Environmental Impact Assessment Report

NISA

North Irish Sea Array

Volume 3: Offshore Chapters

Chapter 10

Marine Geology, Oceanography and Physical Processes

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10. Marine Geology, Oceanography and Physical Processes

10.1 Introduction

This chapter of the Environmental Impact Assessment Report (EIAR) presents an assessment of likely significant effects from the North Irish Sea Array Offshore Wind Farm (hereafter referred to as the 'proposed development') in relation to Marine Geology, Oceanography and Physical Processes during the construction, operation and decommissioning phases.

The topic of Marine Geology, Oceanography and Physical Processes is commonly referred to as "marine processes", or when issues pertain to the nearshore and coastline then the term "coastal processes" is also used. Either term is intended to be inclusive of issues pertaining to marine geology, oceanography, and physical processes at either location. For simplicity, the term "marine processes" is used in this chapter.

This chapter sets out the methodology followed (Section 10.2), describes the baseline environment (Section 10.3) and summarises the main characteristics of the proposed development which are of relevance to marine processes (Section 10.4), including any embedded mitigation. Potential impacts and relevant receptors are identified, and an assessment of likely significant effects on marine processes is undertaken, details of which are provided (Section 10.5).

Additional mitigation measures are proposed to mitigate and monitor these effects if required (Section 10.6) and any residual likely significant effects are then described (Section 10.7). Transboundary effects are considered (Section 10.8), and cumulative effects are considered in Section 10.9 and are summarised in Chapter 38 Cumulative and Inter-Related Effects (hereafter referred to as the 'Cumulative and Inter-Related Effects Chapter'). The chapter then provides a reference section (Section 10.10).

The EIAR also includes the following:

- Detail on the competent experts that have prepared this chapter is provided in Appendix 1.1 in Volume 8
- Detail on the consultation that has been undertaken with a range of stakeholders during the development of the EIAR is set out in Appendix 1.2
- A glossary of terminology, abbreviations and acronyms is provided at the beginning of Volume 2 of the EIAR; and A detailed description of the proposed development including construction, operation and decommissioning is provided in Volume 2, Chapter 6: Description of the Proposed Development – Offshore (hereafter referred to as the 'Offshore Description Chapter'), and Volume 2, Chapter 8: Construction Strategy – Offshore (hereafter referred to as the 'Offshore Construction Chapter').

This chapter should also be read alongside the following appendices:

- Appendix 10.1 – Marine Processes Review of Project Options
- Appendix 10.2 – Modelling Report and
- Appendix 10.3 – Assessment of Spoil Mounds

Appendix 10.1 reviews Project Option 1 and Project Option 2, as outlined in the Offshore Construction Chapter and Offshore Description Chapter, to identify the planned activities likely to develop the greatest source of impacts on receptors, with relevant details from this review summarised in Section 10.4. Appendix 10.2 describes the far-field modelling used to assess how these sources of impacts may propagate over a wider area (via impact pathways). This includes modelling assessments of seabed disturbance type impacts that may develop sediment plumes, as well as blockage type impacts on waves and flows from fixed foundations. Appendix 10.3 provides details of near-field modelling of spoil mounds which are expected to develop when a trailing suction-hopper dredger (TSHD) discharges sediment at various locations across the array area.

All figures within this Chapter are provided in Volume 7A.

10.2 Methodology

10.2.1 Introduction

The assessment of marine processes is consistent with the EIA methodology presented in Volume 2, Chapter 2: EIA and Methodology for the preparation of an EIAR (hereafter referred to as 'EIAR Methodology Chapter').

10.2.2 Source-Pathway-Receptor

The standard source-pathway-receptor approach has been applied where the source of impacts are project activities acting locally (i.e. near-field) within the offshore development area. The type of impact that an activity can have on marine processes can be categorised as either:

- Seabed disturbance – mechanical activities during construction, operational and decommissioning phases which lead to short-term increases in turbidity in the form of sediment plumes or
- Blockage – medium to long-term impacts developing from a layout of fixed foundation structures during the operational phase, which can modify wave energy transmission or develop flow wakes which potentially increase local turbulence and mixing

The Zone of Influence (ZoI) for these impacts (where they may propagate over a wider area and beyond the offshore development area (i.e. the far-field) is determined by the marine processes occurring in proximity to the activity which may then develop an impact pathway (e.g., through wave energy transmission or tidal advection) to reach a more remote receptor.

Where physical features (e.g., the coastline) may be affected by these impacts (either at source or across the pathway) they are identified as marine process receptors (as defined in Section 10.3.10). The magnitude, extent and duration of these impacts is considered against baseline conditions which would be expected to occur if no development took place and the sensitivity of relevant environmental receptors which are expected to be encountered along the impact pathway.

Some impact pathways may reach other types of environmental receptors, and where this is the case, the impacts are considered by the relevant chapter. For example, potential smothering impacts from settlement of sediment plumes on marine benthos are assessed in Volume 3, Chapter 12: Benthic Subtidal and Intertidal Ecology. All interactions between receptors are captured in the Cumulative and Inter-Related Effects Chapter.

10.2.3 Study Area

The extent of the marine processes study area (Figure 10.1) has been determined by encapsulating all relevant sources of impacts on physical processes occurring within the offshore development area, which is the proposed development boundary seaward of the High Water Mark (HWM). This includes sources across the array area, along the offshore Export Cable Corridor (ECC), and at the landfall seaward of HWM, in addition to associated impact pathways, as well as potential overlapping cumulative effects from adjacent projects or activities. Accordingly, the study area encapsulates the entire ZoI and no measurable effects are anticipated beyond the study area. Relevant environmental receptors are those that are contained within the study area and are sensitive to a change in marine processes.

Quantitative modelling supports the assessment of project activities which are considered to lead to the greatest magnitude of impact and consequently the highest likely significant effect on associated receptors. For seabed disturbance impacts, the maximum spread of sediment plumes, which may locally elevate background levels of turbidity, are related to the period with strongest tidal flows which develop the largest tidal excursion distances. Based on flow modelling, the maximum excursion distance for fine material carried in suspension from a representative central area location of the array area is expected to reach around 7.2km in a north-north-west direction on the flood phase of a spring tide and 6.7km in a south-south-east direction on the following ebb phase, with a total tidal excursion of around 13.9km.

For a representative central area of the ECC, the maximum excursion distance reduces slightly to around 6.4km on the flood and 6.3km on the ebb, representing a total excursion distance of around 12.7km. The inequality in the excursion distance between flood and ebb phases of the tide is attributed to tidal asymmetry. The tidal excursion buffer is presented on Figure 10.1. Net excursion from the source of disturbance may extend further on subsequent tides due to this asymmetry (or during periods of strong winds), however, sediment concentrations at this time are likely to be much reduced as material continues to disperse and settle out. In comparison, neap tides develop a proportionally shorter tidal excursion distances due to a period of weaker flows.

For blockage impacts on waves, the relevant spatial extents are the stretch of leeward coastlines which may be reached after waves pass through the array area. In this case, the applicable wave directions are between north-north-east clockwise through to south. Waves from other directions will be fetch limited and propagate away from the leeward coastline.

Figure 10.1 presents the study area for marine processes based on a consideration of the potential extents of impacts due to both seabed disturbance and blockage type impacts. The study area can be described with the following boundaries:

- The northern boundary extends to Ballagan Point (entrance to Carlingford Lough) (around 28km from offshore development area).
- The eastern boundary is coincident with Western Trough where water depths are greater than 100m below Lowest Astronomical Tide (LAT). The M2 wave buoy is also coincident with this boundary (around 26.5km from offshore development area).
- The southern boundary extends to Howth Harbour and the southern limit of Lambay Deep (glacial tunnel valley). This boundary is considered to be beyond any influences from the proposed Dublin Array offshore wind farm (OWF) further to the south (around 23km from offshore development area).
- The western boundary is defined by the stretch of the Irish coastline between north and south boundaries (around 11km from offshore development area).

10.2.4 Relevant Guidance and Policy

This section outlines guidance and policy specific to marine processes, including best practice guidelines. Overarching guidance on EIA is presented in the EIAR Methodology Chapter. Furthermore, policy applicable to the proposed development is detailed in Volume 2, Chapter 3: Legal and Policy Framework.

The assessment of likely significant effects upon marine processes has been made with reference to the following guidance:

- COWRIE (2009). Coastal Process Modelling for Offshore Wind Farm Environmental Impact Assessment: Best Practice Guide. COWRIE COAST-07-08
- National Marine Planning Framework (2021)

The key National Marine Planning Framework (NMPF) policy that is applicable to the assessment of marine processes are summarised in Table 10.1. NMPF policies are addressed in their entirety in Appendix 3.1: NMPF Compliance Report.

Table 10.1 Key NMPF policies relevant to the assessment

Policy Name	Policy description	Where addressed
National Marine Planning Framework (2021)	Sea Floor and Water Column Integrity Policy 1 Proposals that incorporate measures to support the resilience of marine habitats will be supported, subject to the outcome of statutory environmental assessment processes and subsequent decision by the competent authority and where they contribute to the policies and objectives of this NMPF. Proposals which may have significant adverse impacts on marine, particularly deep sea, habitats must demonstrate that they will, in order of preference and in accordance with legal requirements: a) avoid, b) minimise, or c) mitigate significant adverse impacts on marine habitats, or d) if it is not possible to mitigate significant adverse impacts on marine habitats must set out the reasons for proceeding.	Likely significant effects of relevance to Sea Floor and Water Column Integrity Policy 1 are addressed in all impacts within Section 10.5.
	Sea Floor and Water Column Integrity Policy 2 Proposals, including those that increase access to the maritime area, must demonstrate that they will, in order of preference and in accordance with legal requirements: a) avoid, b) minimise, or c) mitigate adverse impacts on important habitats and species.	Likely significant effects of relevance to Sea Floor and Water Column Integrity Policy 2 are addressed in the assessment of all impacts in Section 10.5.
	Sea floor and Water Column Integrity Policy 3 Proposals that protect, maintain, restore and enhance coastal habitats for ecosystem functioning and provision of ecosystem services will be supported, subject to the outcome of statutory environmental assessment processes and subsequent decision by the competent authority, and where they contribute to the policies and objectives of this NMPF. Proposals must take account of the space required for coastal habitats, for ecosystem functioning and provision of ecosystem services, and demonstrate that they will, in order of preference and in accordance with legal requirements: a) avoid, b) minimise, or c) mitigate for net loss of coastal habitat.	Likely significant effects of relevance to Sea Floor and Water Column Integrity Policy 3 are addressed in the assessment of all impacts in Section 10.5.
	Protected Marine Sites Policy 4 Until the ecological coherence of the network of protected marine sites is examined and understood, proposals should identify, by review of best available evidence (including consultation with the competent authority with responsibility for designating such areas as required), the features, under consideration at the time the application is made, that may be required to develop and further establish the network. Based upon identified features that may be required to develop and further establish the network, proposals should demonstrate that they will, in order of preference, and in accordance with legal requirements: a) avoid, b) minimise, or c) mitigate significant impacts on features that may be required to develop and further establish the network, or d) if it is not possible to mitigate significant impacts, proposals should set out the reasons for proceeding.	Likely significant effects on Protected Marine Sites Policy 4 are assessed in Sections 10.5.2.1 to 10.5.2.7 and Section 10.5.3.4.

10.2.5 Data Collection and Collation

Baseline understanding of marine processes has been developed using a combination of publicly available data and information to describe the wider study area, supplemented by more detailed metocean and geophysical survey data for the proposed development area.

10.2.5.1 Metocean Data

The primary metocean parameters of interest include:

- wave height, period, and direction
- water levels
- current flows and direction
- turbidity
- water column temperature and salinity and
- marine climate change projections

A review of available metocean data, leading to recommendations for associated project surveys, is provided in:

- MetOceanWorks (2020a). Metocean Survey Scope. North Irish Sea Array. 05 October 2020
  Relevant metocean data have also been used to demonstrate the validity of existing meso-scale wave and hydrodynamic models to describe the study area. These comparisons are reported in:
- MetOceanWorks (2020b). Metocean Data Overview. North Irish Sea Array. 12 October 2020
  A further study of relevance to the shoreline, coincident with the study area, is:
- RPS (2010). Irish Coastal Protection Strategy Study – Phase III. Work Packages 2, 3 & 4A. Strategic Assessment of Coastal Flooding and Erosion Extents. North East Coast – Dalkey Island to Omeath. Final Technical Report – June 2010. For OPW

In addition to available metocean data, the project has also completed a metocean survey with equipment deployed across two sites, north and south, within the Maritime Area Consent[1] (MAC) boundary issued to the proposed development. The survey collected wave, current and conductivity, temperature and depth (CTD) data from two bedframes, and a surface deployed wavebuoy[2] also obtained wave data. The survey took place from 20th January 2022 to 20th of January 2023, and is reported in:

- Partrac (2022). NISA Offshore Wind Farm. Metocean Campaign. Interim Data Report – Deployment 1. Version 2. May 2022
- Partrac (2023). NISA Offshore Wind Farm. Metocean Campaign. Interim Data Report – Deployment 2/3. Version 1. February 2023

10.2.5.2 Geophysical data

The geophysical parameters of primary interest have been sourced from EMODnet, INFOMAR and site-specific surveys, and include:

- high-resolution bathymetry, enabling identification of macro bedforms (e.g., sandwaves, if present)
- surficial sediment types, inter-tidal and sub-tidal locations (interpreted back-scatter and particle size analysis (PSA) data from the benthic survey)

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[1] Maritime Area Consent is a State consent which provides the right to occupy a part of the maritime area and the ability to subsequently apply for development consent within that maritime area.

[2] Datawell Directional Waverider MKIII wavebuoy

- depth of surficial substrates and
- depth to bedrock
- A review of available offshore geophysical data across the proposed development area is provided in:
- GDG (2020a). North Irish Sea Array – Geophysical Interpretation.
- A review of the landfall areas is provided in:
- GDG (2020b). North Irish Sea Array Wind Farm – Landfall Assessment
- Stockton (2020). NISA Offshore Farm – Export Cable Landfall Feasibility Study. Document No. 100-798-REP-DS-001

In addition to the available geophysical data, the proposed development has also completed a pre-site investigation geophysical survey. This survey was primarily designed to enable the development of a ground model, identify and position of geohazards. Operations comprised multibeam echo sounder (MBES), multibeam backscatter (MBBS), side scan sonar (SSS), single magnetometer (MAG), sub-bottom profiler (SBP), single channel sparker (SCS) and multichannel ultra-high-resolution seismic (MCS). The geophysical data were acquired between 31st May and 30th June 2022 and are reported in:

- Fugro (2022). Geophysical Survey Results Report. Ireland, Irish Sea. F202831-REP-003 03. 29 November 2022. Final. North Irish Sea Array Windfarm Limited [for array area]
- N-Sea. (2023). North Irish Sea Array Windfarm Ltd. Interim Geophysical Survey. Results Report. DOC NO: NSW-PJ00293-RR-DC-SUR-001. Revision 2.0 [for ECC]

10.2.5.3 Particle Size Analysis (PSA)

- The PSA of discrete surficial sediment samples is reported in the benthic survey campaign documentation (see below). The subtidal benthic survey campaign was carried out between the 27th September to 1st October 2022, with 30 sites surveyed. Drop Down Video (DDV) transects were conducted at all sites to inform seabed habitat classification. Sediment was collected at ten sites for PSA and total organic carbon (TOC) content determination. The benthic survey campaign is described in detail in:
- Volume 9, Appendix 12.1: Array Area Benthic Survey Report and
- Volume 9, Appendix 12.2: Cable Route Benthic Survey Report

10.2.6 Methodology for Assessment of Effects

EIA significance criteria for marine processes follows Environmental Protection Agency (EPA) guidance:

- EPA (2022). Guidelines on the information to be contained in Environmental Impact Assessment Reports, May 2022
- The criteria for determining the sensitivity of the receiving environment and the magnitude of impacts for the marine processes assessment are defined in Table 10.2 and Table 10.3 respectively. A matrix was used for the determination of significance in EIA terms (Table 10.4). The combination of the magnitude of the predicted impact with the sensitivity of the receptor determines the assessment of significance of effect.

10.2.6.1 Sensitivity Criteria

The sensitivity of marine processes receptors is defined by both their potential vulnerability to an impact from the proposed development, their recoverability, and the value or importance of the receptor. The criteria for defining marine mammal sensitivity in this chapter are outlined in Table 10.2.

Table 10.2 Sensitivity of the receptor

Receptor sensitivity	Definition
High	Very low or no capacity to accommodate the proposed form of change; and/ or receptor designated and/ or of international level importance. Likely to be rare with minimal potential for substitution. May also be of very high socioeconomic importance (for example, amenity beach).
Medium	Moderate to low capacity to accommodate the proposed form of change; and/ or receptor designated and/ or of regional level importance. Likely to be relatively rare. May also be of moderate socioeconomic importance.
Low	Moderate to high capacity to accommodate the proposed form of change; and/ or receptor not designated but of district level importance.
Negligible	High capacity to accommodate the proposed form of change; and/ or receptor not designated and only of local level importance.

10.2.6.2 Magnitude of impact criteria

A distinction is made throughout the assessment between the magnitude of 'impact' - as defined by the extent, duration, frequency, probability and consequences of the impact - and the resulting significance of the 'effects' upon marine processes receptors (as they are defined in Section 10.3.10). The magnitude of each impact is considered against the magnitude descriptions presented in Table 10.3 and magnitude is then considered alongside the sensitivity of receptor (Table 10.2) to identify any likely significant effects (Table 10.4). Impacts have been considered in terms of whether they may have adverse or beneficial effects.

Where an impact could reasonably be assigned to more than one level of magnitude, professional judgement has been used to determine which level is the most appropriate for the impact. The level has been assigned based on the most appropriate potential consequences of the impact as defined for each level of magnitude (see Table 10.4). For example, an impact may occur constantly throughout the operational period but is not discernible or measurable in practice, therefore it would be concluded to be of a negligible magnitude despite the frequency of the impact.

For the purposes of the definitions below: near-field is defined as occurring around the source of effects within the offshore development area; and far-field is defined as extending beyond these boundaries across the identified ZoI.

Table 10.3 Magnitude of the impact

Magnitude	Definition
High	Permanent changes across the near- and large parts of the far-field to key characteristics or features of the particular environmental aspect's character or distinctiveness.
Medium	Permanent changes, across the near- and parts of the far-field, to key characteristics or features of the particular environmental aspect's character or distinctiveness.
Low	Noticeable, temporary (for part of the project duration) change, or barely discernible change for any length of time, restricted to the near-field and immediately adjacent far-field areas, to key characteristics or features of the particular environmental aspect's character or distinctiveness.
Negligible	Changes which are not discernible from background conditions.

10.2.6.3 Defining the significance of effect

The significance of effect associated with an impact is dependent upon the sensitivity of the receptor and the magnitude of the impact. The assessment methodology for determining the significance of likely significant effects is described in Table 10.4. Effects defined as significant, very significant or profound are considered significant in EIA terms. An effect that has a significance of moderate, slight, not significant, or imperceptible is not considered to be significant in EIA terms.

Table 10.4 Significance of potential effects upon marine processes

			Existing Environment - Sensitivity			
			High	**Medium**	**Low**	**Negligible**
Description of Impact Magnitude	**Adverse impact**	**High**	Profound or very Significant (significant)	Significant	Moderate	Imperceptible
		Medium	Significant	Moderate	Slight	Imperceptible
		Low	Moderate	Slight	Slight	Imperceptible
		Negligible	Not significant	Not significant	Not significant	Imperceptible
	Beneficial impact	**Negligible**	Not significant	Not significant	Not significant	Imperceptible
		Low	Moderate	Slight	Slight	Imperceptible
		Medium	Significant	Moderate	Slight	Imperceptible
		High	Profound or very Significant (significant)	Significant	Moderate	Imperceptible

Where relevant, mitigation measures that are incorporated as part of the proposed development design process and/ or can be considered to be industry standard practice (referred to as 'embedded mitigation') are considered throughout the chapter and are reflected in the outcome of the assessment of effects, described in Section 10.5. Additional mitigation measures that are not embedded and are considered as part of the residual effects assessment are described separately (Section 10.6).

10.3 Baseline Environment

10.3.1 Overview

A baseline description of marine physical features (and processes) in the study area is provided to establish sources, pathways, and receptors which are expected to become influenced by the proposed development activities. Features of the marine processes baseline environment include the local seabed, adjacent coastline, and properties of the water column (in particular; waves, tides, and turbidity). This description helps establish the reference condition (i.e. a do-nothing scenario) against which the potential physical effects of the proposed development are assessed. The relevant period for assessment is the proposed development timescale of three years for construction activities in the offshore development area and 35 years for operation.

10.3.2 Marine Geology

A review of the most recent period of geological evolution and associated marine geology helps explain how the study area formed, the areas most susceptible to change, and features that represent hard (rocky) substrates that are more resistant to erosion or may require an alternative installation option (e.g., drilling for installation of piles where pile driving is not practicable).

10.3.2.1 Recent Geological Evolution

Pleistocene glaciation

Towards the end of the Pleistocene (circa 23,000 years Before Present) sea levels were much lower than present day with most of Scotland, Wales, and Ireland covered by an ice sheet (Clark, et al., 2012). This icesheet included a large glacier which flowed slowly south through the Irish Sea (Irish Sea Glacier).

The action of the glacier (as well as previous periods of glaciation) shaped the main basin of the Irish Sea and incised deep channel features, including Celtic Deep, St. George's Channel, Western Trough, and North Channel, amongst others.

The glaciation process also created large amounts of glacial moraine with a distribution largely mimicking that of the overlying glacier.

Holocene and the marine transgression

Warmer climates marked the end of the Pleistocene and led to the retreat of the ice sheet and melting of glaciers. This caused sea levels to rise rapidly and the commencement of the marine transgression through the Holocene period.

Marine transgression led to the progressive inundation of low-lying coastal land resulting in the landward migration of the coastline. The inundated areas became susceptible to a body of seawater moving through a widening Irish Sea with wave and tidal processes releasing erodible seabed sediments for transport and deposition in more quiescent areas (e.g., the Eastern and Western Irish Sea Mud Belts located in the widest part of the Irish Sea east and west of the Isle of Man, leading to relatively deep layers of Holocene sediments).

Coastal areas with harder geology (i.e., more resistant to erosion) became discrete islands and coastal promontories where faster flows are now evident. In general, these faster flows help to scour away mobile sediments.

10.3.2.2 Relevant Geological Coastal Features

Notable geological features along the coastline of the study area, from north to south, are listed in Table 10.5 and presented in Figure 10.2. This figure also includes regional mapping of Pre-Quaternary seabed lithology from EMODnet (Asch, 2005). Where coastal sites are designated then the associated County Geology Site (CGS) code is also provided in Table 10.5.

Table 10.5 Notable Geological Coastal Sites within the study area

Feature	Description	Site Code
Ballagan Point	Headland feature established as a raised beach fronted by a gravel foreshore defining the entrance to Carlingford Lough. Incorporates Templeton Raised Beach	LH031
Dunany Point	Ridge of Quaternary Age glacial sediments, deposited during deglaciation at the end of the last Ice Age	LH017
Clogher Head	Rocky headland with vegetated sea cliffs designated as a Special Area of Conservation (SAC)	LH011
Braymore Point	Rocky promontory to the north of the landfall area, extending offshore as Cardy Rocks (intertidal feature)	(no site code)
Fancourt Shore	Rocky promontory to the south of the landfall area	DF002
Rockabill	Two small islands formed of Caledonian granite	DF019
Skerries Islands	Including Shenick's, Saint Patrick's and Colt Island, including Red Island. Shenick's Island is a CGS designated site.	DF012
Skerries to Rush	Coastal cliffs formed of lower Carboniferous limestone	DF007
Lambay Island	Largely formed of Ordovician volcanic rock	DF003
Ireland's Eye	Small rocky island north of Howth	DF011

Feature	Description	Site Code
Howth	Peninsula largely formed of Cambrian rocks. Includes Balscaddan Bay and Calremont Strand	DF013 and DF014

10.3.3 Shallow Offshore Geology

The shallow geology across the array area has been mapped by the geophysical survey (Fugro, 2022) and identifies the top of bedrock represented by two geological formations, a layer of Dinantian Limestone and a layer of Innishkeen Formation (sandstone). The depth below seabed to rockhead varies between 5m at the very southern limit of the array area to around 30 to 35m slightly further north (due to abrupt dipping which locally reaches up to 65m). This abrupt change is likely to be associated with the boundary between these two rock types. The majority of the array area has a depth below seabed of between 20 to 30m to the top of the Innishkeen Formation.

Figure 10.3 presents isopach contours of the depth below seabed to the top of the rockhead, interpreted from the geophysical survey for the array area (Fugro, 2022). The isopach contours are also presented against the regional-scale interpretation of pre-Quaternary lithology.

10.3.4 Seabed

10.3.4.1 Bathymetric Profile

The contemporary bathymetry across the study area represents a dynamic equilibrium between prevailing wave and tidal conditions, sediment types, and sediment availability.

Available evidence

The study area is well-provided by high-resolution contemporary bathymetry data and draws on three key datasets which collectively provide 100% coverage.

EMODnet Bathymetry represents a gridded collation of recent surveys with a resolution of 1/16 arc minute (locally equivalent to around 115m north-south and 69m east-west). This regional-scale dataset extends over the entire study area, and beyond, and is used to supplement other datasets across the far-field where there are data gaps. Within EMODnet Bathymetry, the intertidal region of Dundalk Bay appears to be poorly defined, but this is too remote from the proposed development to influence the near-field baseline and is considered sufficient for the purposes of baseline characterisation of the far-field. .

Across Irish coastal waters there is an ongoing programme of high-resolution bathymetry surveys referred to as INFOMAR, funded by the Department of the Environment, Climate and Communications (DECC). Each dataset provides a detailed record of seabed levels for a specific survey period and area. The vertical datum for these surveys is LAT, established according to Vertical Offshore Reference Frames (VORF). The majority of processed data from INFOMAR is also incorporated within EMODnet Bathymetry, but with a reduced level of detail. The INFOMAR dataset is used as a primary dataset to establish bathymetry across the study area.

Site-specific geophysical surveys of the array area (Fugro, 2022) and ECC (N-Sea, 2023) provide the most detailed and up to date bathymetry data across the offshore development area. The vertical datum for these surveys is also LAT, established according to VORF.

Baseline review

Figure 10.4 shows the detailed bathymetry across the offshore development area, established by the site-specific geophysical surveys (Fugro, 2022 and N-Sea, 2023). These data are presented against the EMODnet data for the wider area. Interpretations of the bathymetry data note the following for the study area:

- The seabed profile across the array area and along the ECC appears to be relatively featureless and smooth with no reported sandwaves.
- The deepest part of the array area is in the south-eastern corner, reaching over 62m below LAT.
- The shallowest part of the array area is in the north-west corner, reaching over 34m below LAT.

- The northern arm of the shallow profile sand ridge, emanating from Rockabill, extends across the mid-section of the ECC, locally raising the seabed profile by around 1.0m over a width of approximately 1,000m.
- There are no sandbank features within the study area, although an area of large sandwaves terminate their northerly net transport pathway in the south-eastern part of the study area, mostly beyond 12nm (Figure 10.2).

An initial assessment of seabed mobility has been carried out for the array area by comparing bathymetry from the 2022 geophysical survey with equivalent information from INFOMAR obtained between 2009 and 2016 (GDG, 2022). The overall conclusion from the comparison is seabed levels have remained largely stable across the array area over the 13-year intervening period between surveys.

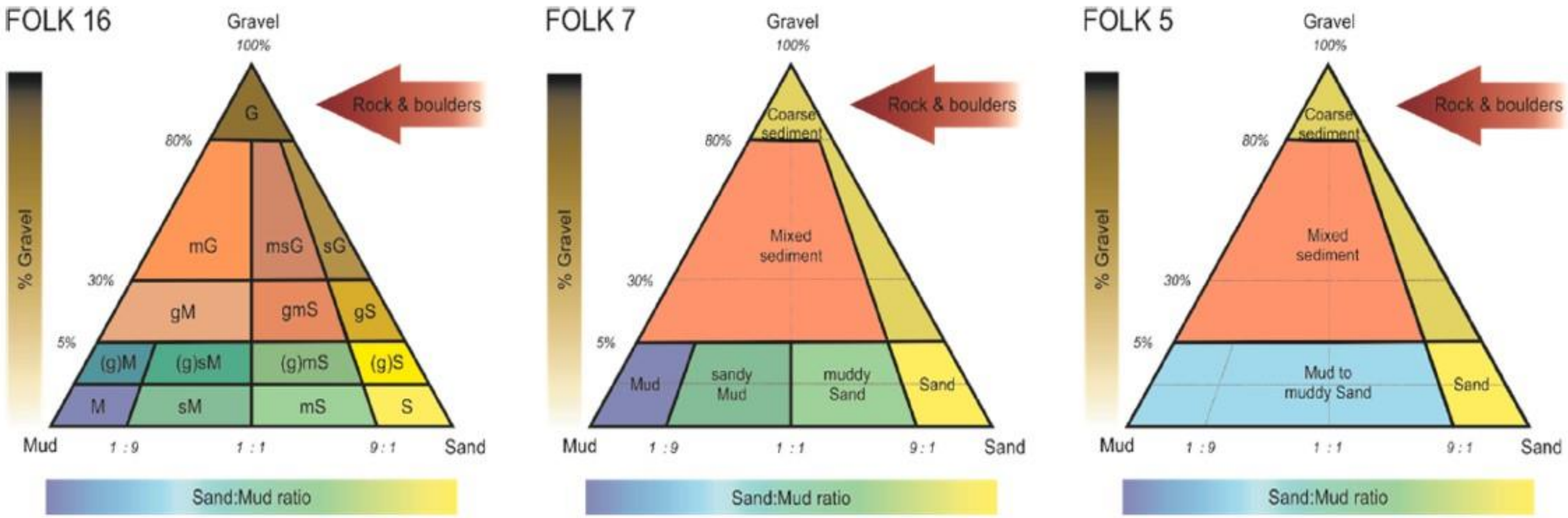
10.3.4.2 Surficial sediment distribution

Available evidence

EMODnet Geology provides a regional scale interpretation of surficial sediment types across the study area and beyond. The Folk 7 classification option, based on six different sediment types (Mud, sandy Mud, muddy Sand, Sand, coarse sediment, and mixed sediment) along with 'rock and boulders', represents the classification scheme which is most compatible with other published interpretations and enables integration with recent interpretations from project geophysical and benthic surveys. The relationship between Folk 5, Folk 7, and Folk 16 is shown in Graph 10.1 (Kaskela, et al., 2019).

An up to date interpretation of surficial sediment is also provided by INFOMAR across Irish coastal waters. This interpretation is limited to Folk 7 and is developed from MBES backscatter and ground-truthed with a spread of sediment grab samples. The majority of processed data is also incorporated within EMODnet Geology for the regional scale.

The geophysical surveys of the array area (Fugro, 2022) and ECC (N-Sea, 2023) include a spatial description of surficial sediments across the offshore development area derived from an interpretation of MBES backscatter and side-scan sonar. The benthic surveys (Appendix 12.1: Array Area Benthic Survey Report; and Appendix 12.2: Cable Route Benthic Survey Report) also include particle size distributions developed from a spread of sediment samples. The classification of sediment types from these datasets has been moderated to Folk 7 to be compatible with both EMODnet Geology and INFOMAR.



FOLK, 16 classes	FOLK, 7 classes	FOLK, 5 classes
Rock & Boulders	Rock & Boulders	Rock & Boulders
Gravel - G sandy Gravel - sG) gravelly Sand - gS	Coarse sediment	Coarse sediment *(Gravel >= 80% or (Gravel >= 5% and Sand >=90%)*
muddy Gravel - mG muddy sandy Gravel - msG gravelly Mud - gM gravelly muddy Sand - gmS	Mixed sediment	Mixed sediment *(Mud 95-10%; Sand < 90%; Gravel >= 5%)*
(gravelly) Mud - (g)M Mud - M	Mud *(Mud >= 90%; Sand < 10%; Gravel < 5%)*	Mud to muddy Sand *(Mud 100-10%; Sand < 90%; Gravel < 5%)*
(gravelly) sandy Mud – (g)sM sandy Mud - sM	sandy Mud *(Mud 50-90%; Sand 10-50%; Gravel < 5%)*	
(gravelly) muddy Sand – (g)mS muddy Sand - mS	muddy Sand *(Mud 10-50%; Sand 50-90%; Gravel <5%)*	
(gravelly) Sand – (g)S Sand	Sand *(Mud < 10%; Sand >= 90%; Gravel < 5%)*	Sand

Graph 10.1 Relationship with Folk Classes

Baseline Review

Figure 10.5 presents the regional-scale variation of surficial sediment types across the study area based on EMODnet Geology and overlain with a more detailed interpretation from INFOMAR within Irish Waters. The majority of the study area comprises of fine sediments; Mud, sandy Mud, and muddy Sand, along with some local-scale variations around small islands and across Dundalk Bay where there are areas of coarse sediment and rock & boulders. The main Western Irish Sea Mud Belt is represented across the north-eastern part of the study area (Mud and sandy Mud). Sand is dominant in the shallower nearshore region as well as the area of large sandwaves in the south-eastern part of the study area, beyond the offshore development area. A small area of mixed sediment seaward of the River Boyne is associated with an active spoil site A1 used by Drogheda Port. A further smaller spoil site (A2) is closer to the coast.

Figure 10.6 shows the local-scale variation of surficial sediment types within the offshore development area based on an interpretation of sediment types from the geophysical surveys (Fugro, 2022 and N-Sea, 2023) and interpreted particle size analysis obtained from the benthic surveys (Appendix 12.1: Array Area Benthic Survey Report; and Appendix 12.2: Cable Route Benthic Survey Report). This interpretation overlays the INFOMAR data for the far-field part of the study area. The surficial sediments across the array area are almost entirely classified as sandy Mud, whereas the ECC is predominantly Sand (based on Folk 7). Particle size data indicates the sand content is mainly fine sand or very fine sand in both the array area and along the ECC. The gravel content in surficial sediments is typically very low throughout, with values between 0 to 1% across the array area, around 1 to 2% across the ECC, with slightly higher values within the intertidal area (up to 22%).

10.3.5 Coastline

10.3.5.1 Available evidence

The description of the coastline within the study area, including the export cable landfall area, is supported by a classification of coastal types provided by EMODnet Geology, an overview from the Irish Coastal Protection Strategy Study (RPS, 2010), and the Project landfall assessment (GDG, 2020).

10.3.5.2 Baseline review

The main section of coastline of interest within the study area is between Clogher Head in the north to Nose of Howth in the south, Figure 10.2. This section of coastline includes the landfall site and is closest to the array area, also being in the lee of any wave attenuation effects. Within this section of coastline, the rocky headlands and gravel beaches are considered to be less sensitive to the effect of waves, whereas long open sandy beaches are likely to be more sensitive.

10.3.5.3 Clogher Head to Boyne Estuary

Clogher Head is a rocky headland (promontory of Silurian quartzite and a Special Area of Conservation (SAC) with vegetated sea cliffs) which defines the northern limit of an eastward facing sand beach fronting upland which extends south to the training wall of the Boyne Estuary, including Baltray Dunes (part of the Boyne Coast and Estuary SAC). The dunes appear to be eroding along the northern end but accreting at the southern end and stable overall (Ryle, et al., 2009). The dunes are mainly sensitive to storm waves with prevailing conditions of southerly waves driving longshore drift along the beach to the north. There is an active nearshore spoil ground (A2: Northern Near-Shore Dumping Site used for sand disposal, Figure 10.5) just off the coast in water depths between 3 to 5m, as well as a further spoil ground around 4km north-east of the northern training wall of the Boyne Estuary in water depths between 13 to 15m (A1: Seaward Dumping Site, Figure 10.5). The disposal licence (EPA Registration Number S0015-03) provides for maintenance dredging of Drogheda Port between the period 2019 to 2029 and for a total quantity of 2,816,000 wet tonnes of spoil from within the commercial estuary of the River Boyne, entrance and seaward approaches. Other spoil grounds were previously located closer to the estuary mouth but are now inactive.

10.3.5.4 Boyne Estuary to River Nanny

The mouth of the Boyne Estuary is protected by training walls to provide navigable access to Drogheda Port. These structures appear to act as barriers to longshore drift and have created the build-up of sands against the southern training wall contributing to the development of Mornington Dunes, part of the Boyne Coast and Estuary SAC. To the south of the Boyne Estuary is an eastward facing “sand beach fronting upland” which extends to the River Nanny. This beach is around 16.7 to 18.5km directly west of the northern part of the array area. The southerly end of this beach in front of Laytown has been subject to periods of erosion due to winter storms driving longshore drift moving sandy sediments along the beach to the north up to the southern training wall of the Boyne Estuary (RPS, 2014).

10.3.5.5 River Nanny to Braymore Point

To the south of the River Nanny is a further section of eastward facing “sand beach fronting upland” which extends to Braymore Point, a rocky promontory. This section of coastline is intersected by a relatively small promontory known as Ben Head. This beach is around 16.8 to 18.5km directly west of the central part of the array area with the upland area classified as a flat to gently undulating glacial outwash plain of sandur gravels (MH008: Laytown to Gormanston GCS). The southern section of this area includes the landfall of a gas interconnector at Gormanston (Interconnector 2 – Scotland to Ireland, IC2) with a pipeline which extends offshore to the north-east and establishes the north-west boundary of the array area. Net longshore drift along this section of shoreline is driven by the prevailing waves from the south-south-east.

10.3.5.6 Braymore Point to Red Island (Skerries)

From Braymore Point to the south, the coastline orientates to the south-east with a mainly low-profile rocky shoreline with occasional small pocket beaches. The landfall site is south of Braymore Point, along Bremore Bay Beach, and covers around 0.64km of shoreline. This beach is a mix of boulders and rock outcrops with shingle and sand at the top of the shore. Further along the coast is Front Strand Beach and Balbriggan Harbour which is protected from waves by two outer breakwaters. Red Island defines the end of this coastal unit and is a peninsula headland classed as erosion-resistant rock and/or cliff without loose material in the nearshore.

Skerries Harbour is located in the lee of Red Island with an outer breakwater providing shelter from northerly waves. This section of coastline is around 16.4 to 17.5km directly west of the southern part of the array area.

10.3.5.7 Red Island (Skerries) to Nose of Howth

Further east of Red Island are two small rocky (erosion resistant) islands; Colt Island and Saint Patrick’s Island, along with Shenick’s Island to the south. These three islands are important for migratory birds and are a protected area known as Skerries Islands Special Protection Area (SPA). This sequence of islands also provides some sheltering to the northerly sandy beaches from prevailing southerly waves. The coastline between Red Island and Nose of Howth is largely easterly facing, is south of the proposed development boundary, and is intersected by three estuaries which are each designated as a SAC; Rogerstown Inlet, Malahide Estuary, and Baldoyle Bay. Lambay Island is a short distance offshore and partly shelters these estuaries from easterly waves and Nose of Howth offers shelter from southerly waves. There are numerous landfalls for cables and pipelines along this section of coastline which are largely aligned to the north-east and establish the southern limit of the array area (see Volume 3, Chapter 20: Infrastructure and Other Users).

10.3.5.8 Coastline Summary

The leeward coastline adjacent to the array area comprises of long open beaches which experience longshore transport with a net drift to the north. These beaches are bounded by rocky (erosion resistant) promontories; Clogher Head and Braymore Point. Contemporary coastal erosion of the sandy shorelines is attributed to acute erosion (i.e., storm specific, event-driven) as opposed to chronic erosion (i.e., gradual, long-term) and a reduced sediment supply (i.e., sediment losses outweigh gains).

Areas immediately south of Braymore Point tend to be fronted by erosion resistant rocky foreshores, followed by a series of naturally sheltered estuaries and inlets further to the south.

10.3.6 Tidal Conditions

10.3.6.1 Available evidence

Available tidal data have been reviewed (MetOceanWorks, 2020) with a gap analysis of existing data underpinning the recommendations for project related metocean surveys which are now completed. Within the study area, this data comprises the following sites, which are also presented on Figure 10.8:

- Irish National Tide Gauge Network - long-term water level monitoring at coastal sites, including;
  - Port Oriel, Clogher Head
  - Skerries Harbour, Red Island
  - Howth
- Tide Tables - tidal predictions at selected coastal sites developed from tidal harmonics, including;
  - Dunany Point
  - River Boyne Entrance, Drogheda
  - Balbriggan, immediately south of the landfall site
  - Malahide
  - Howth
- Metocean Survey – short/ medium-term water level and flow observations at two offshore locations within the proposed development's MAC boundary and which were north-east and south of the array area to help characterise spatial variance in metocean conditions across the array area;
  - Site A, initial northern deployment location (Deployment 1, January to April 2022)
  - Site A2, redeployed further south (Deployment 2 and 3, April to August 2022)
  - Site B, southern deployment (Deployment 1, 2 and 3, January to October 2022)
- Archived data from the British Oceanographic Data Centre (BODC) providing a spread of short-term flow observations. Notably, there are two current meter deployment sites inshore of the northern part of the array area with deployments from 1994.
- Hydrodynamic model – validated against available tidal data including comparisons with the recent metocean surveys. This model supports both the baseline review and impact assessment of marine processes and has previously been used to support preliminary metocean design (MetOceanWorks, 2020).

10.3.6.2 Baseline Review

For offshore areas at depths typically beyond the influence of waves, the local tidal conditions determine the capacity for deposition and erosion of sediments, transport rates as either suspended load (typically for fine sediments) or bed load (typically for coarse sediments), as well as the net direction of transport.

The study area is located at the convergence between a rising flood tide which propagates to the north through the Irish Sea as well as a rising flood tide propagating to the south through North Channel, collectively forming high water conditions. This situation is reversed during the falling ebb tide to achieve low water. These tidal exchanges occur twice daily as a semi-diurnal tide and results in an area of relatively slack water across the study area which is conducive for deposition of fine sediments and over time has formed the Western Irish Sea Mud Belt.

The strength of the tide varies between spring and neap conditions on a fortnightly basis. Across the study area the tidal range increases slightly from the south to the north and east, in line with tidal amplification over increasing distance from a degenerate amphidrome near Courtown, south-east Ireland.

- At Howth (southern limit of study area) the mean spring tidal range is 3.6m and the mean neap range is 2.0m.
- At River Boyne Entrance (opposite the northern part of the array area and mid-way along the coastline of the study area) the mean tidal range increases slightly to 4.2m and the mean neap range is 2.3m.
- For a representative location north of the array area, the mean spring tidal range is predicted as 4.40m and the mean neap tidal range is 2.32m (MetOceanWorks, 2020).

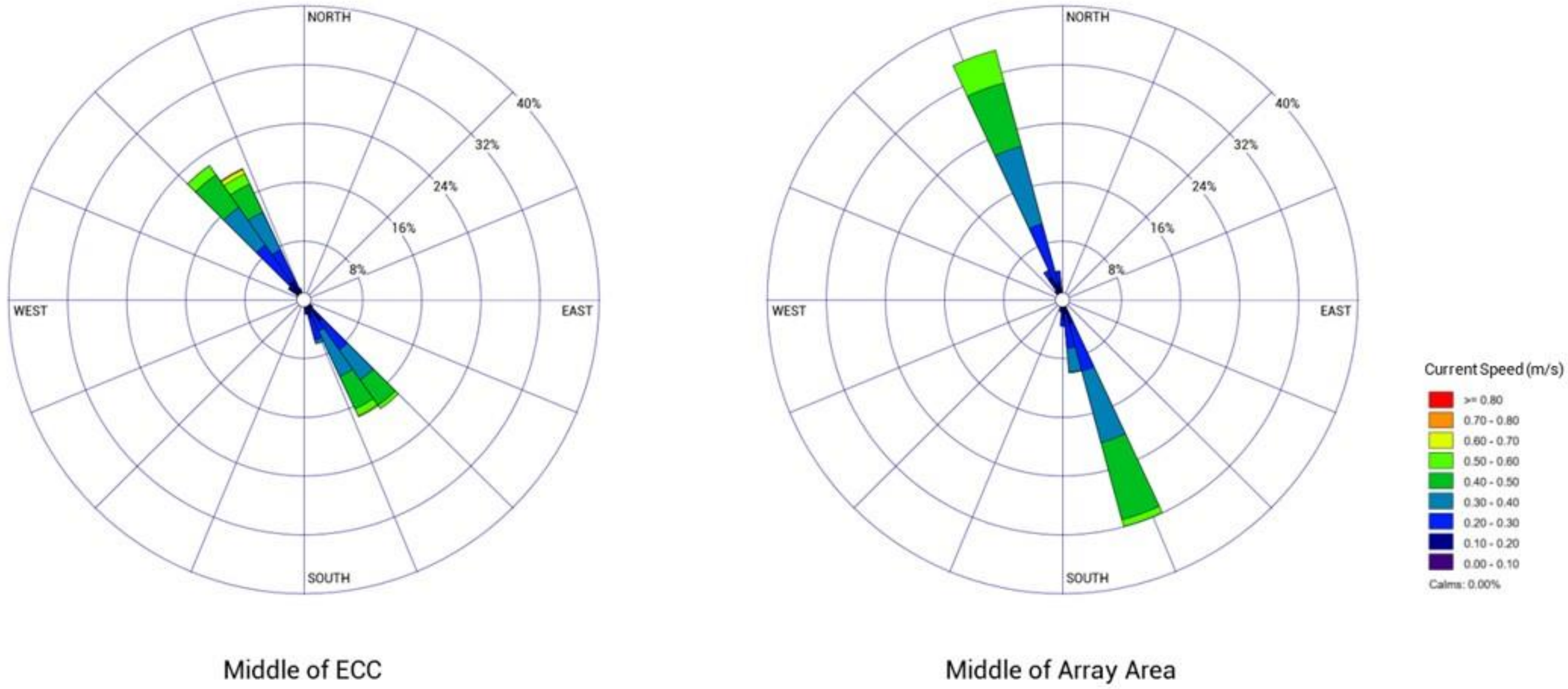
These variations in tidal range are largely consistent with meso-tidal conditions which have ranges between 2 to 4m.

The direction of flood and ebb tidal flows are generally aligned by coastal landforms and deep glacial channels, such as Western Trough. The magnitude of flows varies temporally between ebb and flood phases of the tide as well as between spring and neap tidal ranges. Spatial variation in the magnitude of tidal flows across the study area is influenced by interactions of the opposing tidal waves, water depths, headlands, narrow channels, and the width of the Irish Sea.

10.3.6.3 Tidal axis

The validated hydrodynamic model covering the study area provides the basis for describing (depth-average) tidal conditions. Two representative locations have been considered; the middle of the ECC and the middle of the array area for a 30-day lunar period to include full and new moon spring tides. Current roses for these two locations are presented in Graph 10.2 (current directions flowing ‘to’).

Both locations show a strongly rectilinear reversing flow with the ECC data indicating a flow axis towards the north-west on the flood phase and to the south-east on the ebb. The array area flow data suggests a flood direction to the north-north-west and an ebb to the south-south-east. These flow axes establish the pathways for advection and dispersion of fine sediments carried in suspension.



Graph 10.2 Current Roses

10.3.6.4 Peak flows

The current roses indicate strongest flows on the flood phase of the tide at both locations. The typical maximum peak flow speed (on spring tides) during the flood phase is around 0.48m/s within the middle of the ECC, in contrast, the equivalent peak ebb flow speed is around 0.41m/s.

There are also infrequent atypical peak flood flows which reach up to 0.64m/s which are associated with short periods of imbalance between the opposing tidal waves from the north and south which develops a local gyre. For the array area, the maximum peak flow speed (on spring tides) during the flood phase is around 0.52m/s, in contrast, the equivalent peak ebb flow speed is around 0.46m/s. Peak flows during periods of neap tide show slightly less asymmetry between flood and ebb and typically reach up to 0.3m/s.

10.3.6.5 Tidal excursion

The magnitude, direction and duration of tidal flows determine the excursion distance for fine material carried in suspension. Based on typical flows during a spring tide, the longest tidal excursion for the flood phase from the middle of the ECC is up to 6.4km to the north-west and 6.3km to the south-east on the ebb. For the array area, the equivalent distances are estimated to be 7.2km in a north-north-west (flood) direction and 6.7km in a south-south-east (ebb) direction. Tidal excursions during neap tides are around 50% of those occurring during springs.

10.3.6.6 Tidal asymmetry

Differences in the magnitude and duration of flows between flood and ebb phases of the tide establish important asymmetric characteristics such as unequal tidal excursions (relevant for the net distribution of fine suspended sediment) and unequal peak flows (relevant for net transport of coarser sediments). The present review demonstrates flood tide dominance across the proposed development area which is most prominent during spring tides.

10.3.6.7 Non-tidal influences

Water levels can also vary positively and negatively due to short-term surge events which can be driven by strong winds and / or a rapid change in atmospheric pressure. These variations occur independent of tidal state and can also lead to associated non-tidal effects on flows. Since construction works are unlikely to be conducted during stormy periods then the relevance of non-tidal influences on sediment plumes is considered to be limited.

10.3.7 Waves

10.3.7.1 Available evidence

Available wave data has been reviewed in MetOceanWorks (2020) with a gap analysis of existing data underpinning the recommendations for project related metocean surveys which are now completed. Within the study area, observational data comprises of (Figure 10.7):

- M2 Buoy – 2.5m diameter ODAS weather buoy. Data archive offers long-term wind and wave monitoring (from May 2001 to present, with directional data since September 2009) as part of the Irish Marine Data Buoy Observation Network at a deep-water site (circa 80m) located around 31km to the south-east of the southern part of the array area, and on the boundary of the study area.

- Agri-Food and Biosciences Institute (AFBI) – medium-term monitoring (processed data from September 2019 to July 2021) at a deep-water site (circa 90m) located around 15km to the east of the northern part of the array area and within Western Trough.

- Metocean Survey – short/ medium-term wave observations at two offshore locations north and south of the array area:

- Site A, initial northern deployment location (Deployment 1, January to April 2022) in a water depth of around 56m

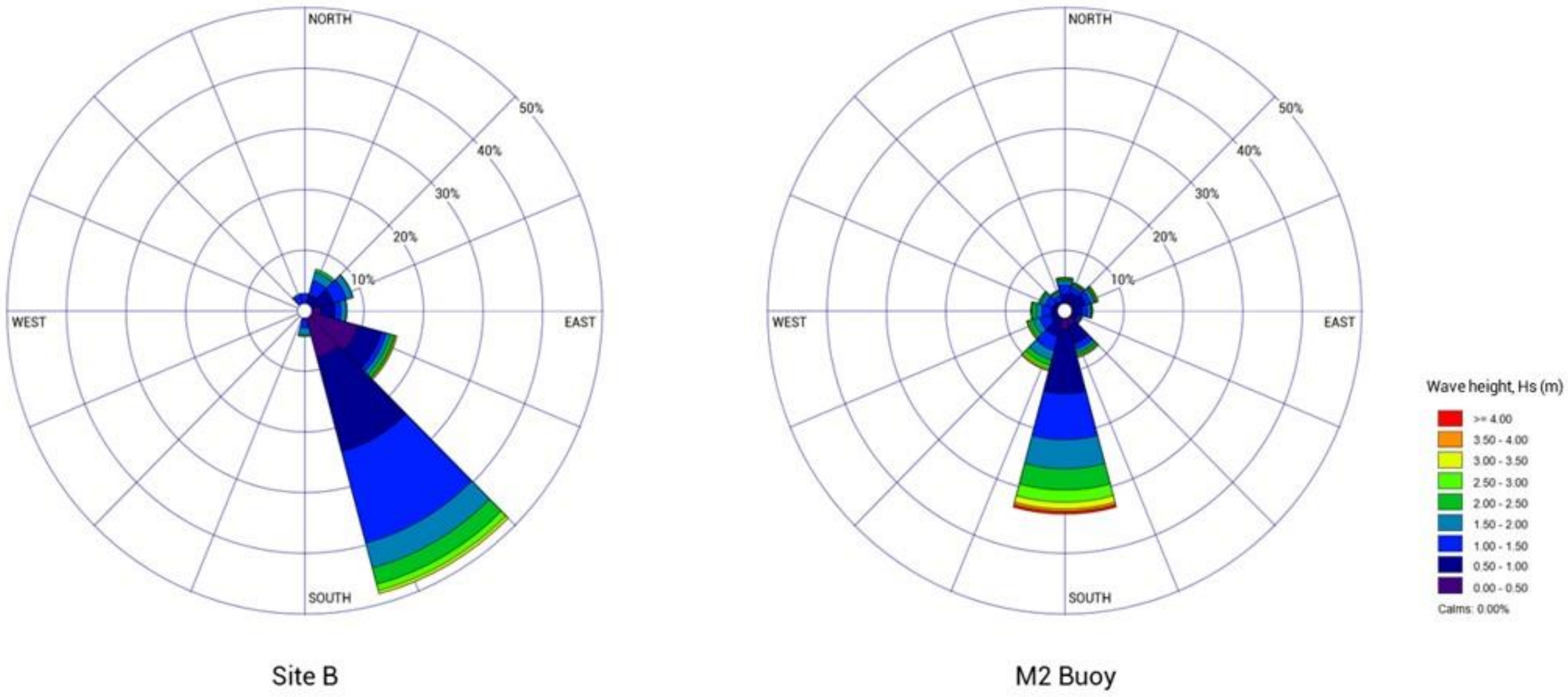
- Site A2, redeployed further south (Deployment 2 and 3, April to August 2022) in a water depth of around 58m
- Site B, southern deployment (Deployment 1, 2 and 3, January to October 2022) in a water depth of around 44m close to the southern boundary of the array area
- Wave model – validated against available wave data including comparisons with the metocean surveys. This model provides long-term data which supports both the baseline review and environmental impact assessment of marine processes (Appendix 10.2: Modelling Report) and has previously been used to support preliminary metocean design (MetOceanWorks, 2020).

10.3.7.2 Baseline review

The proposed development is located in the mid-section of the Irish Sea which is semi-enclosed with openings through the North Channel (to the north-east) and St George's Channel (to the south). The local wave environment is largely determined by fetch-limited wind-generated seas, with shortest fetches to the west towards the adjacent coastline, and longest fetches to the south, the direction which is also partially open to Atlantic swells.

Waves from north-easterly through to south-easterly directions can propagate from deeper water to pass across the array area and then move towards shallower water to reach the leeward coastline (from Clogher Head to Howth). As waves approach shallow water, they begin to shoal and dissipate some of their energy onto the seabed as well as refract in direction towards the coast. Remaining wave energy which arrives obliquely at long open sandy beach drives longshore sediment transport with stormy periods likely to have more destructive influences (i.e., highest rates of transport leading to coastal erosion).

The directional distribution of offshore waves is best demonstrated by wave roses (Graph 10.3 – wave directions 'from') based on long-term wave observations from the M2 Buoy located on the southern part of the eastern boundary of the study area and short-term observation from the metocean survey, Site B, located close to the southern boundary of the array area and also considered generally representative of the array area. It is noted that the observational periods represented in each wave rose covers different dates and numbers of observations, however, the main statistical distribution of wave direction is considered to be well-represented in each case.



Graph 10.3 Wave roses

The M2 Buoy is an open deep-water location considered to be unaffected by any coastal sheltering or depth-related shoaling or refraction effects. The dominant wave direction observed at this location is from the south (195 to 225°N), representing over 33% of all waves in the sample period (2009 to 2022). In comparison, waves measured at Site B indicate a slight change of the prevailing wave direction (south-south-east, 135 to 165°N) which represents 48% of all waves in the sample period (January to October 2022). This prevailing wave direction is consistent with long-term hindcasts reported in MetoceanWorks (2020) which suggest around 27% of all waves from this direction.

The M2 buoy has virtually uninterrupted deep water to the south whereas water depths further south of Site B shallow across Codling Bank to less than 10m. This has the effect of dissipating large waves approaching from the south and drawing in waves (through diffraction) in the lee of this feature leading to the slight change in the dominant wave direction observed at Site B. The prevailing south-south-east wave direction observed at Site B also generally aligns with the long axis of the indicative layout of wind turbine generators (WTG) across the array area. This wave direction is therefore assessed further as one of the impact scenarios since is considered to result in the greatest potential magnitude of impact for wave-related blockage effects due to the presence of foundation structures. The infrequent occurrence of swell waves (with low wave height and longer period) is also limited to waves from this direction.

Apart from the prevailing south-south-east wave direction, a second relevant wave direction is from the east-north-east (45 to 75°N) which aligns with the short axis of WTG alignment across the array area. For Site B, this direction accounts for around 9% of all waves. Waves from this direction develop as a wind-driven sea over a limited fetch length but with no contribution of swell. Long-term hindcasts suggest this direction accounts for around 7% of all waves (MetoceanWorks, 2020).

At Site B, the observed mean zero-crossing wave periods (T_z) are generally in the range 2 to 8 seconds with most waves in the sampling period (28%) between 3 to 4 seconds, all characteristic of locally generated wind-waves. Wave heights are typically between 0.5 to 1.0m. The equivalent near bed orbital velocity for these wave conditions would be 0.0m/s for water depths across the array area, i.e., no possibility to develop any wave driven stirring of seabed sediments. The largest wave height in the observation period was 3.64m with a wave period of 5.61s. The equivalent near bed orbital velocity for this wave would be 0.05m/s in a water depth of 34m (shallowest part of array area) reducing to 0.0m/s in a water depth of 62m (deepest part of the array area).

10.3.8 Sediment Transport

The interaction of wave and tidal processes with the seabed determines the fate of unconsolidated surficial sediments; the conditions for mobilisation, the way sediments are transported (i.e., bed load transport and/or suspended load transport), and the situations which are conducive to deposition. Large rivers and estuaries can also discharge a sediment load into the marine environment which might lead to locally elevated levels of suspended sediment.

The assessment of baseline sediment transport draws on available wave, tidal, and seabed information (bathymetry and sediment distributions), the application of a single point sediment transport model (Sedtrans05; Neumeier, et al., 2008) and standard methods based on Soulsby R.L., (1998), as applicable.

10.3.8.1 Wave influences

The array area is assessed to be too deep for any wave driven sediment transport for either typical conditions or larger waves.

The theoretical water depth from where the largest observed wave would begin to initiate sediment transport is estimated to be around 28m and for the typical wave conditions this depth reduces to around 10m or less. These depths only occur along the ECC at around 10km and 3km, respectively, from the adjacent coastline.

Along the shoreline, wave-driven longshore drift becomes the dominant process for sediment transport with the net direction of transport determined by the dominant wave direction (i.e., waves from the south-easterly sector drive sediment transport in a northerly direction along local beaches).

10.3.8.2 Tidal influences

For the array area, only the times of peak flood and ebb flows during spring tides are assessed to have the capacity to mobilise local surficial sediments (fine sands to silts). This capacity to mobilise seabed sediments increases slightly in the shallower parts of the array area. Given peak flood flows are slightly stronger than those during the ebb then the net direction of any sediment transport will be with the flood tide. In contrast, the magnitude of flows throughout neap tides are considered insufficient to develop any sediment transport and instead would provide a continuous period conducive to sediment deposition. The array area can therefore be considered as a depositional environment overall and an extension of the Western Irish Sea Mud Belt.

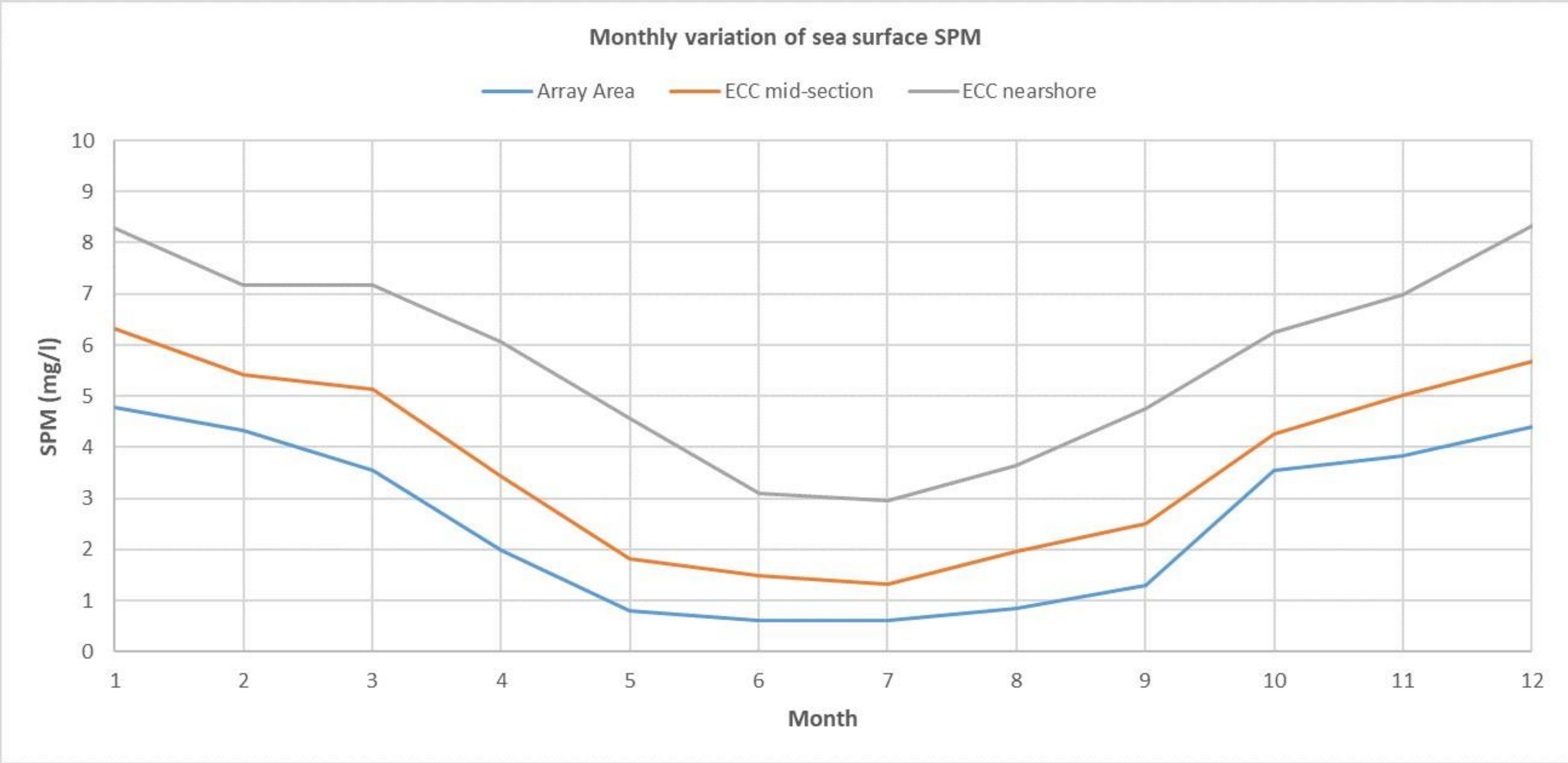
For the central area of the ECC, only times of peak flood flows during spring tides have the capacity to mobilise sediments up to fine sands. The corresponding spring peak ebb flow has the capacity to only mobilise very fine sands into suspension. In contrast, flow conditions during neap tides are insufficient to mobilise any sediment and instead would provide long periods conducive to sediment deposition.

The tidal flood dominance for this part of the Irish Sea is consistent with the direction of net sediment transport deduced from a range of independent indicators, such as asymmetry in the cross-sectional profile of macro-bedforms. This northerly net transport stems from a bedload parting zone established in the narrowest part of the Irish Sea (also generally known as the St George's Channel bedload parting zone), with net transport to the north and south of the parting zone. Figure 10.8 (based on Coughlan, 2015) presents the regional pattern of net sediment transport.

10.3.8.3 Suspended sediments

When finer sediments are mobilised, they are typically carried in suspension, contributing to a period of higher concentrations of suspended particulate matter (SPM) and increased turbidity of seawater. Large rivers, estuaries (such as those discharging into Dundalk Bay), and the dissipation of wave energy along the coastline can also lead to locally enhanced levels of turbidity in the nearshore.

Long-term (1998 to 2015) monthly average levels of sea surface SPM have been deduced from satellite data (Cefas, 2016). These data show strong seasonal variation in SPM with highest levels typically occurring in January and the lowest levels in June / July. Figure 10.9 presents the spatial variation of sea surface SPM concentrations for January and Graph 4 shows the monthly variations for three representative locations; the array area, ECC mid-section and ECC nearshore. The monthly variation is mainly attributed to stronger winds and larger waves during the winter period being able to stir the seabed in the shallower water towards the coastline which leads to the ECC nearshore location developing the highest concentrations which are then dispersed further offshore.



Graph 10.4 Monthly variation of sea surface SPM

Overall, sea surface SPM concentrations within the study area are relatively low. The location with highest sea surface SPM concentrations is Dundalk Bay, a small bay around 25km north-west of the proposed development. This bay is backed by mudflats and salt marshes and receives river discharges from the rivers Flurry, Castletown and Fane. Concentrations near the seabed may be slightly higher than sea surface. The monthly mean sea surface SPM at this location varies from 4.0mg/l in June to 14.0mg/l in January (± 2.0mg/l standard deviation).

For the array area, the monthly mean sea surface SPM varies from 0.6mg/l in June/July to 4.8mg/l in January (± 0.5mg/l standard deviation). In contrast, the metocean survey obtained water samples at Site A2 (north-east of the array) and Site B (south of the array) in January 2023 with the analysis of samples indicating total suspended solid concentrations between 13 to 38mg/l for a range of water depths, noting these samples were taken following a period of strong winds and were below the sea surface. Overall, all concentrations are considered to be relatively low.

For the ECC mid-section, the monthly mean sea surface SPM varies from 1.3mg/l in July to 6.3mg/l in January (± 1.3mg/l standard deviation).

For the nearshore part of the ECC, the monthly mean sea surface SPM varies from 2.9mg/l in July to 8.3mg/l in December (± 1.3mg/l standard deviation).

Short-term increases in SPM will also occur when licensed dumping of dredged spoil at sea occurs. In the case of spoil grounds used by Drogheda Port, the measurable extent of the sediment plume was deemed not to extend further than 600m from the point of discharge (RPS, 2019).

10.3.8.4 Summary of sediment regime

Overall, the array area can be considered as a region of net deposition of fine sediments (fine sands, silts, and muds) which is largely unresponsive to the influence of waves or tides and with generally low concentrations of suspended sediment. These attributes are in common with the wider area known as the Western Irish Sea Mud Belt. Waves and tides have an increased capacity to drive sediment transport for depths less than around 10m. These depths are present in the nearshore part of the ECC where seabed sediments generally have a lower silt content and suspended sediment concentrations of fine sediments are slightly raised compared to deeper regions of the ECC further offshore. At the landfall, wave driven processes become dominant in controlling sediment transport and sediment types. The area comprises of coarser sediment towards the coast, with shingle and sand at the top of the shoreline.

The local environmental conditions across the offshore development area are also considered unfavourable for the formation of sandwaves since the local sediments are too fine and the tidal conditions too weak. The absence of such bedforms is a further indicator of an area of net deposition (array area and offshore sections of the ECC) rather than one with active sediment transport.

10.3.9 Stratification and Fronts

Relatively weak tidal flows combined with deeper water make the majority of the study area prone to thermal stratification through the summer due to periods of increased solar irradiance and lower wind stirring influences. The depth of the thermocline is established as the base of the mixed-layer depth which is typically around 15m below the sea surface during summer. Towards the winter period, reduced solar irradiance combined with increased winds helps to break down the stratification and the study area experiences well-mixed conditions. In surrounding areas of faster flow and shallower depth, seawater remains well-mixed throughout the year. The interface between these two water bodies leads to the development of a seasonal front known as the Western Irish Sea Front (Figure 10.10, based on JNCC, 2004) which is located remote from the study area and beyond the ZoI. Fronts are frequently associated with increased biological productivity.

10.3.10 Marine Processes Receptors

Activities related to construction, operation, and decommissioning phases of the proposed offshore development may develop sources of impacts that have the potential to translate over a wider area via impact pathways and reach a more remote environmental receptor. Marine processes receptors are physical features within the study area that are susceptible to these impacts (beneficial and adverse) and could potentially experience a likely significant effect.

Within the study area, the main marine processes receptors are shown in Figure 10.1 and include:

- Adjacent coastline, including beaches, cliffs, and headlands
- Estuaries
- Nearshore islands
- Seabed, including designated features (e.g. Annex 1 reefs within the Rockabill to Dalkey Island SAC, etc.), adjacent licenced dumping at sea (DAS) spoil sites and
- Marine water body, including stratification and fronts

An impact assessment on anthropogenic physical infrastructure (such as cables and pipelines) is presented within Chapter 20 Infrastructure and Other Users.

In addition, there are other types (non-physical) of marine receptors that may also be susceptible to the impact pathways. For example, seabed disturbance events that develop sediment plumes with short-term raised concentrations of suspended sediment that have the potential to settle out on marine benthos. Where this is the case, the associated sources and pathways are considered within the marine processes chapter, but the impact assessment on the related receptor is provided in the relevant EIA chapter.

10.4 Characteristics of the Proposed Development

This section outlines the characteristics of the proposed development that are relevant to the identification and assessment of effects on marine processes during each phase of the proposed development.

This section outlines the characteristics of the proposed development that are relevant to the identification and assessment of likely significant effects on marine processes during each phase of the proposed development. In this chapter this is limited to activities and infrastructure occurring in the offshore environment and it considers both Project Option 1 and Project Option 2 (the key characteristics of which are provided in Table 12.5 and are detailed in full in the Offshore Description Chapter).

Table 10.6 Key characteristics of Project Option 1 and Project Option 2

Key Offshore Characteristics	Project Option 1	Project Option 2
Array area	88.5km^2	88.5km^2
ECC	36.45km^2	36.45km^2
Landfall	One landfall site, immediately south of Bremore Point, which includes two subtidal exit pits within the ECC	One landfall site, immediately south of Bremore Point, which includes two subtidal exit pits within the ECC
Wind Turbine Generator (WTG)	49 WTGs with 250m rotor diameter	35 WTGs with 276m rotor diameter
WTG Foundations	49 monopiles of 12.5m diameter requiring seabed preparation	35 monopiles of 12.5m diameter or jacket foundations (three or four leg configurations, with 6m diameter pin piles) requiring seabed preparation
Offshore Substation Platform (OSP) Foundations (array area)	One OSP, with either a four-legged jacket foundation with pin piles, or one monopile; or two monopiles	One OSP, with either a four-legged jacket foundation with pin piles, or one monopile; or two monopiles
Cables	Installation of 111km of array cables within the array area and installation of two 18km export cables within the ECC	Installation of 91km of array cables within the array area and installation of two 18km export cables within the ECC

A presentation of the potential impacts in relation to Project Option 1 and Project Option 2 is provided, and the magnitude of those impacts in relation to the size and scale of the proposed development parameters. This enables the identification of the Project Option that will result in the greatest magnitude of impact on receptors and will therefore present the greatest potential for a likely significant effect (Table 12.11).

To determine the magnitude of the impact level, modelling, calculations and mapping have been undertaken for the Project Option with the greatest magnitude of impact, for all impacts for the relevant receptor/s.

The significance of effect assessment is then undertaken for both project options, which considers both receptor sensitivity and the magnitude of the impact and is detailed in Section 10.5.

10.4.1 Parameters for Assessment

Construction, operation and decommissioning activities, and infrastructure and key design parameters, have been considered within this chapter when determining the potential impacts. Further detail on the offshore elements of the proposed development is provided in the Offshore Description Chapter and Offshore Construction Chapter. These parameters apply to both project options and any differences in values that may require consideration have been identified in Table 10.6.

10.4.2 Embedded Mitigation Measures

The design development process for the proposed offshore development has included a reduction in the overall array area which has a potential beneficial reduction to impacts on marine processes receptors.

10.4.3 Potential Impacts

The identification of potential impacts has been undertaken by considering the key characteristics from both project options (refer to Section 10.4.1) and the potential for an impact pathway to have direct or indirect impacts on marine processes receptors (as identified in Section 10.3.10). Each identified impact relevant to marine processes is presented in Table 10.6.

For each impact, the relevant project characteristics of Project Option 1 and 2 are presented to determine the magnitude (size or extent) of the potential impact, defined by the proposed development parameters in the Offshore Description Chapter and in consideration of the WTG Limits of Deviation (LoD[3]), in line with the approach detailed in the EIAR Methodology Chapter. A comparison of the project options has then been undertaken to determine which has the greatest magnitude of impact.

The potential impacts on marine processes for each stage of proposed development are considered. In some cases, the source of effects (occurring in the near-field) is spread further by an impact pathway which may then reach a more distant receptor (located across the far-field). Where appropriate, these types of sources and impact pathways are investigated with appropriate modelling tools described in Appendix 10.2: Modelling Report. Some impact pathways, such as sediment plumes, are more relevant to other types of marine receptors (apart from marine processes) where there is a potential interaction. In these cases the assessment of likely significant effects is considered in the relevant chapter associated with those types of receptors (e.g. benthic ecology, fish and shellfish, marine water and sediment quality).

The significance of effect assessment on marine processes receptors is then undertaken which considers both receptor sensitivity and the magnitude of the impact. This assessment is detailed in Section 10.5.

Appendix 10.1: Marine Processes Review of Project Options provides a detailed review of Project Option 1 and Project Option 2 (drawing from the Offshore Description Chapter) as well as the alternative installation methods (drawing from the Offshore Construction Chapter).

[3] Both Project Option 1 and Project Option 2 layouts have a 500m Limit of Deviation (LoD).

Table 10.6 Potential impacts and magnitude of impact per project option. The project option that has the greatest magnitude of impact is identified in blue.

Potential impact	Project 1 (49 WTG)	Project 2 (35 WTG)	Rationale for the project option with the greatest magnitude of impact	Relevant modelled scenario reference within Appendix 10.1 – 10.3
Construction				
Impact 1 – Physical changes from seabed clearance activities at WTG locations and along cable routes to remove boulders and debris	WTG numbers: 49 Inter-array cable length: 111km ECC length: 18km (with two cables)	WTG numbers: 35 Inter-array cable length: 91km ECC length: 18km (with two cables)	Project Option 1 presents the option with the greatest magnitude for impact on marine processes receptors as it is likely to require the greatest area of seabed clearance due to the larger number of WTGs and greater length of inter-array cables.	Not applicable
Impact 2 – Physical from seabed levelling for Project Option 2	Seabed levelling not applicable to monopile foundations.	Foundation type: jacket or monopile Method: TSHD Diameter of scour protection and seabed prep: 77m Percentage of locations required to be levelled: 50% Total WTG removal volume: 107,004m^3 Diameter of OSP scour protection and seabed prep: 78m Total OSP removal volume: 6,082m^3 Total volume of sediment to be removed: 113,086m^3	Seabed levelling is only a requirement for the jacket type foundation, which is only an option in Project Option 2.	C-01 – Seabed levelling
Impact 3 – Physical changes from increased suspended sediment concentration and settlement from drilling for foundation installation	Number of piles: 49 WTG with singular monopiles and 1 OSP with two monopiles WTG Pile diameter: 12.5m WTG Embedment depth: 50m Percentage of sites: 75% WTG total volume of arisings: 338,243m^3 OSP total volume of arisings: 22,089m^3	Number of piles: 35 WTG with 4-leg jackets and 1 OSP with two monopiles WTG Pile diameter: 6m WTG Embedment depth: 60m Percentage of sites: 100% WTG total volume of arisings: 356,257m^3 OSP total volume of arisings: 22,089m^3	Although the total volumes of drill arisings are comparable, Project Option 2 produces a slightly larger volume due to four piles per foundation and a longer embedment depth.	C-02 Drilling for Foundation Installation

Potential impact	Project 1 (49 WTG)	Project 2 (35 WTG)	Rationale for the project option with the greatest magnitude of impact	Relevant modelled scenario reference within Appendix 10.1 – 10.3
	Total volume arisings: 360,332m^3	Total volume arisings: 378,346m^3		
Impact 4 – Physical changes from increased suspended sediment concentration from cable installation in the array area	Inter-array cable length: 111km	Inter-array cable length: 91km	Project Option 1 will have a slightly longer set of inter-array cables due to more WTG connections. The modelling of considers an array area cable trenching section of 1.9km which can be applied to either Project Option 1 or Project Option 2.	C-03 Cable Installation – array area
Impact 5 – Physical changes from increased suspended sediment concentration from cable installation along the ECC	ECC length: 18km (with two cables) Trench depth: 3m Trench width: 1 m	ECC length: 18km (with two cables) Trench depth:3m Trench width: 1 m	Project Option 1 and 2 will have an equal magnitude of impact as the proposed export cable lengths are the same.	C-04 Cable Installation - ECC
Impact 6 – Nearshore changes due to the excavation of the Horizontal Directional Drilling (HDD) exit pits	Number of nearshore HDD exit pits: 2 Width: 20m Length: 30m Depth: 1.5 – 2.5m Transition zone: 6m wide by 50m long Volume of excavation: 3,960m^3	Number of nearshore HDD exit pits: 2 Width: 20m Length: 30m Depth: 1.5 – 2.5m Transition zone: 6m wide by 50m long Volume of excavation: 3,960m^3	Project Option 1 and 2 will have an equal magnitude of impact as the proposed HDD exit pit locations and the same construction approach to excavation applies to both project options.	C-05 HDD at exit pits
Impact 7 – Nearshore changes from the release of bentonite at the HDD exit pits	Bentonite release from nearshore HDD exit pits Quantity of drilling muds released: 30 tonnes	Bentonite release from nearshore HDD exit pits Quantity of drilling muds released: 30 tonnes	Project Option 1 and 2 will have equal magnitude of impact as the proposed HDD exit pit locations and bentonite release volumes applies to both project options.	C-06 Bentonite release
Impact 8 – Physical changes to seabed from the use of construction vessels	WTG numbers: 49 OSP number: 1	WTG numbers: 35 OPS number: 1	Jack-up vessels deployed to WTG and OSP locations have the potential to leave spud-can depressions on a consolidated muddy seabed. Project Option 1 has more WTG locations than Project Option 2, therefore a slightly greater potential for more seabed depressions.	Not applicable

Potential impact	Project 1 (49 WTG)	Project 2 (35 WTG)	Rationale for the project option with the greatest magnitude of impact	Relevant modelled scenario reference within Appendix 10.1 – 10.3
Operation and Maintenance				
Impact 9 – Physical changes from cable crossings within the array area	Number of cable crossings: 5 Area of seabed covered by each cable crossing: 360m^2 Area of seabed covered by all five cables: 1,800m^2 Cable crossing height: 2.5m Total volume of rock armour at cable crossings: 3188 m^3	Number of cable crossings: 5 Area of seabed covered by each cable crossing: 360m2 Area of seabed covered by all five cables: 1,800m^2 Cable crossing height: 2.5m Total volume of rock armour at cable crossings: 3188 m^3	Project Option 1 and Option 2 will have an equal magnitude of impact as the proposed number of cable crossings in the array area the same for both project options.	Not applicable
Impact 10 - Physical changes from increased suspended sediment concentration from cable repairs and/or reburial	111km inter-array cables and 36km export cables Length of cable repair (per activity): 200m De-burial method: Mass Flow Excavator (MFE) or jetting tools	91km inter-array cables and 36km export cables Length of cable repair (per activity): 200m De-burial method: MFE or jetting tools	Project Option 1 has a greater length of inter-array cables than Project Option 2.	Not applicable
Impact 11 - Physical changes from cable protection	111km inter-array cables and 36km export cables requiring 20% cable protection. Inter-array cables: Cable length requiring protection: 22.2km Area of seabed covered by cable protection: 111,000m^2 Total volume of rock armour: 133,200m^3 Export cables: Cable length requiring protection: 7.2km Area of seabed covered by cable protection: 36,000m^2 Total volume of rock armour: 43,200m^3	91km inter-array cables and 36km export cables requiring 20% cable protection. Inter-array cables: Cable length requiring protection: 18.2km Area of seabed covered by cable protection: 91,000m^2 Total volume of rock armour: 109,200m^3 Export cables: Cable length requiring protection: 7.2km Area of seabed covered by cable protection: 36,000m^2 Total volume of rock armour: 43,200m^3	Project Option 1 has a greater length of inter-array cables than Project Option 2.	Not applicable

Potential impact	Project 1 (49 WTG)	Project 2 (35 WTG)	Rationale for the project option with the greatest magnitude of impact	Relevant modelled scenario reference within Appendix 10.1 – 10.3
Impact 12 – Physical changes to the coastline from a modification in storm waves due to array-scale blockage	Number of piles: 49 WTG with singular monopiles and 1 OSP with two monopiles WTG Pile diameter: 12.5m	Number of piles: 35 WTG with 4-leg jackets and 1 OSP with two monopiles WTG Pile diameter: 6m	Project Option 1 will have the greatest magnitude of impact due to the larger number of WTG causing the potential blockage effect on passing waves.	O-01
Impact 13 - Physical changes to marine processes receptors from modification of the tides due to array-scale blockage	Number of piles: 49 WTG with singular monopiles and 1 OSP with two monopiles WTG Pile diameter: 12.5m	Number of piles: 35 WTG with 4-leg jackets and 1 OSP with two monopiles WTG Pile diameter: 6m	Project Option 1 has the greatest magnitude of impact due to the larger number of WTG causing the potential blockage effect on passing flows.	O-02
Decommissioning				
Impact 14 – Physical changes to marine processes receptors from decommissioning activities	WTG numbers: 49 Inter-array cable length: 111km ECC length: 18km (2 cables)	WTG numbers: 35 Inter-array cable length: 91km ECC length: 18km (2 cables)	Project Option 1 presents the option with the greatest magnitude for impact on marine processes receptors as it is likely to require the greatest removal WTGs.	Not applicable

10.5 Potential Effects

The likely significant effects, both adverse and beneficial, on marine processes for each stage of the proposed development are considered. Specifically, the likely significant effects of the proposed development during its construction, operational, and decommissioning phases associated with the offshore development area on the receiving environment are assessed. The environment in the study area is naturally dynamic, and as such will exhibit some level of natural variation and change over time whether the proposed development proceeds or not. Consequently, the identification and assessment of likely significant effects must be done in the context of natural change, both spatial and temporal.

10.5.1 Do-Nothing Scenario

The do-nothing scenario represents the baseline conditions for marine processes that are expected to prevail without the proposed development taking place and with consideration of an equivalent duration as the MAC (covering construction, operation, and decommissioning periods). Given the proposed development timescales span several decades (i.e., three years for construction activities seaward of the HWM and 35 years for operation) then baseline variability over this period is also considered, including the likely effects of climate change. The future baselines for tidal and wave conditions are described in Section 10.5.1.1 and Section 10.5.1.2 below.

10.5.1.1 Future baseline tidal conditions

Climate change is expected to lead to increased rates of sea level rise globally which will also exhibit some regional variations. For the study area, reference has been made to the Climate Change Sectoral Adaptation Plan for Flood Risk Management (OPW, 2019) which draws on evidence from the IPCC. Two possible scenarios are considered for a projected rate of sea level rise for the study area:

- Mid-Range Future Scenario (MRFS) with a rate of 5mm/year (500mm by 2100) and
- High-End Future Scenario (HEFS) with a rate of 10mm/year (1,000mm by 2100)

In relation to the project timeline, construction is expected to take three years for construction activity seaward of the HWM followed by an operational phase of 35 years. Accordingly, a projected increase in mean sea level from present day to the end of the operational period could be between 190 and 380mm for the two climate change scenarios. The likely consequences of an increasing mean sea level are for an associated increase in extreme water levels, a marginal landward movement of the high-water line, and for wave shoaling effects to commence slightly closer to the shore. These changes are likely to lead to a progressive increase in erosional pressures on the coastline additional to the existing erosional regime. This regional scale effect is anticipated with (i.e. development scenario) or without (i.e. do nothing scenario) any development taking place.

10.5.1.2 Future baseline wave conditions

Climate change effects are not expected to lead to any measurable difference in baseline wave conditions (i.e. detectable above natural variations) over the period of the proposed development, largely because the study area has a fetch-limited sea state and is generally sheltered from swell waves. This situation is anticipated for both with (i.e. development scenario) or without (i.e. do nothing scenario) any development taking place.

10.5.2 Construction Phase

The Offshore Construction Chapter outlines the offshore construction strategy and activities which are largely expected to be carried out on a sequential basis. Some of these activities may develop local seabed disturbance events which may develop sediment plumes with subsequent settlement of material back to the seabed, however, the sequential basis of these activities limits the opportunity for overlapping sediments plumes (i.e., sediment plumes from one activity are expected to fully disperse with material settling out of suspension prior to the occurrence of a subsequent sediment disturbance event due to a different activity).

The time-aggregated impact pathways for different types of construction activities and locations are described by a hydrodynamic and particle tracking model. These models simulate the sediment release (source) and spread of material (typically fine sediments) by tidal advection as a sediment plume (impact pathway), as well as the subsequent settlement back to the seabed.

The sediment plume is established as the elevated concentration of material in suspension above background ambient conditions. Any coarser sediments present will tend to quickly settle back down to the seabed without the opportunity for wider spreading by tidal advection, and remain close to the area of disturbance. Since the magnitude of tidal flows varies between spring and neap tides, and their associated flow directions switch between flood and ebb phases, the modelling has considered separate releases for these four main tidal flow conditions for each construction scenario to cover a representative envelope of possible outcomes. The time-aggregated result represents the area which could potentially be affected by any of the four scenarios. The actual tidal conditions that occur during a short-term period of seabed disturbance are expected to be bounded by these four events.

Predicted levels of elevated suspended sediment carried by a sediment plume represent a temporary period of increase relative to ambient conditions. Elevated suspended sediments are presented with the scale shown in Table 10.7.

Table 10.7 Assessment of elevated suspended sediment concentrations

Suspended Sediment Concentration (mg/l)	Relative to baseline conditions
<1	Trace level, largely undetectable above background
1 to 2	Normal variation in ambient concentration (magnitude of standard deviation)
2 to 5	Typical ambient concentration (summer)
5 to 10	Typical ambient concentration (winter)
10 to 20	2*ambient
20 to 50	4*ambient
50 to 100	10*ambient
100 to 200	20*ambient
200 to 500	40*ambient
500 to 1,000	100*ambient
>1,000	200*ambient

Predicted levels of settled sediment to the seabed are presented with the scale shown in Table 10.8:

Table 10.8 Assessment of depth of settled sediment

Depth of Settled Sediment (mm)	Potential for settlement
<1	Trace level, largely undetectable
1 to 2	Very low level of settlement
2 to 5	
5 to 10	Low level of settlement
10 to 20	
20 to 50	
50 to 300	Considered as “light” risk of smothering for benthic receptor (Tyler-Walter, et al., 2018).
>300	Considered as “heavy” risk of smothering for benthic receptor (Tyler-Walter, et al., 2018).

10.5.2.1 Impact 1 – Physical changes from seabed clearance activities

The construction phase of proposed development will require seabed clearance activities (described in Offshore Construction Chapter for Pre-Lay Grapnel Run and Boulder Clearance) which are planned prior to cable laying in the array area and along the ECC to ensure there are no obstructions that might impede cable laying tools, such as debris and boulders. These activities have the potential to directly impact any physical features within the study area.

Sensitivity of the receptor

The marine processes receptor directly involved in the seabed clearance activity is the seabed itself with the impact limited to the clearance route only. No part of this route is designated for nature conservation. The seabed is considered to have a low sensitivity to this activity as the target for clearance activities are the debris and boulders on the seabed rather than the seabed directly.

Magnitude of impact

The site-specific geophysical surveys indicate that sandwaves are not present (nor would they be expected to develop under the local marine process conditions) within the offshore development area, meaning sandwave clearance is not a requirement. Given the expected seabed clearance requirements are minor, short-term and highly localised then this activity is not considered to develop any major seabed disturbance impacts such as sediment plumes.

The magnitude of impact is assessed as negligible (i.e. short-term and barely discernible changes anticipated in the near-field for limited parts of the cable routes where clearance is required, with no far-field effects) for both Project Option 1 and Option 2.

To note, the same sections of seabed are involved in subsequent cable laying activities which have a higher level of impact over the entire cable route, rather than parts of the route).

Significance of the effect

As the sensitivity of the seabed is low and the magnitude of impact to the seabed is assessed as negligible, the significance of the effect on the seabed for both Project Option 1 and Project Option 2 is determined to be not significant, which is not significant in EIA terms.

10.5.2.2 Impact 2 – Physical changes from seabed levelling (Project Option 2 only)

The construction phase of the proposed development may require seabed levelling (or profiling) where seabed features exist to accommodate the installation process of the jacket foundations in order to give a level and stable platform for the jacket structure prior to placement of seabed frame and piling.

Project Option 2 includes both monopile and jacket foundation options, however, only the jacket foundations require a provision for seabed levelling at up to 50% of locations (WTG and OSP), equivalent to 18 sites. Levelling is required to aid successful placement of scour protection material around the wider base of jacket foundations, noting some sites are expected to already be sufficiently level. Dredging is assumed to be required at only 50% of locations due to the varied seabed conditions across the site, meaning some locations will not require dredging prior to jacket foundation installation. Project Option 1 does not include the jacket foundation option, so seabed levelling requirements are only applicable to Project Option 2. Project Option 1 does not include the jacket foundation option, so seabed levelling requirements are only applicable to Project Option 2.

Sensitivity of the receptor

The marine processes receptors exposed to seabed levelling are isolated parts of the water column (which experience a short-term increase in suspended sediment concentration in the form of sediment plumes developed by overspill and disposal of sediment from the TSHD) and small areas of the corresponding seabed due to settlement from sediment plumes and spoil disposal. The impact pathway does not reach any part of the adjacent coastline, any estuary, or rocky islands in the nearshore, or any marine designated areas. The water column and seabed are considered to have a low sensitivity to this activity, due to its high capacity to accommodate the changes from seabed levelling.

Where relevant, impacts to the water column and seabed are also considered in relation to sensitivity of biological receptors in associated chapters (e.g. risk of smothering of benthic receptors).

Magnitude of impact

The assessed method for seabed levelling with the greatest potential impact is a large trailer suction hopper dredger (TSHD) with a capacity of around 15,000m^3 which removes material from the seabed to fill the hopper, overspills some fine sediment towards the end of the loading cycle, and then transits to a nearby location to dispose of the spoil as a near-instantaneous discharge back to the seabed.

Each WTG foundation requires removal of around 5,945m^3 of sediment, and 6,082m^3 for the OSP, a total of up to 113,086m^3 for all 18 jacket foundation sites requiring levelling. Accounting for bulking-up of sediment in the hopper and overspill losses, there is estimated to be ten loading and disposal cycles to complete all seabed levelling. This dredging would be conducted by a single TSHD working in sequence from site to site. Each site would develop a separate sediment plume which would be short-lived, leading to subsequent settlement spread across a wider area.

The impact pathway of the assessed sediment plume spreading over the far-field is established using modelling tools as impact scenario C-01 and for a representative envelope of four tidal conditions (i.e. ebb and flood releases for both neap and spring tidal conditions). This scenario represents a location toward the mid-section of the northern part of the array area which coincides with the highest content of fine sediment in surficial sediment, as determined by benthic survey grab sampling. Accordingly, all other dredging locations are considered to have seabed conditions with a slightly lower content of fine sediments which would form sediment plumes with slightly lower concentrations of suspended sediment and reduced deposition depth from sediment settlement.

Figure 10.11 presents the time-aggregated marine track of sediment plumes for the four representative tidal scenario impact pathways. The model output represents the maximum elevated level of suspended sediment concentration that occurs at any time during the existence of the plume from the initial releases and over a successive period of 60 hours (equivalent to around five phases of ebb and flood tides) for all four tidal scenarios combined. Any elevated levels are also temporary until plume related sediments have settled out of the water column. Accordingly, the area likely to experience a temporary period of elevated suspended sediment is fully covered in this footprint of potential impact on the water column (equivalent to the ZoI for this impact), noting the actual outcome would follow a single tidal pathway within this footprint and according to the tidal conditions at the time of release. Although all initial tidal excursions (with highest concentrations of suspended sediment up to around 1,000mg/l) remain within the tidal excursion buffer (the maximum extent of the tidal excursion), subsequent excursions (with lower concentrations <100mg/l) tend to develop a net excursion to the north which is due to the flood dominant flow. Although the flood phase release on a spring tide has the potential to cross into UK territorial waters for a short period this is with a very low concentration (<1mg/l) at the trace level and would be undetectable in the marine environment.

The actual size of the sediment plume varies over time and distance from source, initially being small at the time of release then increasing gradually in size due to spreading with advection and dispersion which has the effect of reducing concentrations of suspended sediment. In addition, concentrations also steadily reduce due to settlement of the fine sediment slowly falling out of suspension. After a period of around 20 hours from the initial release the plume is expected to cover an area of between 0.2 to 0.4km^2 on neap releases (peak concentration around 240 to 270mg/l) and 0.8 to 0.9km^2 on spring releases (peak concentration of 100 to 110mg/l). These discrete events are also shown on Figure 10.11 (as foreground plumes), for reference.

Once suspended sediment settles out of suspension from the sediment plume there will be areas of seabed which experience sedimentation. Figure 10.12 presents the footprint of maximum sedimentation from all four tidal scenarios with a distribution which mimics the footprint of the sediment plume. All sedimentation depths of settled sediment remain less than 50mm (0.05m), with depth of sedimentation which rapidly decreases over distance from the source of the sediment release. For the flood release on a spring tide there is potential for some deposition in UK territorial waters, however, the depth of any sedimentation would be <1mm (i.e., trace levels).

In addition to the gradual settlement of suspended sediment from the sediment plume is the near instantaneous disposal of dredged sediment from the TSHD which is expected to develop a spoil mound on the seabed.

Appendix 10.3 presents the assessment of the scale of spoil mounds which are initially expected to cover an area of around 0.19km^2, typically with a height between 0.3 to 1m, and with a maximum height of 1.71m. The area covered by sediment depths above 0.05m is estimated to be around 0.15km^2, and 0.08km^2 for depths above 0.30m (for context, deposition levels of 0.05m and 0.30m are regarded as conditions which would risk the smothering of benthic receptors at “light” and “heavy” levels (Tyler-Walter, et al., 2018)). As long as the disposal location is close by the location of seabed levelling then the sediment types will remain compatible between the spoil mound and the ambient seabed.

All settlement will rejoin the local sediment transport regime which is mainly depositional for fine sediments across the array area.

The magnitude of impact on both the water column and seabed receptors is assessed to be low due to the temporary, localised and low levels of change. This impact is only applicable to Project Option 2 and for jacket foundations.

Significance of the effect

As the sensitivity of the water column and seabed is low and the magnitude of impact to the seabed is assessed as low, the significance of the effect on the water column and seabed marine processes receptors (due to seabed levelling provisions at up to 50% of jacket foundation locations considered in Project Option 2 only), is determined to be slight, which is not significant in EIA terms.

10.5.2.3 Impact 3 – Physical changes to marine processes receptors from increased suspended sediment concentration and settlement from drilling out of piles for foundation installation

The depth below seabed to bedrock across the array area indicates that drilling may be required for the majority of piled foundation sites, with the likelihood increasing with a greater pile embedment depth. The greatest total volume of drill arisings relates to jacket foundations with four piles considered for Project Option 2 (as determined in Appendix 10.1). This total is based on drilling out 100% of piles to an embedment depth of 60m. In contrast, Project Option 1 has a slightly lower total volume of drill arisings based on pile drilling at up to 75% of WTG monopile locations to an embedment depth of 50m, noting impacts are expected to be comparable.

A single drilling platform would be used, limiting the operation to a sequential activity across the array area for each foundation location requiring drilling. Drill arisings would be returned to the drilling platform to be discharged back to the sea via a fall pipe. Each marine discharge may develop a separate sediment plume which subsequently falls out of suspension with settlement on the seabed. The fate of the discharge depends on the size and density of drill cuttings particles, as well as the tidal flows that can advect the material away and local water depths. Since the size of drill cuttings remains unknown at this time, a conservative assumption is made that the majority of particles comprise a range of fine particle sizes that will settle slowly to the seabed and have a greater potential to form a sediment plume than coarser sized cuttings particles. Any coarser particles would expect to fall directly to the seabed, without any opportunity for wider advection, and may form a small cuttings pile at each drilling location.

Sensitivity of the receptor

The marine processes receptors exposed to the discharge of drill cuttings are isolated parts of the water column (which experience a short-term increase in suspended sediment concentration in the form of sediment plumes developed by discharge of fine sized cuttings particles from the drill rig fall pipe) and small areas of the corresponding seabed due to settlement of cuttings. The impact pathway does not reach any part of the adjacent coastline, any estuary, or rocky islands in the nearshore, or any marine designated areas. The water column and seabed are considered to have a low sensitivity to this activity due to their high capacity to accommodate the increased SSC, effecting turbidity but not waves and tides (Table 10.2).

Where relevant, impacts to the water column and seabed are also considered in relation to sensitivity of biological receptors in associated chapters (e.g. risk of smothering of benthic receptors).

Magnitude of impact

Given the sequential drilling from site to site, the individual location which is expected to develop the largest amount of drill cuttings is the OSP with two monopiles requiring embedment depths of 60m taking around 172 hours to complete. This is the same case for both Project Option 1 and Option 2. On this basis, all other drilling activities with different foundation types can be considered to develop a lesser scale of impact from each drilling event from a single location, noting that the largest total volume of drill arisings from all locations remains with the jacket foundation piles being considered for Project Option 2.

The impact pathway of sediment plumes spreading and settling of fine cuttings particles across the far-field due to drill arisings produced from the two OSP monopiles (22,089m^3) is established using modelling tools as scenario C-02.

Based on the longer release period covering both ebb and flood tidal phases, the main variation in impact pathways exists between spring and neap tides and is established by two longer tidal scenarios.

The time-aggregated marine impact pathway of sediment plumes produced by drill cuttings is presented in Figure 10.13 for the two representative tidal scenarios, combined. The model output shows the maximum suspended sediment concentration that occurs at any time from the initial release and over a successive period of 224 hours (equivalent to around 18 phases of ebb and flood tides), noting the actual outcome would follow a single tidal pathway within this footprint and according to the tidal conditions at the time of release. The initial ebb and flood tidal excursions remain within the tidal excursion buffer with subsequent excursions eventually spreading further afield. Notably, the spring release shows a distinctive net excursion to the north with the flood dominant flows which has the potential to cross into UK territorial waters for a short period but with a very low concentration (<1mg/l, trace). The neap release appears more symmetrical between ebb and flood phases. All occasions with an increased concentration of suspended sediment above background > 10mg/l remain within the tidal excursion buffer. Highest concentrations in the range 500 to 1,000mg/l are confined close to the point of discharge. Outside the tidal excursion buffer suspended sediment concentrations are <10mg/l and equivalent to background levels. As an illustration of plume development, at 20 hours the sediment plume from drill arisings during the neap tide release extends around 11.5km to the south covering an area of up to $8km^2$. The maximum elevated concentration of suspended sediment at this time is around 26mg/l. The spring tide release at 20 hours extends over an area of around $10km^2$ and 11.8km to the north with a maximum elevated concentration of around 31mg/l.

The far-field distribution of settled drill cuttings (fines particles) from the OSP location is presented in Figure 10.14 for the combined spring and neap scenarios. The spatial distribution of settled cuttings particles mimics the impact pathway of elevated concentration of suspended sediments and with reduced levels of deposition over distance from the release location. Maximum deposition depths of settled cuttings in the range 20 to 50mm remain close to the drilling location which reduces to between 5 to 10mm up to the adjacent WTG location. Only trace levels (<1mm) exceed the tidal excursion buffer. Subsequent drilling for WTG foundation piles along the same row of turbines has the potential to develop additional levels of deposition which could be additive in some places. For an adjacent WTG location along the same row, an initial depositional depth of up to 5 to 10mm could receive an additional 5 to 10mm. If the produced drill cuttings contained a smaller fraction of fine particles and a correspondingly larger contribution of coarser particles (potentially valid for the bedrock layer) then local cuttings piles could develop close to the base of each drilled foundation with an associated reduction in settlement depths further afield, limiting the chance of additive deposition.

Given that tidal flows across the array area are generally similar, then comparable suspended sediment and deposition results would be expected for all other locations where drilling is required, noting the volume of drill arising from any single WTG location is around 50% less (10,179m^3 for jacket foundations and 9,205m^3 for monopile foundations) than the OSP drilling represented in C-02, so any raised levels of suspended sediment and subsequent settlement would be proportionally less.

The magnitude of impact on both the water column and seabed receptors is assessed to be low due to the generally temporary, localised and low levels of change for Project Option 2 (jacket foundation option with the highest volume of drill cuttings) and therefore slightly lower for Project Option 1 (monopiles) and Project Option 2 (monopiles).

Significance of the effect

As the sensitivity of the water column and seabed is low and the magnitude of impact to the seabed is assessed as low, the significance of the effect on the water column and seabed marine processes receptors due to the discharge of drill cuttings is determined to be slight, which is not significant in EIA terms. This outcome is valid for the location with the highest volume of drill cuttings (OSP monopile option) as well as the aggregate effect of all discharges from either Project Option 1 or Option 2.

10.5.2.4 Impact 4 – Physical changes to marine processes receptors from increased suspended sediment concentration and settlement from cable installation in the array area

The construction of the proposed development will require the installation of inter-array cables within the array area which has the potential so increase SSC and settlement from seabed due to the installation techniques which will consist of one or a combination of trenching, dredging, jetting, ploughing, vertical injection, and rock cutting.

The Offshore Construction Chapter identifies a single cable laying vessel will be operating in the array area meaning the activity will be sequential between WTG and to the OSP. Project Option 1 requires a slightly longer total length of array cable than Project Option 2 due to the greater number of WTG (111km for 49 WTG versus 91km for 35 WTG) which leads to a slightly longer period of cable trenching and a marginally greater volume of sediment disturbance from the trench. In addition, the method of installation considered to develop the largest level of seabed disturbance is the jetting tool which fluidises the seabed sediments from the trench to enable the placement of the cable. Where the seabed is composed mainly of fine sediments then this process will initially develop a near-bed suspension which is then susceptible to wider spreading across the far-field by tidal advection in the form of a sediment plume. The impact pathway of sediment plumes is established using modelling tools as scenario C-03 for a representative cable section in the array area along the northern part of the array area, between WTG, with a release period of around six hours). Four alternative release scenarios consider the variation in impact pathways between flood and ebb releases and spring and neap tides.

Sensitivity of the receptor

The marine processes receptors exposed to short-term sediment disturbance from cable trenching in the array area are isolated parts of the water column (which experience a short-term increase in suspended sediment concentration in the form of sediment plumes) and small areas of the corresponding seabed due to settlement of fine sediments. The impact pathway does not reach any part of the adjacent coastline, any estuary, or rocky islands in the nearshore, or any marine designated areas. The water column and seabed are considered to have a low sensitivity to this activity due to its high capacity to accommodate the increased SSC, impacting turbidity but not waves and tides.

Magnitude of impact

The time-aggregated marine impact pathway of sediment plumes from cable trenching in the array area is presented in Figure 10.15 for the four representative tidal scenarios combined. The model output represents the maximum suspended sediment concentration that occurs at any time from the initial release and for a successive period of 60 hours (equivalent to around five phases of ebb and flood tides), noting the actual outcome would only follow a single tidal pathway within the overall aggregated output. Results indicate that highest suspended sediment concentrations in the range 300 to 500mg/l are limited along the trenching line (i.e. toward the near-field source) and only occur during the period of jetting, reducing thereafter. All concentrations up to 50mg/l remain within the tidal excursion buffer with the potential for a wider spread of lower concentrations beyond the buffer over successive tidal excursions which tend to favour a northerly distribution due to the flood dominant tide. For the flood spring tide release, tidal advection has the potential to carry the plume into UK territorial waters for a short period, but with a very low concentration equivalent to around 1mg/l (trace level). The actual size of an individual sediment plume varies over time and distance from the point of release, initially being small in width but elongated over the length of the section of cable over the six-hour release period. Once trenching activity ends the plume will advect away with the tide and increase in size due to spreading and dispersing which lowers concentrations, along with fine material slowly settling out onto the seabed. After a period of around 20 hours from the initial release the narrow plume covers an area of between 1.7 to 2.1km^2 on neap releases (peak concentration around 20 to 10mg/l, respectively) and 4.7 to 5.5km^2 on spring releases (peak concentration of 11 to 8mg/l, respectively).

The pattern of settlement from sediment plumes is presented in Figure 10.16 which represents the combined footprint from all four release scenarios, noting the outcome of an individual release would follow a single tidal pathway within the overall footprint of deposition. The spatial distribution for areas of settled sediment mimics the impact pathway of elevated suspended sediments with reduced levels of deposition over distance from the release location. Highest levels of deposition between 52 to 65mm occur along the trenching line (i.e., material falling back into the trench in the near-field). Levels above 1mm remain within 3.5km of the trenching line on both flood and ebb tidal axis.

Trace levels (<1mm) spread further afield with a distribution mainly to the north of the trench due to the flood dominant tide. For the flood release on a spring tide there is potential for some trace levels of deposition to occur in UK territorial waters in a small area.

Given that tidal flows across the array area are generally similar, then comparable suspended sediment and deposition results would be expected for all other locations where trenching for cables is required, however, since the relative proportion of fines is also lower elsewhere in the array area then suspended sediment concentrations and settlement would also be proportionally lower. Where there is an adjacent cable line upstream or downstream on the tidal axis then there is a chance for some subsequent overlapping deposition for levels up to 5 to 10mm (i.e. the extent of settlement from one cable line has the chance of reaching the adjacent trench line in the direction of the tidal axis).

Furthermore, if an alternative method of trenching is employed other than jetting then the associated impacts due to seabed disturbance would also be lower.

The magnitude of impact on both the water column and seabed receptors is assessed to be low for both Project Option 1 and Project Option 2 due to the generally temporary, localised and low levels of change. This magnitude of impact is likely to be slightly higher for Project Option 1 compared against Project Option 2 (due to the slightly longer inter-array cables taking slightly longer to complete trenching) but the magnitude level for both remains low.

Significance of the effect

As the sensitivity of the water column and seabed is low and the magnitude of impact to the seabed is assessed as low, the significance of the effect on the water column and seabed marine processes receptors due to cable trenching in the array area from either Project Option 1 or Option 2 is determined to be slight, which is not significant in EIA terms. This outcome is comparable between Project Option 1 and Option 2.

10.5.2.5 Impact 5 – Physical changes to marine processes receptors from increased suspended sediment concentration and settlement from cable installation along the ECC

The construction of the proposed development will require the installation of two export cables within the ECC which has the potential so increase SSC and settlement from seabed due to the installation techniques which will consist of one or a combination of trenching, dredging, jetting, ploughing, vertical injection, and rock cutting.

Both Project Option 1 and Option 2 utilise the same ECC and require the same length of export cable (two cables of 18km), therefore the potential impacts from either project will be the same. In addition, the method of installation considered to develop the largest level of seabed disturbance is the jetting tool which fluidises the seabed sediments from the trench to enable the placement of the cable. Where the seabed is composed mainly of fine sediments then this process will initially develop a near-bed suspension which is then susceptible to wider spreading across the far-field by tidal advection in the form of a sediment plume. The impact pathway of sediment plumes is established using modelling tools as scenario C-04 for a mid-section along the ECC where there is the highest content of fine sediment. Four alternative release scenarios consider the variation in impact pathways between flood and ebb releases and spring and neap tides.

Sensitivity of the receptor

The marine processes receptors exposed to short-term sediment disturbance from cable trenching along the ECC are isolated parts of the water column (which experience a short-term increase in suspended sediment concentration in the form of sediment plumes) and small areas of the corresponding seabed due to settlement of fine sediments. Small parts of the seabed which are reached by trace levels of the sediment plume include the Rockabill to Dalkey Island SAC but only with very low concentrations (1 to 2mg/l, equivalent to the typical variation in ambient levels) and for a short period. The sensitive receptor of interest within the SAC are Reefs [1170] which surround rocky features such as Rockabill.

The impact pathway does not reach any part of the adjacent coastline, any estuary, or rocky islands (apart from Rockabill) in the nearshore, or any marine designated areas. The water column and seabed are considered to have a low sensitivity to this activity due to its high capacity to accommodate the increased SSC, impacting turbidity but not waves and tides.

The SAC has a medium level of sensitivity i.e. the receptor is considered to have a moderate to low capacity to accommodate the proposed form of change, and due to its designation status.

Magnitude of impact

The time-aggregated marine impact pathway of sediment plumes from cable trenching along the ECC is presented in Figure 10.17 for the four representative tidal scenarios. The model output represents the maximum suspended sediment concentration that occurs at any time from the initial release and for a successive period of 60 hours (equivalent to around five phases of ebb and flood tides), noting the actual outcome would only follow a single tidal pathway within this footprint. Results indicate that the highest suspended sediment concentrations in the range 600 to 800mg/l are limited along the trenching line (i.e. around the near-field source) and lasting for the period of trenching. All concentrations above 1mg/l remain within the tidal excursion buffer. For the ebb spring tide release, tidal advection has the potential to carry the plume into the Rockabill to Dalkey Island SAC, but only with very low concentrations (1 to 2mg/l, equivalent to the typical variation in ambient levels) and for a short period. The temporary period of raised suspended sediment (which increases turbidity and lowers light penetration) reaching the SAC is considered to be lower than the monthly variation of average suspended sediments. The actual size of the sediment plume varies over time and distance from source, initially being small in width but elongated over the length of the 1.9km section of cable over the six-hour release period. Once trenching ends, the plume will advect away with the tide and increase in size due to spreading and dispersing which lowers concentrations, along with the gradual settlement of fine onto the seabed. After a period of around 10 hours from the initial release the narrow plume covers an area of between 1.2 to 1.7km^2 on neap releases (peak concentration around 5 to 2mg/l, respectively) and 3.6 to 3.9km^2 on spring releases (peak concentration of up to 2mg/l).

Sediment plumes developed from jetting along the cable trench also lead to the subsequent settlement of fine sediments falling out of suspension across the far-field. The deposition pattern from all four release scenarios is presented in Figure 10.18, noting the outcome of an individual release would follow a single tidal pathway within the overall footprint of deposition. The spatial distribution for areas of settled sediment mimics the impact pathway of elevated suspended sediments and with reduced levels of deposition over distance from the release location. Highest levels of deposition between 17 to 32mm occur along the trenching line (i.e., material falling back into the trench). Levels above 1mm remain within 1km of the trenching line on both flood and ebb tidal axis. Trace levels (<1mm) spread further afield with a distribution mainly to the north of the trench due to the flood dominant tide, although some deposition may spread south as far as the Rockabill to Dalkey Island SAC during an ebb tide spring release period. The level of deposition is considered to be insignificant at around 0.01mm (equivalent to the grain diameter of silt-sized material).

Given that tidal flows along the ECC are generally similar, then comparable suspended sediment and settlement results would be expected for all other locations where trenching for cables is required, noting that sites closer to the shore tend to have a slightly higher contribution of coarser grade sediments which fall out of suspension quicker and therefore advect over a shorter distance, with proportionally less fine sediment available to form sediment plumes.

The magnitude of impact on both the water column and seabed receptors is assessed to be low due to the generally temporary, localised and low levels of change. This magnitude of impact is the same for both Project Option 1 and Option 2.

Significance of the effect

As the sensitivity of the water column and seabed is low and the magnitude of impact to the seabed is assessed as low, the significance of the effect on the water column and seabed marine processes receptors due to the cable trenching along the ECC is determined to be slight, which is not significant in EIA terms. This outcome is the same for both Project Option 1 and Option 2.

For the area of seabed within Rockabill to Dalkey Island SAC, the sensitivity of the receptor is medium and the magnitude of impact is low, the significance of the effect from Project Option and Project Option 2 on the seabed is also considered to be slight.

10.5.2.6 Impact 6 – Nearshore changes due to the excavation of the HDD exit pits

The construction of the proposed development requires HDD operation of two separate bore operations – one for each of the offshore export cables.

Project Option 1 and Option 2 both require two HDD exit pits to be excavated side-by-side in the nearshore, seaward of the Low Water Mark (LWM), one for each circuit. These exit pits will each be 20m wide, 30m long and with a depth from 1.5 to 2.5m. They will potentially remain open for several months until the export cable is pulled ashore. Thereafter, the exit pits will be infilled, and the seabed is expected to quickly recover to pre-excavation conditions. During the temporary period the exit pits remain open there may be some very localised and minor modifications to nearshore waves and flows in the subtidal, depending on the local seabed profile (e.g. waves may experience reduced local shoaling across an open pit, local flow deviation may occur around any spoil mound), although these impacts are not expected to develop any changes along the adjacent coastline, such as a period of increased erosion.

The excavation activity will disturb the local seabed with the potential to generate a sediment plume in the nearshore, depending on the method of excavation and the relative content of fine sediments which are expected to coarsen towards the coast. The method of excavation considered to develop the most seabed disturbance into the local water column is the Mass Flow Excavator (MFE) option. The impact pathway of sediment plumes developed by the excavation of exit pits is established using modelling tools as scenario C-06 for a representative nearshore location. Coarse sediments would fall directly back to the seabed adjacent to the exit pits and not be involved in any sediment plumes.

Sensitivity of the receptor

The marine processes receptors exposed to excavation of two nearshore (subtidal) HDD exit pits are isolated parts of the water column which experience a short-term increase in suspended sediment in the form of sediment plumes developed by MFE and small areas of the corresponding seabed due the temporary presence of the exit pits and localised settlement of fines from sediment plumes. The adjacent coastline and the local area designated for bathing waters are also considered here as a potential receptors, due to their close proximity of the nearshore exit pits.

The sensitivity of the nearshore water column and seabed to this activity is considered low due to a to high capacity to accommodate the short-term proposed form of change.

The sensitivity of the local bathing waters (Balbriggan, Front Strand Beach) to this activity is considered to be medium due to the moderate socioeconomic importance of this receptor.

The sensitivity of the coastline is considered negligible due to a high capacity to accommodate the form of change.

The impact pathway does not reach any estuary, or rocky islands in the nearshore, or any marine designated areas.

Magnitude of impact

Figure 10.19 presents the time-aggregated marine impact pathway of sediment plumes of fine sediment developed from excavation of the two adjacent HDD exit pits and for the four representative tidal scenarios (peak ebb and flood releases for both spring and neap tides). The actual outcome would only follow a single tidal pathway within the overall footprint of increased levels of suspended sediment concentration. Spring tide releases indicate a maximum excursion distance of the sediment plume along the coast of around 2.2km to the north-west (flood) and to the south-east (ebb) for concentrations >1mg/l, equivalent to trace levels. Neap releases travel a shorter distance along the coast of around 1.3km on flood and ebb. All releases cross in front of Balbriggan Bay (around 1.5km south of the exit pits) but with concentrations that remain low at all times (<10mg/l) and for a short duration (<4 hours). The highest elevated concentrations remain close to the exit pits with levels up to 1,120mg/l.

The areas with settled fine sediment from all four release scenarios mimic the impact pathway of sediment plumes Figure 10.20. The maximum spread of settlement on the seabed is around 2.5km to the north-north-west and south-south-east of the exit pit trench with greatest depths of deposition remaining closest to the exit pits with levels between 68 to 193mm.

Any exit pit option located closer to the coast is likely to experience slightly weaker tidal flows and slightly coarser sediments, leading to a reduced excursion of suspended sediment and higher deposition rates closer to each pit. In all cases, exit pits remain in the sub-tidal zone and avoid inter-tidal areas.

The magnitude of impact on the water column and seabed to this activity is considered low due to the temporary changes which are likely to barely discernible above background levels and also limited in spatial coverage.

The magnitude of the bathing waters (Balbriggan, Front Strand Beach) and coastline is considered negligible since the impact pathways are short-term and are unlikely to reach these receptors despite their close proximity.

These magnitudes of impact on nearshore receptors are the same for both Project Option 1 and Option 2.

Significance of the effect

The sensitivity of the water column and seabed is low and the assessed magnitude of impact is low, as such the significance of the effect on the water column and seabed marine processes receptors due to the excavation of nearshore exit pits is determined to be slight, which is not significant in EIA terms.

As the sensitivity of the bathing waters is medium and the magnitude of impact is assessed as negligible, significance of the effect on bathing waters (Balbriggan, Front Strand Beach) is considered not significant, which is not considered significant in EIA terms.

As the sensitivity of the coastline is negligible and the magnitude of impact is assessed as negligible, the significance of the effect on the adjacent coastline due to the temporary period the exit pits remain open is determined to be imperceptible, which is not significant in EIA terms.

Each of these assessment outcomes are the same for both Project Option 1 and Option 2.

10.5.2.7 Impact 7 – Nearshore changes from the release of bentonite at the HDD exit pits

Each of the two HDD events will emerge in nearshore exit pits in sequence from the landward direction with an initial punch out event when drilling muds (i.e., bentonite) will be released under pressure for a short period (around 10 tonnes of drilling muds over a period of around 200 seconds). This will be followed by a longer reaming period (around 20 tonnes over around 24 hours) when there will be a further volume of bentonite emerging under lower pressure. The impact pathway of nearshore plumes developed by the release of bentonite is established using modelling tools as scenario C-07. Bentonite is used as a drilling mud lubricant so the entire release is represented as silts meaning the spread of bentonite is greater than for the excavated sediments from the exit pit which are have a wider distribution of sediment sizes.

Sensitivity of the receptor

The marine processes receptors exposed to the release of bentonite from the two nearshore (subtidal) HDD exit pits are isolated parts of the water column which experience a short-term increase in turbidity in the form of bentonite plumes and small areas of the corresponding seabed due the localised settlement of fines from the plume. The adjacent coastline and the local area designated for bathing waters are also considered here as potential receptors due to their close proximity of the nearshore release.

The sensitivity of the nearshore water column and seabed to this activity is considered low due to a to high capacity to accommodate the short-term proposed form of change.

The sensitivity of the local bathing waters (Balbriggan, Front Strand Beach) to this activity is considered to be medium due to the moderate socioeconomic importance of this receptor.

The sensitivity of the coastline is considered negligible due to a high capacity to accommodate the form of change.

The impact pathway does not reach any estuary, or rocky islands in the nearshore, or any marine designated areas.

Magnitude of impact

The time-aggregated marine impact pathway of bentonite plumes from HDD exit pits is presented in Figure 10.21 for the four representative tidal scenarios for elevated suspended sediment levels, noting the actual outcome would only follow a single tidal pathway within this overall footprint of potential impact. Spring tide releases indicate a maximum excursion distance of around 1.1km to the north-west (flood) and 0.8km to the south-east (ebb) for concentrations >1mg/l. Neap tide releases travel a shorter distance along the coast. Concentrations >1mg/l do not reach Balbriggan Bay (around 1.5km south of the exit pits). The highest elevated concentrations remain close the exit pits with levels up to 29mg/l.

The areas with settled bentonite from all four release scenarios mimic the impact pathway of the bentonite plumes (Figure 10.22). The maximum spread of deposition is around 1.7km to the north-north-west and 1.4km to the south-south-east of the exit pit trench with greatest depths of deposition remaining closest to the pits with levels between 0.3 to 0.7mm (trace levels).

The magnitude of impact on the water column and seabed to this activity is considered low due to the temporary change across a limited area.

The magnitude of the bathing waters (Balbriggan, Front Strand Beach) and coastline is considered negligible since the impact pathways are short-term and are unlikely to reach these receptors despite their close proximity.

These magnitudes of impact on nearshore receptors are the same for both Project Option 1 and Option 2.

Significance of the effect

As the sensitivity of the water column and seabed is low and the magnitude of impact is assessed as low, the significance of the effect on the water column and seabed marine processes receptors due to the release of bentonite is determined to be slight, which is not significant in EIA terms.

As the sensitivity of the bathing waters (Balbriggan, Front Strand Beach) is medium and the magnitude of impact is assessed as negligible, the significance of effect is considered not significant, which is not considered significant in EIA terms.

As the sensitivity of the coastline is negligible and the magnitude of impact is assessed as negligible, the significance of the effect on the adjacent coastline due to the temporary period the exit pits remain open is determined to be imperceptible, which is not significant in EIA terms.

These outcomes are the same for both Project Option 1 and Option 2.

10.5.2.8 Impact 8 – Physical changes to the seabed from the use of construction vessels

Jack-up vessels are expected to be used in the array area during the pile driving and drilling process as well as subsequently for lifting foundations and topsides into place at each WTG location and the OSP. Due to the relatively muddy seabed, the jack-up legs are expected to be fitted with spudcans to distribute weight across the seabed, however some seabed depressions are still expected where there is soft sediment. For illustrative purposes, a six-legged jack-up vessel is assumed to be fitted with spudcans with a 20m diameter, noting other jack-up options with fewer legs and/or smaller spudcans may be used. For the example case, each jack-up event could develop a set of six seabed footprints totalling around 1,885m^2.

Sensitivity of the receptor

The relevant marine processes receptor to this activity is the local seabed within the array area. The sensitivity of the receptor to this activity is considered low due to the limited spatial extent of any change which will be restricted to the near-field.

Magnitude of impact

For Project 1, there are 49 WTG and one OSP (50 locations), which could lead to a total seabed footprint of around 94,248m^2, representing approximately 0.11% of the array area of 88.5km^2. In comparison, Project Option 2 requires 35 WTG and one OSP (36 locations), which would lead to a total seabed footprint of around 67,858m^2 (0.08%).

If multiple visits are required during the construction phase (potentially up to three visits) then some overlapping footprints would be expected which would increase the total seabed footprint.

Scouring around jack-up legs is not expected when spudcans are used and if the jack-up is on station for only a short period. Notably, SS Downshire is a charted wreck located in the south-eastern part of the array area, however the local seabed does not indicate any strong evidence of local scouring with only a locally raised seabed profile across remnants of the wreck.

When jack-up legs are raised there is the potential for a very limited amount of seabed disturbance causing some fine sediments to be raised in suspension but this is considered to be too small-scale to develop any sediment plumes. Once the legs are raised the sides of the depressions may partially collapse to achieve an angle of repose where unconsolidated sediment is present. Over the longer-term, general sediment transport and deposition active over the area will gradually smooth away and infill these features although it is uncertain how long this may take and to what extent any depressions will eventually be infilled. Existing geophysical evidence across the array area (Fugro, 2022) already reports multiple seabed depressions which are associated with historical gas venting (rather than active venting), noting these features have not yet been infilled by general sediment transport and deposition. Similar long-lasting spudcan depressions have also been observed at other offshore wind farms founded on consolidated muddy seabeds.

The magnitude of impact from this activity on receptors is determined to be low for both project options since the depressions may be noticeable but also restricted to the near-field.

Significance of the effect

As the sensitivity of the seabed is low and the magnitude of impact assessed is low, the significance of the effect on the seabed marine processes receptors due to the jack-up vessels operating in the array area is determined to be slight, which is not significant in EIA terms. This outcome is the same for both Project Option 1 and Option 2.

10.5.3 Operational Phase

Chapter 6 provides a description of the offshore components of the project that are planned to remain in place for the duration of the operational phase, a period of 35 years. Individual offshore structures have the potential to interfere with passing waves and flows with the scale and type of such effect depending on the shape and size of the structure. This is generally referred to as a structure-scale blockage effect (i.e. effects propagate from the locality of individual foundations). In addition, the alignment (relative to incident flows and waves) and spacing between multiple structures forming the array has the potential to influence a larger array-scale blockage effect (i.e. the aggregate result of all structure-scale interactions across the array area). In addition, maintenance and repairs may also be required during this period including removing and replacing cables, and placement of cable protection.

10.5.3.1 Impact 9 – Physical changes to marine processes receptors from cable crossings within the array area

During the operation of the proposed development, there is the potential for cable crossings to affect passing waves and modify tides.

Sensitivity of the receptor

The main consequence of this activity is the direct presence of the structures on the seabed receptor within the array area, with the sensitivity of the seabed considered to be low given that this area is not within a designated site and has a high capacity to accommodate the presence of cable crossings within the area.

Magnitude of impact

A provision is made for five cable crossings within the array area for both Project Option 1 and Option 2. These crossings will be small-scale and separated, each covering an area of up to 360m^2 with heights up to 2.5m above the local seabed. The array area is too deep for these crossings to affect passing waves. Tidal flows would only be locally modified towards the seabed, noting flows at these depths are expected to be lower than equivalent depth-average values.

As commented on previously, local scouring around low profile seabed anomalies is not anticipated to be prevalent, as evidenced by the profile of the seabed around the charted wreck SS Downshire in the south-eastern part of the array area.

The magnitude of impact from the presence of five cable crossings in the array area is determined to be low due to barely discernible changes over a small part of the array area.

Significance of the effect

As the sensitivity of the seabed is low and the magnitude of the impact is assessed as low, the significance of the effect on the seabed marine processes receptors due to the presence of five cable crossings is determined to be slight, which is not significant in EIA terms. This outcome is the same for both Project Option 1 and Option 2.

10.5.3.2 Impact 10 – Physical changes from increased suspended sediment concentration from cable repairs and reburial

During the operation and maintenance period, export cables and inter-array cables may require reburial or repair, a process which would involve de-burial, recovery and relaying of cables. This activity is considered to be infrequent and limited to short-sections of cables up to 200m in length on each occasion. The de-burial activity is likely to use either MFE or jetting tools to clear away sediments to expose the damaged cable.

Sensitivity of the receptor

The locations where cable repairs may be required are unknown at this time but could occur within the array area and/or the ECC. The environmental receptors in these areas are the same as for the initial cable laying activity during the construction phase. This includes isolated parts of the water column (which experience a short-term increase in suspended sediment concentration in the form of sediment plumes) and small areas of the corresponding seabed due to settlement of fine sediments.

For the ECC, the risk remains that small parts of the northern part of the Rockabill to Dalkey Island SAC could be reached by trace levels of the sediment plume but only with very low concentrations (1 to 2mg/l, equivalent to the typical variation in ambient levels) and for a short period. The sensitive receptor of interest within the SAC are Reefs [1170] which surround rocky features such as Rockabill.

The general water column and seabed are considered to have a low sensitivity to this activity due to its high capacity to accommodate the increased SCC, impacting turbidity but not waves and tides. The Rockabill to Dalkey SAC has a medium level of sensitivity, in part due to its designated status but noting any changes are only likely to occur in a very small part of this SAC.

Magnitude of impact

The de-burial process has the potential to develop short-term periods of sediment disturbance and associated plumes of fine sediment, where present. The scale of any sediment plume is considered to be comparable to the original cable laying activity occurring during the construction phase (Impact 4 and 5) for the same location, environmental conditions, and for the same method of disturbance, however, repairs are limited to only a short section of cable on each occasion which means the period of disturbance will be substantially shorter.

The magnitude of impact on both the water column and seabed receptors is assessed to be low due to the generally temporary, localised and low levels of change. This magnitude of impact could be considered slightly greater (but still low overall) for Project Option 1 compared to Project Option 2 due to slightly more inter-array cables which may be subject to cable repairs.

Significance of the effect

As the sensitivity of the water column and seabed is low and the magnitude of the impact assessed is low, the significance of the effect on the water column and seabed marine processes receptors due to infrequent and short sections of cable de-burial is determined to be slight, which is not significant in EIA terms.

As the sensitivity of the seabed within Rockabill to Dalkey Island SAC is medium and the magnitude of impact assessed is low, the significance of effect on the seabed is also considered to be slight.

This outcome is the same for both Project Option 1 and Option 2.

10.5.3.3 Impact 11 – Physical changes from cable protection

Sensitivity of the receptor

The main consequence of this activity is the direct presence of the small-scale cable protection structures on the seabed receptor with the sensitivity of the seabed considered low given that this area is not within a designated site.

Magnitude of impact

Cable protection (e.g., rock armour or mattresses) may be required when full cable burial is not possible during installation or when remedial repairs are needed during the operational phase to help maintain cable burial.

The notional dimensions for cable protection are a base width up to 5m and a height of 2m with a cross-section in the form of a trapezoid. The typical size of rock armour cable protection material is 0.45m.

A contingency provision of 20% of the total cable length (inter-array and export cables) is made for use of cable protection over the lifetime of the project, noting the full amount may not be needed. In addition, the locations and occasions where cable protection may be required remain unknown at this time. The greatest level of impact due to cable installation is represented by the full utilisation of the cable protection provisions over the project lifetime, however, this is also considered a highly unlikely situation. In addition, no cable protection measures will be required inshore of HDD exit pits, since HDD is through rock.

For Project Option 1, 111km of inter-array cables is planned for. The 20% contingency leads to up to 22.2km requiring cable protection, covering 111,000m^2 of seabed and require a total volume of 133,200m^3 of rock armour.

For Project Option 2, this reduces to 91km of inter-array cables, 18.2km contingency with cable protection covering up to 91,000m^2 and a total volume of 109,200m^3.

The provisions for the 36 km of export cables are the same for both project options, with a contingency for up to 7.2km of cable protection covering 36,000m^2 and a total volume of 43,200m^3 of rock armour.

When required, the placement of cable protection will be in discrete short lengths and represent a localised change of substrate type as well as introducing a small-scale modification to the seabed profile. Depending on the rock size, local water depth, alignment relative to wave and tidal flows, and local seabed mobility conditions, there is also the potential for the development of local scour around the periphery of the cable protection in some cases. This effect is more likely towards shallower sites than deeper sites.

The magnitude of impact from the presence of small-scale cable protection structures is determined to be low. This magnitude of impact could be considered slightly greater (but still low overall) for Project Option 1 compared to Project Option 2 due to slightly more inter-array cables which may be subject to cable protection.

Significance of the effect

As the sensitivity of the seabed is low and the magnitude of impact is assessed as low, the significance of the effect on the seabed marine processes receptors due to the presence of small-scale cable protection structures is determined to be slight, which is not significant in EIA terms.

This outcome is the same for both Project Option 1 and Option 2.

10.5.3.4 Impact 12 – Physical changes to the coastline from a modification in storm waves due to array-scale blockage

Over the operational period, each foundation in the array area has the potential to interact with passing waves leading to local wave reflection/scattering, potential diffraction and energy absorption, this is referred to as structure-scale blockage which occurs at individual infrastructure.

The scale of this interaction depends on the properties of the incident waves (wave height, period, and direction) and the scale and type of structure involved. The aggregate result of all structure-scale interactions across the array area is referred to as the potential array-scale blockage on wave energy transmission.

Once waves pass through the array area, any project related wave modifications quickly dissipate in magnitude across the far-field (i.e. beyond the array area where interactions are formed). When waves reach shallow water then other interactions occur, including wave shoaling, refraction and eventually breaking, with the dissipation of wave energy along an open sandy beach driving longshore drift.

Large storm waves are generally considered to be a destructive force on the coastline, noting that contemporary coastal erosion of the local sandy shorelines is attributed to acute erosion (i.e., storm specific, event-driven), so any slight storm related wave height reductions or changes in direction caused by array-scale wave blockage could be considered to be a potential beneficial effect. In contrast, rocky shorelines would not be expected to be sensitive to any slight changes in waves. The consequence of array-scale blockage on storm waves is investigated with suitable wave modelling tools as impact pathway O-01 (Appendix 10.2).

Appendix 10.1 compares the contributing elements of Project Option 1 and Option 2 (foundation type and number) which establish array-scale blockage. This assessment identifies the 49 WTG monopile foundations and one OSP planned for Project Option 1 has the largest overall blockage area when compared with Project Option 2 (monopiles or jacket foundations). Accordingly, the wave modelling adopts the configuration of Project Option 1 alongside the baseline case (defined with no foundation structures). The quantification of array-scale wave blockage is then determined for a set of representative conditions by comparing the results from Project Option 1 versus the baseline case. These differences are considered for wave height, period, and direction.

The representative wave conditions are defined by two primary wave directions; the prevailing wave direction from the south-south-east (Section 10.3.7) and a second direction from east-north-east which is the most direct (shortest) impact pathway onto the adjacent coast. For each wave direction the following four wave conditions are examined:

- P50, representing the 50% probability of non-exceedance per year, equivalent to a typical annual wave condition
- 1 in 1 year return period, equivalent to the peak storm event which is likely to occur each year, on average
- 1 in 10 year return period, equivalent to a peak storm event that has a frequency of occurrence once every 10 years, on average
- 1 in 50 years return period, equivalent to a peak storm event that has a frequency of occurrence once every 50 years, on average. A value commonly used as a design condition

In each case, the duration of any impact is limited to the duration of the storm period which is likely to be several hours at most.

Sensitivity of the receptor

The main marine processes receptor to this type of change is the leeward coastline which responds to wave driven beach processes, this type of coastline is typically characterised by long open sandy beaches, i.e. sand beach fronting upland (> 1km long). The sensitivity of this type of receptor to changes in nearshore waves and wave driven processes (i.e. littoral transport, erosion and accretion) is considered medium given a limited opportunity for this type of receptor to accommodate this type of change.

Other types of coastline morphology, such as erosion resistant rock and/or cliff (e.g. Braymore Point) or gravel beaches, are considered to have negligible or low sensitivity, respectively.

Some wave height reductions also extend (as an impact pathway) into the northern part of the Rockabill to Dalkey Island SAC for east-north-easterly storm waves, reaching Rockabill (in the range -0.10 to -0.05m for the 1 in 50 year return period storm but nil for the more typical P50 wave condition (representing the 50% probability of non-exceedance per year, equivalent to a typical annual wave condition)).

The SAC is designated for Annex 1 Reefs (intertidal and subtidal) around rocky islands, including Rockabill. Although this is essentially a rocky shoreline, the level of sensitivity of this receptor to changes in wave conditions is considered medium.

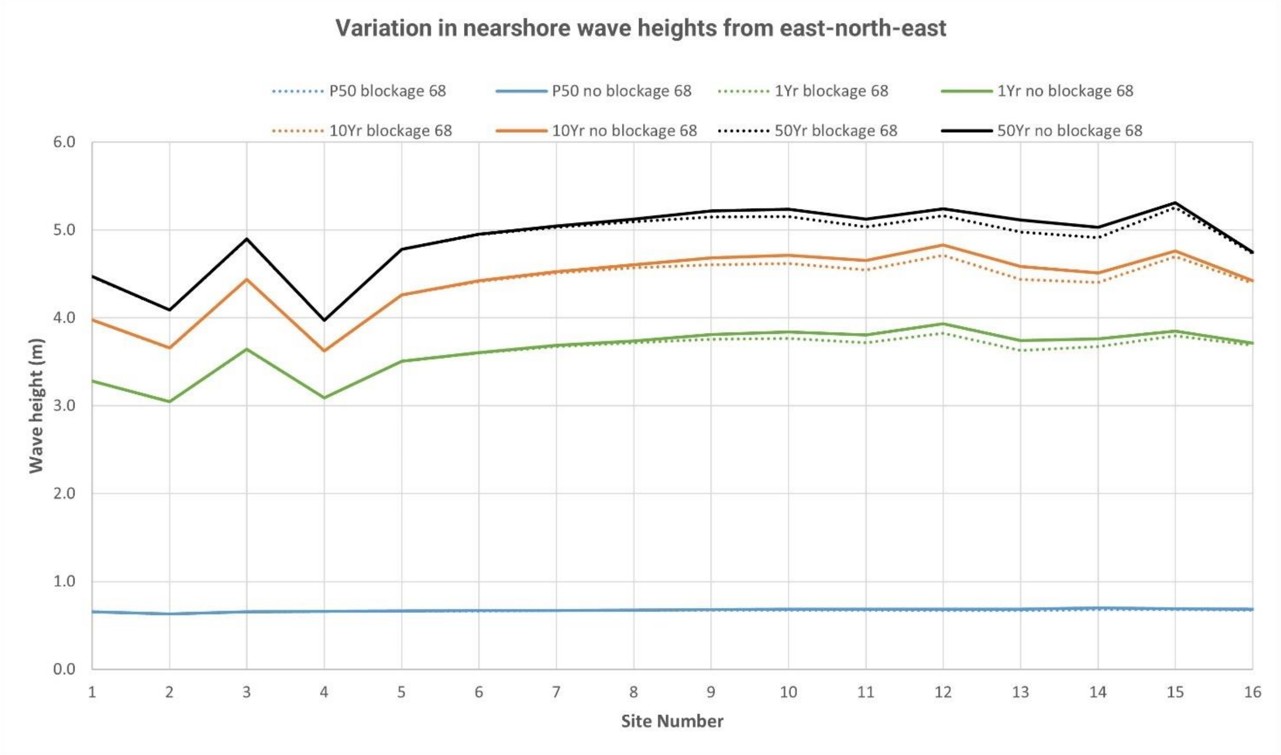
Magnitude of impact

Figure 10.23 and Figure 10.24 present the predicted reduction (project minus baseline) in wave heights for the 1 in 50 year return period wave conditions approaching from the east-north-east and south-south-east (prevailing wave direction), respectively. The 1 in 50 year return period is an infrequent event which is used to demonstrate the largest overall likely effect of array-scale wave blockage, noting all other shorter return periods demonstrate a proportionally lower scale of wave blockage effects. The most prominent wave modifications are within the array area with local reductions in wave height in the range -0.65 to -0.60m in the lee of individual foundations. These structure-scale effects aggregate to develop an array-scale reduction in wave height across the leeward far-field that dissipates in magnitude towards the coast. For waves from the east-north-east, the leeward reduction in wave heights extends between the Boyne Estuary and south to The Skerries, including Rockabill. For waves from the south-south-east (prevailing wave direction), the reduction in wave height across the leeward far-field extend between Clogher Head and north towards Ballagan Point, including the location of Oriel OWF. Once waves reach depths of around 10m the dominant wave process becomes shoaling into shallower water depths with wave reductions from the array already dissipated to the range -0.10 to -0.05m (n.b. all wave reductions inshore of around 10m depth are effectively the same for both project and baseline conditions, due to shallow water issues).

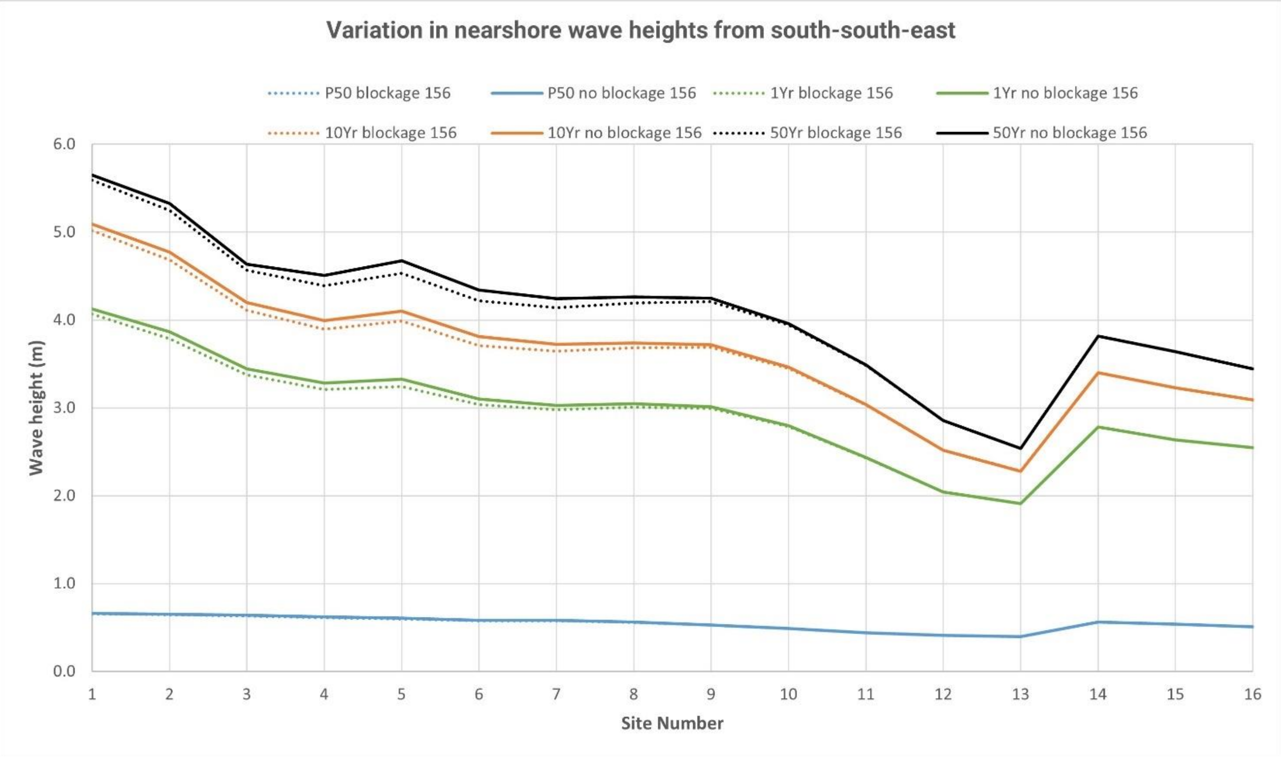
Modification of wave heights for all return periods and directions along the 10m depth contour are considered for 16 nearshore sites located along the 10m isobath. (Graph 5 - Part 1 for east-north-east and Part 2 for south-south-east).

Graph 10.5 – Part 1 presents changes in nearshore waves from east-north-east. The P50 wave condition shows very little change in wave heights in the nearshore with the largest local reduction of up to 0.02m (Site 13 – south of the ECC) relative to a baseline of 0.69m (or 2.4% reduction). In comparison, the 1 in 1 year return period shows a reduction up to 0.11m relative to a baseline of 3.74m (or a 3.0% reduction) for the same site. The 1 in 10 year event shows a reduction of up to 0.15m relative to a baseline of 4.59m (or a 3.3% reduction), and the 1 in 50 year event shows a reduction of up to 0.14m relative to a baseline of 5.11m (or a 2.7% reduction).

Graph 10.5 – Part 2 presents changes in nearshore waves from the prevailing south-south-east direction. The P50 wave condition also shows very little change in wave heights in the nearshore with the largest local reduction of up to 0.01m (Site 5 – off Clougher Head) relative to a baseline of 0.60m (or 1.3% reduction). In comparison, the 1 in 1 year return period shows a reduction up to 0.08m relative to a baseline of 3.32m (or a 2.5% reduction) for the same site. The 1 in 10 year event shows a reduction of up to 0.12m relative to a baseline of 4.10m (or a 2.8% reduction), and the 1 in 50 year event shows a reduction of up to 0.14m relative to a baseline of 4.67m (or a 3.0% reduction).



Part 1 – east-north-east wave direction



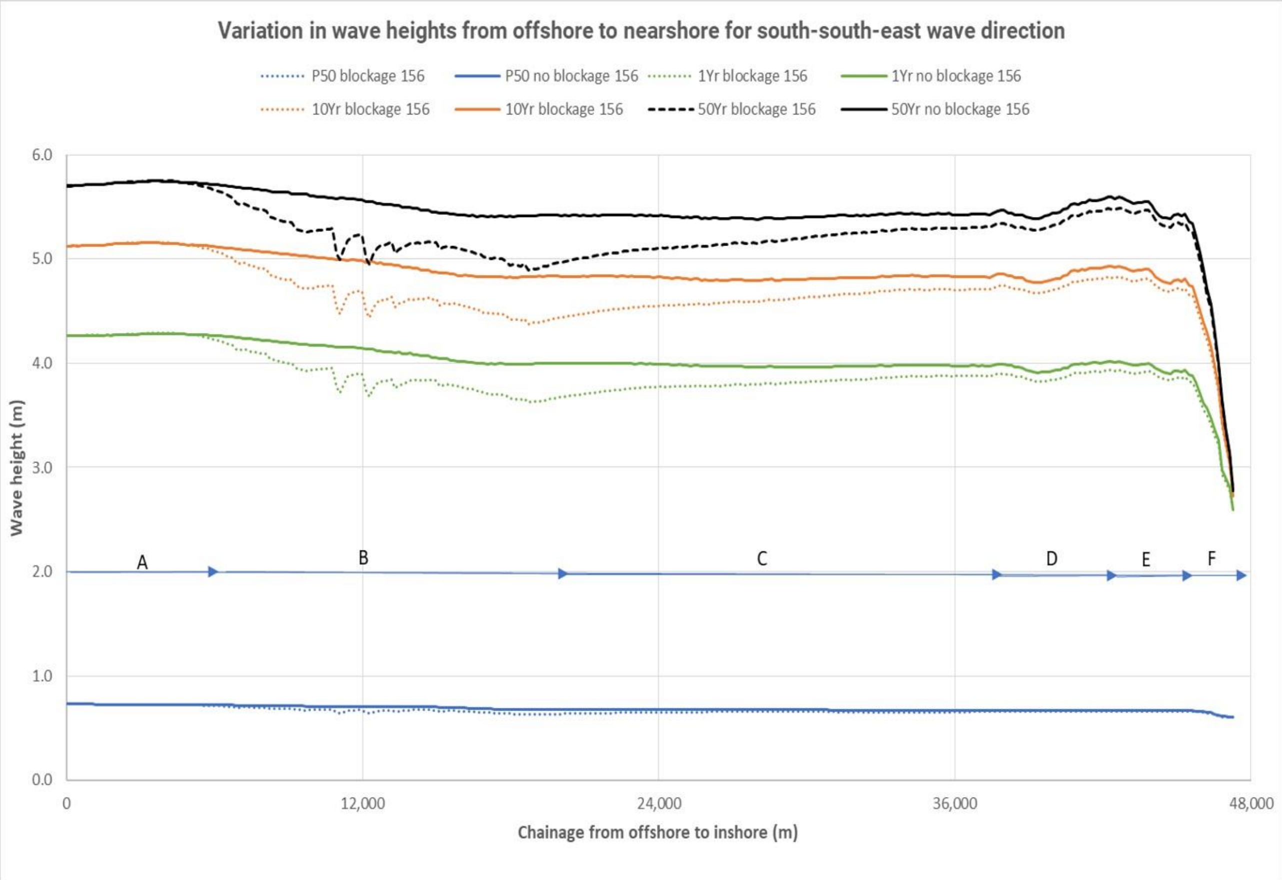
Part 2 – south-south-east wave direction

Graph 10.5: Variations in near-shore wave heights

Graph 10.5 offers a further presentation of predicted reductions in wave heights for the prevailing south-south-east wave direction for all wave return periods and for a transect from offshore (upwind of the array area) to the coastline near Ballagan Point. Six zones are identified:

- A – upwind location of the array area where baseline conditions (no blockage) and wave array (blockage) conditions are the same.
- B – wave blockage zone creating near-field wave height reductions across the array area.

- C – wave height reductions begin to spread and dissipate across the far-field, inshore of the array area.
- D – waves passing through the Oriel OWF array area.
- E – waves travel onwards towards the nearshore after passing through Oriel OWF, no additional wave blockage effects are accounted for from array-scale blockage effects due to Oriel OW.
- F – shallow depths up to the coastline, leading to rapid wave shoaling with comparable outcomes between baseline and array-scale blockage conditions, demonstrating shallow water effects are the dominant influence on waves at this location.



Graph 10.6 Variation in wave heights from offshore to near-shore for south-south-east wave direction

In summary, array-scale blockage has the capacity to reduce local wave heights in the near-field but thereafter these reductions dissipate and spread out across the far-field. When waves approach the nearshore then shallow water interactions become dominant and any further changes in wave height bring parity to baseline conditions. Waves from the prevailing south-south-east direction which pass through the array area are not involved in beach processes south of Clogher Head. Waves from east-north-east occur less frequently than the prevailing south-south-east direction (around 7% compared to around 27%, determined by long-term hindcasts (MetOceanWorks (2020)) but approach the closest leeward coastline between the Boyne Estuary and Skerries after passing through the array area. There is minimal detectable reduction in wave heights against the coastline due to array-scale wave blockage.

The magnitude of impact from changes in waves which reach the leeward coastline (sandy beaches) or Rockabill is determined to be low for infrequent periods of large storms (e.g. 1 in 1, 1 in 10 or 1 in 50 year return period events) but negligible for more frequent typical conditions (e.g. P50 wave condition), especially because shallow water interactions on waves become the dominant influence across this part of the far-field. Furthermore, for storm periods, this magnitude of change could also be considered as low (beneficial) in regard to (slightly) reducing wave energy reaching the coast.

The magnitude of impact to leeward coastline which have the form of erosion resistant cliff/rock and gravel beaches is considered to be negligible since they are considered unresponsive to the predicted level of change in waves.

Significance of the effect
The sensitivity of the Annex 1 Reef features within the Rockabill to Dalkey Island SAC is medium and the magnitude of impact is assessed as low, the significance of effects is considered as slight, which is not significant in EIA terms.

As the sensitivity of the leeward coastline is medium and the magnitude of impact is assessed as ranging between low (adverse) and low (beneficial).

The significance of the effect on leeward coastlines of the form of long open sandy beaches is determined to be slight (adverse) or slight (beneficial), which is not significant in EIA terms. This outcome is determined for Project Option 1 which was assessed to have a slightly larger array-scale blockage potential, noting Project Option 2 would expect to lead to a proportionally lower magnitude of impact due to a comparatively lower array-scale blockage potential.

As the magnitude of impact assessed for impacts on leeward coastline of the form of erosion resistant rock/and or cliff (e.g. Bremore Point) and gravel beaches is negligible, the significance of effect is considered to be not significant, which is not significant in EIA terms.

10.5.3.5 Impact 13 – Physical changes to marine processes receptors from modification of tides due to array-scale blockage
Over the operational period, each foundation in the array area also has the potential to interact with passing flows leading to local flow retardation (in front), acceleration (around) and turbulent wakes (behind). These interactions are due to structure-scale blockage occurring at individual sites. The scale of this interaction depends on the properties of the incident flows (ambient turbulence, flow speed, and direction) and the scale and type of structure involved. The aggregate result of all structure-scale interactions across the array area is referred to as the potential array-scale blockage on tidal flows. The consequence of array-scale blockage on tidal flows has been investigated with suitable hydrodynamic modelling tools as impact pathway O-02 (Appendix 10.2).

Appendix 10.1 compares the contributing elements of Project Option 1 and Option 2 (foundation type and number) which establish array-scale blockage. This assessment identifies the 49 WTG monopile foundations and one OSP planned for Project Option 1 has the largest overall blockage area when compared with Project Option 2 (monopiles or jacket foundations). Accordingly, the hydrodynamic modelling adopts the configuration of Project Option 1 alongside the baseline case (defined with no foundation structures). The quantification of array-scale tidal flow blockage is then determined for a set of representative conditions by comparing the results from Project Option 1 versus the baseline case. These differences are considered for flow speed, direction, and water levels.

The four representative tidal conditions are considered:

- Peak flood on spring tide
- Peak ebb on spring tide
- Peak flood on neap tide
- Peak ebb on neap tide.

In each case, the duration of any effect is limited to the duration of the peak tidal flows which is likely to be several minutes at most. Since modifications to tidal flows are also proportional to the magnitude of the incident conditions, then all lower magnitude tidal flows occurring at other times during the tidal cycle are considered to developed smaller scale changes when compared to peak flow events.

Sensitivity of the receptor
The main marine processes receptor to this type of change is the local water column and seabed with the sensitivity of these receptors considered to be low due a moderate to high capacity to accommodate the form of change and the receptor not being designated.

Within the water column, seasonal stratification is also considered here as a receptor, with the sensitivity of this receptor also considered as low.

There is no impact pathway of any relevance which would cause an effect within the Rockabill to Dalkey Island SAC, so this receptor is not considered further.

Magnitude of impact

Figure 10.25 presents the predicted change in tidal flows at the time of peak flood flows on a spring tide, the condition with the strongest period of tidal flows. The lowest limit for determining a change in tidal flows between the development case and baseline case is set at 0.002m/s, noting this is considered below the limit of conventional and reliable flow measurement. Any changes below 0.002m/s are considered as nil, or no detectable change.

The most notable change is due to local-scale (near-field) drag effects caused by the foundation structure which create flow accelerations (red) around and between each foundation and individual wakes in their lee (flow reductions (blue) with increased turbulence). Flow accelerations around the foundations can also lead to local scouring of the seabed which is mitigated with the placement of scour protection. All changes in tidal flows remain at a very small scale (generally less than 0.02m/s relative to a baseline condition) and are most evident during times of peak flows on spring tides. The majority of changes in flow speed remain within the array area as small-scale near-field changes around individual foundations without any notable array-scale changes extending into the far-field.

Seasonal thermal stratification (in the vertical water column demonstrated as a thermocline) is a notable feature of the baseline environment which develops during warmer summer periods. The development of turbulence flow wakes (mainly acting in the horizontal) has the potential to increase mixing processes but this is not considered sufficient to be of significant magnitude or extent to lead to any breakdown of thermal stratification either locally or at the array-scale.

Figure 10.26 presents the predicted change in tidal flow direction at the time of peak flood flows on a spring tide, complementing the prediction of changes in tidal flow speed. A cut-off limit of 0.1° is used as a valid change in flow direction, noting this is considered the limit of conventional and reliable measurement. The most notable change in direction across the array area is due to local flows deviating around each foundation, there is also some additional flow deviation at the array-scale at the northerly corners of the array boundary, although these are only at a very low level (0.1 to 0.2°). The majority of changes in flow direction remain within the array area and as small-scale changes (<0.9°) around individual foundations without any wider array-scale changes extending into the far-field to reach any marine process receptors.

Figure 10.27 presents the predicted change in tidal levels (i.e. sea surface elevation) at the time of peak flood flows on a spring tide. A cut-off limit of 0.002m is used as a valid change in surface elevation, noting this is considered well below the limit of conventional and reliable measurement. The most notable changes in surface elevations are at the upstream and downstream array boundaries (first and last rows of WTG to incident flow direction) where there is a very small change at the scale of 0.002 to 0.004m (positive change upstream due to flows being held up by the array and negative change downstream to balance out the upstream changes). These changes reverse on the ebb tide and in proportion to the magnitude of flows. There is some partial overlap in increased surface elevation at the scale of 0.002 to 0.003m extending to the north-eastern part of the Rockabill to Dalkey Island SAC, however, this is not considered relevant, is not associated with any measurable difference in flow speed or direction, and is not a criteria which the associated with Annex 1 Reef receptors would be sensitive to, noting also the main pathway remains as a change in flows.

The magnitude of impact from changes in tidal conditions on the local water column (including stratification) and seabed is considered low (noticeable changes largely restricted to near-field and limited to times of peak flow).

Scour protection around foundations also mitigates the potential for any changes in tidal flows leading to local scouring of the seabed which reduces the magnitude of impact on this receptor to negligible.

Significance of the effect

As the sensitivity of the water column and seabed is low and the magnitude of impact is assessed as low, the significance of the effect on the water column (including stratification) is considered to be slight which is not significant in EIA terms.

As the sensitivity of the seabed to settlement is low and the magnitude of impact is assessed as low, the significance of the effect on the seabed (with scour protection) is considered to be imperceptible which is not significant in EIA terms.

These outcomes are determined for Project Option 1 which was assessed to have a slightly larger array-scale blockage potential, noting Project Option 2 would expect to lead to a proportionally lower magnitude of impact due to a comparatively lower array-scale blockage potential.

10.5.4 Decommissioning

10.5.4.1 Impact 14 – Physical changes to marine processes receptors from decommissioning activities

The main activities during the decommissioning phase which might lead to short-term periods of seabed disturbance include removal of foundations to 1m - 2m below the seabed, as well as discrete sections of cables, where required. Notably, most of the anticipated decommissioning activities are likely to take place across the array area.

Sensitivity of the receptor

The marine processes receptors related to seabed disturbance are the water column (turbidity) and seabed (settlement) which are considered to have a low level of sensitivity to this activity.

The marine processes receptors related to the cessation of wave blockage is the leeward coastline which is considered to have a medium level of sensitivity to this issue.

The main marine processes receptors related to the cessation of tidal flow blockage is the water column and removal of any turbulent mixing, noting the seabed would already have scour protection in place. The water column is considered to have a low level of sensitivity to this issue.

Magnitude of impact

Decommissioning impacts are expected to cause lower magnitude effects than those assessed for the respective installation methods during the construction phase (i.e. smaller sediment volumes, less areas involved, shorter duration of any disturbance, lower amounts of settlement, etc.) which are all assessed to be not significant in EIA terms and therefore will also be not significant for decommissioning impacts.

The following types of project infrastructure are expected to remain *in situ*:

- Foundation pile lengths greater than 1m to 2m below seabed
- Cables (except where removal is required)
- Scour protection
- Rock protection over cables.

In addition, the removal of foundations also leads to the cessation of any array-scale wave or tidal blockage issues due to the presence of foundation structures during the operational phase. This removal effectively reinstates the baseline conditions.

Project Option 1 has more WTG locations than Project Option 2 and is considered to lead to a slightly greater level of seabed disturbance.

The decommissioning activities which may develop seabed disturbance will be localised, short-term and temporary, leading to a low level of impact on the water column (turbidity) and seabed (settlement) receptors.

The removal of foundations will lead to the cessation of array-scale wave blockage with a low impact (negative) at the coastline for large storm conditions, since any slight moderation of waves when array-scale wave blockage occurred during the operational phase will cease. The magnitude of impact for more typical waves (e.g. P50) is considered negligible.

The removal of foundations will lead to the cessation of array-scale tidal flow blockage with a low impact (beneficial) on the water column in terms of stratification.

Significance of the effect

The significance of seabed disturbance on the water column (turbidity) and seabed (settlement) is considered to be slight which is not significant in EIA terms.

The significance of removal of foundations on the coastline is considered to be slight (negative) which is not significant in EIA terms.

The significance of removal of foundations on the water column (stratification) is considered to be slight (beneficial) which is not significant in EIA terms.

These outcomes are determined for Project Option 1 which was assessed to have more WTG foundations removed and a slightly larger array-scale blockage potential, noting Project Option 2 would expect to lead to a proportionally lower magnitude of impact on each receptor due to slightly less WTG foundations and a comparatively lower array-scale blockage potential.

10.6 Mitigation and Monitoring Measures

Throughout the development stage, the design of the proposed development has evolved such that no additional mitigation or monitoring measures are considered necessary during the construction, operation and decommissioning phases additional to standard asset monitoring already planned for over the operational period, as outlined in Chapter 6.

10.7 Residual Effects

This section presents the residual effects of the proposed development. No mitigation measures have been identified since none of the identified effects are significant in EIA terms. Residual effects remain the same as the pre-mitigation effects and are presented in Table 10.9.

Table 10.9 Residual effects relating to marine processes

Potential impact	Potential likely significant effect – Project Option 1	Potential likely significant effect – Project Option 2	Residual effect – Project Option 1	
Construction				
Impact 1 – Physical changes to marine processes receptors from seabed clearance activities	Seabed - Not significant	Not significant	Not significant	Not significant
Impact 2 – Physical changes to marine processes receptors from seabed levelling for Project Option 2	Water column and seabed marine processes - Slight	Water column and seabed marine processes - Slight	Water column and seabed marine processes - Slight	Water column and seabed marine processes - Slight
Impact 3 – Physical changes to marine processes receptors from increased suspended sediment concentration from drilling for foundation installation	Water column and seabed marine processes - Slight	Water column and seabed marine processes - slight	Water column and seabed marine processes - Slight	Water column and seabed marine processes - Slight
Impact 4 – Physical changes to marine processes receptors from increased suspended sediment concentration from cable installation in the array area	Water column and seabed marine processes - Slight	Water column and seabed marine processes - Slight	Water column and seabed marine processes - Slight	Water column and seabed marine processes - Slight

Potential impact	Potential likely significant effect – Project Option 1	Potential likely significant effect – Project Option 2	Residual effect – Project Option 1	
Impact 5 – Physical changes to marine processes receptors from increased suspended sediment concentration from cable installation in the ECC	Water column, seabed marine processes, seabed within Rockabill to Dalkey Island SAC - Slight	Water column, seabed marine processes, seabed within Rockabill to Dalkey Island SAC - Slight	Water column, seabed marine processes, seabed within Rockabill to Dalkey Island SAC - Slight	Water column, seabed marine processes, seabed within Rockabill to Dalkey Island SAC - Slight
Impact 6 – Nearshore changes due to the excavation of the Horizontal Directional Drilling (HDD) exit pits	Water column and seabed marine processes - Slight Bathing waters – Not significant Coastline - Imperceptible	Water column and seabed marine processes - Slight Bathing waters – Not significant Coastline - Imperceptible	Water column and seabed marine processes - Slight Bathing waters – Not significant Coastline - Imperceptible	Water column and seabed marine processes - Slight Bathing waters – Not significant Coastline - Imperceptible
Impact 7 – Nearshore changes from the release of bentonite at the HDD exit pits	Water column and seabed marine processes - Slight Bathing waters – Not significant Coastline - Imperceptible	Water column and seabed marine processes - Slight Bathing waters – Not significant Coastline - Imperceptible	Water column and seabed marine processes - Slight Bathing waters – Not significant Coastline - Imperceptible	Water column and seabed marine processes - Slight Bathing waters – Not significant Coastline - Imperceptible
Impact 8 – Physical changes to seabed from the use of construction vessels	Seabed - Slight	Seabed - Slight	Seabed - Slight	Seabed - Slight
Operation				
Impact 9 – Physical changes to the coastline from a modification in storm waves due to array-scale blockage	Seabed - Slight	Seabed - Slight	Seabed - Slight	Seabed - Slight
Impact 10 – Physical changes from increased suspended sediment concentration from cable repairs	Water column, seabed marine processes, seabed within Rockabill to Dalkey Island SAC - Slight	Water column, seabed marine processes, seabed within Rockabill to Dalkey Island SAC - Slight	Water column, seabed marine processes, seabed within Rockabill to Dalkey Island SAC - Slight	Water column, seabed marine processes, seabed within Rockabill to Dalkey Island SAC - Slight
Impact 11 – Physical changes from cable protection	Seabed - Slight	Seabed - Slight	Seabed - Slight	Seabed - Slight
Impact 12 – Physical changes to the coastline from a modification in storm waves due to array-scale blockage	Beaches – Slight (adverse)-Slight (beneficial) Annex 1 Reef features - Slight	Beaches – Slight (adverse)-Slight (beneficial) Annex 1 Reef features - Slight	Beaches – Slight (adverse)-Slight (beneficial) Annex 1 Reef features - Slight	Beaches – Slight (adverse)-Slight (beneficial) Annex 1 Reef features – Slight
Impact 13 – Physical changes to marine processes receptors from modification of the tides due to array-scale blockage	Water column – Slight Seabed – Imperceptible	Water column – Slight Seabed – Imperceptible	Water column – Slight Seabed – Imperceptible	Water column – Slight Seabed – Imperceptible

Potential impact	Potential likely significant effect – Project Option 1	Potential likely significant effect – Project Option 2	Residual effect – Project Option 1	
Decommissioning				
Impact 12 – Physical changes to marine processes receptors from decommissioning activities	Water column and seabed – Slight Coastline – Slight Water column -Slight (beneficial)	Water column and seabed – Slight Coastline – Slight Water column - Slight (beneficial)	Water column and seabed – Slight Coastline – Slight Water column - Slight (beneficial)	Water column and seabed – Slight Coastline – Slight Water column - Slight (beneficial)

10.8 Transboundary Effects

Transboundary effects are defined as those effects upon the receiving environment of other states, whether occurring from the proposed development alone, or cumulatively with other projects in the wider area. This assessment considers the potential for transboundary residual effects of the proposed development (i.e. after mitigation measures have been applied for the proposed development).

The potential exists for some sediment plumes to advect over several tidal cycles in a net northerly direction, due to a flood dominant tide, and move into UK Waters. This situation would be limited to periods of spring tides when the tidal excursion is at the greatest and for seabed disturbance locations (WTG sites or inter-array cables) in the northern part of the array area. For equivalent locations in the southern part of the array area, the net excursion of sediment plumes is not be expected to reach UK waters.

From the source, the concentration of suspended sediments in the plume diminish over time due to settling out of material and spreading and dilution due to tidal advection and dispersion. These factors ensure that the suspended sediment plume concentrations reaching UK waters are considered to be imperceptible against background levels (Figure 10.11, 10.17 and 10.19). If any of the material manages to settle out at this time then the levels of deposition also remain very low and are also considered to be imperceptible (Figure 10.12, 10.18 and 10.20). As such, no likely significant transboundary effects are anticipated.

10.9 Cumulative Effects

Likely significant cumulative effects of the proposed development in-combination with existing and/or approved projects for Marine Geology, Oceanography and Physical Processes have been identified, considered and assessed. The methodology for this cumulative assessment is a three-stage approach which is presented in the Cumulative and Inter-Related Effects Chapter.

The Cumulative and Inter-Related Effects Chapter contains the outcome of Stage 1 Establishing the list of ‘Other Existing and/or Approved Projects’; and Stage 2 ‘Screening of ‘Other Existing and/or Approved Projects’. This section presents Stage 3, an assessment of whether the proposed development in combination with other projects, grouped in tiers, would be likely to have significant cumulative effects.

The assessment specifically considers whether any of the approved developments in the local or wider area have the potential to alter the significance of effects associated with the proposed development.

Developments which are already built and operating, and which are not identified in this chapter, are included in the baseline environment or have been screened out as there is no potential to alter the significance of effects.

The assessment of cumulative effects has considered likely significant effects that may arise during construction, operation and decommissioning of the proposed development. Cumulative effects were assessed to a level of detail commensurate with the information that has either been directly shared with the proposed development, or was publicly available at the time of assessment.

Given the location and nature of the proposed development, a tiered approach to establishing the list of other existing and/or approved projects has been undertaken in Stage 1 of the cumulative effects assessment. The tiering of projects is based on project relevance to the proposed development and it is not a hierarchical approach nor based on weighting. Further information on the tiers is provided in Section 13.9.2 and in the Cumulative and Inter-Related Effects Chapter.

10.9.1 Marine Geology, Oceanography and Physical Processes cumulative screening exercise

The existing and/or approved projects selected as relevant to the cumulative effects assessment of impacts to marine processes are based on an initial screening exercise undertaken on a long list (see Cumulative and Inter-Related Effects Chapter). Consideration of source-pathway-receptor, data confidence and temporal and spatial scales has allowed the selection of the relevant projects included in the marine processes cumulative short-list.

When assessing likely significant effects for marine processes, projects were screened into the assessment based on a 24km screening range surrounding the array area, and a 24km range around the offshore ECC representing twice the tidal ellipse distance for a single tidal cycle and therefore encompasses the combined extent of impacts to marine processes receptors from the proposed development and also any regional projects likely to contribute to cumulative effects under a precautionary assumption that other projects may have a similar ZoI to the proposed development.

For the full list of projects considered, including those screened out, please see the Cumulative and Inter-Related Effects Chapter and Appendix 38.1.

10.9.2 Projects considered within the cumulative effect assessment

The planned, existing and/or approved projects selected through the screening exercise as potentially relevant to the assessment of impacts to marine processes are presented in Table 10.9.

The tiers for the assessment are:

- Tier 1 is limited to the Operation and Maintenance Facility (OMF) for the proposed development. The OMF option being considered involves the adaption and leasing part of an existing port facility at Greenore. Further detail is provided in the Offshore Description Chapter.
- Tier 2 is the east coast Phase One Offshore Wind Farms.
- Tier 3 is all other projects that have been screened in for this topic.

The tiering structure is intended to provide an understanding of the potential for likely significant effects of the proposed development with the construction of its OMF (tier one); followed by a cumulative assessment of the likely significant effect of that scenario combined with the east coast Phase One Offshore Wind Farms (tier two); and lastly the combination of tier one and tier two with all other existing and/or approved projects that have been screened in (tier three).

There are no impact pathways identified with the Tier 1 OMF or the Tier 2 Phase One OWF projects to the south of the study area since the prevailing wave directions and net transport pathways for tidal advection and sediments are to the north. The only Phase One OWF linked by a potential pathway of impact is Oriel Wind Park and due to a cumulative effect on prevailing south-south-easterly waves reaching the leeward coastline. The potential tidal advection pathways from the proposed development array area includes an initial northerly passage which subsequently moves to the north-east following the alignment of the coastline which avoids the Oriel Wind Park array area.

If the construction phase of both projects overlaps then there may be limited occasions when plumes / settlement from the proposed development and Oriel Wind Park overlap in the far-field, although this would not expect to occur during periods of neap tides and be limited to low values of impact.

The associated confidence in this assessment is presently limited by the lack of information to establish the construction or operational impacts of Oriel Wind Park.

Table 10.7 Projects and plans considered within the cumulative impact assessment

Development type	Project	Status	Data confidence	Distance to the proposed development		Justification for screening into the cumulative effects assessment
				Array area	ECC	
Tier 1	**OMF**	**This project is not screened into the marine processes cumulative effects assessment due to the onshore (landward HWM) nature of the infrastructure and associated offshore works being outside of the tidal excursion considered for the cumulative effects assessment.**				
Tier 2						
Phase One Offshore wind farm	Oriel Wind Park	Pre-consent	Medium – scoping report available at time of writing. A foreshore licence has been granted for site investigations (2022-2027). Reference FS007383. Construction periods have been shared between Phase One projects.	16.9km	21.6km	Location of Oriel Wind Park in the lee of array-scale wave blockage from NISA for prevailing wave direction. Overlap in construction period, Oriel Wind Park due to construct during 2026-2028.
Tier 3						
Subsea cables	Havhingsten Telecoms Cable	Active	High	0.7km	9.7km	Subsea cable may require maintenance activities which may result in short-term, temporary seabed disturbance
	Rockabill Telecoms Cable	Active	High	4.9km	13.0km	
	East West Interconnector	Active	High	5.0km	11.4km	
	HIBERNIA 'C'	Active	High	7.7km	17.0km	
	SIRIUS SOUTH	Active	High	9.4km	18.7km	
	CeltixConnect - Sea Fibre Networks	Active	High	11.3km	20.1km	
	ZAYO Emerald Bridge One	Active	High	12.1km	20.2km	
O&G pipelines	PL938: Interconnector Scotland to Ireland IC1	Active	High	4.2km	10.6km	Pipelines may require maintenance activities which may result in short-term, temporary seabed disturbance.

Development type	Project	Status	Data confidence	Distance to the proposed development		Justification for screening into the cumulative effects assessment
				Array area	ECC	
	PL1890: Interconnector Scotland to Ireland IC2	Active	High	0.5km	2.7km	
Dumping at Sea	Drogheda Port Company – Dumping Site A1	Active	High	15.3km	14.3km	Ongoing dumping at sea activities within the ZoI and within the proposed development construction phase may result in a cumulative increase in SSC
	Drogheda Port Company – Dumping Site A2	Active	High	15.3km	14.3km	Ongoing dumping at sea activities within the ZoI and within the proposed development construction phase may result in a cumulative increase in SSC
Coastal Assets & Infrastructure	Greater Dublin Drainage Outfall Pipe	Licence valid 2020 to 2045	High	11.3km	24.8km	Installation activities are likely to result in temporary, short-term seabed disturbances

10.9.3 Project impacts and options included in the assessment

The identification of potential impacts for the cumulative assessment has been undertaken by considering the relevant characteristics from both project options (refer to Section 10.4) and the potential for a pathway for them to have direct and indirect effects on known receptors (as identified in Section 10.3) when combined with other projects.

For each impact, the project option with the greatest potential for a likely significant effect has been determined based on the comparison and justification provided in Table 10.6. The impacts considered in the cumulative assessment are presented in Table 10.10. As the residual effects for Project Option 1 and Project Option 2 are the same (as identified in Section 10.7), the cumulative effects assessment presented in this section applies to both options.

Table 10.8 Potential cumulative impacts and tiers for assessment

Potential cumulative impact	Phase	Tiers and Projects	Justification for inclusion in cumulative effects assessment
Impact 1 - Physical changes to marine processes receptors from cumulative increase in suspended sediment concentration and deposition	Construction and operation	Tier 2 – Phase One Projects – Oriel Wind Park Tier 3 – Subsea cables; O&G pipelines, dumping at sea, coastal assets & infrastructure	There is the potential for activities to temporally overlap with the construction phase and potential for cumulative SSC and sediment deposition to occur within the modelled plume footprint.
Impact 2 - Physical changes to the coastline from modification in storm waves due to cumulative blockage from infrastructure	Operation	Tier 2 – Phase One Projects – Oriel Wind Park Tier 3 – Coastal assets & infrastructure	Potential for cumulative changes to hydrodynamics, waves and sediment transport.

10.9.4 Cumulative Impact 1 - Physical changes to marine processes receptors from cumulative increase in suspended sediment concentration and deposition during construction and operation

10.9.4.1 Tier 1

The OMF is outside of the screening range. Additionally, assessments undertaken for the proposed development indicates that there are no marine processes related impact pathways which extend far enough north to interact with the likely ZoI of the proposed OMF. Therefore, this project is not screened into the assessment.

10.9.4.2 Tier 1 and 2

No Tier 1 projects have been carried forward into this assessment.

The interaction of sediment plumes from the proposed development with activities from Oriel Wind Park is considered unlikely, even if construction activities occurred at the same time. Impact pathways are likely to be mutually exclusive and not overlap. The sensitivity of receptors within the ZoI are considered to be low to increased SSC and deposition and the magnitude of impact is assessed to be negligible for Project Option 1 and Project Option 2. The significance of the cumulative effects is determined to be imperceptible for Project Option 1 and Project Option 2, which is not significant in EIA terms.

10.9.4.3 Tier 1, 2 and 3 (All tiers)

No Tier 1 projects have been carried forward into this assessment.

The interaction of sediment plumes from the proposed development with any other Tier 3 projects and activities within the screening range (such as spoil disposal at the nearshore DAS site north of the ECC) with Tier 2 is considered unlikely, even if construction activities occurred at the same time.

Impact pathways are likely to be mutually exclusive. The sensitivity of receptors within the ZoI are considered to be low to increased SSC and deposition and the magnitude of impact is assessed to be negligible for Project Option 1 and Project Option 2. The significance of the cumulative effects is determined to be imperceptible for Project Option 1 and Project Option 2, which is not significant in EIA terms.

10.9.5 Cumulative Impact 2 – Physical changes to the coastline from modification in storm waves due to cumulative blockage from infrastructure

10.9.5.1 Tier 1

Assessments undertaken for the proposed development indicates that there are no marine related impact pathways which extend far enough north to interact with the likely ZoI of the proposed OMF. Therefore, this project is not screened into the assessment.

10.9.5.2 Tier 1 and 2

No Tier 1 projects have been carried forward into this assessment.

There is a small chance that wave blockage effects propagating from the proposed development (limited to times of peak storm events from the prevailing south-south-east wave direction) to interact with similar effects occurring across Oriel Wind Park to develop a greater level of wave height reduction along the south-easterly part of the Cooley Peninsula. As these waves approach the leeward coastline and move into shallower water then wave shoaling would expect to dominate to further reduce wave heights. The local shoreline is described as a gravel beach fronting upland and is considered not to be sensitive to any small (in the order of 0.05 to 0.10m), indiscernible changes in wave height. The sensitivity of receptors within the ZoI is considered to be medium due to the Rockabill to Dalkey Island SAC, and the magnitude of impact is assessed to be negligible for Project Option 1 and Project Option 2. The significance of the cumulative effects is determined to be slight for Project Option 1 and Project Option 2, which is not significant in EIA terms.

10.9.5.3 Tier 1, 2 and 3 (All tiers)

No Tier 1 projects have been carried forward into this assessment.

The interaction of blockage effects from the proposed development with any other Tier 3 activities and infrastructure within the screening range (such as the Greater Dublin drainage outfall pipe) with Tier 2 is considered unlikely. Impact pathways are likely to be mutually exclusive in location. The sensitivity of receptors within the ZoI are considered to be medium due to the Rockabill to Dalkey Island SAC, and the magnitude of impact is assessed to be negligible for Project Option 1 and Project Option 2. The significance of the cumulative effects is determined to be slight for Project Option 1 and Project Option 2, which is not significant in EIA terms.

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