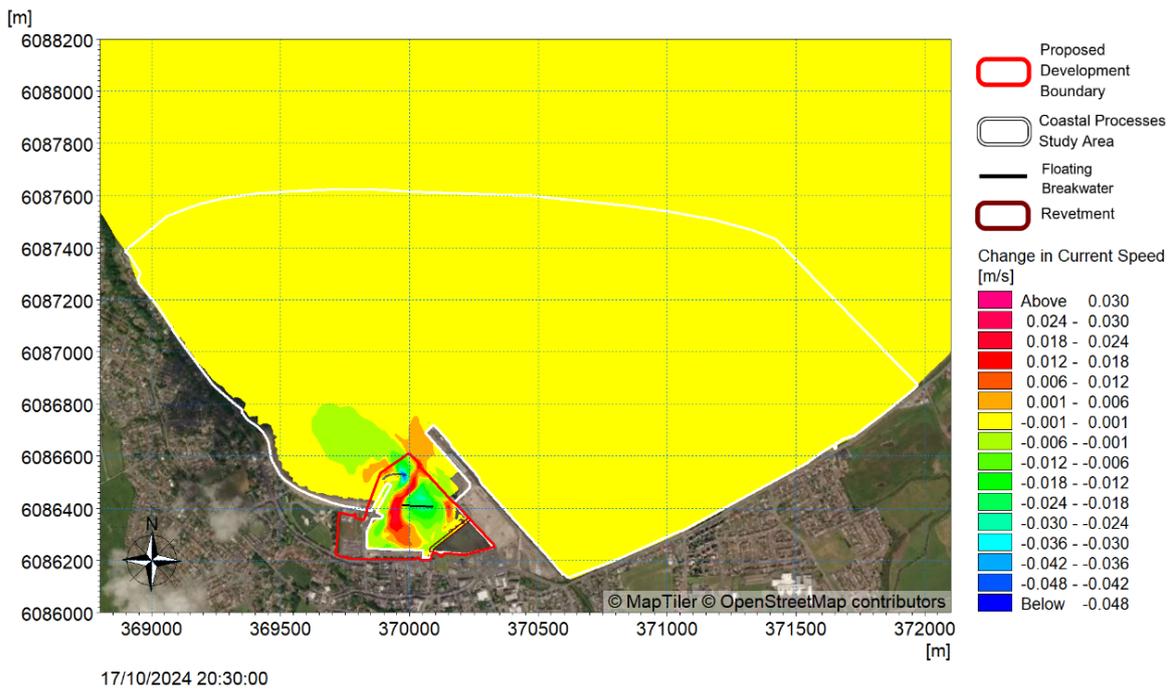


Figure 7-48: Difference in typical spring mid-flood tidal patterns post construction

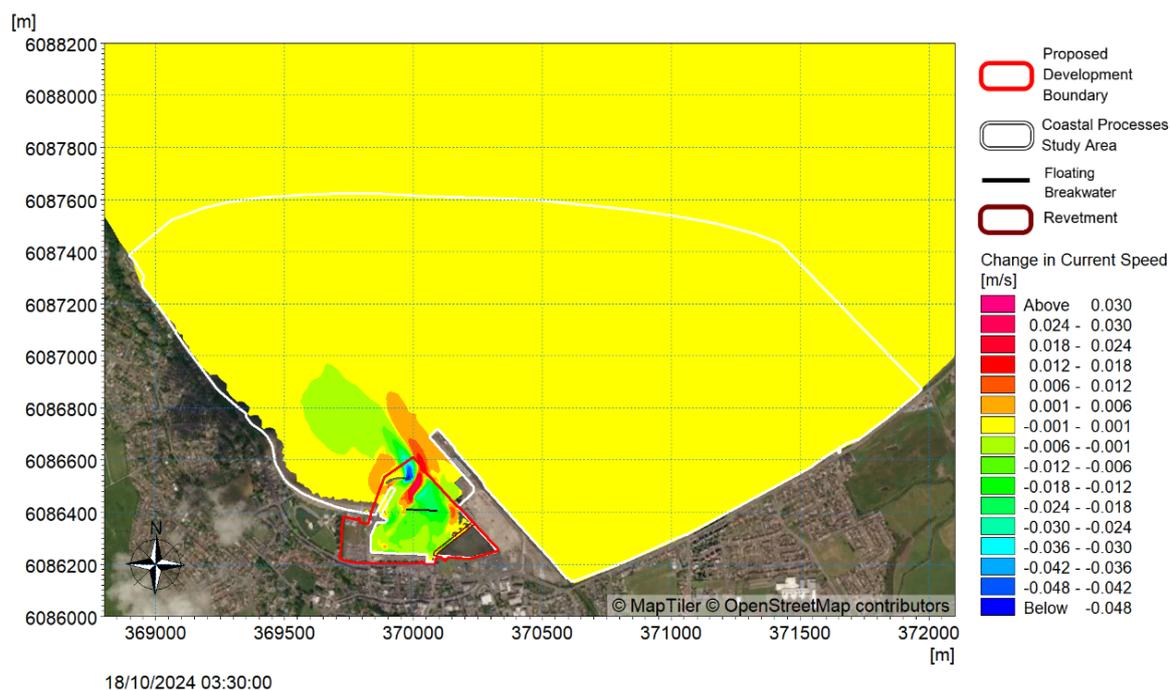


Figure 7-49: Difference in typical spring mid-ebb tidal patterns post construction

7.142 The post-construction tidal regime for mid-flood and mid-ebb during the typical neap tides are shown in **Figure 7-50** and **Figure 7-51** respectively; these correspond with **Figure 7-13** and **Figure 7-14** for the baseline condition. The corresponding differences in magnitude for flood and ebb tides are shown in **Figure 7-52** and **Figure 7-53** respectively. The difference in current speeds exhibit a similar pattern as those for the spring tides however the magnitude and extent of the changes are reduced, with discernible changes extending less than 200m from the proposed development. As with the spring tides, current speeds are reduced in the lee of the breakwater extension with corresponding increases in the vicinity of the harbour entrance as the flow path is realigned.

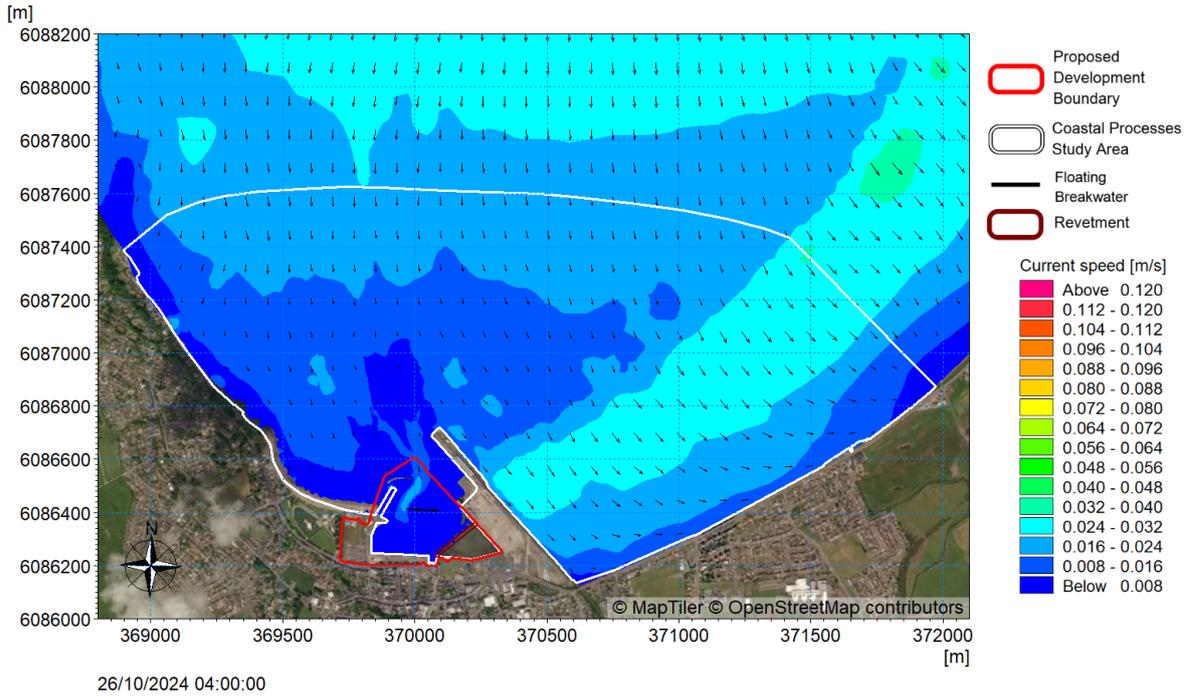


Figure 7-50: Typical neap mid-flood tidal patterns – post-construction

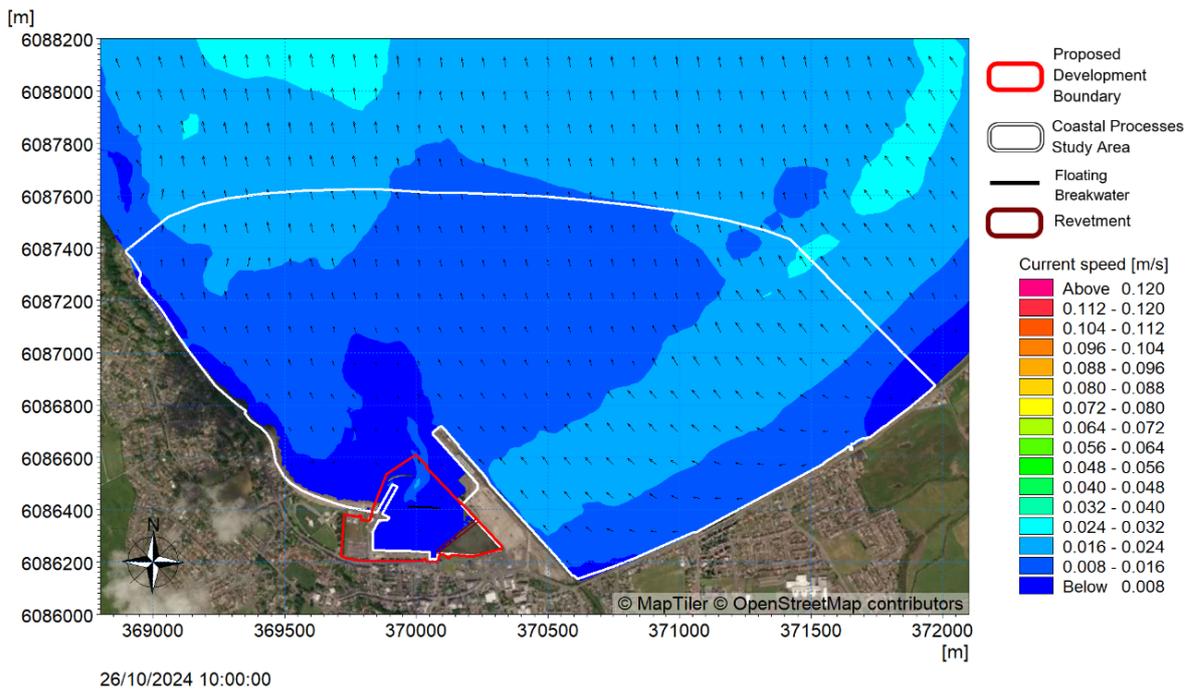


Figure 7-51: Typical neap mid-ebb tidal patterns – post-construction

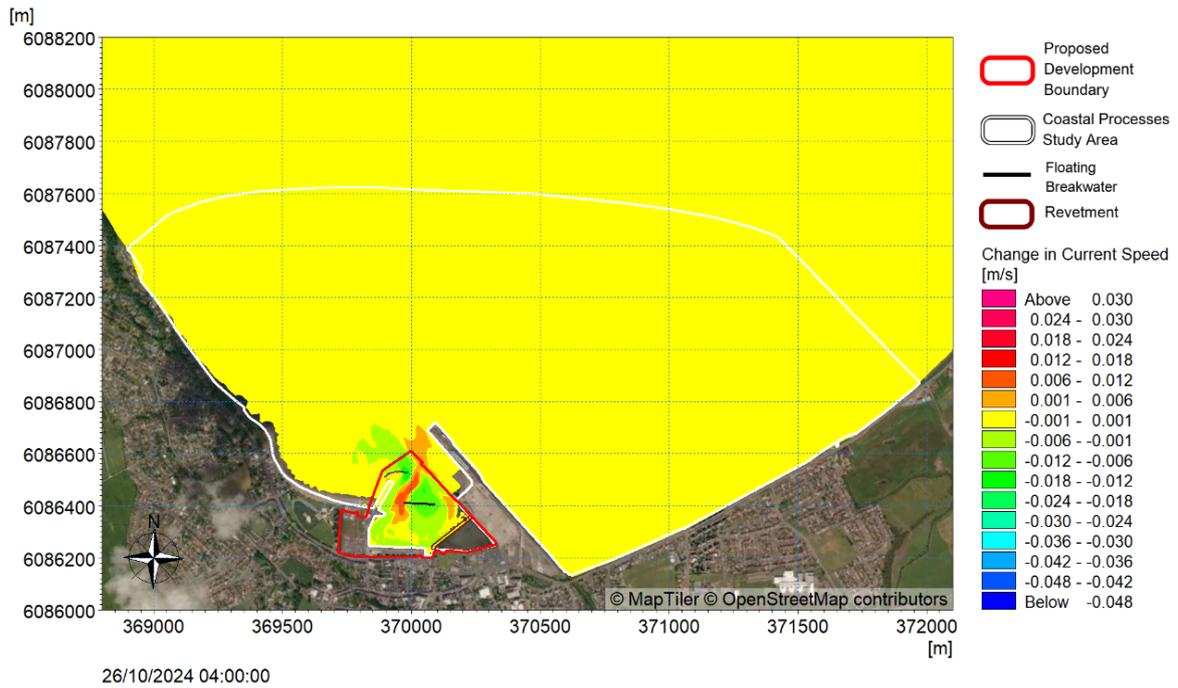


Figure 7-52: Difference in typical neap mid-flood tidal patterns post construction

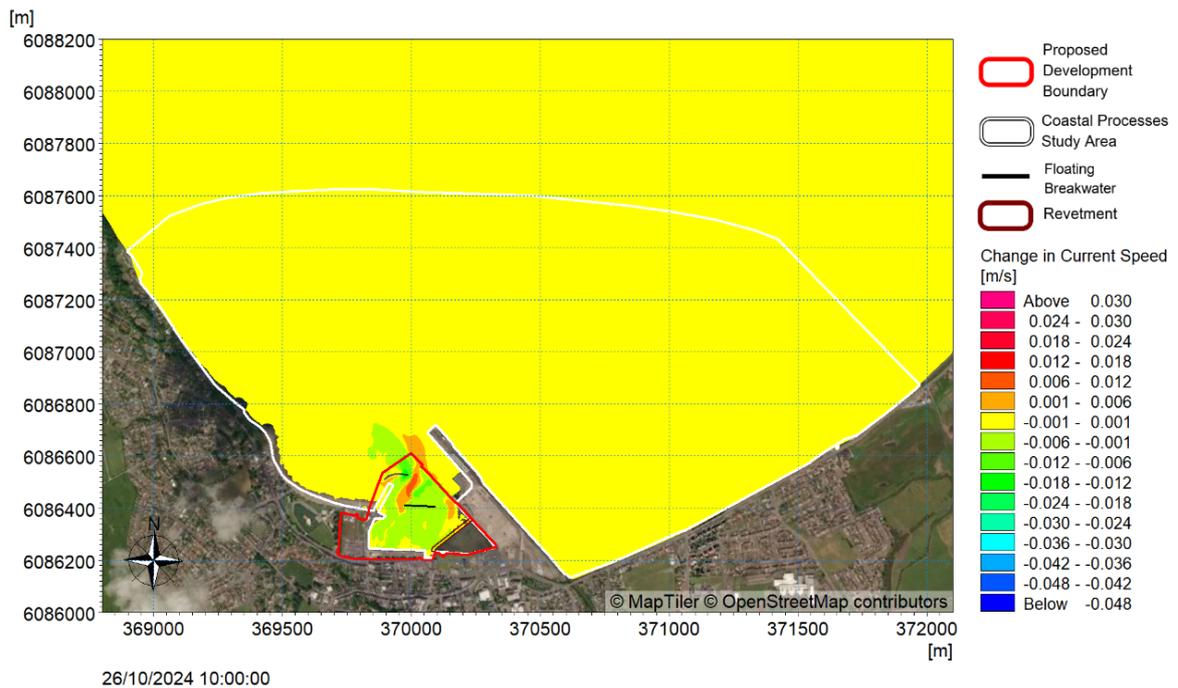


Figure 7-53: Difference in typical neap mid-ebb tidal patterns post construction

7.143 The modelling demonstrated that the magnitude of the changes to tidal flow is limited both in magnitude and spatial extent. There are localised changes in tidal flow as a result of the re-direction of flow around the extended breakwater however most changes occur within the harbour and will not impact on coastal processes within the wider domain. Changes have a low magnitude, being typically less than ± 0.001 m/s and extended less than 500m from the

development area. Baseline tidal currents differ greatly within the study area due to the variation between spring and neap tides and would be of low sensitivity to changes of the order of magnitude demonstrated.

- 7.144 There are no areas designated for coastal process features or bathing waters located within the coastal processes study area. It is therefore concluded that due to the limited nature, both in magnitude and spatial extent, and the low sensitivity of tidal currents, the impact is considered to be of negligible significance of effect and not significant in EIA terms.

Potential Changes to Baseline Wave Climate

- 7.145 Following a similar approach to tidal currents, the numerical modelling study outlined in [Modelling Methodology](#) was used to quantify the potential operational impacts of the proposed development with respect to wave climate which forms the sensitive receptor/pathway for assessment. As before, the baseline model was updated to incorporate the proposed development including the revetment with reclaimed area, floating breakwater and breakwater extension and capital dredging, as illustrated in **Figure 7-7**. The model simulations were then re-run for the post-construction scenario and changes in conditions quantified. The minimum change in wave height presented is $\pm 0.01\text{m}$ or 10mm which represents typically less than 1% change in wave height of the smallest wave climates presented for the assessment.
- 7.146 The 1 in 1 year return periods for waves approaching from 315° , 345° and 015° are presented in **Figure 7-54**, **Figure 7-55** and **Figure 7-56** respectively. These correspond with **Figure 7-15**, **Figure 7-16** and **Figure 7-17** for the baseline condition and utilise the same colour palette and scale. The difference in significant wave heights for these three directions are shown in **Figure 7-57**, **Figure 7-58** and **Figure 7-59**. Similarly, the 1 in 50 year return periods for waves approaching from 315° , 345° and 015° are presented in **Figure 7-60**, **Figure 7-61** and **Figure 7-62** respectively. These correspond with **Figure 7-18**, **Figure 7-19** and **Figure 7-20** for the baseline conditions. The difference in significant wave heights for these three directions are shown in **Figure 7-63**, **Figure 7-64** and **Figure 7-65** implementing the same colour palette as the difference in 1 in 1 return period wave heights.
- 7.147 The magnitude and extent of the changes follow a similar pattern for each of the return periods and wave directions and they are therefore discussed collectively to avoid repetition. The provision of the breakwater extension and floating breakwater reduces the wave climate in the marina basin to $<0.5\text{m}$ in all events (as per the intended purpose of the offshore elements of the proposed development). Changes in the wave climate beyond the proposed development boundary are seen to be limited to a distance of *circa* 250m and are characterised by a small increase in wave height, typically less than 100mm, extending from the seaward face of the floating breakwater. The origin of this increase is twofold, firstly the floating breaker and to a degree the breakwater extension will reflect some wave energy back into the Loch. Secondly, the increased water depth in the dual purpose superyacht berthing area on the north side of the

floating breakwater will allow larger waves to develop than was previously the case. However, the berthing facility on the floating breakwater will not be occupied during storm conditions.

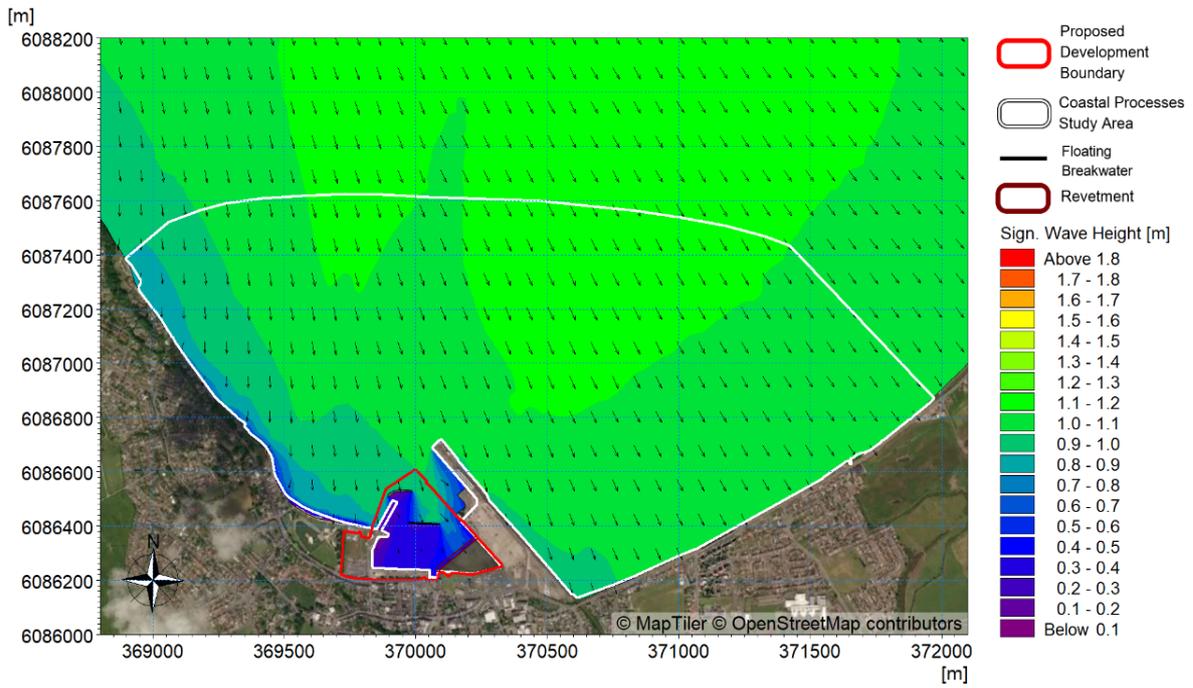


Figure 7-54: Wave climate 1 in 1 year storm from 315° - post-construction

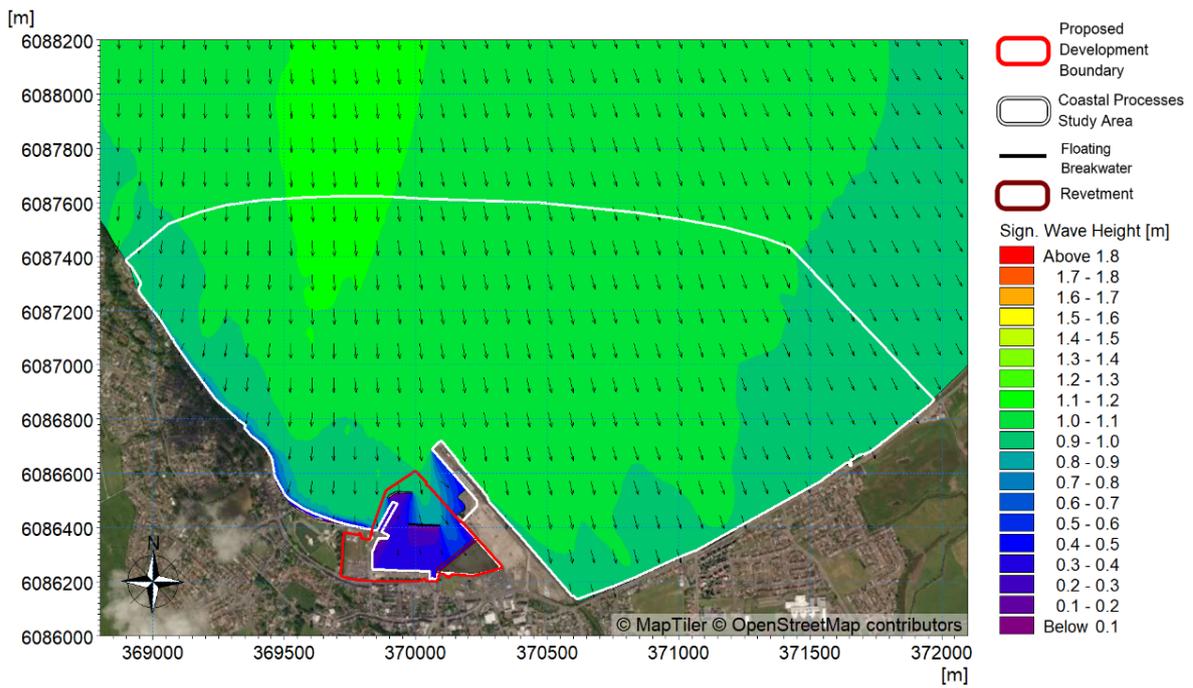


Figure 7-55: Wave climate 1 in 1 year storm from 345° - post-construction

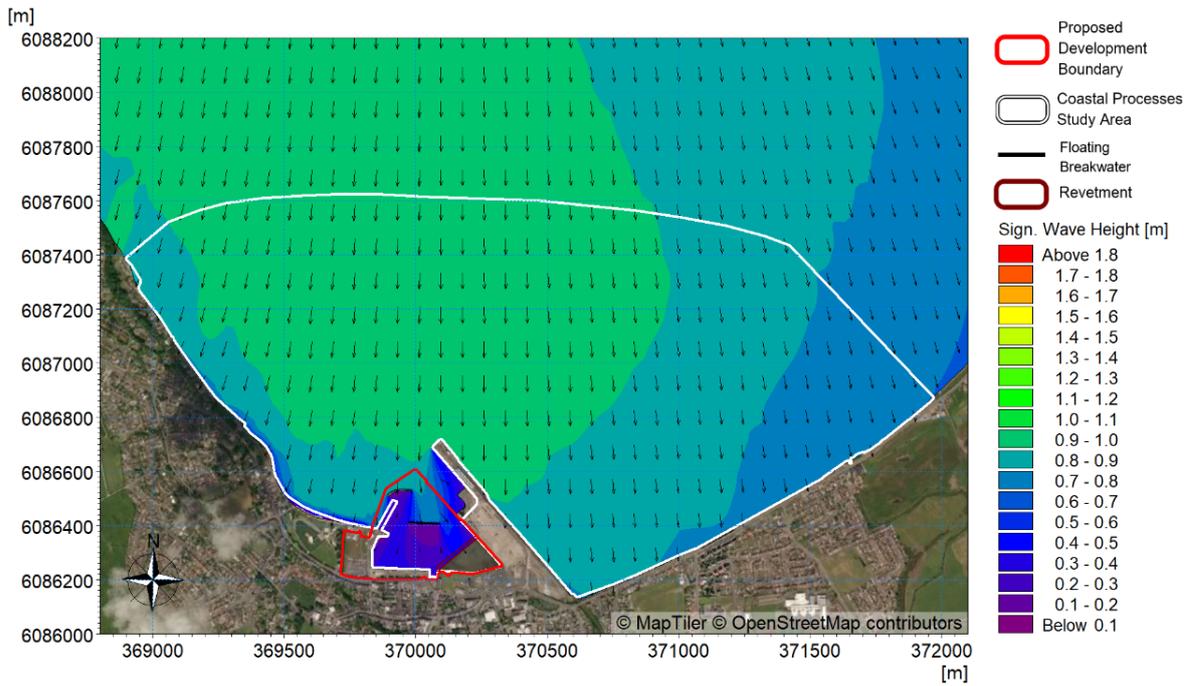


Figure 7-56: Wave climate 1 in 1 year storm from 015° - post-construction

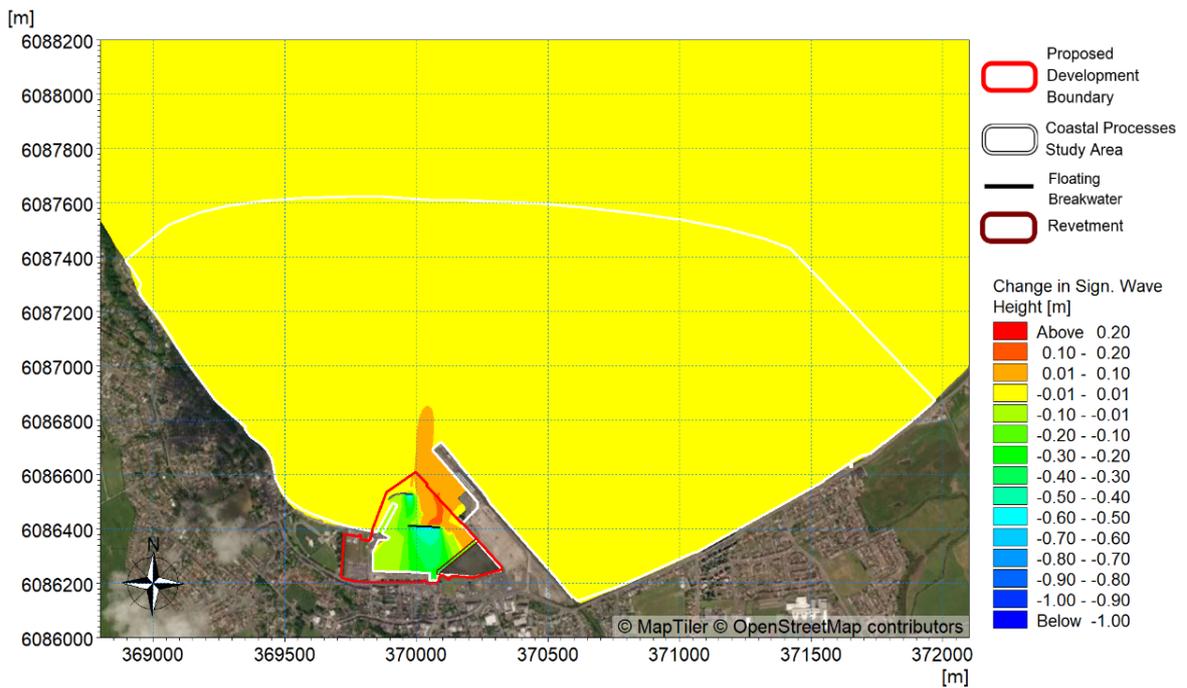


Figure 7-57: Difference in wave climate 1 in 1 year storm from 315° post construction

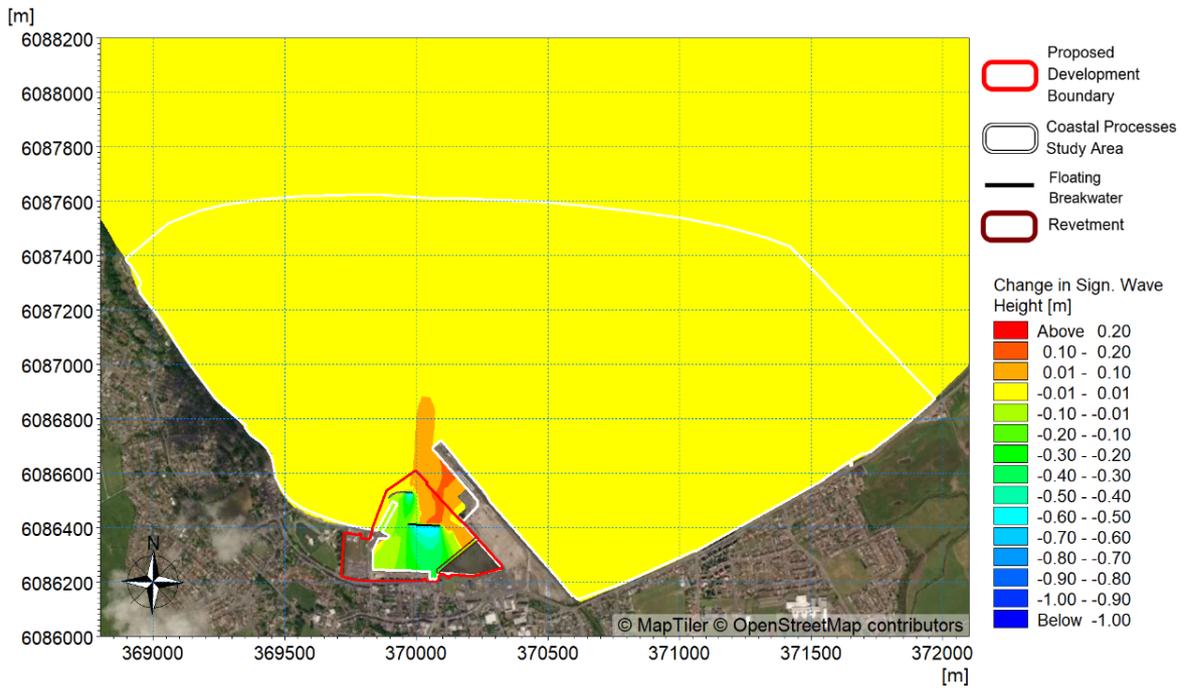


Figure 7-58: Difference in wave climate 1 in 1 year storm from 345° post construction

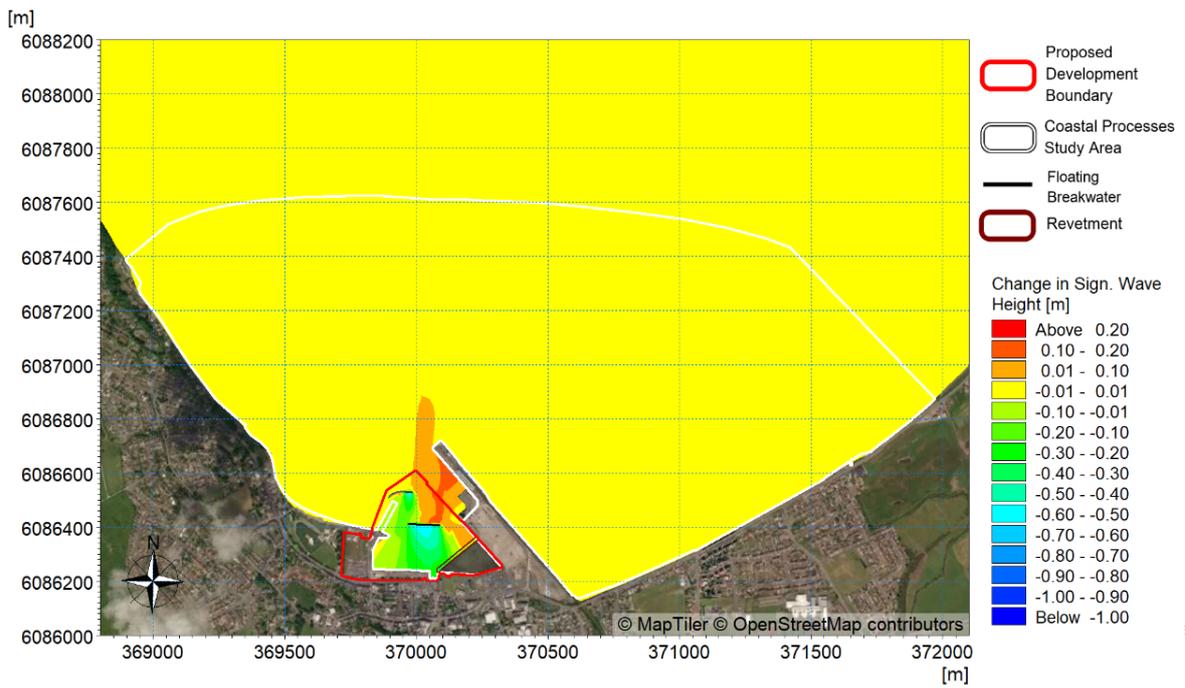


Figure 7-59: Difference in wave climate 1 in 1 year storm from 015° post construction

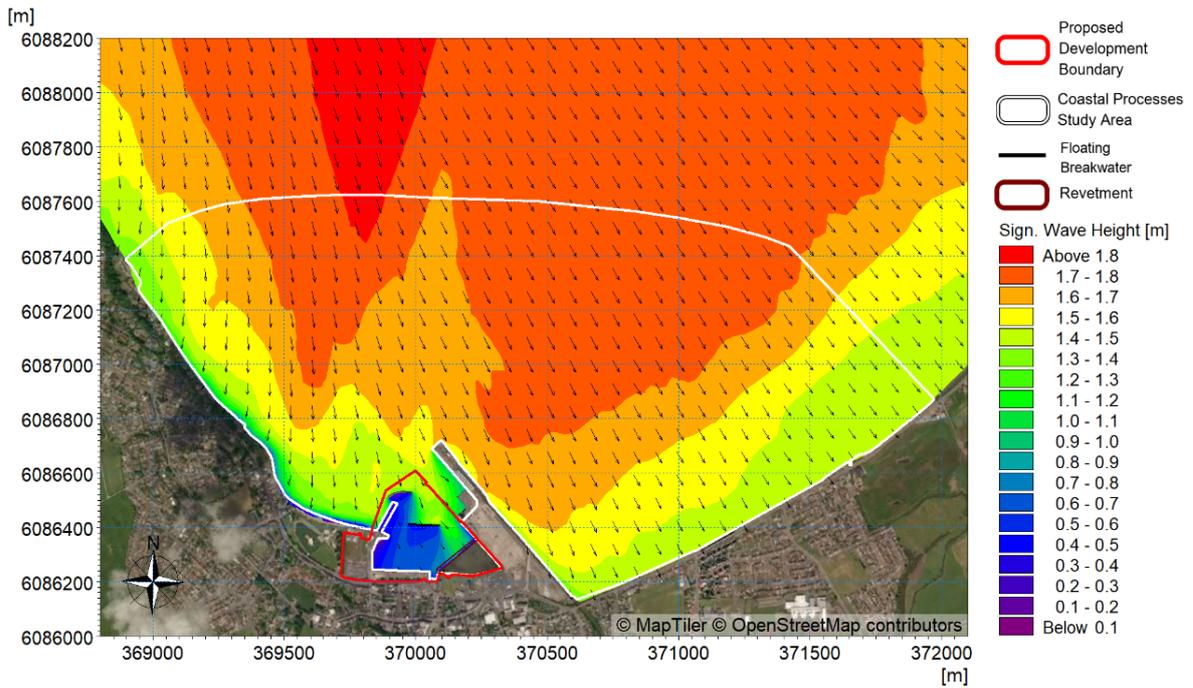


Figure 7-60: Wave climate 1 in 50 year storm from 315° - post-construction

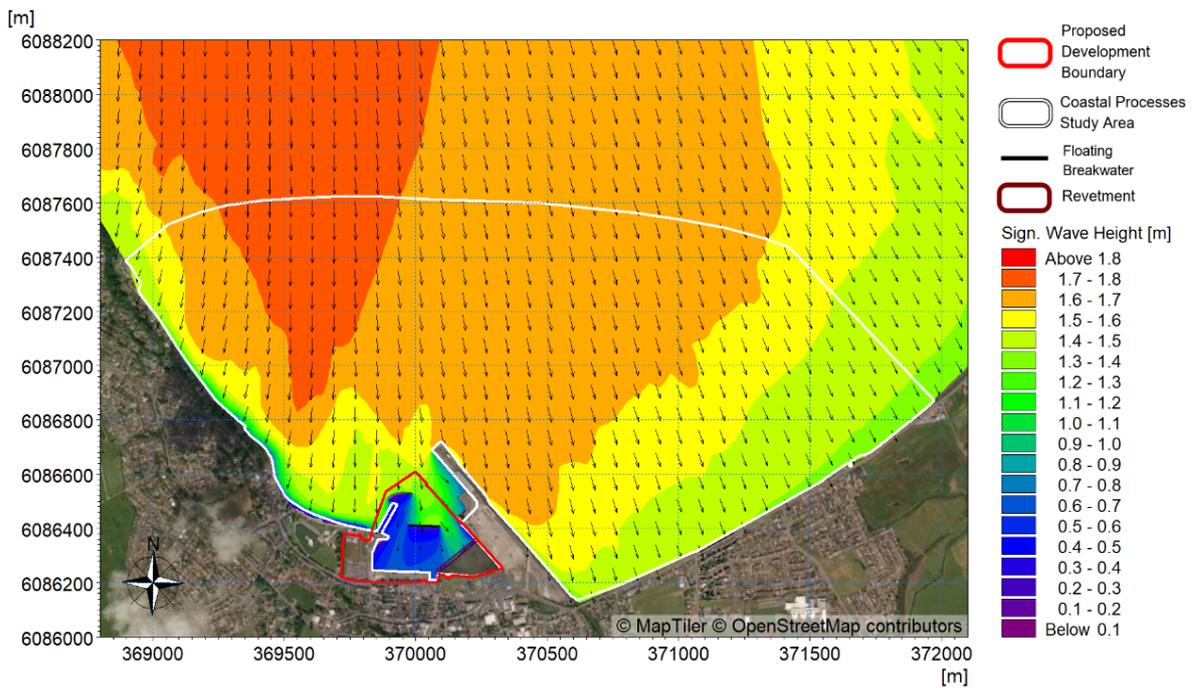


Figure 7-61: Wave climate 1 in 50 year storm from 345° - post-construction

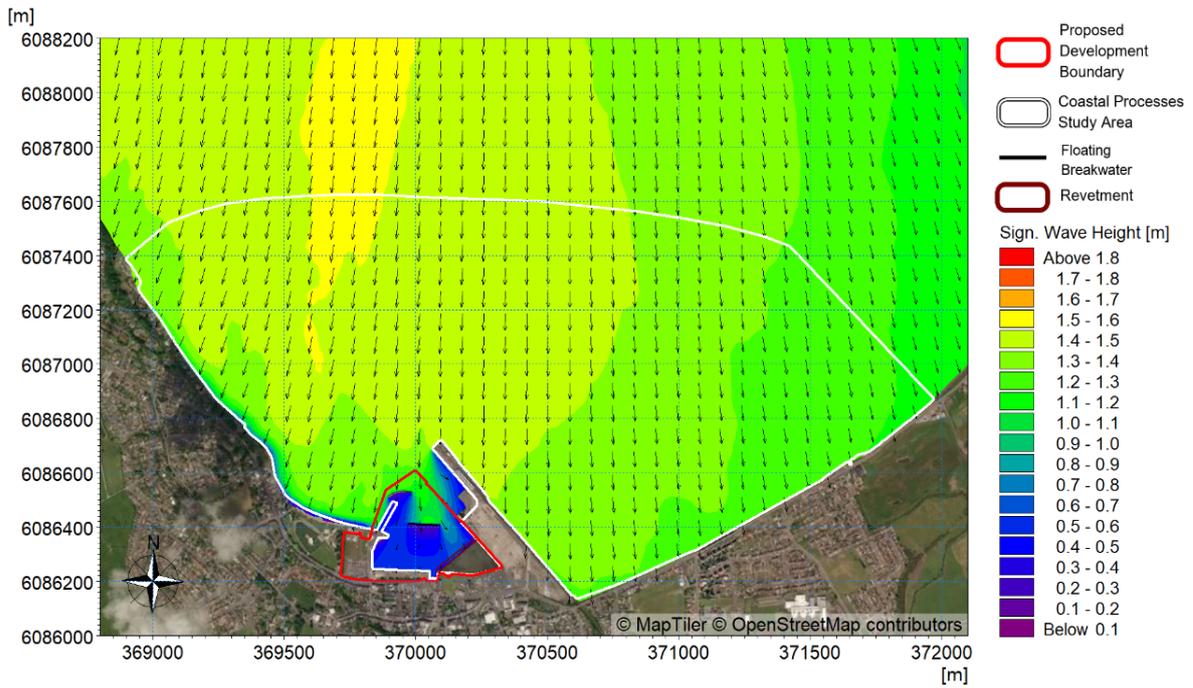


Figure 7-62: Wave climate 1 in 50 year storm from 15° - post-construction

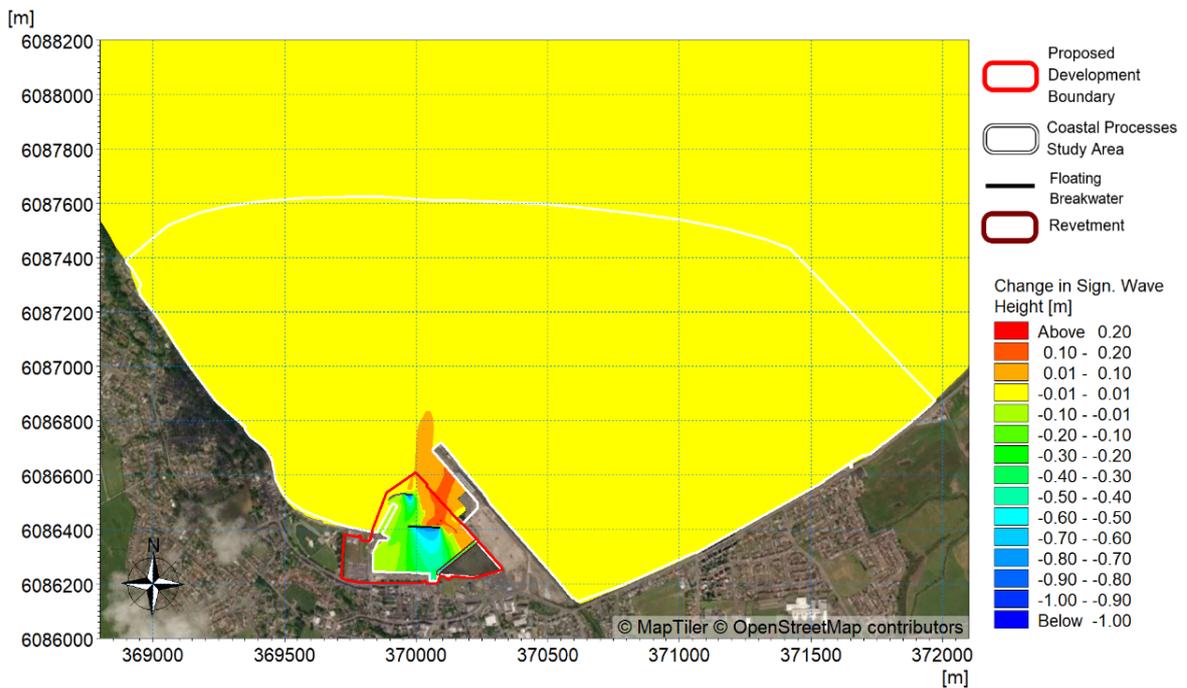


Figure 7-63: Difference in wave climate 1 in 50 year storm from 315° post construction

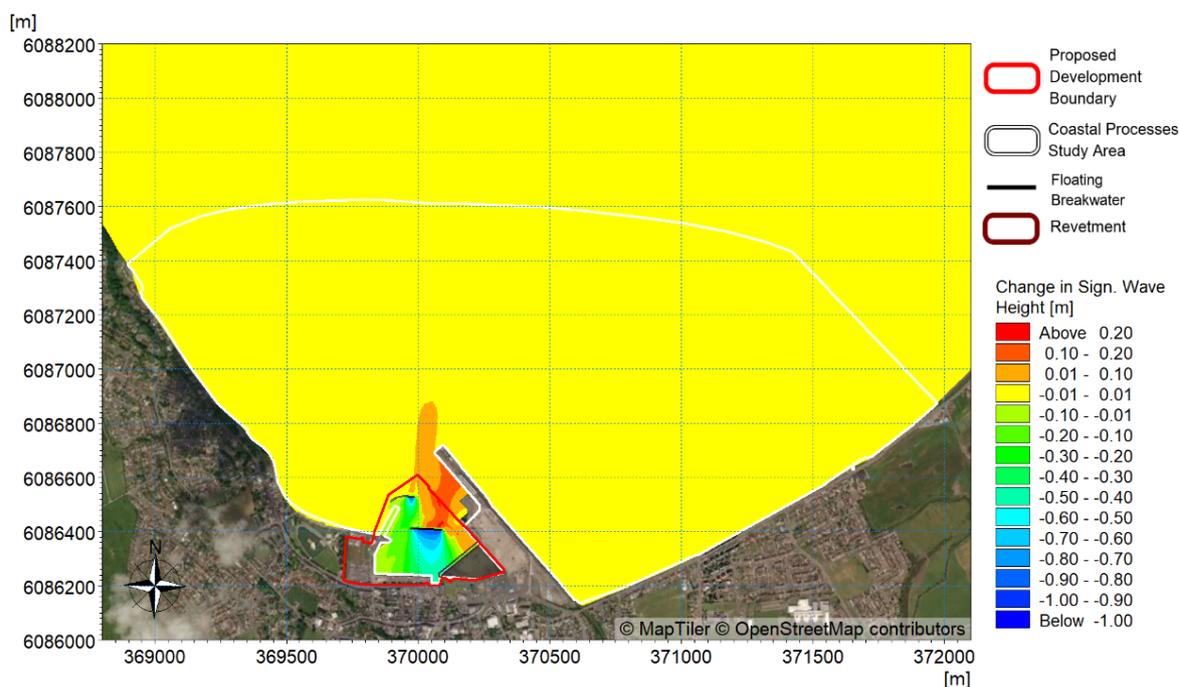


Figure 7-64: Difference in wave climate 1 in 50 year storm from 345° post construction

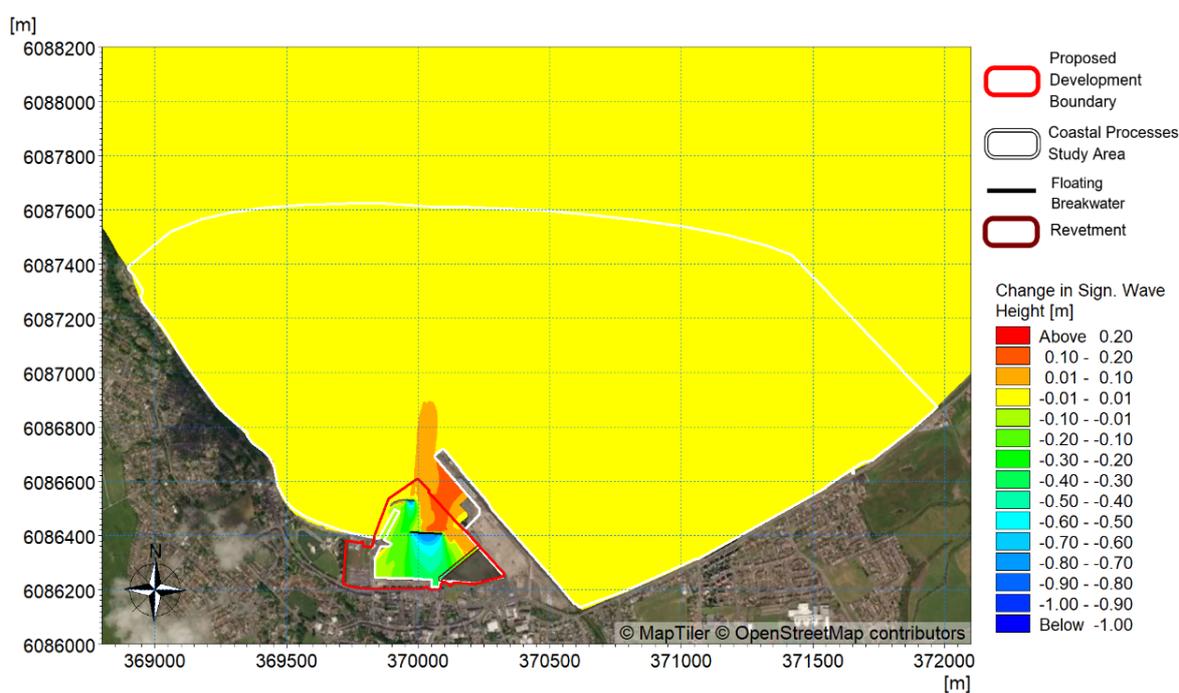


Figure 7-65: Difference in wave climate 1 in 50 year storm from 15° post construction

7.148 The modelling demonstrated that the magnitude of the changes to wave climate is limited both in magnitude and spatial extent. The breakwater extension and floating breakwater reduce the wave climate within the harbour, however changes in the wider domain are typically less than $\pm 10\text{mm}$ and extend less than 250m from the development area and may therefore be characterised as being of low magnitude. The baseline wave climates differ greatly within the

study area due to the range of wind speeds and directions experienced in the area and would therefore have low sensitivity to changes of the order of magnitude demonstrated.

- 7.149 There are no areas designated for coastal process features or bathing waters located within the coastal processes study area. It is therefore concluded that due to the limited nature, both in magnitude and spatial extent, and the low sensitivity of wave climate, the impact is considered to be of negligible significance of effect and not significant in EIA terms.

Potential Changes to Baseline Sediment Transport

- 7.150 As with the baseline scenarios presented in [Baseline Conditions](#) the sediment transport regime was examined for calm (pure tide) and for a typical annual event. As previously, the numerical modelling study outlined in [Modelling Methodology](#) was used to quantify the potential operational impacts of the proposed development with respect to sediment transport which forms the sensitive receptor/pathway for assessment. The baseline model was updated to incorporate the proposed development including the revetment with reclaimed area, floating breakwater and breakwater extension and capital dredging, as illustrated in **Figure 7-7**. The model simulations were then re-run for the post-construction scenario and a quantification of changes undertaken.
- 7.151 As noted previously, it can be difficult to illustrate differences in factors such as sediment transport and littoral currents as these are vector parameters, i.e. they are associated with both magnitude and direction. Within this assessment the arithmetic change in sediment transport rate is presented whereby the post-construction parameter is subtracted from the baseline condition; therefore increases are indicated by positive values. As before, it should also be recognised increases and decreases of a similar order of magnitude generally indicates a change in direction, i.e. an alteration of pathway rather necessarily relating to a significant change in the sediment transport regime.
- 7.152 The post-construction sediment transport regime for mid-flood and mid-ebb during the typical spring tides are shown in **Figure 7-66** and **Figure 7-67** respectively; these correspond with **Figure 7-29** and **Figure 7-30** for the baseline condition. The corresponding differences in magnitude for flood and ebb tides are shown in **Figure 7-68** and **Figure 7-69** respectively. It was assumed that following dredging no loose material was available for transport within the dredged areas in line with the GI data. It is recognised that under calm conditions the driving force for sediment transport is the tidal current regime. Therefore the difference in post-construction sediment transport is akin to the differences in tidal regime discussed previously in [Potential Changes to Baseline Tidal Regime](#). Changes within the harbour are complex where transport is decreased in areas where water depths are increased and in adjacent areas transport is increased as a result in the change of the flow pattern due to bed profile. Similarly, sediment transport is increased at the breakwater extension due to increased tidal velocity and flow being redirected around the structure and into the dredged harbour approach which shows decreased transport rates where less material is available for transport.

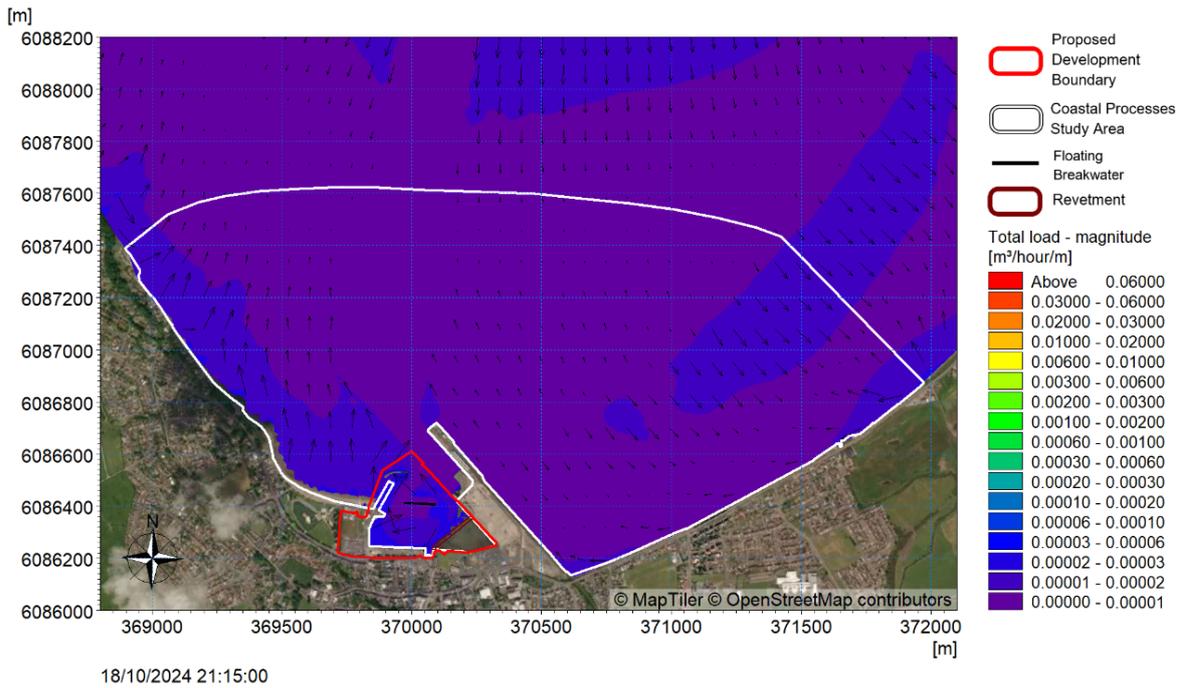


Figure 7-66: Sediment transport spring tide flood tide – post-construction

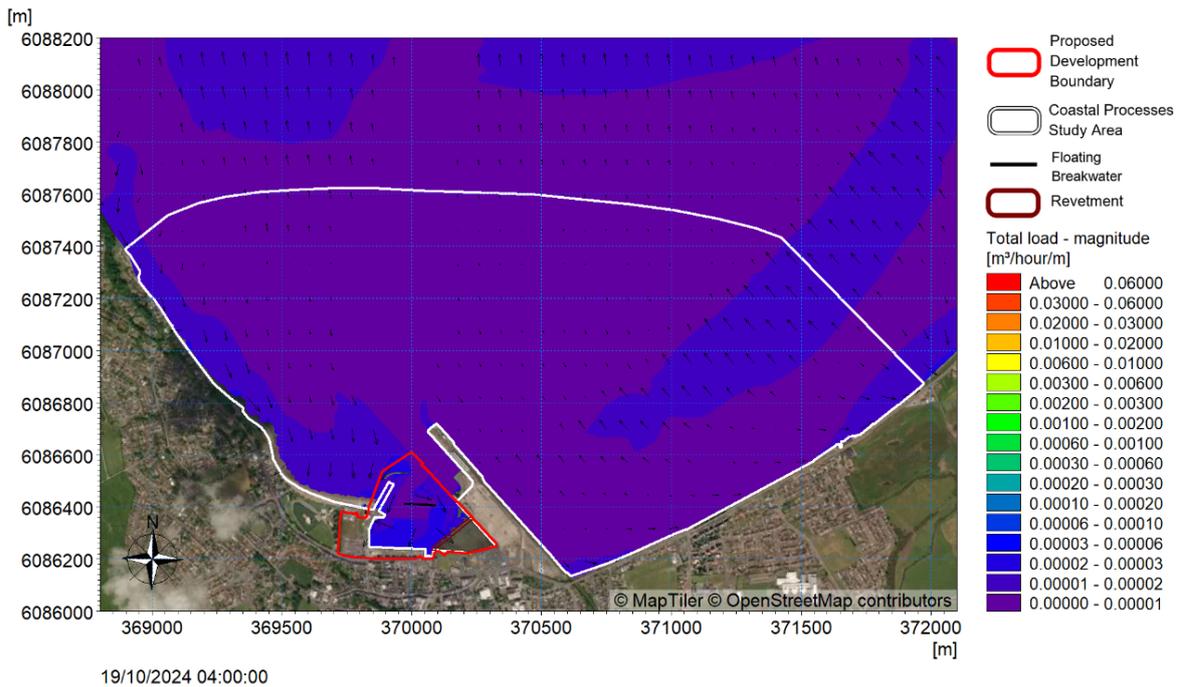


Figure 7-67: Sediment transport spring tide ebb tide – post-construction

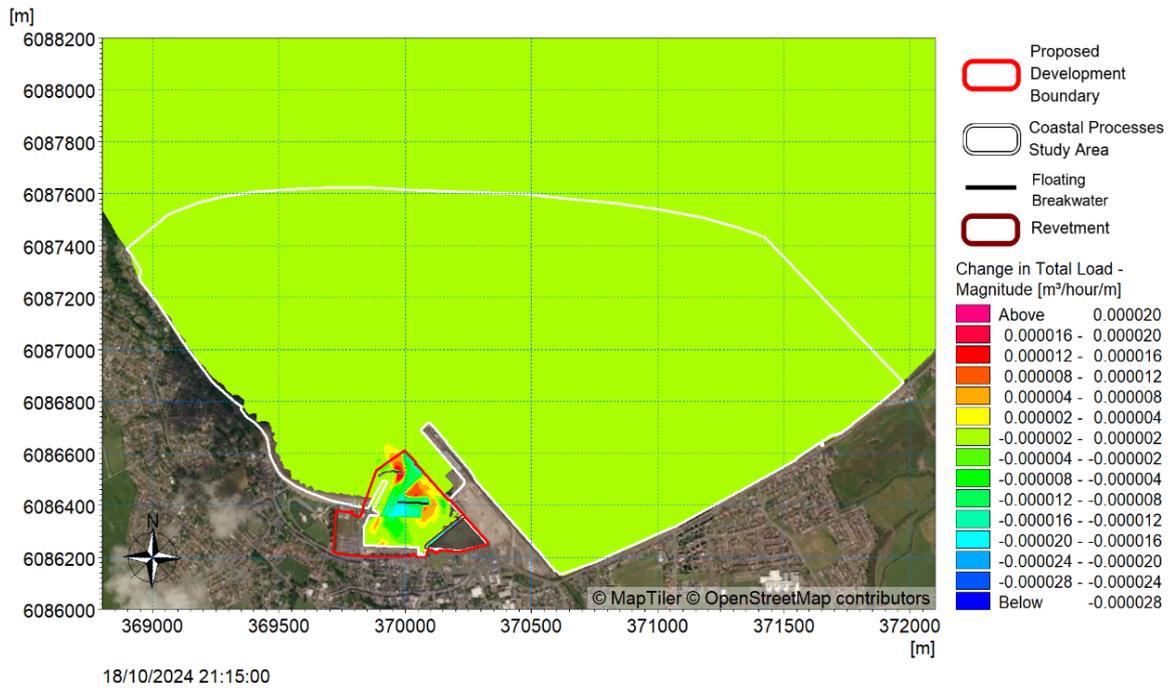


Figure 7-68: Difference in sediment transport spring tide flood tide post construction

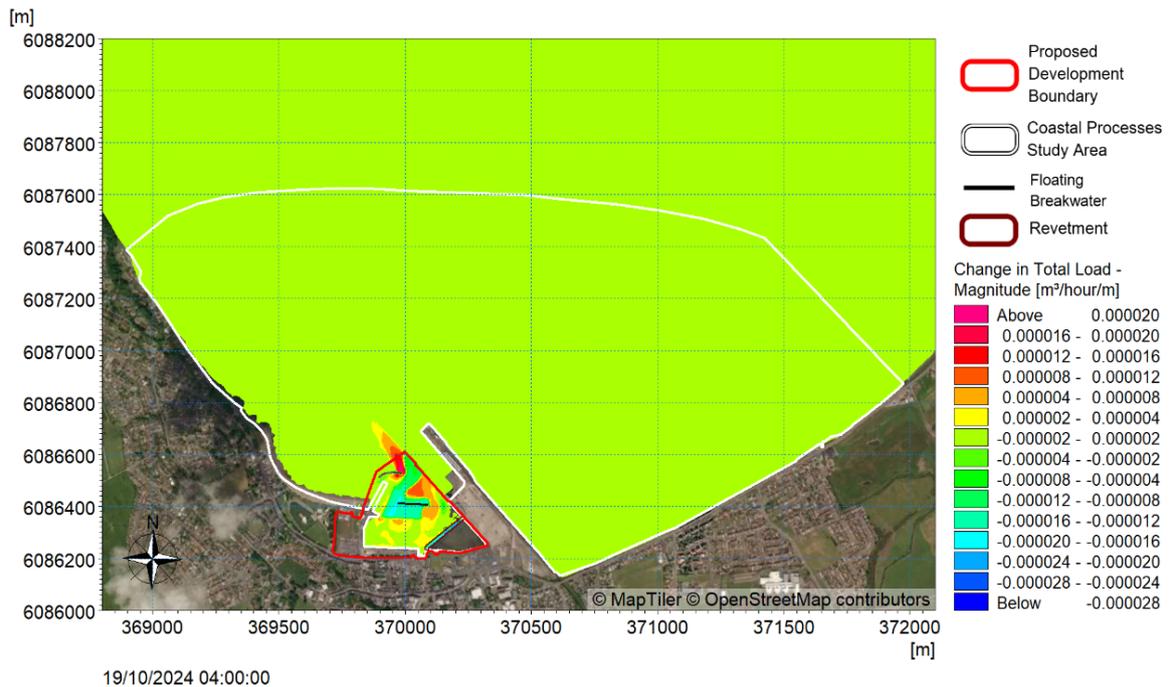


Figure 7-69: Difference in sediment transport spring tide ebb tide post construction

7.153 The following figures present the post-construction conditions for a 1 in 1 year event from the north-west. For this scenario a series of plots are presented; they relate to littoral currents, i.e. currents which are comprised of both the contributions of tidal current and wave climate which drive sediment transport and also sediment transport rates. They consider two points in time

- during the event, mid-flood and mid-ebb tide which are the same as those for the baseline condition.
- 7.154 For the mid-flood output, the post-construction littoral currents and sediment transport rates are shown in **Figure 7-70** and **Figure 7-71** respectively which correspond to **Figure 7-31** and **Figure 7-32** for baseline conditions. The differences in these parameters are presented in **Figure 7-72** and **Figure 7-73**. Similarly for the ebb tide, littoral currents and sediment transport rates are shown in **Figure 7-74** and **Figure 7-71** respectively (corresponding to **Figure 7-33** and **Figure 7-34** for baseline conditions) whilst the differences in these parameters are presented in **Figure 7-76** and **Figure 7-77**.
- 7.155 As with the baseline condition, the littoral currents and sediment transport figures show circulatory patterns within the harbour. These are altered due to the changes in bathymetry and the influence of the breakwater. However it should be noted that the littoral current speeds and resulting sediment transport remains of low magnitude within the harbour basin during the storm event. During the flood tide changes in littoral currents are limited to less than 1mm/s in the immediate vicinity of the proposed development. The corresponding sediment transport plots show isolated locations along the edge of the Loch Ryan navigation channel where a small increase is paired with a small decrease, these are at a level which may be associated with model closure. Hydrodynamic, wave and sediment transport modules are coupled together and are solved iteratively therefore there is a window of closure associated with each parameter and the minimal difference in sediment transport parameters in the areas beyond the immediate vicinity of the proposed development are of a similar scale to model resolution.
- 7.156 This is also the case for ebb tide, where similar pairs of changes are visible along the edge of the navigation channel. Littoral currents and associated sediment transport is seen to be altered within 300m of the proposed development with small increases on the north east side adjacent to the outer breaker water. To provide context to these differences the alteration to sediment transport in the form of bed level change over the course of the event was examined. **Figure 7-78** illustrates the change in bed thickness, i.e. sediment transport over the course of the storm event post construction whilst **Figure 7-79** shows the difference in the change from the baseline condition presented previously in **Figure 7-35**. The minimum difference plotted was 1mm; a level indiscernible from natural variation.
- 7.157 There were no differences in resulting bed levels due to sediment transport beyond the immediate vicinity of the development area and sediment transport regimes along the coastline remain unaltered. Within the proposed development area there are both regions of increased bed levels associated with the dredged extent and also related areas of reduced levels. These are in the order of 10mm and illustrate the redistribution of sediment within the harbour basin due to the change in bathymetry and associated littoral currents during a storm event.
-

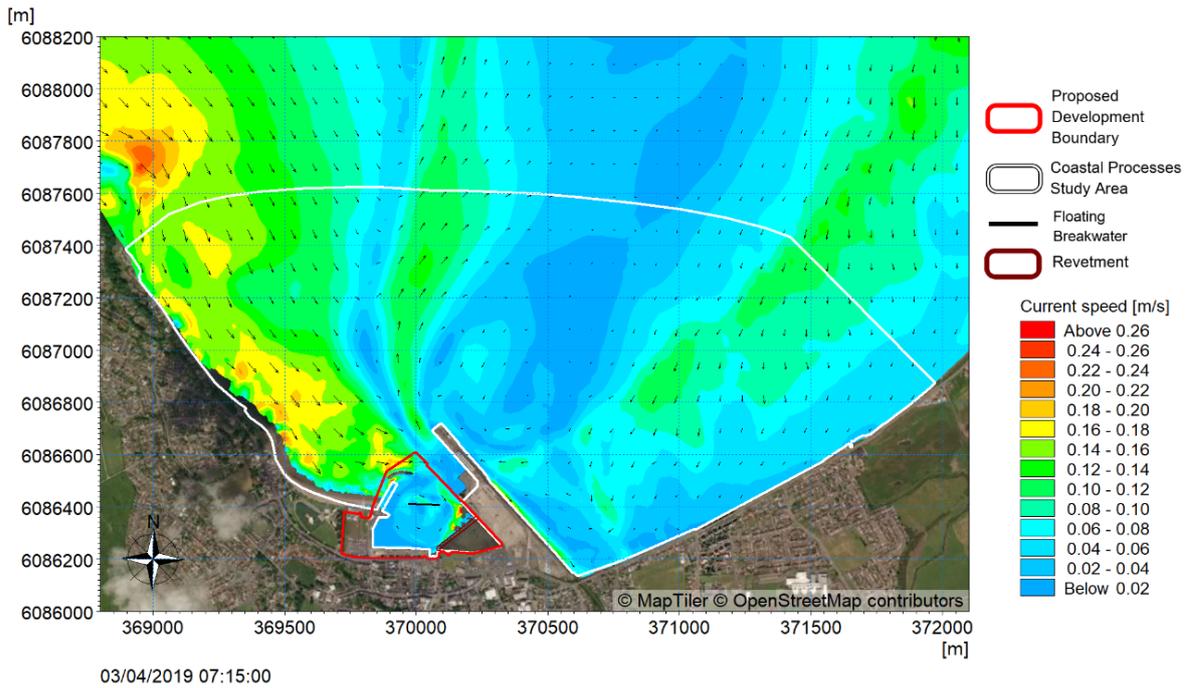


Figure 7-70: Littoral currents 1 in 1 year event flood tide – post-construction

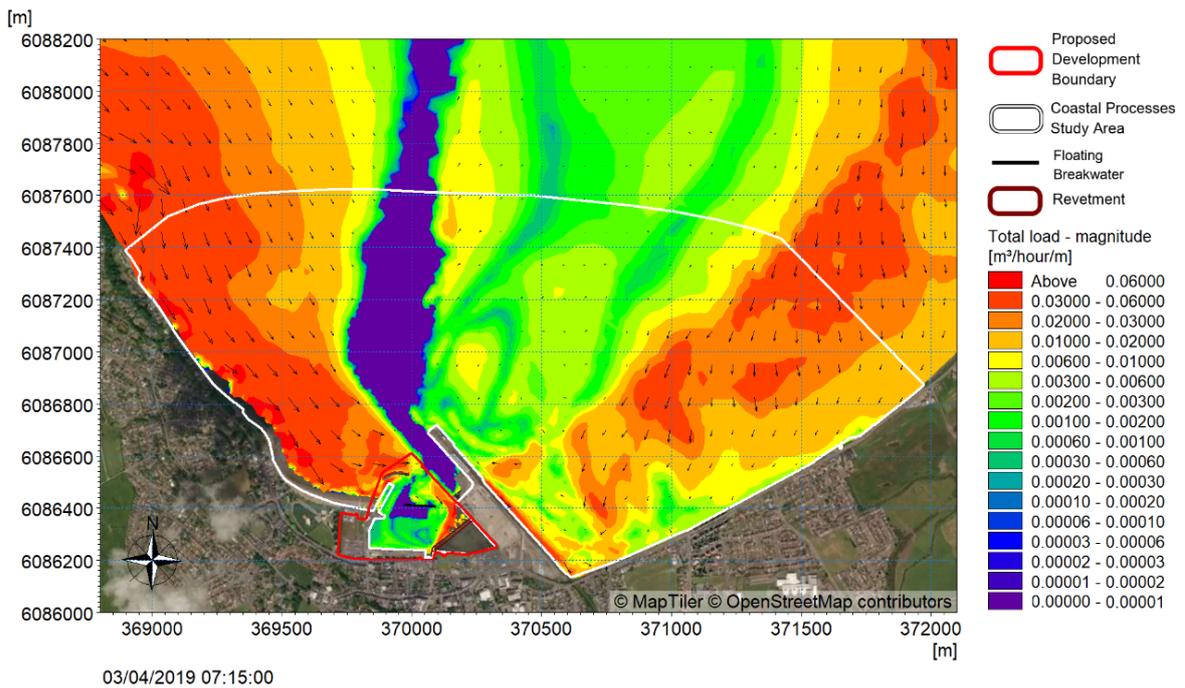


Figure 7-71: Sediment transport 1 in 1 year event flood tide - post-construction

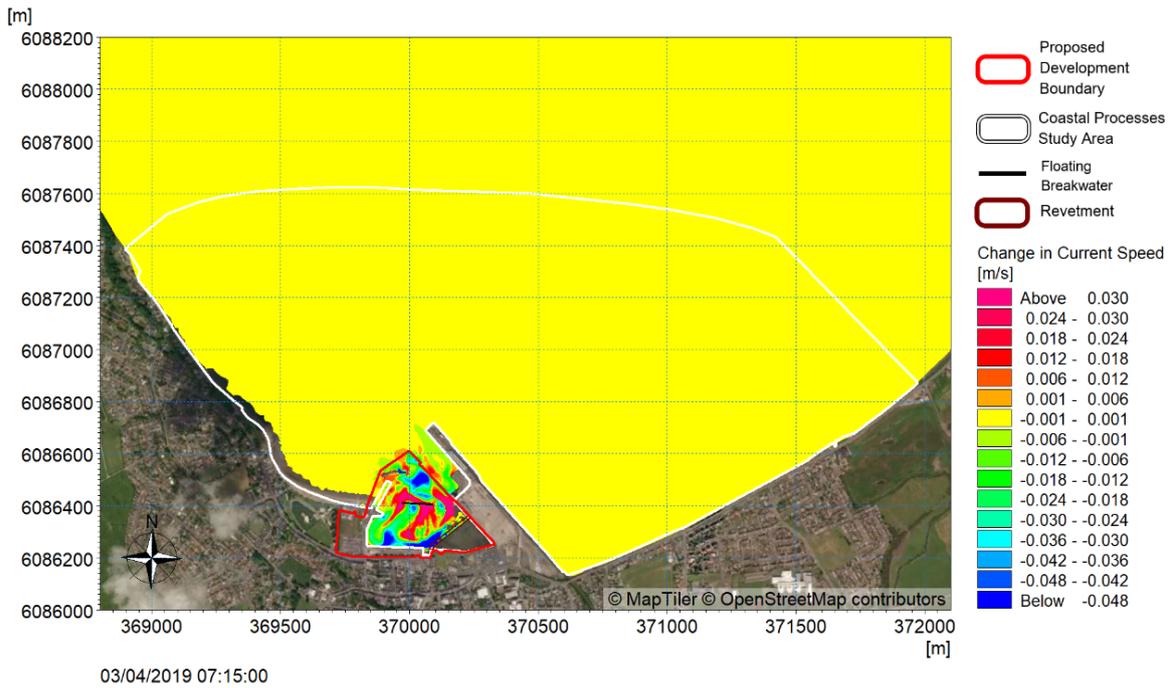


Figure 7-72: Difference in littoral currents 1 in 1 year event flood tide post construction

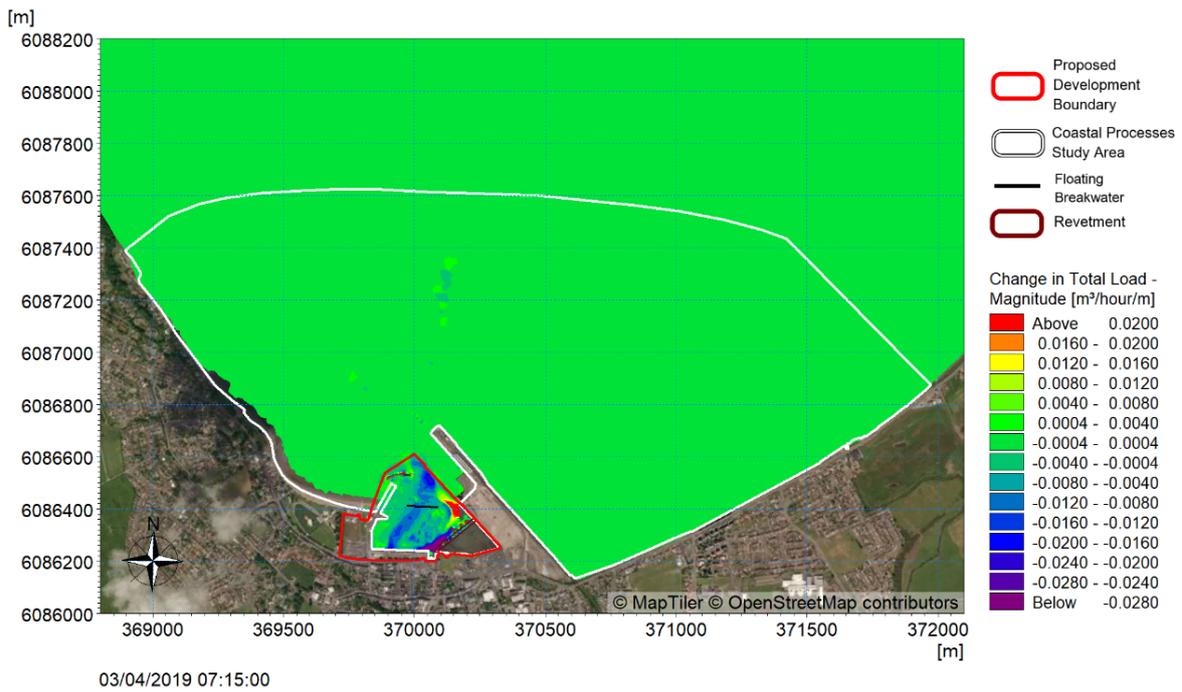


Figure 7-73: Difference in sediment transport 1 in 1 year event flood tide post construction

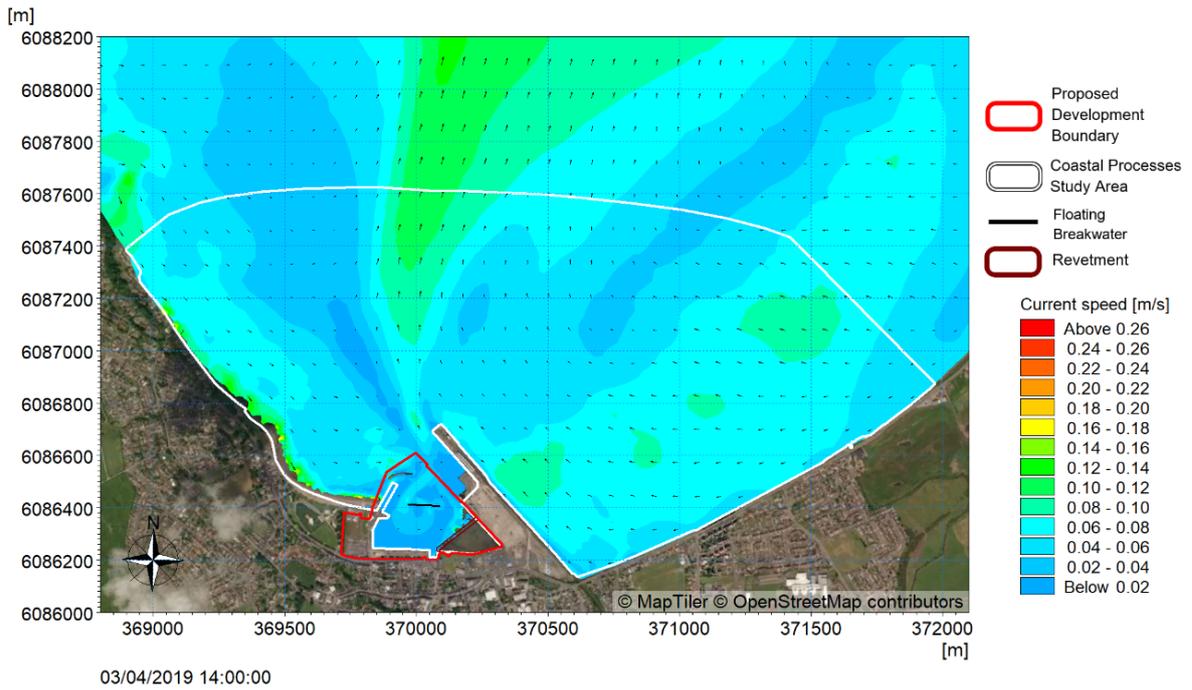


Figure 7-74: Littoral currents 1 in 1 year event ebb tide - post-construction

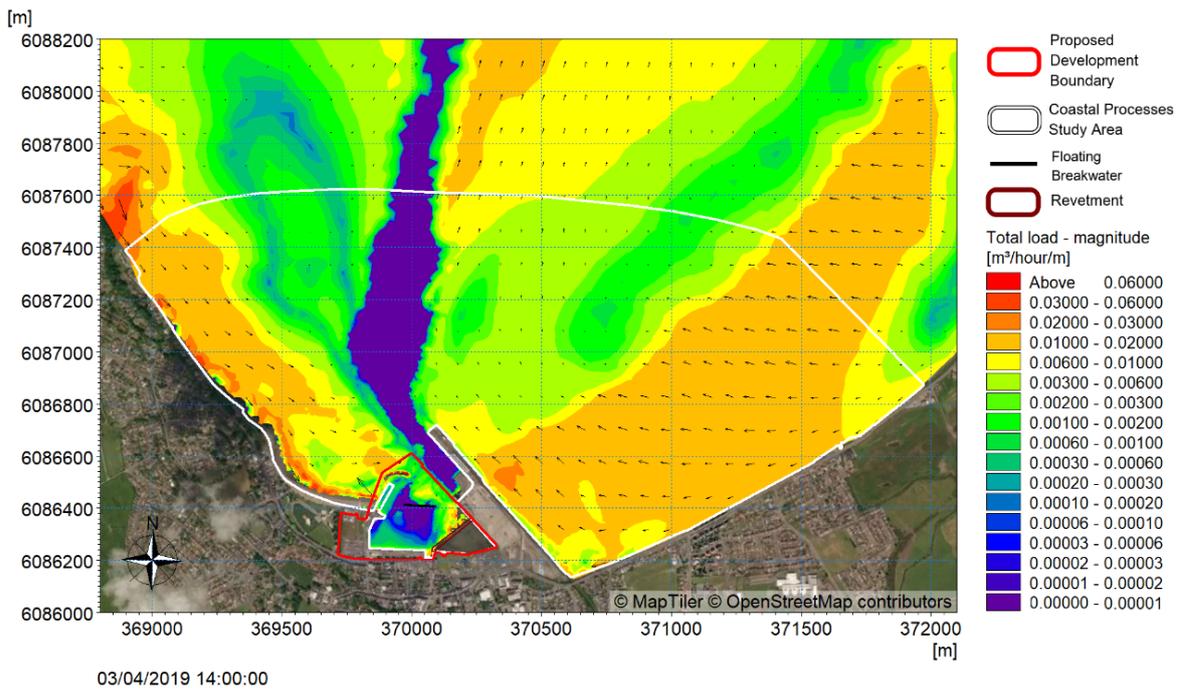


Figure 7-75: Sediment transport 1 in 1 year event ebb tide - post-construction

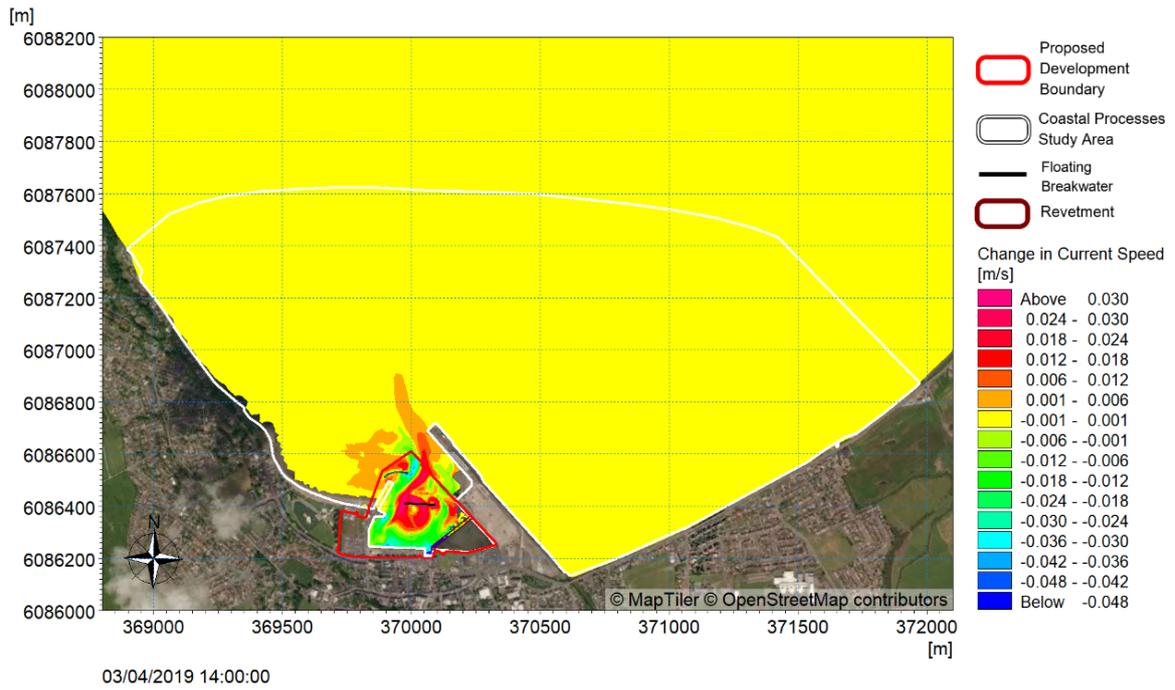


Figure 7-76: Difference in littoral currents 1 in 1 year event ebb tide post construction

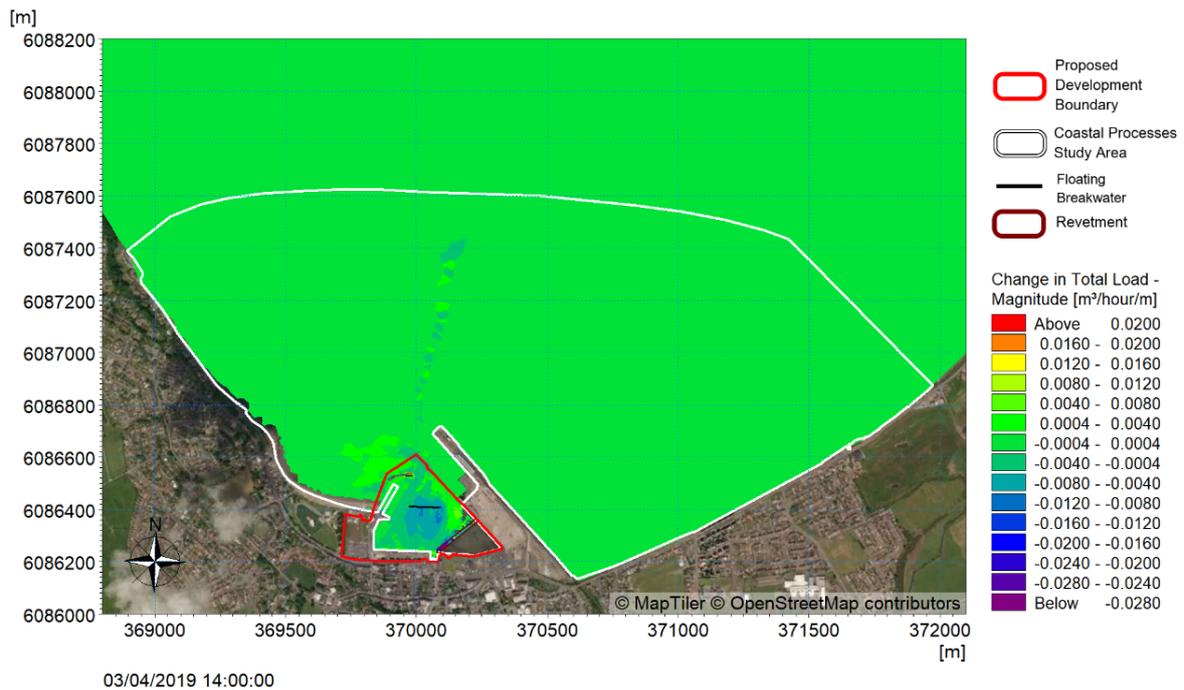


Figure 7-77: Difference in sediment transport 1 in 1 year event ebb tide post construction

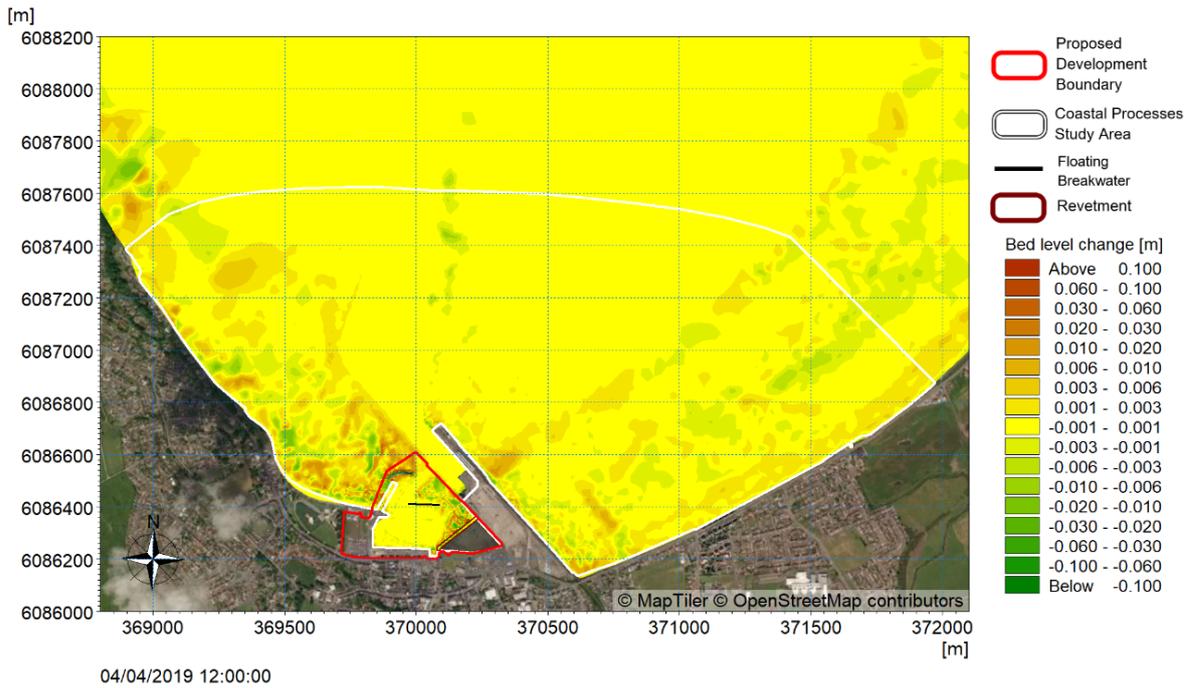


Figure 7-78: Change in bed thickness 1 in 1 year event - post-construction

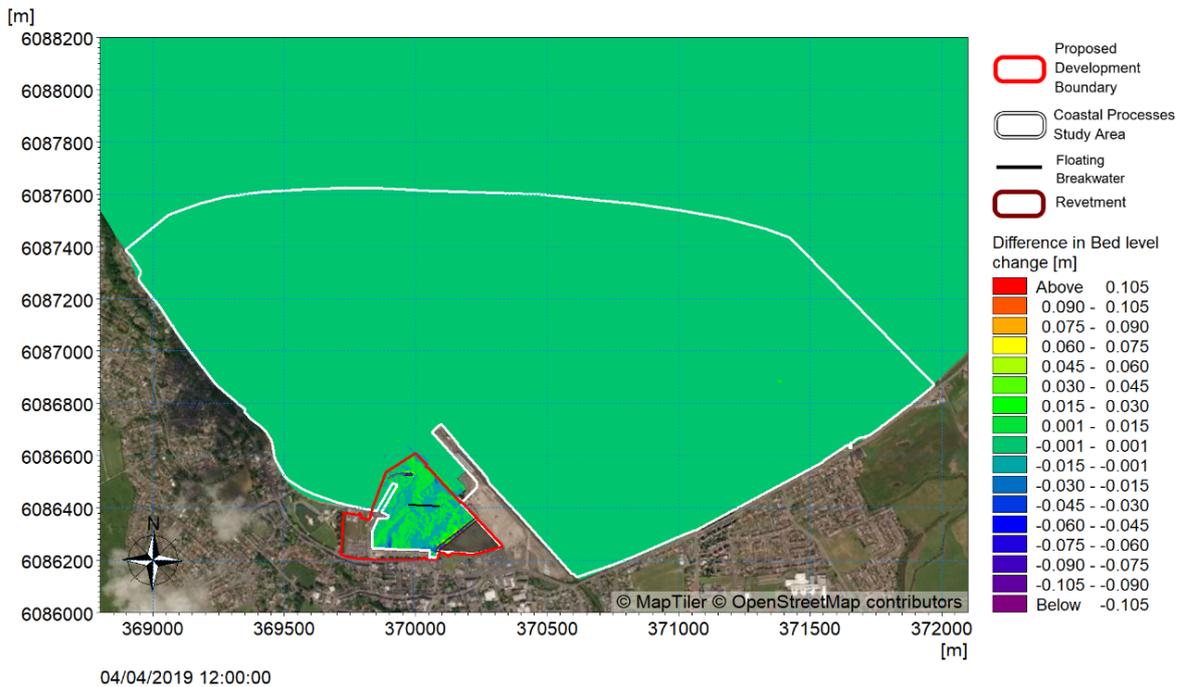


Figure 7-79: Difference to change in bed thickness 1 in 1 year event post construction

7.158 Tidal and littoral currents are variable within the study area due to the range of tidal and meteorological conditional experienced and would therefore have low sensitivity to the changes in sediment transport in the order of magnitude quantified by modelling of the proposed development. There are no areas designated for coastal process features or bathing waters

located within the coastal processes study area. It is therefore concluded that due to the confined nature, both low in magnitude and limited spatial extent, and the low sensitivity of sediment transport regime, the impact is considered to be of negligible significance of effect and not significant in EIA terms.

Maintenance Dredging

- 7.159 Stranraer Harbour has a long history of development and associated dredging activities. The current marina was dredged in 2012 when 6,305m³ of deposits comprising of clay, sand, silt and gravel were removed. In 2020 a licence²³ was granted for 30,000 wet tonnes to be dredged and small scale maintenance dredging is undertaken as required. The proposed capital dredging will provide a general depth of water of 2.5m with additional 0.5m margin in all states of the tide (relative to LAT, lowest astronomical tide). In the area where larger vessels such as superyachts can berth, the provided depth will be 4.0m with an additional 0.5m margin. A dredging plan has been developed for the marina expansion project whereby maintenance dredging will be undertaken to keep the access channels and berths at their designed depths. It involves removing recently accumulated sediments such as mud, sand and gravel.
- 7.160 It is anticipated that, as is currently the case, maintenance dredging would be required from time to time, in line with the dredging plan. The volume and frequency will depend on the tolerances with regards to berthing facilities and the redistribution of sediment within the marina with boat movements, etc. Dredging requirements over the past 15 to 20 years with the harbour in the present form have indicated an accumulation of *circa* 2,000m³ of sediment per year. It should be noted that the siltation which occurs within the harbour largely comes in from the west between pier and outer breakwater. Numerical modelling of both calm and storm conditions demonstrated that the proposed development does not alter sediment transport regimes along the shoreline to the east or west of the harbour. It is therefore anticipated that future dredging requirements will not be significantly altered.
- 7.161 In terms of magnitude of impacts for these activities on the relevant sensitive receptor/pathway of SSC and subsequent deposition; the largest maintenance dredging licences/campaigns which have been undertaken²⁴ in the harbour have typically been 10-15% of the total proposed capital dredging. Plume modelling was not undertaken specifically in relation to maintenance dredging but in terms of SSC these values would be of a similar magnitude to the construction phase, as the dredging/spill rates would be similar to construction operations, but they would occur over a significantly reduced period of time. Deposition of spilled sediment would be

²³ Marine Licence 00008983 (Marine Scotland)

²⁴ Stranraer Harbour Dredging Best Practical Environmental Option Assessment, Dumfries and Galloway Council, March 2019

similarly reduced from the capital dredging levels, i.e. fractions of a millimetre beyond the immediate vicinity of the harbour.

- 7.162 There are no areas designated for coastal process features or bathing waters located within the coastal processes study area. Loch Ryan is however a SEPA Shellfish Water Protected Area which is assessed in **Chapter 11.0: Water Quality** and **Chapter 13.0: Fish Ecology**.
- 7.163 As previously noted, coastal processes have low sensitivity to changes in SSC, i.e. increased SSC would not change the viscosity of the receiving water such that tidal currents would be altered. Sedimentation levels due to maintenance dredging activities are of the order of fractions of a millimetre within a water depth of several metres and represent values within the range of natural variation and would therefore not impact on hydrodynamic conditions. Modelling indicated that settled material is resuspended on subsequent tides and is drawn into the underlying sediment transport regime which exhibits high levels of turbidity and variation in SSC, as illustrated in [Baseline Conditions](#).
- 7.164 Given the low sensitivity of coastal processes to changes in SCC and the negligible magnitude of sedimentation, the impact of maintenance dredging activities is therefore considered to be of negligible significance of effect and not significant in EIA terms.

Do Nothing Scenario

- 7.165 In the event that the proposed development is not taken forward the existing marina facilities at Stranraer would remain the same. This option would mean no investment in the existing marina beyond regular repair and renewal. The existing baseline sediment transport would continue and, as is currently the case, siltation would occur within the existing marina basin. Therefore under the 'Do Nothing Scenario' maintenance dredging would still be required to provide continued berthing facilities at the current level and ongoing impacts would be akin to those assessed in [Maintenance Dredging](#) activities.

Summary of Assessment

- 7.166 The potential effects scoped into the coastal processes assessment can largely be broken down into two main groups:
- The installation of the marine infrastructure and associated dredging which are accompanied with increased SSC; and
 - The presence of the marine infrastructure which have the potential to change coastal processes, (i.e. tides, waves and sediment transport).
- 7.167 **Table 7-13** provides a summary of the activities associated with the construction and operational phases of the proposed development and the potential effects on coastal processes. In terms of the physical presence of infrastructure and associated changes in bathymetry influencing tides, waves and sediment transport, impacts will escalate from the baseline condition (no infrastructure or impact) to the completed development though the

course of the construction phase. Therefore, as a worst case scenario, these impacts will be the same as the operational phase and have been assessed on this basis.

Table 7-13: Summary of Activities and Potential Effects relevant to Coastal Processes

Activity	Potential Effect	
Construction Phase		
Capital Dredging	Increase in SSC and subsequent deposition	
Presence of proposed development <ul style="list-style-type: none"> • Breakwater Extension • Floating Breakwater • Reclamation • Revised bathymetry 	Changes to Baseline Tidal Regime	Impacts will escalate from the baseline condition (no infrastructure or impact) to the completed development though the course of the construction phase
	Changes to Baseline Wave Climate	
	Changes to Baseline Sediment Transport	
Operational Phase		
Maintenance Dredging	Increase in SSC and subsequent deposition	Significantly reduced from construction phase Remains under 'Do nothing' scenario
Presence of proposed development <ul style="list-style-type: none"> • Breakwater Extension • Floating Breakwater • Reclamation • Revised bathymetry 	Changes to Baseline Tidal Regime	
	Changes to Baseline Wave Climate	
	Changes to Baseline Sediment Transport	

7.168 There are currently no areas designated specifically for coastal processes attributes in the vicinity of the proposed development, the assessment was therefore undertaken with regards to both receptors relating to coastal features and those which form pathways for other designated features. The proposed development includes permanent changes to the marine environment relating to infrastructure, i.e. the extension of the existing breakwater and provision of a floating breakwater. Additionally, dredging to accommodate the new marina layout will result in changes in bathymetry which will give rise to changes in tidal flow. By design, the provision of infrastructure will alter the wave climate within the harbour to facilitate berthing, therefore the assessment focused on potential impacts beyond those intended changes to coastal processes. A summary of the impact assessment is provided in **Table 7-14**. The assessment concluded that impacts occurred only very close to development and largely related directly to purpose of the infrastructure. Small changes in coastal processes were found to be neither adverse nor beneficial.

Table 7-14: Summary of Impacts relating to Coastal Processes

Sensitive Receptor / Pathway	Phase ²⁵		Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Mitigation Measures
	C	O				
SSC and subsequent deposition resulting in alterations to bathymetry	Y	Y	C: Low O: Negligible	Low	C: Negligible O: Negligible	No effects which are significant in EIA terms have been identified therefore no specific mitigation is recommended with respect to coastal processes
Changes to Baseline Tidal Regime	Y	Y	C: Low O: Low	Low	C: Negligible O: Negligible	
Changes to Baseline Wave Climate	Y	Y	C: Low O: Low	Low	C: Negligible O: Negligible	
Changes to Baseline Sediment Transport Regimes and Pathways	Y	Y	C: Low O: Low	Low	C: Negligible O: Negligible	

²⁵ C: Construction Phase; O: Operational Phase

Mitigation, Monitoring and Residual Effects

Mitigation/ Monitoring

- 7.169 During the construction phase, the proposed marine based development principally relates to increased dredging and provision of breakwaters to accommodate a new marina layout. The assessment considered increased SSC due to the sediment spill during dredging operations and the extent of sediment plumes and subsequent deposition of this material. No effects which are significant in EIA terms have been identified therefore, in respect of SSC and deposition, no specific monitoring or additional mitigation is recommended.
- 7.170 In terms of the physical presence of infrastructure and associated changes in bathymetry influencing tides, waves and sediment transport, impacts will escalate from the baseline condition (no infrastructure or impact) to the completed development though the course of the construction phase. The proposed development includes permanent changes to the marine environment relating to infrastructure, i.e. the extension of the existing breakwater and provision of a floating breakwater. Additionally, dredging to accommodate the new marina layout will result in changes in bathymetry which will give rise to changes in tidal flow conditions. The provision of infrastructure is designed to alter the wave climate within the harbour to facilitate berthing, therefore the assessment focused on potential impacts beyond those intended changes to coastal processes. No effects which are significant in EIA terms have been identified therefore, in terms of coastal processes, no specific monitoring or mitigation is recommended beyond those discussed in [Embedded Mitigation](#).
- 7.171 Monitoring will be undertaken to support the dredging plan which has been developed for the proposed development whereby maintenance dredging will be undertaken to maintain access channels and berths at their designed depths by removal of accumulated sediments such as mud, sand and gravel.

Residual Effects

- 7.172 No effects which are significant in EIA terms have been identified therefore further mitigation is not required. As such, residual effects will remain consistent with those outlined in the impact assessment presented.
-

Cumulative Effects

7.173 The Cumulative Effects Assessment (CEA) takes into account the impact associated with the proposed development together with other projects and plans. **Chapter 25: Cumulative Effects** provides a summary of the other planned and ‘committed’ developments in the locality of the application site which could result in cumulative effects with the proposed development in terms of environmental impact. The projects and plans selected as relevant to the CEA presented within this chapter are based upon the results of a screening exercise undertaken on this ‘long list’. Each project has been considered on a case by case basis for screening in or out of the chapter’s assessment based upon data confidence, effect-receptor pathways and the spatial/temporal scales involved. The specific projects, plans and activities scoped into the CEA, are outline in **Table 7-15**.

Table 7-15: List of other projects, plans and activities considered within the CEA

Project/Plan	Status	Location/Distance from proposed development	Description of Project/Plan	Comment/Note
Stranraer Watersports Association Marine Licence 00010772 (Marine Scotland)	Awaiting Determination	Stranraer Marina, Stranraer 500m	Marine Licence Application – 18 Moorings	Stranraer Watersports Association Marine Licence 00010772 (Marine Scotland)
Stranraer Watersports Association Marine Licence 00010825 (Marine Scotland)	Awaiting Determination	Stranraer Marina, Stranraer 100m	Construction of: Platform for instructor shelter. Removal of: 2 no. redundant sewer outfall pipes & debris, unlit beacon, removal of boulders, beach clearance	At the time of drafting it is understood that this application is being updated to comprise the removal of two redundant outfalls and boulders only
Stranraer Watersports Association Marine Licence 00010841 (Marine Scotland)	Awaiting Determination	Stranraer Marina, Stranraer <1km	Marine Construction & Pontoon Deposit - 8 (pontoons) + 3 (racing markers). Moorings are for offshore pontoons as opposed to vessels. Small craft (e.g. SUP, dinghies) will dock against the pontoons temporarily as rest stations. No vessels will be moored to the racing markers.	At the time of drafting it is understood that this application is in the process of being withdrawn by the Applicant

- 7.174 It is anticipated that the proposed development will be constructed over a period of 24 months. During this period there is the potential for cumulative effects with regards to SSC and deposition for projects which include activities which have the potential to elevate SSC and are also undertaken within the dredging plume envelope. It is noted that sediment plumes generated from other projects would be subject to dispersion by the same tidal currents as the proposed development. This means that plumes would not travel towards one another and would only coalesce when sediment is released from one project into the plume extent of a second. There is limited potential for cumulative impacts for other coastal processes (tidal regime, wave climate and sediment transport) as the 'project alone' impacts were seen to be limited to the immediate vicinity of the proposed development.
- 7.175 Marine Licence application 00010775 relates to the placement of 18 offshore moorings. They are located in three groups of six. The closest group to the proposed development is at a distance of *circa* 500m; whilst the furthest group is *circa* 1,500m to the north of the development boundary. Initial placement of the moorings may give rise to localised, temporary increases in SSC, however cumulative impacts with the proposed development are very unlikely and, should they occur will be of negligible magnitude. The presence of the moorings will not impact on coastal processes and therefore cumulative impacts would not occur in combination with the proposed development.
- 7.176 Marine Licence application 00010825 relates to the removal of the remnants of the two outfalls which lie on the seabed to the west of the West Pier, as indicated on the Admiralty chart 1401-2 in **Figure 7-80**. The Stranraer Water Sports Association (SWA) works lie outside the proposed development boundary of the Stranraer Marina Expansion Scheme. The boulders and the two outfalls will be removed by a vessel-mounted or tracked excavator, depending on the weather, wind (speed and direction) and pressure. All the removed boulders and redundant outfalls will be moved above MHWS. During the removal activities there is the potential for increased SSC as seabed sediment is disturbed and the offshore works may potentially occur within the dredging plume envelope for the proposed development. However it is considered that the likelihood of these projects being undertaken concurrently is very low. Notwithstanding this, any potential cumulative impacts would be of low magnitude given the negligible contribution from each project.
- 7.177 The removal of the outfall remnants and boulders would not significantly impact coastal processes. The initial removal of the outfalls may alter sediment transport in the short term as any material which has accreted on the western edge is released, as illustrated in **Figure 7-81**. However in the medium to longer term coastal processes would not be impacted and no cumulative impacts would arise in combination with the proposed development.
-

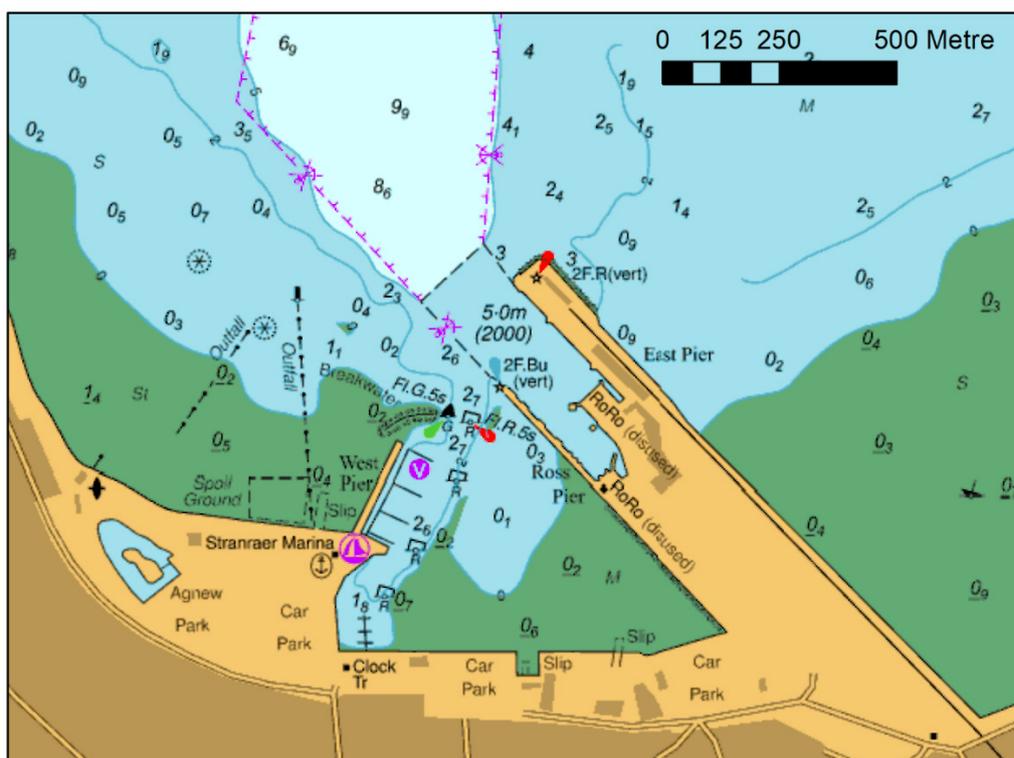


Figure 7-80: Difference to change in bed thickness 1 in 1 year event post construction

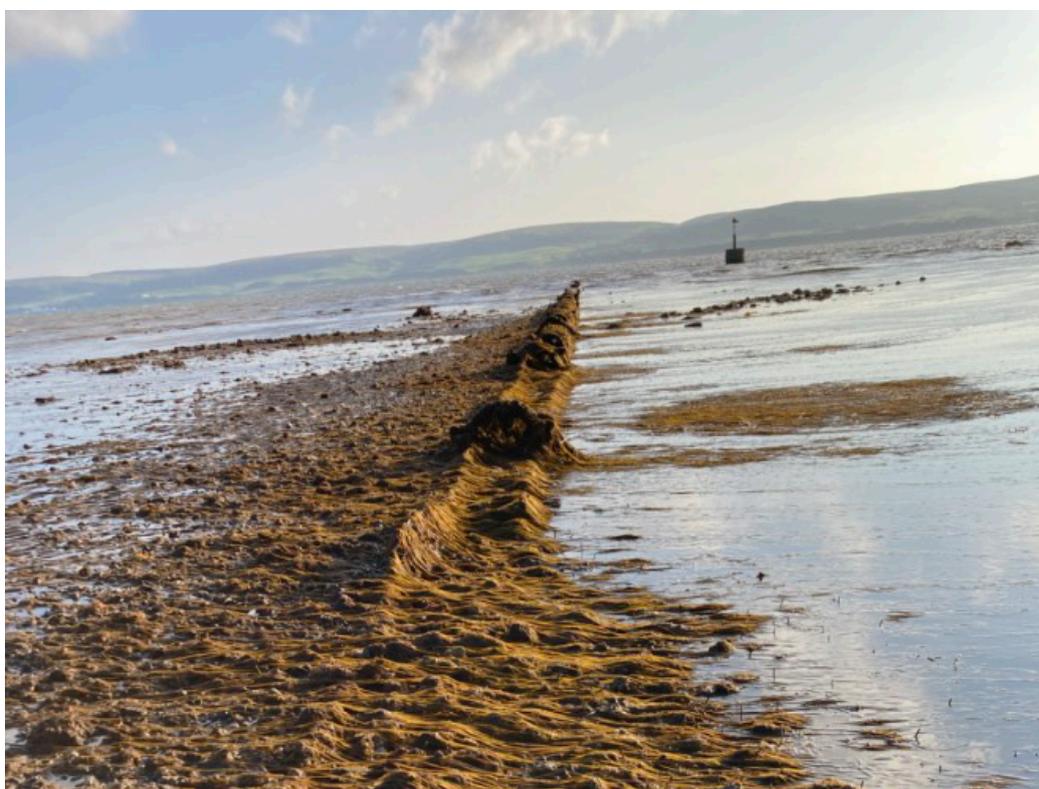


Figure 7-81: Remnants of outfall to be removed under ML00010825

- 7.178 At the time of drafting it is understood that Marine Licence application 00010825 is being updated to comprise only the removal of the two redundant outfalls and boulder clearance, as discussed. Should the application remain as it is currently published²⁶, it will also incorporate construction of a permanent concrete instructor platform and beach clearance activities, including litter and natural debris removal. The instructor platform will fall within the designated site boundary for the onshore works associated with the Stranraer Watersports Hub project and therefore has no pathway for cumulative impacts with offshore development activities as use of the slipway to access the site will be undertaken at low water. Similarly for beach clearance activities, obstructions within the intertidal zone will be removed by appropriate mechanical machinery when the tide is suitably low.
- 7.179 It is understood that the related Marine Licence application 00010841 is also in the process of being withdrawn. However, should this project proceed on the basis as it is currently published, it will comprise mooring for eight pontoons and provision of three racing markers. Small craft will dock against the pontoons temporarily as rest stations. Pontoons require four moorings each, laid in a rectangle measuring *circa* 11m by 12m on sea bed and will therefore be of diminutive size. The closest pontoon is located *circa* 100m north of the breakwater. As noted for the permanent moorings under licence application 00010772, initial placement of the moorings may give rise to localised, temporary increases in SSC, however cumulative impacts with the proposed development are very unlikely and, should they occur will be of negligible magnitude. The presence of the moorings and racing markers will not impact on coastal processes and therefore cumulative impacts would not occur in combination with the proposed development.
- 7.180 The CEA concluded that there will be no significant cumulative effects from the proposed development alongside other projects/plans.

Summary and Conclusions

- 7.181 An EIA was undertaken for coastal processes which encompassed:
- tidal elevations and currents;
 - waves;
 - seabed sediments;
 - suspended sediments; and
 - sediment transport.
- 7.182 There are currently no areas designated specifically for coastal processes attributes in the vicinity of the proposed development. The assessment was undertaken with regards to both receptors relating to coastal features and also those which form pathways for other designated features and comprised the following:

²⁶ <https://marine.gov.scot/marine-licence-applications>

- SSC and subsequent deposition resulting in alterations to bathymetry;
- Changes to baseline tidal regime;
- Changes to baseline wave climate; and
- Changes to baseline sediment transport regimes and pathways.

7.183 The assessment was supported by numerical modelling which was used to quantify the magnitude of the impacts on the sensitive receptors and pathways. **Table 7-16** provides a summary of the activities associated with the construction and operational phases of the proposed development and the potential effects on coastal processes.

Table 7-16: Summary of Activities and Potential Effects relevant to Coastal Processes

Activity	Potential Effect	
Construction Phase		
Capital Dredging	Increase in SSC and subsequent deposition	
Presence of proposed development <ul style="list-style-type: none"> • Breakwater Extension • Floating Breakwater • Reclamation • Revised bathymetry 	Changes to Baseline Tidal Regime	Impacts will escalate from the baseline condition (no infrastructure or impact) to the completed development though the course of the construction phase
	Changes to Baseline Wave Climate	
	Changes to Baseline Sediment Transport	
Operational Phase		
Maintenance Dredging	Increase in SSC and subsequent deposition	Significantly reduced from construction phase Remains under 'Do nothing' scenario
Presence of proposed development <ul style="list-style-type: none"> • Breakwater Extension • Floating Breakwater • Reclamation • Revised bathymetry 	Changes to Baseline Tidal Regime	
	Changes to Baseline Wave Climate	
	Changes to Baseline Sediment Transport	

7.184 The proposed development encompasses a range of embedded mitigation measures including:

- provision of offshore infrastructure designed to reduce the wave climate and enhance berthing facilities within the confines of the harbour;
- a floating breakwater with dual purpose for berthing super yachts during calm conditions reducing the requirement for additional infrastructure;

- the reuse of dredged material in reclaimed land area, rather than having to dispose and move it off site; and
- driven piles that will not give rise to significant increases in SSC as material is consolidated within the seabed.

7.185 During the construction phase, the proposed marine based development principally relates to increased dredging and provision of breakwaters to accommodate a new marina layout. The assessment considered increased SSC due to the sediment spill during dredging operations and the extent of sediment plumes and subsequent deposition of this material. No effects which are significant in EIA terms have been identified therefore, in terms of SSC and deposition, no specific monitoring or additional mitigation is recommended.

7.186 In terms of the physical presence of infrastructure and associated changes in bathymetry influencing tides, waves and sediment transport, impacts will escalate from the baseline condition (no infrastructure or impact) to the completed development though the course of the construction phase. The provision of infrastructure is designed to alter the wave climate within the harbour to facilitate berthing, therefore the assessment focused on potential impacts beyond those intended changes to coastal processes. No effects which are significant in EIA terms have been identified therefore, in terms of coastal processes, no specific monitoring or additional mitigation is recommended. A summary of the impact assessment is provided in **Table 7-17**.

Table 7-17: Summary of Impacts relating to Coastal Processes

Sensitive Receptor / Pathway	Phase ²⁷		Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Mitigation Measures
	C	O				
SSC and subsequent deposition resulting in alterations to bathymetry	Y	Y	C: Low O: Negligible	Low	C: Negligible O: Negligible	No effects which are significant in EIA terms have been identified therefore no specific mitigation is recommended with respect to coastal processes
Changes to Baseline Tidal Regime	Y	Y	C: Low O: Low	Low	C: Negligible O: Negligible	
Changes to Baseline Wave Climate	Y	Y	C: Low O: Low	Low	C: Negligible O: Negligible	
Changes to Baseline Sediment Transport Regimes and Pathways	Y	Y	C: Low O: Low	Low	C: Negligible O: Negligible	

²⁷ C: Construction Phase; O: Operational Phase

7.187 It is concluded that there will be no significant effects arising from the proposed development during the construction and operational phases. It is also concluded that there will be no significant cumulative effects from the proposed development alongside other projects/plans.