NORTH FALLS

Offshore Wind Farm

ENVIRONMENTAL STATEMENT

Chapter 8 Marine Geology, Oceanography and Physical Processes

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Glossary of Acronyms

DECC	Department of Energy and Climate Change
3D	Three Dimensional
CD	Chart Datum
CEA	Cumulative Effects Assessment
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CPA	Coast Protection Act
DCO	Development Consent Order
DESNZ	Department for Energy Security & Net Zero
EACG	East Anglia Coastal Group
EEA	European Economic Area
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EPP	Evidence Plan Process
ETG	Expert Topic Group
FEPA	Food and Environmental Protection Act
GBS	Gravity Base Structure
GGOW	Greater Gabbard Offshore WindfarmWind FarmWindfarm
GWF	Galloper Offshore Windfarm Wind Farm
HAT	Highest Astronomical Tide
HDD	Horizontal Directional Drilling
HRA	Habitat Regulations Assessment
IFCA	Inshore Fisheries and Conservation Authorities
KKE	Kentish Knock East
km	Kilometre
km^2	Kilometre Squared
LAT	Lowest Astronomical Tide
m	Metre
m/s	Metres Per Second
m^2	Metre Squared
m^3	Metre Cubed
MCZ	Marine Conservation Zone
MCZA	Marine Conservation Zone Assessment
mg/l	Milligrams Per Litre
MHWS	Mean High Water Spring
MLWS	Mean Low Water Spring
mm	Millimetre

MMO	Marine Management Organisation
MPS	Marine Policy Statement
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
OCP	Offshore Converter Platform
OSP	Offshore Substation Platform
OWF	Offshore Wind Farm
PEIR	Preliminary Environmental Information Report
PINS	Planning Inspectorate
RWE	RWE Renewables UK Swindon Limited
s	Second (unit of time)
SAC	Special Area of Conservation
SEER	SEE Renewables Offshore Windfarm Holdings Limited
SMP	Shoreline Management Plan
SPA	Special Protection Area
S-P-R	Source-Pathway-Receptor conceptual model
SSC	Suspended Sediment Concentration
SSSI	Site of Special Scientific Interest
UKCP18	United Kingdom Climate Projections 2018
UKHO	UK Hydrographic Office

Glossary of Terminology

Amphidromic point	The centre of an amphidromic system; a nodal point around which a standing-wave crest rotates once each tidal period.
Array area	The offshore wind farm area, within which the wind turbine generators, array cables, platform interconnector cable, offshore substation platform(s) and/or offshore converter platform will be located.
Array cables	Cables which link the wind turbine generators with each other, the offshore substation platform(s) and/or the offshore converter platform.
Astronomical tide	The predicted tide levels and character that would result from the gravitational effects of the earth, sun and moon without any atmospheric influences.
Bathymetry	Topography of the seabed.
Beach	A deposit of non-cohesive sediment (e.g. sand, gravel) situated on the interface between dry land and the sea (or other large expanse of water) and actively 'worked' by present-day hydrodynamic processes (i.e. waves, tides and currents) and sometimes by winds.
Bedforms	Features on the seabed (e.g. Sandwaves, ripples) resulting from the movement of sediment over it.
Bedload	Sediment particles that travel near or on the bed.
Clay	Fine sediment with a typical particle size of less than 0.002mm.
Climate change	A change in global or regional climate patterns. Within this chapter this usually relates to any long-term trend in mean sea level, wave height, wind speed etc, due to climate change.
Closure depth	The depth that represents the 'seaward limit of significant depth change, but is not an absolute boundary across which there is no cross-shore sediment transport.
Coastal processes	Collective term covering the action of natural forces on the shoreline and nearshore seabed.
Cohesive sediment	Sediment containing a significant proportion of clays, the electromagnetic properties of which causes the particles to bind together.
Crest	Highest point on a bedform or wave.
Current	Flow of water generated by a variety of forcing mechanisms (e.g. waves, tides, wind).
Ebb tide	The falling tide, immediately following the period of high water and preceding the period of low water.
Erosion	Wearing away of the land or seabed by natural forces (e.g. wind, waves, currents, chemical weathering).
Evidence Plan Process	A voluntary consultation process with specialist stakeholders to agree the approach to the EIA and information to support the Habitat Regulations Assessment (HRA).
Flood tide	The rising tide, immediately following the period of low water and preceding the period of high water.
Glacial till	Poorly-sorted, non-stratified and unconsolidated sediment carried or deposited by a glacier.
Gravel	Loose, rounded fragments of rock larger than sand but smaller than cobbles. Sediment larger than 2mm (as classified by the Wentworth scale used in sedimentology).
Habitat	The environment of an organism and the place where it is usually found.
High water	Maximum level reached by the rising tide.
Holocene	The last 10,000 years of earth history.

Hydrodynamic	The process and science associated with the flow and motion in water produced by applied forces.
Intertidal	Area on a shore that lies between Lowest Astronomical Tide (LAT) and Highest Astronomical Tide (HAT).
Landfall	The location where the offshore cables come ashore at Kirby Brook.
Long-term	Refers to a time period of decades to centuries.
Low water	The minimum height reached by the falling tide.
Mean sea level	The average level of the sea surface over a defined period (usually a year or longer), taking account of all tidal effects and surge events.
Megaripples	Bedforms with a wavelength of 0.6 to 10.0m and a height of 0.1 to 1.0m. These features are smaller than sandwaves but larger than ripples.
Neap tide	A tide that occurs when the tide-generating forces of the sun and moon are acting at right angles to each other, so the tidal range is lower than average.
Nearshore	The zone which extends from the swash zone to the position marking the start of the offshore zone).
Numerical modelling	Refers to the analysis of coastal processes using computational models.
Offshore	Area seaward of nearshore in which the transport of sediment is not caused by wave activity.
Offshore cable corridor	The corridor of seabed from the array area to the landfall within which the offshore export cables will be located.
Offshore converter platform	Should an offshore connection to an HVDC interconnector cable be selected, an offshore converter platform would be required. This is a fixed structure located within the array area, containing HVAC and HVDC electrical equipment to aggregate the power from the wind turbine generators, increase the voltage to a more suitable level for export and convert the HVAC power generated by the wind turbine generators into HVDC power for export to shore via an HVDC cable supplied by a third party.
Offshore export cables	The cables which bring electricity from the offshore substation platform(s) to the landfall.
Offshore project area	The overall area of the array area and the offshore cable corridor.
Offshore substation platform(s)	Fixed structure(s) located within the array area, containing electrical equipment to aggregate the power from the wind turbine generators and convert it into a more suitable voltage for export to shore via offshore export cables.
Onshore cable route	Onshore route within which the onshore export cables and associated infrastructure would be located.
Onshore substation	A compound containing electrical equipment required to transform and stabilise electricity generated by the Project so that it can be connected to the National Grid.
Onshore export cables	The cables which take the electricity from landfall to the onshore substation. These comprise High Voltage Alternative Current (HVAC) cables, buried underground.
Platform interconnector cable	Cable connecting the offshore substation platforms (OSP) or the OSP and offshore converter platform (OCP).
Pleistocene	An epoch of the Quaternary Period (between about 2 million and 10,000 years ago) characterised by several glacial ages.
Quaternary Period	The last 2 million years of earth history incorporating the Pleistocene ice ages and the post-glacial (Holocene) Period.
Sand	Sediment particles, mainly of quartz with a diameter of between 0.063mm and 2mm. Sand is generally classified as fine, medium or coarse.
Sandwave	Bedforms with wavelengths of 10 to 100m, with amplitudes of 1 to 10m.

Scour protection	Protective materials to avoid sediment being eroded away from the base of the wind turbine generator foundations and offshore substation platform foundations as a result of the flow of water.
Sea level	Generally, refers to 'still water level' (excluding wave influences) averaged over a period of time such that periodic changes in level (e.g. due to the tides) are averaged out.
Sea-level rise	The general term given to the upward trend in mean sea level resulting from a combination of local or regional geological movements and global climate change.
Sediment	Particulate matter derived from rock, minerals or bioclastic matter.
Sediment transport	The movement of a mass of sediment by the forces of currents and waves.
Shore platform	A platform of exposed rock or cohesive sediment exposed within the intertidal and subtidal zones.
Short-term	Refers to a time period of months to years.
Significant wave height	The average height of the highest of one third of the waves in a given sea state.
Silt	Sediment particles with a grain size between 0.002mm and 0.063mm, i.e. coarser than clay but finer than sand.
Spring tide	A tide that occurs when the tide-generating forces of the sun and moon are acting in the same directions, so the tidal range is higher than average.
Storm surge	A rise in water level on the open coast due to the action of wind stress as well as atmospheric pressure on the sea surface.
Study area	Area where potential impacts from the Project could occur, as defined for each individual ES topic.
Surge	Changes in water level as a result of meteorological forcing (wind, high or low barometric pressure) causing a difference between the recorded water level and the astronomical tide predicted using harmonic analysis.
Suspended sediment	The sediment moving in suspension in a fluid kept up by the upward components of the turbulent currents or by the colloidal suspension.
Swell waves	Wind-generated waves that have travelled out of their generating area. Swell characteristically exhibits a more regular and longer period and has flatter crests than waves within their fetch.
Thalweg	A line connecting the lowest points of successive cross-sections along the course of a valley or river.
The Applicant	North Falls Offshore Wind Farm Limited (NFOW).
The Project or 'North Falls'	North Falls Offshore Wind Farm, including all onshore and offshore infrastructure.
Tidal current	The alternating horizontal movement of water associated with the rise and fall of the tide.
Tidal range	Difference in height between high and low water levels at a point.
Tide	The periodic rise and fall of the water that results from the gravitational attraction of the moon and sun acting upon the rotating earth.
Wave climate	Average condition of the waves at a given place over a period of years, as shown by height, period, direction etc.
Wave height	The vertical distance between the crest and the trough.

8 Marine Geology, Oceanography and Physical Processes

8.1 Introduction

1. This chapter of the Environmental Statement (ES) considers the likely significant effects of the North Falls offshore wind farm (hereafter 'North Falls' or 'the Project') on marine geology, oceanography and physical processes. The chapter provides an overview of the existing environment for the proposed offshore project area, followed by an assessment of the likely significant effects for the construction, operation and maintenance, and decommissioning phases of the Project.

2. This chapter has been written by Royal HaskoningDHV, with the assessment undertaken with specific reference to the relevant legislation and guidance, of which the primary sources are the National Policy Statements (NPS). Details of these and the methodology used for the Environmental Impact Assessment (EIA) and Cumulative Effects Assessment (CEA) are presented in Section 8.4.

3. The assessment of effects on marine geology, oceanography and physical processes informs the following linked chapters (Volume 3.1):
   - ES Chapter 9 Marine water and sediment quality (Document Reference: 3.1.11);
   - ES Chapter 10 Benthic and intertidal ecology (Document Reference: 3.1.12);
   - ES Chapter 11 Fish and shellfish ecology (Document Reference: 3.1.13);
   - ES Chapter 14 Commercial fisheries (Document Reference: 3.1.16); and
   - ES Chapter 16 Offshore archaeology and cultural heritage (Document Reference: 3.1.18).

4. Information to support the marine geology, oceanography and physical processes assessment includes:
   - Interpretation of survey data specifically collected for North Falls including bathymetry, geophysical (shallow geology) and environmental (sediment particle size) data;
   - The existing evidence base of the effects of offshore wind farm developments on the physical environment;
   - Bespoke numerical modelling of wave heights and directions at North Falls;
   - Numerical modelling studies undertaken for Galloper Offshore Wind Farm (GWF) and Greater Gabbard Offshore Windfarm (GGOW) and their associated ES chapters; and
   - Discussion and agreement with key stakeholders.

8.2 Consultation

5. Consultation regarding marine geology, oceanography and physical processes has been undertaken in line with the general process described in ES Chapter 6 EIA Methodology (Document Reference: 3.1.8). The key elements to date have included scoping and the ongoing technical consultation via the Seabed Expert Topic Group (ETG) (including Natural England, the Marine Management Organisation (MMO), and Centre for Environment, Fisheries and Aquaculture Science (Cefas).

6. Further consultation on marine geology, oceanography and physical processes has been conducted through consultation on the North Falls Physical Processes Method Statement submitted to the ETG in June 2021 as part of the Evidence Plan Process (EPP). This document provided data requirements and a method for the assessment of likely significant effects on the baseline marine physical processes due to the Project (outlined in Section 8.4.3).

7. The feedback received has been considered in preparing the ES. Table 8.1 Consultation responsesprovides a summary of how the consultation responses received to date have influenced the approach that has been taken.

8. This chapter has been updated following the consultation on the PEIR to produce the final assessment. Full details of the consultation process are presented in the Consultation Report, provided as part of the Development Consent Order (DCO) application.

Table 8.1 Consultation responses

Consultee	Date / Document	Comment	Response / where addressed in the ES
Natural England; MMO; The Wildlife Trust; Kent and Essex IFCA; Cefas	05/07/21 Seabed ETG meeting	The Applicant provided an introduction to the Project and presented the proposed approach to the EIA and scoping prior to submission of the scoping report to the Planning Inspectorate. Key comments from stakeholders are therefore captured within the scoping opinion described below.	N/A
Essex County Council	20/08/2021 Scoping opinion	In section 2.1.1.3 re Coastal Processes (para 150) it is surprising to find such little attention is paid to the Essex and South Suffolk Shoreline Management Plan (SMP). The preferred policy for this section of coast (Policy Development Zone C2 in the SMP) for Epoch 3 (2055 to 2015) is for Hold the Line / Managed Realignment meaning there is no certainty that this section of frontage will continue to be managed in the same way into the future. It should be noted that even for the earlier periods (present day to 2055) where the current preferred policy is for one of 'Hold The Line', this will only be possible if there is sufficient funding available to undertake the required works. The SMP notes that "in the long term, holding the line at this location will be challenging and that funding may have to come from a variety of sources."	The SMP is discussed in Sections 8.5.9, 8.5.10 and 8.6.1.1. Impacts on the coast are assessed in Sections 8.6.2.9 and 8.6.3.6.
Essex County Council	20/08/2021 Scoping opinion	There is mention that the defences are under pressure and that Tendring District Council has undertaken works, to stabilise the area (para 135), but further detail is not provided. It is believed that the works referred to here, are the significant works which were undertaken in 2014 to afford protection to a 5km length from Clacton on Sea to just west of the Gunfleet Sailing Club. Whilst this is a scheme designed for 100 years of protection, it is reliant on ongoing maintenance at an estimated cost of £1.2million every 10 years, and it should be noted that it might well be challenging to secure this funding. It should also be noted that the eastern end of this significant scheme is where the coast protection responsibilities of Tendring District Council end, with the remaining and substantive length of the frontage being considered for the onshoring in the scoping study falling under the responsibility of the Environment Agency. The way the scoping report is written is misleading as it implies that Tendring District Council has undertaken works along the whole	

Consultee	Date / Document	Comment	Response / where addressed in the ES
		section, which is not the case and yet the whole frontage is under pressure. A more precise location would need to be providing for where the cables will come ashore before it is possible to determine which organisation is responsible for coast protection there.	
Essex County Council	20/08/2021 Scoping opinion	In para 140 (2.1.3.1) the risks of increased suspended sediments and changes to seabed levels are highlighted for during construction. The Paragraph also notes that nearshore cable installation could result in changes to shoreline levels due to deposition or erosion. Para 142 also highlights that effects during operation could occur due to the physical presence of infrastructure (foundations and any cable protection above the seabed) and that these may result in changes to waves / tidal currents which could affect the sediment transport regime and / or seabed morphology. The similar impacts on marine geology and physical processes seen during the construction period are also likely to occur during decommissioning (para 143). With such a significant coast protection scheme having been undertaken in the area in recent years at a total cost of £36 million (including £3 million contribution from Essex County Council) it is vital that any impacts are fully modelled, and results taken into account to ensure that no work is undertaken which could undermine or negatively impact on these previous investments.	Justification for using conceptual methods to predict effects is provided in Section 8.4.6. The assessment is based on a source-pathway-receptor (S-P-R) conceptual model, whereby the source is the initiator event, the pathway is the link between the source and the receptor affected, and the receptor is the receiving entity. The use of numerical modelling for tidal currents and sediment dispersion is disproportionate to the potential impact that would occur. In these cases, the S-P-R conceptual model is proportionate and the MMO consider the approach outlined to assess the potential impacts of the Project on the physical environment to be sufficient (see consultation response from MMO below). Consideration of the risk of increased suspended sediments is described in Section 8.6.2.1 and Section 8.6.2.2. Changes to bed level in Section 8.6.2.3 and 8.6.2.4 and the physical presence of infrastructure during the operation phase in Section 8.6.3.1 and Section 8.6.3.2. Following Section 42 consultation and feedback received from Natural England and the MMO through the EPP, numerical modelling of waves has now been completed for potential operational impacts due to the presence of the foundation structures.
Essex County Council	20/08/2021 Scoping opinion	Para 141 confirms that the EIA will include assessment of the effects of disposal of dredged or drilled material and that a licence application for disposal of dredged material within the wind farm boundary will be included within the DCO application, if required. It is important that the beneficial use options of any dredged material (which can often be used in other coast protection schemes) are fully scoped and where possible, suitable receiving sites identified in a detailed study.	The assessment considers disposal at sea. This is the standard approach for offshore wind farms, however the Applicant is open to considering the feasibility of alternative suggestions by Essex County Council (or others).
Essex County Council	20/08/2021	In light of the comments above, studies would need to be undertaken to fully evaluate the impacts of any scheme on	Consideration of the potential for likely significant effects on the form and function of bedload sediment transport processes due to

Consultee	Date / Document	Comment	Response / where addressed in the ES
	Scoping opinion	coastal processes including the effects on foreshore and structures;	foundation and cable installation is described in Section 8.6.2.9, Section 8.6.3.3 and Section 8.6.3.5. The assessment is completed using a conceptual evidence-based approach.
Marine Management Organisation	19/07/2021 Scoping opinion	The MMO consider the approach outlined by The Applicant to assess the potential impacts of the project on the physical environment to be sufficient.	Noted
Marine Management Organisation	19/07/2021 Scoping opinion	The Applicant intends to use bathymetric survey data from 2005.The MMO are unaware of the sediment dynamics in this region, hence it is not possible to comment on the appropriateness of these data. If the region is dynamic, these data could poorly represent the current situation.	Bathymetric surveys of the array area and offshore cable corridor were undertaken by Fugro between May and September 2021. Results are described in Section 8.5.1.
Marine Management Organisation	19/07/2021 Scoping opinion	The MMO would like to comment that the proposed wave data capture for a relatively short period between November 2004 and March 2005. While these will help characterise modal conditions over the winter period, the short time span will mean they are of limited use when looking at extreme events. This should be considered by The Applicant.	A suite of wave data has been used to inform this assessment – these are outlined in Section 8.4.2 and described in Section 8.5.5.
Marine Management Organisation	19/07/2021 Scoping opinion	The list of activities that could potentially interact with this project are outline in paragraphs 105 and 106 of the Scoping Report. The MMO consider these capture all industries that are likely to interact with the Project.	Noted.
Natural England	16/08/2021 Scoping opinion	Marine Geology, Oceanography and Physical Processes Natural England advises that, based on the information provided, there is insufficient information on the baseline conditions, required studies and methodologies, receptors, potential environmental impacts, and approaches to impact assessment. Further information will be needed in the Environmental Statement to form a robust understanding of the worst case design scenario and its impacts during the construction, operation, decommissioning (and repowering) phases of the Project.	Section 8.5 provides a detailed description of baseline conditions. Receptors are outlined in Section 8.6.1. Potential environmental impacts are outlined in Section 8.6 – Section 8.9. Approaches to impact assessment are outlined in Section 8.4. The worst case design scenario for marine geology, oceanography and physical processes over the lifespan of the Project is outlined in Section 8.3.2.
Natural England	16/08/2021 Scoping opinion	Section 2.1 Following the review of the existing environment, baseline characteristics and data in this section, the Worst-Case Design Scenario for marine geology, oceanography and physical	The worst case design scenario for marine geology, oceanography and physical processes over the lifespan of the Project is outlined in Section 8.3.2.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		processes should be presented for the lifespan of the project in the ES. In addition, the range of any mitigation measures captured within the design envelope aimed at minimising environmental effects should be considered.	Mitigation measures are outlined in Section 8.3.3.
Natural England	16/08/2021 Scoping opinion	Section 2.1 Section 2.1 considers 'Marine Geology, Oceanography, and Physical Processes, however, there is little mention of the Marine Geology. Baseline conditions for marine geology should also be included here, including a broad-scale description of the regional geology, contemporary form of the seabed and adjacent coast, their development in response to the last glaciation and sea level rise. In addition, baseline marine geology information should include the geological make-up and surficial sediment cover of the seabed across the Zone of Influence of the proposed development.	Regional geology of the offshore project area is described in Section 8.5.2. Surficial sediment cover of the seabed across the Zone of Influence (ZoI) of the proposed development is described in Section 8.5.6 and shown in ES Figure 8.9 (Document Reference: 3.2.4) and ES Figure 8.10 (Document Reference: 3.2.4).
Natural England	16/08/2021 Scoping opinion	Section 2.1.1 Storm surges Given that the North Sea is subject to the influence of storm surges, they will need to be considered in the EIA.	Storm surges in the North Sea are considered in Section 8.5.3.4.
Natural England	16/08/2021 Scoping opinion	Section 2.1.1 Sediment Transport Description of suspended and bedload sediment transport across the project area should be included, including the source of sediment across the area, sediment transport pathways, partings, sources and sinks. A map showing these features would be useful. A map of seabed mobility would also be useful in the ES.	Bedload sediment transport and suspended sediment is discussed in Sections 8.5.7 and 8.5.8, respectively. A map of sediment transport pathways is provided in ES Figure 8.11 (Document Reference: 3.2.4).
Natural England	16/08/2021 Scoping opinion	Section 2.1.1 Climate change Consideration of climate change impacts over the operational	Climate change impacts have been considered in Section 8.5.10.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		period of North Falls OWF will need to be included in the ES. These impacts will become important if they cause an alteration in the baseline conditions and become detectable above natural inter-annual variations.	
Natural England	16/08/2021 Scoping opinion	Section 2.1.1.1 Figures 2.1 and 2.2 show Offshore Bathymetry and Offshore Sediment Types. There are no maps showing bedrock geology, or bedforms across the project area. Bedrock geology and seabed morphology mapping should also be included in the ES.	ES Figure 8.1 and ES Figure 8.2 (Document Reference: 3.2.4) show bathymetry and bedforms across the North Falls array area and offshore cable corridor, respectively.
Natural England	16/08/2021 Scoping opinion	Section 2.1.1.1 Point 133 The Inner Gabbard and The Galloper sandbanks are mentioned in this section, but not identified on Figure 2.2 (or Figure 2.1). These features should be identified in the relevant ES figures.	The Inner Gabbard and Galloper sandbanks are shown in ES Figure 8.12 (Document Reference: 3.2.4).
Natural England	16/08/2021 Scoping opinion	Section 2.1.1.1 Point 133 Studies to inform the baseline have been taken from GGOW from 2005.These studies are now 16 years old. Whilst the GGOW studies provide useful information on seabed sediments within the GGOW project area, site- specific and more recent information for the North Falls OWF project area will also be required to form the baseline.	A site-specific geophysical survey and grab sampling campaign was completed by Fugro from May to August 2021 (Section 8.5.6). Seabed sediment data from GGOW was used only for comparison.
Natural England	16/08/2021 Scoping opinion	Section 2.1.1.1 Point 134 Typical and maximum significant wave heights of 3.6m and 6.2m, respectively, were recorded [at GGOW, 2005]. The larger waves tended to originate from the north-east. As with the comment above, the GGOW (2005) metocean surveys are now quite old. These surveys pre-date construction of the GGOW and Galloper OWF and thus, more recent and site-specific wave data should also be used to form the baseline for North Falls and in turn, help inform the EIA.	A suite of wave data has been used to inform this assessment – these are outlined in Section 8.4.2 and described in Section 8.5.5.

Consultee	Date / Document	Comment	Response / where addressed in the ES
Natural England	16/08/2021 Scoping opinion	Section 2.1.2 Table 2.1 & Table 2.2 GGOW geophysical surveys were undertaken in 2004/5, and for GWF in 2009. GGOW geotechnical survey was undertaken (array only) in 2004. GGOW benthic survey was undertaken in 2004/5. GWF benthic survey was undertaken in 2009. GGOW metocean survey (array only) was undertaken in 2004/5. GGOW coastal processes assessment (array only) was carried out in 2005. GWF coastal processes assessment (array only) was carried out in 2011. North Falls geophysical survey, grab sampling and particle size analysis are being carried out in 2021, for both the array and offshore export cable corridor (OECC). We welcome the collection of site- specific contemporary geophysical and sediment sample data for the North Falls OWF project area; however, Table2.2 should state the nature of the geophysical survey (i.e. sub-bottom profiler, side scan sonar, multi beam echo sounder, and magnetometer). There is no mention of further geotechnical surveys following the survey in 2004 for GGOW, yet it is important to ensure that adequate information is collected during the early geophysical and geotechnical survey campaigns to enable careful selection of the cable route and to aid cable burial. Therefore, we advise that additional geotechnical information will be required for North Falls. Similarly, the metocean and coastal processes data listed in Tables 2.1 & 2.2 are old and pre-date the construction of GWF. There is no mention of suspended sediment concentration data measurements, nearshore sediment transport measurements, sediment transport pathways, or sediment cells. These will need to be considered in the ES along with potential impacts on them due to the proposed development. We also advise that hydrodynamic impacts on the wave and current regime will need to be examined through modelling to characterise the wave-current climate across the Zone of Influence and help form an understanding of the potential impacts of the Project on receptors. To this end, more up- to-	A site-specific sediment sampling survey was carried out by Fugro between May to August 2021 and samples were analysed by an MMO accredited laboratory. An outline of the site-specific survey is provided in Table 8.5. A site-specific geotechnical survey will be undertaken post consent to inform the foundation design and cable installation. The worst case scenario, takes into account the range of infrastructure and methods that could be required based on knowledge of geology in the region, including lessons learned from GGOW and GWF. Therefore, geotechnical surveys are not required to inform this ES chapter. Justification for using conceptual methods to predict effects with regards impacts on the tidal current regime is provided in Section 8.4.6. The assessment is based on a S-P-R conceptual model, whereby the source is the initiator event, the pathway is the link between the source and the receptor affected, and the receptor is the receiving entity. The use of numerical modelling for tidal currents and sediment dispersion is disproportionate to the potential impact that would occur. In these cases, the S-P-R conceptual model is proportionate. Following Section 42 consultation and feedback received from Natural England and the MMO through the EPP, numerical modelling of waves has now been completed for potential operational impacts due to the presence of the foundation structures. The assessment for impacts to the tidal regime and wave regime are presented in Section 8.6.3.1 and Section 8.6.3.2. The MMO consider the approach outlined to assess the potential impacts of the Project on the physical environment to be sufficient (see consultation response from the MMO above). Cumulative effects of hydrodynamic and sediment transport impacts with existing and planned offshore wind farms are assessed in Section 8.8.3.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		date and site-specific data will be needed to characterise the wave-current regime across the Zone of Influence. In turn, this characterisation should consider a range of spatial (near- and far-field) and temporal scales for the entire lifespan of the proposed development. Furthermore, the cumulative effects of hydrodynamic and sediment transport impacts due to the proposed development in combination with existing adjacent offshore windfarms (i.e. GGOW and GWF) and planned OWFs (i.e. Five Estuaries), will need to be investigated. This investigation will need to consider cumulative impacts on the integrity of coastal and offshore receptors.	
Natural England	16/08/2021 Scoping opinion	Section 2.1.2 Point 139 Wave buoy at West Gabbard. West Gabbard 2 waverider buoy is well located for the North Falls OWF project. It might also be useful to incorporate data from the South Knock waverider buoy in the ES as this is further inshore and downwind of the existing GGOW and GWF.	The South Knock and West Gabbard 2 waverider buoys have been included in Section 8.5.5.
Natural England	16/08/2021 Scoping opinion	Section 2.1.2 Point 139 Other data sources. We recommend the EIA utilises the following data sources: Regional geology – BGS Holocene evolution – Shennan et al Sand transport pathways map – Kenyon and Cooper Bedforms – BGS SSC data – Cefas, satellite data etc	The data sources listed are utilised in Section 8.5 and listed in Section 8.4.2.
Natural England	16/08/2021 Scoping opinion	Section 2.1.3.1 Potential impacts during construction Although potential impacts are considered, it is not stated how these potential impacts will be assessed (e.g. seabed morphological change investigations, plume modelling, sediment mobility studies, shoreline profile surveys etc). This information	The assessment of likely significant effects during construction has been completed using a conceptual evidence-based approach. Justification for using conceptual methods with regards hydrodynamic impacts on the wave and current regime is provided in Section 8.4.6.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		needs to be provided in the ES and should be agreed through the EEP.	
Natural England	16/08/2021 Scoping opinion	Section 2.1.3.2 Potential impacts during operation and maintenance. As with the comment above, it is not stated how these potential impacts will be assessed (e.g. regional scale hydrodynamic modelling, seabed morphological change and sediment transport process studies, scour prediction modelling, shoreline profile surveys, coastal erosion/accretion analysis.	As above.
Natural England	16/08/2021 Scoping opinion	Section 2.1.3.4 Potential cumulative impacts There is the potential for North Falls to affect sediment transport pathways and downdrift receptors that are susceptible to sediment transport pathway changes. There is also the potential for the proposed development to create a wave sheltering effect when considered in combination with GGOW, GWF, and the planned Five Estuaries project. These potential cumulative impacts will need to be adequately assessed in the ES. Moreover, coastal erosion/accretion and shoreline management implications will also need to be considered due to the in-combination effects.	Cumulative effects are considered in Section 8.8.
Natural England	16/08/2021 Scoping opinion	Section 2.1.3.6 Table 2.3 Summary of potential impacts on marine geology, oceanography and physical processes. This table is too general and non-specific. The ES should consider specific potential effects for each phase of the Project lifespan and for both near-field and far- field scales. For example, changes to water levels resulting from installation equipment and construction activity for both the near- and far-field etc. Justification for scoping in/out residual impacts should also be included. Potential effects should be broken down more specifically for consideration in the ES (e.g. for hydrodynamic regime, changes to water levels, tidal currents, and wave height should be considered separately). Seabed	Table 2.3 in the Scoping Report provided a general summary of potential impacts on marine geology, oceanography and physical processes, however the ES provides an assessment of likely significant effects. See Section 8.6.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		features (bedforms), sediment regime, coastal processes, coastal frontage/landfall should also be considered.	
Natural England	16/08/2021 Scoping opinion	Section 2.1.4 Point 147 "A conceptual evidence-based assessment will draw from the results of the studies outlined above, including modelling undertaken for the GWF, which overlaps with the southern array of North Falls." Please see our comment to Point 2.1.2 above. Model results from the GWF, whilst useful, are pre-construction and do not consider the cumulative effects of the GGOW, GWF, North Falls (and Five Estuaries). Therefore, we advise further hydrodynamic modelling is needed to inform the EIA, with particular regard to establishing changes in wave height reduction, and the potential impacts on sensitive receptors of the North Falls project, both alone and cumulatively.	Justification for using conceptual methods with regards to impacts on the current regime is provided in Section 8.4.6. The assessment is based on a S-P-R conceptual model, whereby the source is the initiator event, the pathway is the link between the source and the receptor affected, and the receptor is the receiving entity. The use of numerical modelling for tidal currents and sediment dispersion is disproportionate to the potential impact that would occur. In these cases, the S-P-R conceptual model is proportionate. Following Section 42 consultation and feedback received from Natural England and the MMO through the EPP, numerical modelling of waves has now been completed for potential operational impacts due to the presence of the foundation structures. The assessment of impacts to the tidal regime and wave regime are presented in Section 8.6.3.1 and Section 8.6.3.2, respectively. The MMO consider the approach outlined to assess the potential impacts of the Project on the physical environment to be sufficient (see consultation response from the MMO above).
Natural England	16/08/2021 Scoping opinion	Section 2.1.4 Table 2.1.4 Marine geology, oceanography and physical processes receptors A source-pathway-receptor map (both for marine and coastal physical processes receptors as well as other dependent environmental receptors) should be provided in the ES. Offshore sandbanks/sandbank systems and other significant bedforms (designated or otherwise) within or in the vicinity of the development area, should be considered as receptors and included in the impact assessment.	Receptors are detailed in Section 8.6.1 and presented in ES Figure 8.15 (Document Reference: 3.2.4).
Natural England	16/08/2021 Scoping opinion	Section 2.13.1.7 Para 391 & 392 Mineral aggregate extraction areas adjacent to/overlapping the array(s) and/or export cable corridor. Further consideration of the cumulative effects of North Falls construction and aggregate extraction activities on the release of suspended sediments into the water column, sediment transport	Consideration of cumulative effects is presented in Section 8.8.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		processes and nearby designated sites (e.g. Kentish Knock East Marine Conservation Zone (MCZ)) should be presented in the ES.	
Planning Inspectorate	26/08/2021 Scoping opinion	Inter-array cabling and offshore export cables are described as having a target minimum cable depth of 0.5m to 3m where buried; indicative maximum diameters and lengths of cabling are noted but it is stated that the final layout will be determined post consent to fit with the final layout of the WTG. The ES should describe the range of burial depths that have been considered as part of the assessment and the degree of confidence in these parameters. It should establish the parameters likely to result in the maximum adverse effects and include an assessment of these to determine likely significance of effects.	The burial depths that have been used as part of the assessment are presented in Table 8.2. The assessment of the likely significance of effects is presented in Section 8.6.2 for the construction phase, Section 8.6.3 for the operation phase and Section 8.6.4 for the decommissioning phase.
Planning Inspectorate	26/08/2021 Scoping opinion	Paragraph 140 of the Scoping Report identifies a potential need for seabed preparation for installation of cables and foundations, including sand wave clearance and boulder removal. The ES should identify the worst case footprint of seabed disturbance that would arise from offshore construction activities, and the maximum footprints of all permanent components should also be identified. Should seabed preparation involve dredging, the ES should identify the quantities of dredged material and likely location for disposal.	The worst case footprint of seabed disturbance that would arise from offshore construction activities, the maximum footprints of all permanent components and volume of dredged material generated during seabed preparation are outlined in Table 8.2.
Planning Inspectorate	26/08/2021 Scoping opinion	Paragraph 86 of the Scoping Report (detailing the overarching assessment methodology for the EIA) states that study areas defined for each receptor are based on the Zone of Influence (ZoI) and relevant characteristics of the receptor (e.g. mobility / range). However, the Inspectorate notes that for many of the aspect chapters included, study areas and ZoIs have not been stated. Where this detail has been provided, it is not clear how these study areas relate to the extent of the impacts and likely significant effects associated with the Proposed Development, how they have been used to determine a ZoI, and what receptors have been identified within the ZoI. The ES should provide a robust justification as to how study areas have been defined and why the defined study areas are appropriate for assessing potential impacts.	The study area for marine geology, oceanography and physical processes is described in Section 8.3.1.

Consultee	Date / Document	Comment	Response / where addressed in the ES
Planning Inspectorate	26/08/2021 Scoping opinion	Some aspect sections of the Scoping Report have identified specific receptors, whereas others identify broad categories of receptors only. Specific receptors should be identified within the ES, alongside categorisation of their sensitivity and value. Section 1.8.2.1 of the Scoping Report explains the generic approach to defining receptor sensitivity in order to assess the potential impacts upon each receptor. The inspectorate expects a transparent and reasoned approach to be applied to assigning receptor sensitivity to be defined and applied across the aspect chapters.	The definition of sensitivity for a morphological receptor is outlined in 8.7.
Planning Inspectorate	26/08/2021 Scoping opinion	The ES should include details of difficulties (for example technical deficiencies or lack of knowledge) encountered compiling the required information and the main uncertainties involved.	Assumptions and limitations are presented in Section 8.4.7
Planning Inspectorate	26/08/2021 Scoping opinion	Section 1.7.2 and Table 1.4 of the Scoping Report explains that an EPP with specialist stakeholders commenced in 2021 to agree the 'detailed methodologies for data collection and undertaking the impact assessments' in respect of certain aspects to be scoped into the ES. This approach to agreeing the finer details of the assessment is welcomed. Other aspects, including fisheries, aviation and radar, and shipping and navigation, would fall outside of the EPP but the Applicant has committed to consultation at an early stage of the assessment process. The Applicant should ensure that any agreements reached during EPP or other consultation process are evidenced within the ES.	This table includes a summary of EPP consultation. Agreement/disagreement logs, compiled throughout the EPP will be used to prepare statements of common ground with stakeholders to inform the Examination process.
Planning Inspectorate	26/08/2021 Scoping opinion	Section 1.9.3 of the Scoping Report sets out the planning policy and legislation context for the Proposed Development. It would be beneficial for the aspect chapters of the ES to also include reference to aspect specific planning policy and legislation, where this has been used to inform the methodology used for assessment.	Topic specific planning policy and legislation is outlined in Section 8.4.1.
Planning Inspectorate	26/08/2021 Scoping opinion	The Scoping Report does not contain a specific section about waste; however, the Inspectorate notes that an assessment of the effects of disposal of dredged or drilled material during offshore construction is scoped into the ES (paragraph 141) and	Information regarding the amount of arisings that will be produced during offshore construction, operation and decommissioning during dredging and drilling is presented in Table 8.2.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		that the scope of the traffic and transport assessment will include construction vehicle movements associated with export of material (paragraph 667). The ES should include information regarding the expected quantities and types of all types of waste that will be produced during construction, operation and decommissioning, including arisings from onshore activity in addition to offshore dredging and drilling. The ES should include an assessment of effects relating to waste in relevant aspect chapters where significant effects are likely to occur, including for example in relation to transport effects as a result of movement of waste.	ES Appendix 19.3 (Document Reference: 3.3.22) provides a Waste Assessment, which includes information on the expected quantities and types of waste that will be produced during onshore construction, operation and decommissioning.
Planning Inspectorate	26/08/2021 Scoping opinion	Any mitigation relied upon for the purposes of the assessment should be explained in detail within the ES. The likely efficacy of the mitigation proposed should be explained with reference to residual effects. The ES should also address how any mitigation proposed is secured, with reference to specific DCO requirements or other legally binding agreements.	A summary of mitigation embedded into the design of the Project is presented in Section 8.3.3.
Planning Inspectorate	26/08/2021 Scoping opinion	Paragraph 142 Table 2.3 Effects on hydrodynamic regime (waves and tidal currents) during construction and decommissioning. The Applicant states that this effect arises as the result of the presence of physical infrastructure (i.e. large foundations and cable protection on the seabed) which is only applicable to the operation phase of the Proposed Development. On the basis that this matter will be assessed within the operation phase assessment, the Inspectorate is satisfied that this matter can be scoped out for construction and decommissioning.	Noted.
Planning Inspectorate	26/08/2021 Scoping opinion	Paragraph 140 Table 2.3 Effects on seabed level (due to deposition of suspended sediment, and seabed preparation and/or drill arisings) during operation and decommissioning. The Applicant states that seabed level effects will occur only during the construction phase (i.e. during installation activities	Noted. It is understood the Planning Inspectorate is referring to operation and decommissioning in the final paragraph of this comment

Consultee	Date / Document	Comment	Response / where addressed in the ES
		for cables and foundations) and are not applicable to the operation and decommissioning phases. On the basis that this matter will be assessed within the construction phase assessment, the Inspectorate is satisfied that this matter can be scoped out for construction and decommissioning.	
Planning Inspectorate	26/08/2021 Scoping opinion	Table 2.3 Changes to seabed morphology (due to the presence of foundation structures and cable protection) during construction and decommissioning. The Applicant states that this effect arises as the result of the presence of physical infrastructure (i.e. large foundations and any cable protection on the seabed) which is only applicable to the operation phase of the Proposed Development. On the basis that this matter will be assessed within the operation phase assessment, the Inspectorate is satisfied that this matter can be scoped out for construction and decommissioning.	Noted.
Planning Inspectorate	26/08/2021 Scoping opinion	Paragraph 140 Table 2.3 Indentations on the seabed due to installation vessels during operation and decommissioning. On the basis that this matter applies only to construction and will be assessed within the construction phase assessment, the Inspectorate is satisfied that this matter can be scoped out for operation and decommissioning.	Noted.
Planning Inspectorate	26/08/2021 Scoping opinion	Paragraph 145 Table 2.3 Transboundary effects. Based on the conclusions of the GWFF in 2011, whose ZoI is stated to be similar to that of the Proposed Development, the Applicant proposes to scope transboundary effects in relation to Marine Geology, Oceanography and Physical Processes out of the assessment. The Proposed Development is also 20km from the Economic Exclusion Zone.	Noted.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		The Inspectorate agrees that this matter can be scoped out of the ES.	
Planning Inspectorate	26/08/2021 Scoping opinion	Study area and assessment The Inspectorate notes that the Scoping Study Area is very large to account for uncertainty surrounding the exact routes of onshore elements of the Proposed Development. The ES should ensure that it is clear where the ongoing assessment work has refined the options and addressed potentially significant effects through design.	This is addressed in ES Chapter 4 Site Selection and Assessment of Alternatives (Document Reference: 3.1.6) and embedded mitigation sections of each technical chapter where relevant
Planning Inspectorate	26/08/2021 Scoping opinion	Para 135 Physical processes baseline The Scoping Report uses information from the Essex and Suffolk Shoreline Management Plan (2010) to provide a baseline for the Tendring Peninsula and notes that since that document was prepared, repairs have been made to the sea defences in the area. The existing physical coastal defences should be described in the ES. Given the likelihood of changes to sea defences, both through ongoing active maintenance and the deterioration of these types of structures that could be expected over time, the ES should review the available information to ensure that it represents a robust basis for the assessment.	The existing physical coastal defences have been described in Section 8.6.1.1.
Planning Inspectorate	26/08/2021 Scoping opinion	Table 2.1 and 2.2 Para 139 Existing datasets and surveys. The ES should explain how the surveys outlined in Table 2.2 will be used to support the desk-based data that has been collected. The ES should be clear on the reasons for the selection of datasets, with reference to, for example, established guidance, consultee feedback or other evidence and by the choice of an appropriate study area.	Data sources used are described in Section 8.4.2.
Planning Inspectorate	26/08/2021 Scoping opinion	Para 140 Table 2.3 Construction effects	The Applicant has committed to Horizontal Direction Drilling (HDD) at landfall and the onshore drilling location will be set back, approximately 400m from the coast. The depth profile of the HDD

Consultee	Date / Document	Comment	Response / where addressed in the ES
		The ES should assess the potential for significant effects on coastal processes from the onshore elements of the Proposed Development during both construction and operation. The ES should assess the potential for significant effects from seabed scour during construction and decommissioning activities, in addition to wave and tidal currents.	below ground would be designed to ensure there would be no change at the coastline. Therefore, there is no potential pathway for impact between any onshore elements and the coast. Instead, the potential impact of offshore elements, including the HDD exit point, on coastal processes during both construction and operation have been assessed in Section 8.6.2 and Section 8.6.3. The ES also considers potential for seabed scour in Section 8.6.3.3 and Section 8.6.3.5.
Planning Inspectorate	26/08/2021 Scoping opinion	Para 139 Approach to assessment The ES should define the aspect specific methodology used to determine significant effects, including defining levels of receptor sensitivity and magnitude of effect. Where modelling is used to predict effects, the ES should ensure that explanation is given as to the choice and selection of models, and how the model and outputs have been verified to provide confidence in the results. The assessment should also define where effects are considered to be significant and not significant, referring back to the use of the methodology.	This is considered standard practice and is outlined in Section 8.4. Further justification for use of the GWF modelling results is provided in Section 8.4.6.
Natural England	14/07/2023 PEIR Section 42 Response	Key Concern We are concerned that the baseline is currently insufficient to inform the impact assessment. The reliance on old hydrodynamic, wave and sediment transport data from the existing adjacent operational Greater Gabbard and Galloper Offshore Wind Farms (OWFs) to characterise prevailing conditions at North Falls, needs to be further justified in order to demonstrate applicability to North Falls. The physical environment across the North Falls south array, in particular, differs markedly from those across the Greater Gabbard array areas and Galloper north array area. Moreover, Galloper and Greater Gabbard now form part of the baseline for North Falls. Therefore, given the importance of establishing a robust baseline to inform the impact assessment, not only for the Project alone, but also in combination, we advise carrying out an additional assessment to verify the suitability of the existing	Updated baseline information on tidal currents, waves and sediments that are bespoke to the Project is provided in Section 8.5.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		datasets as analogues, and calibrate them, for the prevailing conditions at North Falls.	
Natural England	14/07/2023 PEIR Section 42 Response	Key Concern Robustness of approach taken to assessing impacts. Provide further justification and rationale for the applicability of Galloper OWF model data to North Falls and further evidence to support the largely qualitative conceptual evidence-based assessment.	Numerical modelling of waves has now been completed for potential operational impacts due to the presence of the foundation structures. The assessment of tidal currents and suspended sediment concentration (SSC) remain conceptual, supported by an improved baseline presented in Section 8.5. This is because the use of numerical modelling for tidal currents and sediment dispersion is disproportionate to the potential impact that would occur. The assessment of impacts to the tidal regime and wave regime are presented in Section 8.6.3.1 and Section 8.6.3.2, respectively.
Natural England	14/07/2023 PEIR Section 42 Response	Key Concern Adequacy of baseline characterisation. Use site-specific data to characterise the wind, wave, tide and sediment transport regimes across the North Falls study area and/or calibrate data from Greater Gabbard OWF.	Updated baseline information on tidal currents, waves and sediments that are bespoke to the Project is provided in Section 8.5.
Natural England	14/07/2023 PEIR Section 42 Response	Table 8.2 Worst Case Scenario UXO clearance, pre-lay grapnel run, and boulder clearance maximum design scenario (MDS) parameters have not been included in the table of realistic WCS. We advise a realistic WCS for seabed preparation activities will need to consider UXO clearance, pre-lay grapnel run and boulder clearance, including area of impact (source and receiving locations for boulders), and any assumptions regarding methods.	UXO clearance, pre-lay grapnel run, and boulder clearance have been added to the realistic worst case scenario in Table 8.2.
Natural England	14/07/2023 PEIR Section 42 Response	Section 5.6.4.1.5 & Table 5.15 Worst Case Scenario The WCS for sandwave levelling is based on the entire length of the offshore export cable corridor and all array and interconnector cables (array areas). This equates to a total sandwave clearance volume of c. 59 million m3, which is a	The potential sandwave levelling requirements along the export cable and offshore array cables are estimated to be 1.5Mm^3 and 29Mm^3, respectively. These realistic worst case scenarios are described in Table 8.2.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		significant volume. We would advise that this is not a realistic WCS, given that there appear to be large areas across the Project area that seem unlikely to require sandwave levelling, for example, where there is exposed bedrock. We advise further analysis of project specific acoustic data and ground conditions to assess the realistic requirements for sandwave levelling. It would also be useful to include Table 5.15 in Chapter 8 (Marine Geology, Oceanography and Physical Processes) as this provides the anticipated sandwave levelling volumes for the offshore export cable corridor, array areas (including array/interconnector cables, Wind Turbine Generator (WTG) and Offshore Substation Platform (OSP) foundation and installation). The total sandwave levelling should also be included for all the above areas i.e., whole project area.	
Natural England	14/07/2023 PEIR Section 42 Response	Table 8.5 & Section 8.4.2.2 Survey Data Acquisition The site-specific geophysical surveys and benthic survey are of sufficient quality and quantity for characterising the existing seabed physical environment. However, site-specific metocean (wind, wave, water level and current) and sediment transport regime data have not been collected. Instead, the baseline characterisation relies heavily upon measured and modelled data from the nearby operational GGOW wind farm in 2005 and 2011, respectively. We advise that best practice is for site-specific wind, wave, tide and sediment transport regime data to be used. If a different approach is to be taken, then strong justification and robust evidence will need to support the proposed approach.	Updated baseline information on metocean (tidal currents, waves) and sediments that are bespoke to the Project is provided in Section 8.5. Wind data is not required for the EIA and will be collected for the engineering detailed design as required.
Natural England	14/07/2023 PEIR Section 42 Response	Sections 8.4.6.1 & 8.5.4 Data Gaps Modelled tidal current data from GGOW (2005) and measured tidal current data for GGOW (November 2004 to March 2005) have been used to define the tidal current baseline for North Falls. Tidal currents closer to the coast have been obtained from the East Anglia Coastal Group (2010). We note (Section 8.4.6.1)	Updated baseline information on tidal currents that are bespoke to the Project is provided in Section 8.5.4.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		'it is anticipated that, given the similar water depths (apart from local variations caused by interactions with the sand banks) the current conditions across North Falls are similar'. However, we cannot agree with this assumption owing to the: • age of the GGOW data • depth distribution and seabed topography differences between GGOW & North Falls • uncertainty regarding the tidal regime • adjacent built GGOW and GWF. • planned Five Estuaries (VE) OWF. We advise it is best practice to characterise the tidal regime at North Falls and the wider study area for the planned operational period of the development, as well as taking into account how the tidal regime might respond to the cumulative effects of a cluster of nearby OWFs (GGOW, GWF, and VE), climate change, and sea level rise over the same period. We advise validating the GGOW data with measurements of tidal behaviour at North Falls, to support the assumption that they are representative of the North Falls tidal regime.	
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.5.7 Data Gaps This regional bedload sediment transport pathway information is based on very old studies: Kenyon and Cooper (2005) and Reynaud and Dalrymple (2012). If available, use more up to date data.	The regional sediment transport map of Kenyon and Cooper (2005) and the data of Reynaud and Dalrymple (2012) remain the best overview of regional sediment transport available.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.5.4.1 Data Analysis, Modelling and Reporting The Zone of Potential Influence has been informed by an understanding of the spring tidal ellipses across the study area, however, there is no map to illustrate how these vary across the study area.	Figure 8.16 has been updated to show the tidal ellipses that support definition of the Zone of Potential Influence.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		Please provide a map showing the extent and orientation of spring tidal ellipses across the Project study area.	
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.4.3/Point 28 Data Analysis, Modelling and Reporting We note that a conceptual evidence-based assessment has been adopted, on the basis that numerical modelling of marine geology, oceanography and physical processes effects of North Falls would be disproportionate. However, the conceptual approach taken is a largely qualitative assessment of impacts, whilst the Greater Gabbard and Galloper Offshore Wind Farms (OWFs) data relate to the prevailing conditions at the time of their assessments, i.e., 2005 and 2011, respectively. The only site-specific information that has been collected are geophysical and benthic survey data. Furthermore, the Project designs differ considerably between the modelled designs of GGOW/GWF and that of North Falls. We would like to see further evidence provided to calibrate and validate the existing data from other OWFs and provide confidence in the results.	Numerical modelling of waves has now been completed for potential operational impacts due to the presence of the foundation structures. The assessment of tidal currents and SSC remain conceptual, supported by an improved baseline (calibration/validation) presented in Section 8.5 and the justification in Section 8.4.6.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.4.6/Point 43 Data Analysis, Modelling and Reporting Following on from Point 42 discussed above, it is stated that water depths at GGOW and GWF are comparable to those at North Falls. We agree that the range of water depths across the North Falls arrays are similar to those across the GGOW and GWF arrays, but not their distribution. This is because the topography of the seabed across the North Falls arrays and interconnector corridor is generally quite different to those across the GGOW arrays and GWF northern array. The seabed in the west of the North Falls arrays and along the interconnector cable corridor sits in water depths of c. 60m Lowest Astronomical Tide (LAT). Furthermore, the seabed across the west of the North Falls arrays is flat, featureless, and in deep water, unlike the GGOW arrays and the north GWF array which are situated in shallower water and are dominated	An updated comparison of the bathymetries of North Falls, GGOW and GWF has now been included in Section 8.4.6.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		by the presence of linear (Inner & Outer Gabbard and The Galloper) sandbanks. A more detailed comparison of the North Falls array & interconnector bathymetry and seabed topography with those of GWF and GGOW, should be included in the final assessment.	
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.4.6/Point 44/ Figure 8.1 Data Analysis, Modelling and Reporting It is 'anticipated that, given the similar water depths (apart from local variations caused by interactions with the sand banks), the current conditions across North Falls are similar'. However, Figure 8.1 shows that there are notable differences in bathymetry and seabed topography between the North Falls, and GGOW/GWF arrays, which will influence characterisation of the wave and tide behaviour within and in the vicinity of the North Falls arrays. We advise that it should be demonstrated that the 2005 GGOW tidal data are representative of the prevailing current conditions at the North Falls array areas (ideally at the time the Project is implemented).	Updated baseline information on tidal currents that are bespoke to the Project is provided in Section 8.5.4 demonstrating the similarity of the recent data with that modelled at GWF.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.4.6/Point 45 Data Analysis, Modelling and Reporting The GGOW wave data form the basis for the North Falls wave climate baseline characterisation. To adequately assess the impacts of the North Falls project requires an understanding of the baseline conditions prior to, and at the time of, the Project proceeding. Given that the GGOW wave data were collected between November 2004 and March 2005, it is possible that the present-day baseline differs from that established for GGOW and GWF. Furthermore, GGOW and GWF now form part of the baseline, along with other nearby operational windfarms, which may have altered the baseline. We advise that it should be demonstrated that the 2004-2005 GGOW wave data are representative of the prevailing wave conditions at the North Falls project (ideally at the time the Project is implemented). The wave climate baseline	Numerical modelling of waves has now been completed for potential operational impacts due to the presence of the foundation structures. This replaces the conceptual assessment completed in the PEIR. Updated baseline information on waves that are bespoke to the Project is provided in Section 8.5.5.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		characterisation needs to consider a range of wave conditions across the study area, ideally over a sufficiently long timescale, to establish baseline variability.	
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.4.6.2 Data Analysis, Modelling and Reporting The modelling for GGOW and GWF assessed 140 WTGs each with a diameter of 36m and 35m, respectively for Gravity Base Structure (GBS). Whilst the North Falls MDS comprises up to 72 GBS WTGs with a diameter of 65m. It is suggested that the larger number of WTGs assessed in the modelling of the GGOW and GWF provide a conservative proxy for the North Falls assessment. However, we would advise that the larger MDS WTG and OSP foundations of the North Falls arrays could potentially have a more pronounced and/or extensive effect on waves and tides, and a greater cumulative effect (depending on the final array spacing and foundation design) than that modelled for GGOW and GWF. We advise that, in line with best practice, the WCS North Falls array foundations, indicative layout, and number of structures should be used to inform the physical processes impact assessment.	A larger number of narrower-spaced foundations is considered to have a larger effect on physical processes than a smaller number of wider-spaced foundations. On an individual basis, a larger turbine will have a greater effect on tidal currents and waves than a smaller turbine, but the combined effect with the rest of the array foundations will be less for wider-spaced larger foundations than for narrower-spaced smaller foundations. Hence, the layouts of GGOW and GWF are conservative proxies for North Falls. However, wave modelling has now been undertaken for the North Falls array. This is based on the refined worst case scenario of up to 57 GBS wind turbine foundations.
Natural England	14/07/2023 PEIR Section 42 Response	Section 5.7.1, Section 8.6.2 and Table 8.2 Identified Impacts We welcome the Project's commitment to avoid direct disturbance in the intertidal zone, by using HDD techniques to install the export cable at the landfall. It is stated that up to 5 HDDs will be installed, with the drill exit location in the subtidal zone below mean high water springs (MHWS) (up to 8m depth). However, there is no further information on the Maximum Design Scenario (MDS) parameters for the HDD exit pits, requirements for beach access, installation of cofferdams, the use and anticipated amount of cable protection over ducts or cable ends, jack up rigs/barges and/or vessels with anchoring. More detailed information will need to be provided in the ES regarding the anticipated HDD activities, including access routes from the intertidal until the exit pits. Potential impacts arising from	There is no planned requirement for beach access or installation of cofferdam. There will be no surface laid cable protection at the HDD exit pit. The potential impact of offshore elements, including the HDD exit point, on coastal processes during both construction and operation have been assessed in Section 8.6.2 and Section 8.6.3.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		HDD activities will also need to be considered and assessed in the ES.	
Natural England	14/07/2023 PEIR Section 42 Response	Sections 8.5.3.2 & 8.5.3.3 Identified Impacts It is stated that the northern and southern arrays experience a macrotidal regime. However, the mean spring tidal ranges for the northern array and southern array, are 2.5m and 3-3.5m, respectively. These suggest a mesotidal regime (2-4m tidal range). We advise this should be clarified.	Correct – this has been clarified.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.5.9 Identified Impacts We understand that the landfall area will be refined following PEIR. Hence, at present there is no specific detailed information on the potential impacts of the proposed development to physical processes or the physical environment at landfall. Following refinement of the landfall area, we advise that potential impacts to physical processes and the physical environment, including the nearshore zone, should be considered and assessed separately in the ES. Potential impacts to Holland Haven Marshes SSSI should also be considered as it lies adjacent to the seawall at landfall.	The Applicant has committed to HDD at landfall and the landfall compound, where the HDD will be located,will be set back approximately 400m from the coast. The depth profile of the HDD below ground would be designed to ensure there would be no change at the coast. Therefore, there is no potential pathway for impact between any onshore elements and the coast. The potential impact of offshore elements, including the HDD exit point, on coastal processes during both construction and operation have been assessed in Section 8.6.2 and Section 8.6.3.
Natural England	14/07/2023 PEIR Section 42 Response	Sections 8.5.10 & 8.6.11, Point 103 Identified Impacts The intertidal zone at landfall is relatively narrow and, despite the presence of the seawall, the beach level will lower over the lifetime of the project. How will general beach lowering, and buried asset integrity be assessed over the long term? Will a minimum beach level be defined in order to establish whether remedial intervention will be needed? We advise consideration is given to how the coast at landfall will alter throughout the lifetime of the Project.	The depth profile of the HDD below the beach would be designed to ensure there would be no exposure of the cable over the long-term, with fluctuations in beach level.
Natural England	14/07/2023 PEIR Section 42 Response	Sections 8.6.2.1.2 & 8.6.2.1.3 Identified Impacts In Section 8.6.2.1.2 it states that due to the 'nature of the	The refined boundary of the array area means that it does not overlap KKE MCZ. Hence, the original assessment continues to apply as described in Section 8.6.2.1.

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		pressure (increases in suspended sediment concentrations (SSCs) due to seabed preparation for foundation installation), there is no pathway for impact to all identified receptors so therefore they are not sensitive to this pressure'. However, we note that KKE Marine Conservation Zone (KKE MCZ) overlaps with the south array and has been identified in Table 8.13 as a receptor. Therefore, we consider that there is a pathway for impact to KKE MCZ which should be acknowledged in this impact assessment (Although we appreciate that KKE MCZ is considered and assessed in the Marine Conservation Zone Assessment (MCZA)). The sensitivity and significance of effect should be assessed on the basis that there is a pathway for impact to an identified receptor i.e., KKE MCZ.	
Natural England	14/07/2023 PEIR Section 42 Response	Sections 8.6.2.2.2 & 8.6.2.2.3 Identified Impacts It is stated that due to 'the nature of the pressure (increase in SSCs due to drill arisings for installation of piled foundations) there is no pathway for effect to any identified receptor so therefore they are not sensitive to this pressure.' Similarly, it is stated that the 'impacts on SSCs…do not directly affect the identified receptor groups'. However, as stated above, we advise that KKE MCZ overlaps with the south array, and has been identified as a receptor. Therefore, we advise that there is a pathway for impact to an identified receptor. We advise this should be reflected in the impact assessment for increases to SSCs due to drill arisings. In turn, sensitivity and significance should be revised accordingly.	The refined boundary of the array area means that it is does not overlap KKE Marine Conservation Zone. Also, the impacts on SSCs do not directly affect the KKE MCZ because in terms of its physical processes, this receptor is dominated by processes that are active along the seabed and not affected by suspended sediment in the water column. Hence, the original assessment continues to apply as described in Section 8.6.2.2. The effects on flora and fauna associated with the MCZ are assessed in ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12).
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.3/Points 135-137 Identified Impacts It is stated that sediment settlement due to preparation for foundation installation could form a mound likely to be tens of centimetres to a few metres high, local to the release point. What is the anticipated realistic mound height? With regards to the sediment mounds, it is also suggested that 'overall changes in elevation of the seabed are small compared to the absolute depth of water (up to 59m below LAT)'. However, water depths in	The precise dimensions of the resulting mound are unknown and will depend on release volumes, location of release points, and how long the release takes place for. It is anticipated that the mound will not exceed a few metres. Maps of predicted thickness and footprints of mounds is disproportionate to the potential impact given that most of the sediment will be redistributed (and the mound will change shape) by physical processes over the short- to medium-term.

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		the north array range from 12.0-59.4m below LAT and in the south array range from 3.3-55.6m below LAT. Therefore, if a large sediment mound a 'few metres high' is deposited on the seabed in 3.3m water depth, it could affect the hydrodynamic and sediment transport regimes. In the ES should provide predicted thickness of sediment following deposition for the dominant sediment types across the north and south arrays. It would also be useful to provide maps showing sediment settlement thickness and footprint for a sediment release point in the north array and the south array (at the overlap with KKE MCZ).	It is accepted that a mound of several metres in shallow water would be a significant change in the bed elevation. However, the mounds will be mobile and driven by the physical processes, rather than the physical processes being driven by them. This means that over time the sediment comprising the mound will gradually be re-distributed by the prevailing waves and tidal currents. This reworking will be more pronounced in shallow water depths where waves will impinge on the bed and reduce the height of the mound more rapidly. Also, shallow water depths are restricted to small areas at the periphery of the array area, and so the number of mounds in these depths would be limited.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.3/Point 138 Identified Impacts It states that over time the sediment comprising the mound will gradually be re-distributed by the prevailing waves and tidal currents. Is there any evidence from the adjacent operational OWFs to support this conclusion? Provide supporting evidence/reference.	Monitoring of mounds was not a requirement of the adjacent wind farms and so data is unavailable. However, using expert judgement based on sediment particle size and the prevailing physical conditions, the re-distribution would take place. When an unconsolidated mound is placed on the seabed that has a similar particle size to the surrounding seabed, it will be mobilised by the prevailing physical drivers, and gradually lowered to be in equilibrium with those drivers.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.4/Point 154 & Table 8.18 Identified Impacts We note that no specific calculations have been undertaken to understand the likely time taken for the mounds to fully erode. We understand impacts to KKE MCZ are assessed in the MCZA, however, because it could be affected by changes to the wider physical environment and physical processes, it is also a marine processes receptor and impacts to it should be assessed as precisely as possible since there are a number of habitats/species sensitive to smothering. It is stated that over time the mound will be winnowed by tidal currents and the mound would lower through erosion. Can this be quantified/verified? Can site-specific data be used to estimate the timescale for the mound to be winnowed/eroded away? Or are there any data available on mound residence time for drill arising mounds from GGOW and GWF?	Due to the post-PEIR refinement to the array area, there will be no mounds within the KKE MCZ. An assessment of mounds within the remaining array area is provided in Section 8.6.2.4, however it is not possible to quantify erosion of the mounds. It is unlikely that the mounds will fully erode given their composition, but gradual winnowing would take place over time. The mounds are likely to be present on the seabed over the long-term. The winnowing of the mud clasts will be almost imperceptible as a process, with individual mud particles stripped off the clasts by tidal currents. There would be no increase in SSCs and no smothering of habitats because the winnowing process is on a particle-by-particle basis.

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		We advise that monitoring requirements need to be evaluated for drill arising mounds if these will be present in KKE MCZ. However, please note that we advise that infrastructure and associated implications are avoided within the KKE MCZ and that mitigations measures would need to be adopted.	
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.5/Point 160 Identified Impacts Related to our comment on WCS for sandwave clearance, we note that 'sandwave levelling (pre-sweeping) may be required along the offshore cable corridor (OCC) prior to installation' i.e., the entire route. This is not a realistic WCS. Figure 8.12 presents the seabed morphology across the OCC which shows sandwaves to be present across <20% of the OCC and megaripples <55% (max) of the OCC. We advise using project-specific geophysical survey data to refine down this WCS to make it more realistic. It would also be helpful if areas of designated seabed overlapping or adjacent to the OCC could be identified on Figure 8.12.	The potential sandwave levelling requirement along the offshore cable corridor is estimated to be 1.5Mm^3. This realistic worst case scenario is described in Table 8.2. The position of receptors relative to the offshore cable corridor is shown on Figure 8.15.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.5.2/Point 162 Identified Impacts Anticipated HDD exit pit locations and MDS parameters have not been provided. In the ES, more specific details will be needed on the HDD Exit Pit MDS e.g., excavated sediment volume, water depth, number of pits, maximum depth, likely duration pit will remain open at any given time, and the fate of removed sediment.	The volumes of sediment associated with the HDD exit pits and the disposal of this sediment is included within the values provided for the offshore cable corridor. The water depth at the HDD exit pit locations will be 1 to 8m below MHWS. There will be up to three exit pits, for two offshore export cables and one for contingency. The parameters used for the marine geology, oceanography and physical processes assessment are provided in Table 8.2 and further information on the landfall construction works is provided in ES Chapter 5 Project Description (Document Reference: 3.1.17). Sediment arising from the landfall HDD will be disposed of on land.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.5.2/Point 162 Identified Impacts It is stated that export cable installation has the potential to disturb the seabed down to 1.2m with a width of up to 24m. This is confusing. In Table 8.2, export cable trench dimensions are 1m width x 1.2m depth, whereas cable sandwave levelling has a disturbance width of 24m x 5m depth. This should be clarified.	24m changed to 1m in the main text to be consistent with the correct numbers in Table 8.2.

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Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.5.2/Point 164 Identified Impacts It is anticipated that changes in SSC due to export cable installation would be less than those for foundation installation activities. This is not a useful analogy because these two activities do not take place in the same location and the methods used are likely different and hence the changes to physical processes. We advise that this should not be used as an analogy.	Noted, this analogy has been removed.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.5.2/Point 173 Identified Impacts No sensitivity has been assessed. Yet there is the potential for impacts to designated areas along the coast adjacent to proposed landfall, MLS SAC, and Annex I sandbanks. Include sensitivity assessment for all receptors within the Zone of Influence (ZoI).	The impacts on SSCs due to export cable installation do not directly affect the identified receptor groups for marine geology, oceanography and physical processes. This is because the receptors are dominated by processes that are active along the seabed and not affected by suspended sediment in the water column. Hence, there is no pathway for effect and sensitivity is not required (consistent with other assessments of SSC in the chapter). The effects on benthic receptors are assessed in ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12).
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.5.3 Identified Impacts It has been concluded that the effects on SSCs due to export cable installation would have no change upon the identified receptors. Can further evidence be provided to support this conclusion? We advise further evidence is provided to support this conclusion. Can maps be provided to show potential increase in SSC due to cable trenching and sandwave levelling, for different sediment fractions and tidal scenarios at different locations along the OCC (e.g., inshore, next to MLS SAC, Annex I sandbank)?	The impacts on SSCs due to export cable installation do not directly affect the identified receptor groups for marine geology, oceanography and physical processes. This is because the receptors are dominated by processes that are active along the seabed and not affected by suspended sediment in the water column. However, there may be impacts arising from subsequent deposition of the suspended sediment on the seabed and these are discussed under Construction Impact 4 (Section 8.6.2.6). The impact on SSCs does have the potential to affect other receptors and the assessment of effect significance is addressed within the relevant chapters of this ES (Section 8.10).
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.7.2/Point 185 Identified Impacts Sandwave levelling may be required for the array/interconnector cable prior to installation. Table 8.2 includes sandwave levelling for all array cables and the entire interconnector cable corridor. As we advised earlier for the OCC, this is not a realistic WCS.	The potential sandwave levelling requirement along the offshore array cables is estimated to be 29Mm^3. This has been refined based on analysis of the geophysical data. This realistic worst case scenario is described in Table 8.2. The potential direct and indirect effects are assessed in Section 8.6.2.9, where the assessment of the array area and offshore export

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		We advise using project-specific geophysical survey data to refine down this WCS to make it more realistic. The total area of impact (both direct and indirect) should be assessed. The area of KKE MCZ, Annex I sandbanks, and those sandbanks whose ecological structure and functionality warrant protection affected should be provided in the ES, including extent and location along with the extent of impact on each affected feature.	cables is combined. The interconnector cable corridor has been removed from the design.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.7/Point 188 Identified Impacts No sensitivity has been assessed. Yet there is the potential for impacts to the KKE MCZ and Annex I sandbanks. Include sensitivity assessment for all receptors within the ZoI.	The impacts on SSCs due to offshore array cable installation do not directly affect the KKE MCZ and Annex I sandbanks receptors for marine geology, oceanography and physical processes. This is because the receptors are dominated by processes that are active along the seabed and not affected by suspended sediment in the water column. However, there may be impacts arising from subsequent deposition of the suspended sediment on the seabed and these are discussed under Construction Impact 6 (Section 8.6.2.8). The impact on SSCs does have the potential to affect other receptors and the assessment of effect significance is addressed within the relevant chapters of this ES (Section 8.10).
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.7. Identified Impacts It is stated that the effects on SSCs due to array and interconnector cable installation will have no change upon the identified receptors groups. However, this conclusion is based on conceptual evidence-based assessment which indicates that the SSC changes due to array and interconnector cable installation would be similar to those due to disturbance of near-surface sediments during foundation and export cable installation. Provide further justification for the conclusion made and assess the WCS for sediment plume extent, concentration, and persistence with particular regard to KKE MCZ and Annex I sandbanks.	Section 8.6.2.7 assesses changes to SSC which do not directly affect the KKE MCZ and Annex I sandbanks receptors. This is because these receptors are not driven by processes that occur in the water column (i.e. suspended sediment), but rather by processes that are active on the seabed (i.e. bedload sediment). Hence, there may be potential impacts if the suspended sediment is deposited on the bed from the plume. These potential impacts are covered in Section 8.6.2.8.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.8/Point 197 Identified Impacts The overall effect significance of array and interconnector cable installation under a WCS on seabed level changes for Annex I	The conceptual evidence-based assessment of deposition from the plume generated from offshore array cable installation indicates that the changes in seabed elevation would be effectively immeasurable within the accuracy of any numerical model or bathymetric survey.

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		sandbanks, KKE MCZ and Orford Inshore MCZ, is considered to be negligible adverse (no significant effect). However, the WCS for sediment settlement thickness and deposition footprint have not been provided which makes it difficult to assess impacts to sensitive receptors. Please assess the WCS, and provide maps, for sediment settlement thickness and footprint with particular regard to the Annex I sandbanks and KKE MCZ.	This is because, after this initial deposition, the deposited sediment will be continually re-suspended to reduce the thickness to a point where it will be effectively zero. This will be the longer-term outcome once the sediment supply from cable installation has ceased. This means that given these very small magnitude changes in seabed level arising from cable installation, the effects on the Annex I sandbanks and KKE MCZ would not be significant.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.9/Point 204 & 8,6,2,2 & Section 5.6.10 (Chapter 5) Identified Impacts It is stated that any excavated sediment due to sandwave levelling would be disposed of within the North Falls offshore project area. The extent and disposal locations would be determined post consent. It is also stated that given the relatively low volumes of sand likely to be affected, the overall changes to the seabed would be minimal. Natural England is concerned that the whole offshore project area could be used for spoil disposal, particularly designated sites. We seek clarification on the area of MPA likely to be affected (extent and location), the extent of impact (area, volume, percentage loss etc)? We also seek clarity on how impacts to other features will be avoided? Natural England advises that an estimate of the area likely to be affected in relation to Marine Protected Areas (MPA), (e.g. Margate and Long Sands Special Area of Conservation (MLS SAC), KKE MCZ), and Annex I sandbanks should be provided. This should include the extent and location of the impacted area. We advise consideration is given to how impacts to other features will be avoided. Furthermore, consideration should be given to mitigation in the form of intelligent, directed placement of excavated material (such as through use of a fall pipe).	The offshore project area no longer overlaps any designated sites and therefore there will be no sediment disposal in a designated site.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.9/Point 205 Identified Impacts It is suggested that sandwaves subject to levelling for North Falls are likely to recover over a short period of time, based on evidence from Race Bank OWF (Inner Dowsing Race Bank and North Ridge SAC) and Haisborough Hammond and Winterton	The Inner Dowsing Race Bank and North Ridge SAC and Haisborough Hammond and Winterton SAC represent highly conservative examples of impacts and recovery, as previous impacts in these areas were associated with works within the SACs, whereas for North Falls there is no direct overlap with a designated site.

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		SAC (HHW SAC). We do not agree that the examples of sandwave recovery provided are useful. In Natural England's Relevant Representations (2018) for Norfolk Vanguard on sandwave levelling in HHW SAC, we advised that 'Natural England continues to have residual concerns in relation to the overall impacts to the form and function of the Annex I sandbank sandwave fields and their potential recoverability'. We would draw the Project's attention to Natural England's Benthic Ecology Relevant Representations (2019) for Norfolk Boreas OWF, in which we advised that '…there is currently no evidence for timescales for recovery of sandwaves from sandwave clearance, or that the [HHW SAC] sandbank system will remain undisturbed. Initial monitoring from Race Bank showed that some dredged areas showed some signs of infill within a few months of dredging and other areas did not. Whilst we agree that theoretically larger morphological processes should enable the sandbank to recover, the impact is none the less significant and timescales for recovery are unclear.' Furthermore, in 2021, Natural England provided a response to the SoS regarding sandwave levelling within HHW SAC for Norfolk Boreas. In this we 'highlighted that there was insufficient evidence to demonstrate that full recovery of the Sandbank system is achievable and within the affected Annex I Sandbank systems'. We advise the Project considers alternative approaches to establishing likelihood of sandwave recovery, influence on sediment transport patterns and morphology, including adjacent sandbank systems.	
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.9.1to 8.6.2.9.3 Identified Impacts Following our comments above regarding uncertainty in relation to sandwave recovery, we would advise that this uncertainty should also be reflected in the assessments of magnitude, sensitivity and overall effect significance for the Essex coast, MLS SAC, Annex I sandbanks, and those sandbanks whose ecological structure and functionality warrant protection. We advise consideration is given to revising the magnitude, sensitivity and effect significance for the Essex coast, MLS SAC,	

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		Annex I sandbanks, and those sandbanks whose ecological structure and functionality warrant protection, for impacts to bedload sediment transport due to sandwave levelling.	
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.3.1.2/Table 8.32 Identified Impacts The value of the Suffolk and Essex coasts has been assessed as 'medium'. We would advise that their value is 'high', given that they are significant strategically, environmentally important and with minimal potential for substitution. Furthermore, Table 8.32 has not considered the sensitivity of receptors to potential turbulent wakes and scour due to the presence of the WTGs and OSP foundations. We advise that the Suffolk and Essex coasts are of high value. We also advise that assessment of sensitivity of receptors (in particular KKE MCZ and Annex I sandbanks) should consider sensitivity to potential turbulent wakes and scour developing due to the presence of WTG and OSP foundations.	Value changed to high. No change to significance of effect. The potential impact of turbulent wakes has been considered as part of the overall conceptual evidence-based assessment of changes to tidal currents in Section 8.6.3.1. It is indicated that there is no interaction with wakes from adjacent foundations due to the relatively large separation distances. The potential for seabed scour is covered in Section 8.6.3.3 and Section 8.6.3.5.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.3.1.3/Point 231 Identified Impacts It is stated that no significant impact on the tidal current regime is anticipated for North Falls and therefore on the Annex I sandbanks and KKE MCZ. However, this assessment has not considered the potential impact on these receptors due to turbulent wakes. Determination of effect significance should consider potential for turbulent wakes and scour developing due to the presence of WTG and OSP foundations (with particular regard to KKE MCZ and Annex I sandbanks).	Changes to tidal currents would be both low in magnitude and largely confined to local wake or wave shadow effects attributable to individual wind turbine foundations and, therefore, would be small in geographical extent. Hence, any scour due to wakes would also be local and insignificant and would have no effect on KKE MCZ (as its boundary does not overlap with North Falls) and negligible effect on the Annex I sandbanks.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.3.2.3/Point 242 Identified Impacts It has been concluded that no pathway exists between the source and the Essex coast, Suffolk coast, and MLS SAC. However, changes to the wave energy transmission and the nearshore wave climate due to cable protection, cable crossings and temporary cofferdams have not been considered in this impact assessment.	A commitment has been made to install the offshore export cables at the landfall using HDD techniques, thus avoiding direct disturbance in the intertidal zone. There will be no cable protection at the HDD exit pit. This means that there is unlikely to be any changes to the wave regime inside the closure depth for this coast because the cable will be buried. The impact of the HDD exit pits during construction would be short-lived and local. Cable protection, berms and crossings in deeper water will have little effect on waves.

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		We advise consideration of modification to wave energy transmission and nearshore wave climate due to the presence of rock berms, cable crossings, temporary cofferdams etc. as these could affect seabed and coastal morphology.	
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.3.4.2 Identified Impacts We cannot agree with the conclusion that the loss of seabed area due to infrastructure within the arrays will have a negligible adverse effect on sandbanks (and associated sandwaves) and KKE MCZ, because there is insufficient evidence at present regarding the location, area, extent of impacts. In the ES, we advise the Project to provide more specific evidence regarding the location, area, extent of impact due to loss of seabed due to array infrastructure, with particular regard to sensitive receptors, areas of designated seabed etc. We would also advise consideration of conservation objectives and other anthropogenic pressures being exerted on these sites.	The worst case footprint on the seabed is associated with the maximum number of 57 GBS wind turbine foundations and scour protection, two GBS OSP/ offshore converter platform (OCP) foundations with scour protection, and up to 20% of array cable protection (38km) (Table 8.2). This constitutes only 5.7% of the array area, and hence the loss of seabed within the Annex I sandbanks will be much less than this (about 0.6% given their extent within the array area – Figure 8.12). At the scale of the study area this is negligible. There will be no effect on KKE MCZ because there is no overlap with North Falls footprints.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.3.6 Identified Impacts We note the seaward limit for wave-driven sediment transport, closure depth, is estimated to be approximately 1.5km from the coast, within 5m water depth. (Note: VE OWF estimate 1.6km). Will the Project commit to avoiding the placement of cable protection in the shallow nearshore? Consider committing to avoid cable protection placement within the shallow nearshore zone?	There will be no cable protection at the HDD exit pit which will be located c. 1.5km from the shore.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.4.3 Methodology Section 8.4.3 discusses the general approach to assessing potential direct and indirect impacts on marine geology, oceanography, and physical processes (based on sensitivity of receptor and magnitude of impact), but details of specific analytical methods have not been provided. Furthermore, it is stated that the impact assessment has considered two spatial scales (direct and indirect), but temporal variability is not	The methodology for assessment of wave modelling has been revised and cross reference to the wave modelling report (Appendix 8.1) added in Section 8.4.3, which provides further information on the methodology. The assessment of marine geology, oceanography and physical processes is based on expert judgement and experience of assessments undertaken on previous wind farms. Conceptual-based assessment does not use any particular analytical technique or modelling technique but utilises all the evidence available in all its forms. Temporal variability is

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		discussed. Which best practice and/or guidance documents have been used to inform the assessment? It would be helpful if the potential impacts/pathway effects considered in the physical processes assessment could be summarised here, also stating whether they relative to a receptor and/or pathway. It should also be shown how temporal variability has been taken into account in the impact assessment. If industry best practice and/or guidance documents have been used to inform the impact assessment, this should be stated.	discussed throughout regarding whether the effect is temporary or permanent.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.3.6 Methodology We understand that the Project has committed to install the export cable at landfall using HDD techniques, thus avoiding direct disturbance in the intertidal zone, which we welcome. However, given that the landfall location is still to be refined, there is uncertainty regarding the successful use of HDD methods at the present time. We would advise that trenching and associated impacts be considered and assessed as the WSC until the landfall area has been refined.	A landfall area has been selected, discussed further in ES Chapter 4 Site selection and assessment of alternatives (Document Reference: 3.1.6). The method for cable installation at landfall is described in ES Chapter 5 Project Description (Document Reference: 3.1.7). This will be by HDD and therefore this is the only method that is required to be assessed.
Natural England	14/07/2023 PEIR Section 42 Response	Tables 8.7-8.9 Methodology Tables 8.7-8.9 provide definitions of sensitivity, value, and magnitude for a morphological receptor. How do these definitions relate to pathway effects? Please clarify how these definitions relate to pathway effects.	The S-P-R is the conceptual model that determines whether the effect can be potentially significant or not. The matrix quantifies the magnitude of this potential impact on the receptors for marine geology, oceanography and physical processes.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.3.1/Points 11 & 12 & Table 8.13 Methodology The limits of the far-field impacts have been established based upon the excursion of one spring tidal ellipse (approx. 15km). However, littoral sub-cell boundaries, prevailing wave conditions, evidence from existing wind farms on the likely spatial extent of changes to wave conditions, are also important considerations that should be drawn upon to inform the limit of the wider study area. In turn, we advise that there are a number of nationally and internationally designated marine and coastal conservation sites	Numerical modelling of waves has now been completed for potential operational impacts due to the presence of the foundation structures. The assessment of impacts to the wave regime including any at the coast are presented in Section 8.6.3.2. It is accepted that there are nationally and internationally designated marine and coastal conservation sites and sensitive habitats along the Essex/Suffolk coasts. These sites are integral to the definition of these coasts as sensitive receptors, and it is not necessary to break this down into individually named sites. They are considered in the impact assessment as part of the defined sensitive receptors. A

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		and sensitive habitats along the Essex/Suffolk coasts (i.e., the wider study area) that could be affected by changes to physical processes. These designated should be included in the Essex/Suffolk coasts receptor group and considered in the impact assessment. We advise that the anticipated maximum ZoI should take into account littoral sub-cell boundaries, prevailing wave conditions, and evidence from existing wind farms on the likely spatial extent of changes to wave conditions. Designated sites along the adjacent coastline to landfall, that overlap the wider study area, should be screened into the impact assessment. A map showing the limits of the wider study area, receptors and designated sites within the study area would also be useful.	map showing the receptors is provided as Figure 8.15, which contains all those receptors of significance to marine geology, oceanography and physical processes.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.1, Points 115-121 Methodology Two approaches have been taken to assessing the impact of SSC changes due to seabed preparation for foundation installation in the North Falls arrays. The first is, as stated in Point 118, a 'more qualitative expert-based assessment'. The second, is based on the GWF Delft3D plume model. It is stated that 'the modelling studies for the GWF represent a suitable analogue for verifying the conclusions of the more qualitative expert-based assessment' owing to the similarities in sediment types and distributions across the North Falls and GWF sites, and the similarities in water depths. As discussed earlier, we agree that sediment types and distributions are similar, and the range of water depths, but not the seabed topography and depth variations across the two sites. GWF model simulation was carried out on installation of 45m diameter GBS foundations on the Galloper sandbank. Conversely, the North Falls MDS GBS foundations are 65m diameter and the western half of the arrays appear to be located in deeper water where the seabed is also quite flat and featureless. The GWF simulation seabed sediment release volume was 7,200m^3 whereas the seabed sediment release volume for the North Falls MDS GBS foundation would be 19,242m^3 (based on a 70m diameter GBS seabed prep area dredged to 5m).	An updated comparison of the bathymetries of North Falls, GGOW and GWF has now been included in Section 8.4.6. The assessment of sediment dispersion in the water column due to seabed preparation for foundation installation that was completed at Five Estuaries Wind Farm has been added to Section 8.6.2.1 to add supporting evidence. The total volume of sediment released during seabed preparation was estimated as 1.19Mm^3 at Five Estuaries which is conservative compared to the estimated release of 1.14Mm^3 at North Falls, and so the results of the Five Estuaries assessment is conservative and a good analogy.

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		Therefore, the North Falls sediment release volume is 2.8 times greater than that simulated for GWF. Consequently, we have concerns with regards to the validity of the qualitative assessment and the applicability of the GWF model to the prevailing conditions at North Falls. Further evidence should be provided to demonstrate the suitability of the qualitative expert-based assessment and the applicability of the GWF model for assessing impacts due to seabed preparation related SSC changes at North Falls.	
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.1/Point 120 Methodology We have concerns with the use of a largely qualitative assessment coupled with the GWF (2011) sediment plume model data from GWF to assess the impacts of SSC changes due to seabed preparation in the North Falls arrays. The lack of site-specific data leads to uncertainty regarding the prevailing conditions at North Falls and, thus, the impact assessment to determine how conditions will change relative to this baseline. We advise a further assessment to establish the likely nature of sediment plumes (footprint, concentration, and duration), as a result of the MDS sediment disturbance during seabed preparation in the arrays. Maps of potential change in SSCs would be useful for sediment disturbance due to foundation seabed preparation in the north and south arrays (particularly at the overlap with KKE MCZ), including sediment plume footprint, concentration, duration for various tidal scenarios and sediment size fractions. The WCS for SSC changes, including distance to sensitive feature or species, simultaneous operations, foundation design etc. also need to be considered. Particular consideration should also be given in this assessment as to the likely nature of sediment plumes due to foundation seabed preparation in the KKE MCZ, this will also help inform the MCZA.	The assessment of sediment dispersion in the water column due to seabed preparation for foundation installation that was completed at Five Estuaries Wind Farm has been added to Section 8.6.2.1 to add supporting evidence. The assessment used spreadsheet numerical models to determine potential impact and provided indications of potential footprints. Hence, the method is semi-quantitative. The total volume of sediment released during seabed preparation was estimated as 1.19Mm^3 which is conservative compared to the estimated release of 1.14Mm^3 at North Falls, and so the results of the Five Estuaries assessment is conservative and a good analogy.
Natural England	14/07/2023	Section 8.6.2.2/Point 128 Methodology	For SSCs released due to drilling activities, only 10% of the 34 largest wind turbines and one OSP/OCP foundation would require drilling (up to four of the total 57 across the array area). Given the

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	PEIR Section 42 Response	As discussed above, we have concerns with the use of a largely qualitative assessment to assess the impacts of SSC changes due to drill arisings for installation of piled foundations for WTGs and OSPs, we have concerns with the qualitative assessment of sediment plume impacts due to drill arisings for installation of piled foundations for WTGs and OSPs. Can the conceptual evidence-based assessment predictions be validated? We advise a further assessment to establish the likely nature of sediment plumes (footprint, concentration, and duration), as a result of the MDS sediment disturbance during drilling for installation of piled foundations for WTGs and OSPs. Please also refer to our recommendation above regarding maps of potential change and particular consideration of KKE MCZ.	small scale of the disturbance compared to seabed preparation activities, a conceptual evidence-based assessment is considered proportionate to the potential impact that may occur.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.5.2/Point 167-168 Methodology It is stated that the GWF modelling study provides a suitable analogue for the North Falls assessment of increased SSCs due to export cable installation. Whilst the OCC lengths are similar, the locations are not. The GWF OCC extends from the north GWF array to the coast at Sizewell, Suffolk. whereas the North Falls south array to landfall on the Tendring Peninsula, Essex. Anticipated volume of sediment disturbance due to cable trenching also differ: 300,960m^3 for North Falls OCC and 180,000m^3 for GWF. Lastly, in 8.4.6.1, it states that the 'location of the landfall for North Falls will be the Tendring peninsula…this is different to the landfall for GGOW and GWF, and so a bespoke desk-based assessment of the offshore cable corridor and the landfall search area is provided.' Further evidence should be provided to support the use of the GWF numerical model simulations to support predictions of SSC changes due to export cable installation along the North Falls OCC.	The basis for using the GWF modelling results as an analogy for potential impacts along the North Falls offshore cable corridor was based on the similarities in the environment rather than geographical overlap. As described in Section 8.4.6, there are similarities in water depth, sediment types, metocean conditions and length of the offshore cable corridor for GWF and the proposed North Falls project. This makes the GWF modelling study a suitable analogue for the present assessment.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.6.3 Methodology Please see our comments regarding the use of GWF plume modelling simulations and conceptual evidence-based approach.	The conceptual evidence-based assessment of deposition from the plume generated from cable installation indicates that the changes in seabed elevation would be effectively immeasurable within the accuracy of any numerical model or bathymetric survey. This is

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		Can maps be provided to show potential settled sediment thickness and footprint due to cable trenching and sandwave levelling, for different sediment fractions and tidal scenarios at different locations along the OCC (e.g., inshore, next to MLS SAC, Annex I sandbank)?	because, after this initial deposition, the deposited sediment will be continually re-suspended to reduce the thickness to a point where it will be effectively zero. Hence, the need to show potential settled sediment thickness and footprint would not add any meaningful information for the impact assessment..
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.2.10.3/Point 219 Methodology Following on from our comments above, we note that the likely effect of indentations on the seabed due to installation vessels is considered to be negligible adverse. In turn, this is considered not significant in relation to Margate and Long Sands SAC, Annex I sandbanks and KKE MCZ. However, impacts due to these activities have been considered in isolation here, and the wider picture regarding the form and function of the seabed morphological features is likely to be affected. We advise the form and function of the seabed morphological features not just impacts due to individual installation activities, is considered.	Section 8.6.2.10 specifically assesses the impact of the footprint of the installation vessels. Consideration of the morphological effects on the seabed of other activities are covered in other sections.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.3.1/Point 224 Methodology It is stated that no significant impact on the tidal current regime was predicted for GWF, and the same conclusion is drawn for the North Falls arrays (based on the similarities between the two OWFs). However, as discussed earlier, there are notable differences in their seabed topography and depth variation. There are also significant differences between the North Falls MDS (which has not been considered in the tidal regime impact assessment) and that modelled for GWF. Consequently, it would be useful to know how applicable the GWF tidal model predictions are to North Falls? Can they be calibrated for the seabed features and bathymetry at North Falls? Turbulent wakes caused by foundations interfering with flow could lead to increased turbidity within the wake and scour to develop. Given the proximity of the North Falls arrays to sensitive receptors (e.g., KKE MCZ Annex I sandbanks, and those	Updated baseline information on tidal currents that are bespoke to the Project is provided in Section 8.5.4 demonstrating the similarity of the recent data with that modelled at GWF. Hence, the discussion of bathymetry with respect to tidal currents is not relevant, because the calibration is reflected in the tidal current comparison. The potential impact of turbulent wakes has been considered as part of the overall conceptual evidence-based assessment of changes to tidal currents in Section 8.6.3.1. It is indicated that there is no interaction with wakes from adjacent foundations due to the relatively large separation distances. The potential for seabed scour is covered in Section 8.6.3.3 and Section 8.6.3.5. Changes to tidal currents would be both low in magnitude and largely confined to local wake or wave shadow effects attributable to individual wind turbine foundations and, therefore, would be small in geographical extent. Hence, any scour due to wakes would also be local and insignificant and would have no effect on KKE MCZ (as its boundary does not overlap with North Falls) and negligible effect of the Annex I sandbanks.

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		sandbanks whose ecological structure and functionality warrant protection), this will need to be considered and assessed. This MDS for North Falls should be presented, including the anticipated minimum turbine spacing. Rationale for the applicability of the GWF tidal current assessment to North Falls should be provided, or a project-specific tidal regime analysis carried out. In the ES, turbulent wakes due to the array foundations will also need to be considered and assessed, with particular regard to impacts to sensitive receptors that overlap or in the vicinity of the North Falls array(s).	
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.3.2 Methodology As stated in Point 232, 'North Falls has the potential to alter the baseline wave regime, particularly in respect of wave heights and directions.' This also applies to GGOW and GWF which are now built and form part of the baseline for North Falls. The anticipated construction date for North Falls is 2025, and the GGOW wave data was collected in 2004-2005, whilst the GWF wave assessment was carried out in 2011. Therefore, whilst these studies provide useful local background information, it needs to be demonstrated how accurately their data predict baseline conditions at the time the North Falls project is implemented. This is important, because it is this baseline against which the Project's physical processes impacts should be assessed. Please demonstrate how/if the GWF wave model and GGOW wave data provide a representative estimate of the present-day North Falls baseline wave climate. Consideration also needs to be given to future scenarios within the lifetime of the development.	Numerical modelling of waves has now been completed for potential operational impacts due to the presence of the foundation structures. This replaces the conceptual assessment completed in the PEIR. Updated baseline information on waves that are bespoke to the Project is provided in Section 8.5.5.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.3.2.4/Point 234 Methodology The GWF wave assessment only considered three return periods (10 in 1 year, 1 in 1 year, and 1 in 10 year). What about higher return periods? We would advise considering higher return periods e.g., 1 in 50 year and 1 in 100 year.	Numerical modelling of waves has now been completed for potential operational impacts due to the presence of the foundation structures. Model runs were completed for waves from the north-north-west, north, east and south-south-west for three return periods (1 in 1 year, 1 in 50 year and 1 in 100 year). Simulations were completed for the effect of North Falls both individually and cumulatively with other wind farm developments (either in the planning phase or constructed).

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Natural England	14/07/2023 PEIR Section 42 Response	Section 8.3.2.4/Point 236 Methodology It is suggested, based on other studies, that 'even under a WCS of the largest diameter GBS, are relatively small in magnitude (typically less than 10% of baseline wave heights in close proximity to each wind turbine, reducing with greater distance from each wind turbine). Effects are localised in spatial extent, extending as a shadow zone typically up to several tens of kilometres from the site along the axis of wave approach, but with low magnitudes'. What is the WCS wave shadow for North Falls? Please provide a map showing the WCS wave shadow for North Falls. Assess the spatial extent of projected changes to the wave regime downwind of the arrays and consider how/if the reductions on significant wave height could affect morphological processes (e.g., at KKE MCZ, Annex I sandbanks etc).	Figure 8.17 presents worst case changes to waves for North Falls, which are described in Section 8.6.3.2.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.3.2.3/Point 240 Methodology The discussion of significance of effect refers to 'near field wave conditions at GGOW in 2005 and wave hindcast data for the north-western European Continental Shelf and the Baltic Sea and was not recorded in the vicinity of North Falls'. The former of these data are old, and the latter not in the vicinity of North Falls. Project-specific data should be used if existing up to date and site-specific data are not available. We advise that the Project seek more up to date and project-specific wave data.	Updated baseline information on waves that are bespoke to the Project is provided in Section 8.5.5.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.3.3 Methodology It is stated that the predicted reductions in tidal regime and wave regime due to the presence of the WCS GBS foundations would result in a reduction in the sediment transport potential across the areas. The assessment of this impact has, again, been based on the GWF (2011). Therefore, we refer the Project to our earlier comments on the tide and wave impact assessments. In regard to the ABPmer (2011) study to assess the potential impact to	The significance of changes in tidal flow and wave heights during the operational phase of North Falls are low in the near-field and negligible in the far-field. Hence, changes in sediment transport driven by these two processes would be similarly low in the near-field and negligible in the far-field. These magnitudes of significance are supported by the numerical modelling assessments at GGOW and GWF. Also, new information from Five Estuaries Wind Farm has been added to Section 8.6.3.3.3 to further support the conclusions of the assessment.

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		regional bedload transport processes caused by changes in flow vectors and bed shear stress due to installation of GWF. Given the concerns with respect to seabed morphology and the form and function of Annex I sandbanks due to the presence of GWF, can the same study be carried out for North Falls? Can seabed mobility across the study area be mapped? Owing to the lack of relevant site-specific data, and uncertainty with regards to the applicability of existing OWF data, we cannot agree with the impact assessment at this stage. It would be useful to see a similar study carried out for North Falls i.e., a comparison of bed shear stress values before and after construction during times of peak flow within the study area, in order to understand potential changes to seabed morphology, areas of designated seabed, the form and function of Annex I sandbanks etc.	The inclusion of a bespoke study to map bed shear stress against seabed particle size (mobility study) would be disproportionate, given the change in tidal current flow (proxy for bed shear stress) due to the Project is negligible.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.3.6 Methodology The locations where cable protection measures are most likely to be required are areas of cable crossings and in areas of seabed characterised by exposed bedrock. We welcome the Project's commitment to consider an appropriate landfall location and OCC which aims to minimise the requirement for cable protection and, in turn, sediment transport effects, as far as practicably possible. We also welcome the Project's commitment to install the export cables at landfall using HDD techniques and thus, avoid direct disturbance in the intertidal zone. We look forward to seeing refinement of the landfall location and OCC and, in turn, cable protection requirements. In the ES, the Project should provide a map showing indicative locations for cable protection and cable crossings. We would also advise consideration and assessment of potential changes to the hydrodynamic regime, sediment transport pathways, and morphology due to the presence of cable protection measures and/or cable crossings in shallow/nearshore areas. In the ES, the EIA will need to consider the impact of cable protection throughout the lifetime of the Project (i.e., construction, maintenance, additional for exposed assets, and left in situ at the time of decommissioning).	A commitment has been made to install the export cable at the landfall using HDD techniques, thus avoiding direct disturbance in the intertidal zone. There will be no surface laid cable protection at the HDD exit pit. This means that there is unlikely to be any changes to the wave regime and sediment transport inside the closure depth for this coast because the cable will be buried. The impact of the HDD exit during construction would be short-lived and local. Cable protection, berms and cable crossings in deeper water will have little effect on waves or tidal currents. The location of cable protection and cable crossings in the offshore cable corridor will be determined post consent, subject to the findings of Geotechnical surveys and the final location of other cables such as international or UK interconnector cables and the Five Estuaries export cable.

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Natural England	14/07/2023 PEIR Section 42 Response	Section 8.6.3.6.1 Methodology The magnitude of impact on seabed morphology and sediment transport under the WCS for export cable protection has been assessed as negligible for the 'landfall intertidal zone,' however, the landfall zone has not been determined yet and is due to be refined post-PEIR. It is not clear what this assessment has been based on, but we would welcome further information to support this conclusion. If available, provide supporting information regarding the magnitude of impact on seabed morphology and sediment transport within the intertidal zone at landfall. Furthermore, we advise that the Project will need to consider how the coast at landfall may alter throughout the lifetime of the development, both in terms of vertical change in beach profile and coastal retreat/management.	A commitment has been made to install the export cable at the landfall using HDD techniques, thus avoiding direct disturbance in the intertidal and shallow subtidal zones. This means that there is unlikely to be any changes to the seabed morphology and sediment transport inside the closure depth for this coast because the cable will be buried. The depth profile of the HDD below the beach would be designed to ensure there would be no exposure of the cable over the long-term, with fluctuations in beach profile and coastal retreat management.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.7 Methodology Where it is deemed necessary to carry out levelling or lowering of sandwaves related to a designated feature, the Project should consider monitoring to validate predictions of sandwave recovery. Cables/protection buried in the intertidal zone should be monitored to ensure assets remain below winter beach level. Monitoring should be considered to validate predictions of sandwave recovery. Also consider monitoring of buried infrastructure/assets in the intertidal zone to ensure asset integrity through the lifetime of the Project.	Regular bathymetry surveys of the offshore cables will be undertaken which would provide information on depth of burial and therefore provide an indication of sandwave recovery. This is discussed further in the In-Principle Monitoring Plan (document reference 7.10)
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.8.2 Methodology Table 8.47 provides a summary of the Projects considered in the Cumulative Effects Assessment (CEA) for marine geology, oceanography, and physical processes. However, there is no accompanying map to show the location of the plans or projects included in Table 8.47.	The plans and projects considered in the CEA are now shown in Figure 8.19.

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		Please provide a map to show the Projects/plan/activities considered and screened in the CEA.	
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.8.3.2 Methodology There is the potential for construction-related activities to overlap between North Falls and VE along their OCCs. For example, sediment plumes due to simultaneous operations at locations aligned with respect to the tidal axis. To what extent would sensitive areas of seabed be disturbed during seabed preparation and cable installation activities, or changed due to increased SSCs and sediment deposition (e.g., MLS SAC, Annex I sandbanks, protected sites along the coast)? We advise consideration is given to construction related impacts on sensitive receptors and designated sites (e.g., MLS SAC, Annex I sandbanks, designated sites along adjacent coastline at landfall) due to simultaneous operations (SIMOPs) between North Falls and VE. Provide MDS for overlapping plumes, increased SSCs, subsequent sediment deposition, area of impact etc.	This has been considered in Section 8.8.3.2. With respect to mapping plumes and deposition, the longer-term outcome once the sediment supply from cable installation has ceased, would be cumulative concentrations at background levels and bed thicknesses effectively zero. This means that the effects on the Annex I sandbanks, MLS SAC and the coast would not be significant.
Natural England	14/07/2023 PEIR Section 42 Response	Section 8.8.3.3/Point 328 Methodology It is stated that it was agreed that 'no assessment of cumulative effects was required for GWF with other Round 2 sites in the Thames strategic area and therefore they are not considered for North Falls'. This statement does not consider that significant time has passed since then and it is possible that the cumulative effects of multiple OWF projects have now altered the wave, tidal and sediment transport regime baseline. We advise that without current evidence to support this statement, it should not be assumed to be accurate. We would draw the Project's attention to VE OWF PEIR Volume 4, Annex 2.2: Physical Processes Model Design and Validation which assesses the potential for cumulative interaction with other wind farms located in the VE study area. We also advise that these potential cumulative effects should be fully considered and assessed.	Cumulative operational wave and tidal current impacts with adjacent wind farms are covered in Sections 8.8.3.3 and 8.8.3.4, respectively.

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Natural England	14/07/2023 PEIR and MCZA Section 42 Response	Chapter 8/Table 8.13 MCZA Screening The relevant site features have been identified. However, we would include Blackwater MCZ in the list of Principal Receptors in Table 8.13 of Chapter 8 Marine Geology, Oceanography and Physical Processes owing to the potential for construction activity-related impacts at landfall for the Project alone and in-combination. We would recommend that you update the assessment to include the Blackwater MCZ.	The Blackwater MCZ is integral to the definition of the Essex coast as a sensitive receptor, and it is not necessary to break down the coast into individually named sites. They are considered in the impact assessment as part of the defined sensitive receptor and potential impacts are universally applied across all. A map showing the receptors is provided as Figure 8.15, which contains all those receptors of significance to marine geology, oceanography and physical processes.
Natural England	14/07/2023 PEIR and MCZA Section 42 Response	MCZ Assessment We are concerned that use of the GWF sediment plume model output may not be directly applicable to the site-specific prevailing conditions of North Falls, in particular within and near to KKE MCZ. We advise calibration of the GWF model output with data specific to the prevailing conditions at KKE MCZ in order to provide confidence in the MCZA methodology and conclusions.	The assessment of sediment dispersion in the water column due to seabed preparation for foundation installation that was completed at Five Estuaries Wind Farm has been added for supporting evidence. The total volume of sediment released during seabed preparation was estimated as 1.19Mm^3 which is conservative compared to the estimated release of 1.14Mm^3 at North Falls, and so the results of the Five Estuaries assessment is conservative and a good analogy.
Natural England	14/07/2023 PEIR and MCZA Section 42 Response	MCZA, Section 8.2.1.2 MCZ Assessment The conceptual-based and GWF model plume results should be calibrated for the prevailing conditions at the area of the south array that overlaps with KKE MCZ and the adjacent seabed area. Point 183 suggests that although 'SSC will be elevated, they are likely to be lower than concentrations that would develop in the water column during storm conditions. Also, once installation is completed, tidal currents are likely to rapidly disperse the suspended sediment (i.e., over a period of a few hours) in the absence of further sediment input.' Can this be validated using site specific data? We advise that the Project should try to quantify the impacts on the protected features of the site to inform the MCZA, as precisely as possible. A map should be provided showing the plume extent, SSC concentration and persistence for WCS construction activities	The Project does not now overlap with KKE MCZ. Data on SSCs released at Five Estuaries Wind Farm have been used to support the conclusion that tidal currents are likely to rapidly disperse the suspended sediment (over a period of a few hours) in the absence of further sediment input. Five Estuaries concluded that after about 24 to 48 hours following cessation of activities there would be no measurable change from baseline SSC. Hence, the need to map plume extent and persistence would not add any meaningful information for the impact assessment because the longer-term outcome once the sediment supply from cable installation has ceased, would be cumulative concentrations at background levels.

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		relating to SSC changes, for example, foundation seabed preparation, drill arisings, simultaneous operations etc. As stated earlier, we also advise that the conceptual-based and GWF model plume results should be calibrated for the prevailing conditions at the area of the south array that overlaps with KKE MCZ and the adjacent seabed area.	
Essex County Council	14/07/2023 PEIR Section 42 Response	Shoreline Management In our previous response to the EIA Scoping Report we took the opportunity to highlight a number of points relating to the Essex and South Suffolk Shoreline Management Plan (SMP) which is the SMP of relevance for the proposed onshoring location. Whilst our comments are reflected in the table 8.1 in Chapter 8, it is felt that the references to the SMP cited in your response have not adequately acknowledged the particular constraints affecting the section proposed for the landfall.	The SMP is discussed in Sections 8.5.9, 8.5.10 and 8.6.1.1. Impacts on the coast are assessed in Sections 8.6.2.9 and 8.6.3.6. Text has been changed to reflect the potential long-term policy.
Essex County Council	14/07/2023 PEIR Section 42 Response	We highlighted previously that the preferred policy for this section of coast for Epoch 3 (2055 to 2105) is for Hold the Line / Managed Realignment ie a dual policy, which gives no certainty that this section of frontage will be managed in the same way as currently into the future. We also highlighted that the SMP states that, for the earlier periods (present day to 2055), where the preferred policy is for Hold the Line, that this will only be possible if there is sufficient funding available to undertake the required works. The SMP also highlights that “in the long term, holding the line at this location will be challenging and that funding may have to come from a variety of sources”.	
Essex County Council	14/07/2023 PEIR Section 42 Response	The SMP also states on p 89 section 3.3 that a defence that is economic to maintain (i.e. benefits: costs ration greater than 1) may not also be afforded from finite public finances, and this should be considered by the proposed developer.	
Essex County Council	14/07/2023 PEIR Section 42 Response	Essex County Council also highlighted that when the major coast protection scheme along the Clacton to Holland on Sea frontage was undertaken, that it would be reliant on undertaking ongoing maintenance at an estimated cost of £1.2million every 10 years and we highlighted that this might also be challenging to secure.	
Essex County Council	14/07/2023 PEIR Section 42 Response	In table 8.1 you respond to Essex County Council’s comments with references to several pages where the SMP is referenced in your report, however the information presented at these points	

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		8.5.9, 8.5.10 and 8.6.1.1 do not always reflect the text in the SMP accurately.	
Essex County Council	14/07/2023 PEIR Section 42 Response	In 8.5.9 it is stated that "The Shoreline Management Plan (SMP) (EACT, 2010) states that the intended management along this frontage is 'hold the line' and would 'sustain and support its viability of the seaside towns and their communities, tourism and commercial activities'. This point suggests that this is the sole intent of management for this frontage, and should be corrected to specify that the intended of management in future epochs could change to include managed realignment as without doing so you are creating a false sense of security that this line will be held into the longer term. It is not clear that any scoping or potential impacts that could relate to a change of policy has been undertaken by the developer.	
Essex County Council	14/07/2023 PEIR Section 42 Response	In 8.5.10 it is stated that trends in coastal erosion will be driven by the shoreline management plan which is currently to hold the line … it should be noted that no natural processes that cause coastal erosion will be driven by a plan. Whilst it is accepted that you have referenced Essex County Council's comments relating to the SMP in this section regarding the potential for a change in policy and the need for ongoing maintenance funding (outlined in the Project Appraisal Report for the Clacton to Holland-on-Sea coast protection scheme), the potential impacts of a change in management at the landfall location or the inability to undertaken the regular and costly maintenance, on the proposed development have not been adequately addressed. It is suggested that the applicant fully considers the implications of a managed realignment on the siting of the onshoring of the cabling and associated infrastructure, as well as the access and egress for construction and any ongoing maintenance.	Section 8.5.10 has been revised and considers the implications of a managed realignment at the landfall.
East Suffolk Council	06/07/2023 PEIR Section 42 Response	Coastal geomorphology The PEIR assessment materials include Chapter 8 Marine Geology Oceanography and Physical Processes as well as the accompanying ES Figures (Document Reference: 3.2.4). Section 3.1 within the PEIR Non-Technical Summary concludes 'With the implementation of mitigation measures, North Falls is predicted to have no greater than negligible adverse (not significant in EIA terms) effects on marine geology, oceanography and physical processes during all project phases…. There is potential for cumulative effects to occur with a	Numerical modelling of waves has now been completed for potential operational impacts due to the presence of the foundation structures for North Falls alone and cumulatively with other wind farms. The cumulative results are described in Section 8.8.3.3 and shown in Figure 8.20.

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		number of other offshore wind farms and other projects. However, when considering proposed mitigation measures, it is not anticipated that cumulative effects are likely to be significant in EIA terms'. As set out in ESC's non-statutory consultation response, our coastal management concern focusses on the potential for an increasingly dense wall of offshore wind turbines having an effect on their lee side, such that this alters wind driven wave patterns through a reduction in wind energy. Our comments therefore focus on the assessment of how wave energy will be affected as this appears to have the greatest potential to cause an impact on the East Suffolk coastline. The impact of wave energy interruption by turbine foundations arising from both this development in isolation and the entire licensed turbine field, for a number of wave directions, needs to be fully understood and modelling should include possible effects to the ESC shoreline. This is considered important because if there is a measurable impact which reduces wave energy on approach to the East Suffolk shoreline from an east/southeast direction, then it has potential to alter the net sediment drift balance at the shoreline. There are coastal locations where a reduction in the southerly component of net drift may be significant e.g., East Lane Bawdsey and Thorpeness. It is requested that the final impact assessments undertaken for this project demonstrate consideration of the impact of wind energy interruption by the turbine array on lee side wave energy, in addition to turbine foundation interruption impacts, and this should provide a commentary on how this impact may impact net sediment trends over East Suffolk shorelines.	
MMO	14/07/2023 PEIR Section 42 Response	Table 8.2 in Chapter 8 provides a comprehensive summary of the potential impacts throughout the construction, operation and decommissioning phase. These are appropriate the MMO has no concerns regarding any impacts on coastal processes being scoped out.	Noted.
MMO	14/07/2023 PEIR Section 42 Response	Chapter 8 sets out the evidence base and potential impacts to be scoped-in to the assessment and these are appropriate. Where there is uncertainty about the exact design of the windfarm infrastructure, the Applicant has considered the most likely worst-	Noted.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		case scenario, which is an appropriate method for undertaking such impact assessments.	
MMO	14/07/2023 PEIR Section 42 Response	The proposed embedded mitigative steps, including maximising the spacing between individual wind turbines to reduce their impact on coastal processes; Favouring pile driving over drilling for installation; micro-siting cables and turbines, and; burying cables wherever possible to minimise impacts, are welcomed.	Noted.
Ralph Brayne (Cefas) & Yolanda Foote (Natural England)	19/10/23 Seabed ETG meeting	Did you do any assessment on change in wave direction as a result of the development? It is noted that this is an unusual request for offshore wind farms but longshore sediment transport can be highly influenced by those small changes in wave direction consistently applied over time. Impacts on wave direction may have an effect on the MCZ.	Wave direction modelling results have been extracted and included in Section 8.6.3.2 (Project alone) and Section 8.8.3.3 (cumulative).

8.3 Scope

8.3.1 Study area

9. The study area for marine geology, oceanography and physical processes has been defined based on both the near-field (within the offshore project area) and far-field (beyond the offshore project area and across the wider regional seabed and coastal) environments.

10. The offshore project area is in the southern North Sea (ES Figure 8.1 and ES Figure 8.2 (Document Reference: 3.2.4)). The array area covers approximately 95km^2 of the seabed and lies adjacent to GGOW and GWF. The offshore cable corridor links the array area to the landfall area at Kirby Brook on the Tendring Peninsula, Essex.

11. The limits of the far-field impacts are based on an understanding of the tidal regime, discussed further in Section 8.6.3.1. Changes associated with the tidal regime would have returned to background levels immediately outside the excursion of one spring tidal ellipse, approximately 15km from the North Falls offshore project area.

12. For the CEA, a range of 30km from the North Falls offshore project area has been used to provide a conservative search area for the screening of plans and projects which have potential to interact with the impacts of North Falls. This distance considers the potential of other projects cumulative effects far-field. Therefore, conservatively, a buffer area of two spring tidal ellipse excursions is considered for the CEA.

8.3.2 Realistic worst case scenario

13. The final design of North Falls will be confirmed through detailed engineering design studies that will be undertaken post-consent. To provide a precautionary but robust impact assessment at this stage of the development process, realistic worst case scenarios have been defined in terms of the likely significant effects that may arise. This approach to EIA, referred to as the Rochdale Envelope, is common practice for developments of this nature, as set out in Planning Inspectorate Advice Note Nine (2018). The Rochdale Envelope for a project outlines the realistic worst case scenario for each individual impact, so that it can be safely assumed that all other scenarios within the design envelope will have less impact. Further details are provided in ES Chapter 6 EIA Methodology (Document Reference: 3.1.8).

14. One area of optionality is in relation to the national grid connection point (discussed further in ES Chapter 5 Project Description (Document Reference: 3.1.7)). The following grid connection options are included in the Project design envelope:

- Option 1: Onshore electrical connection at a national grid connection point within the Tendring peninsula of Essex, with a project alone onshore cable route and onshore substation infrastructure;
- Option 2: Onshore electrical connection at a national grid connection point within the Tendring peninsula of Essex, sharing an onshore cable route and onshore duct installation (but with separate onshore export cables) and co-

locating separate project onshore substation infrastructure with Five Estuaries; or

- Option 3: Offshore electrical connection, supplied by a third party.

15. The realistic worst case scenarios for the likely significant effects scoped into the EIA for the marine geology, oceanography and physical processes assessment are summarised in Table 8.2. These are based on North Falls parameters described in ES Chapter 5 Project Description (Document Reference: 3.1.7), which provides further details regarding specific activities and their durations.

16. For marine geology, oceanography and physical processes, options 1 and 2 would be the same, and these represent the worst case scenario described in Table 8.2 and assessed in Section 8.6. For option 3, there would be no project export cables to shore. Within the array area, under options 1 and 2 there would be two OSPs, whereas for option 3 there would be one OCP and up to one OSP, but with no change to the worst case foundation infrastructure.

Table 8.2 Realistic worst case scenarios

Potential impact	Parameter	Worst case	Notes
Construction			
Impact 1a: Changes in SSCs due to seabed preparation for installation of turbine and OSP/OCP foundations	Volume of sediment disturbed	• Seabed preparation volume for each GBS = 70m preparation diameter x 57 wind turbines x average 5m sediment depth = **1,096,809m³** • Seabed preparation volume for two offshore substation platforms = 70m preparation diameter x 2 x average 5m sediment depth = **38,485m³** Worst case scenario volume for seabed preparation for foundation installation = **1.14Mm³**	Seabed preparation (sandwave levelling) may be required with an average sediment depth of 5m. The worst case scenario assumes that sediment would be dredged and returned to the water column at the sea surface during disposal from the dredger vessel.
Impact 1b: Changes in SSCs due to drill arisings for installation of piled foundations for wind turbines and OSPs/OCP	Volume of drill arisings	Drill arisings at 10% of the wind turbines = **34,728m³** (based on 10% of 34 of the largest turbines which is the worst case scenario and an average drill arising per turbine foundation of 10,214m³) Drill arisings at one monopile OSP/OCP = 11,451m³ (based on 50% of the OSPs/OCP needing drilling) Worst case scenario volume for drill arisings for foundation installation = **46,179m³** Note that drill arisings would not occur if GBS are used and therefore this parameter cannot be added to the maximum seabed levelling for GBS described above.	Assumes average 45m drill depth and 17m drill diameter at the wind turbines and 42m drill depth and 18m drill diameter at the OSP/OCP.
Impact 2a: Changes in seabed level due to seabed preparation for installation of turbine and OSP/OCP foundations	As Construction Impact 1a	As Construction Impact 1a	As Construction Impact 1a.
Impact 2b: Changes in seabed level due to drill arisings for installation of piled foundations	As Construction Impact 1b	As Construction Impact 1b	As Construction Impact 1b.

Potential impact	Parameter	Worst case	Notes
for wind turbines and OSPs/OCP			
Impact 3: Changes in SSCs due to export cable installation (Options 1 and 2 only)	Volume of sediment disturbed	• HDD exit pits = three (two offshore export cables and one contingency) • Export cable sandwave levelling = **1,544,891m^3** • Export cable burial = 125.4km long (two cables of 62.7km each) with an average 1m trench width x average 1.2m burial depth = **150,480m^3** Worst case scenario volume due to export cable installation = **1.70Mm^3** • A pre-grapnel run would be required during cable installation, however this is run along the surface of the seabed and would have minimal SSC volume.	The offshore HDD exit location will be subtidal, up to c. 1.5km from the shore, in 1 to 8m water depth. Sediment displacement is included in the totals for the export cable.
Impact 4: Changes in seabed level due to export cable installation	As Construction Impact 3	As Construction Impact 3	As Construction Impact 3.
Impact 5: Changes in SSCs due to offshore array and platform interconnector cables installation	Volume of sediment disturbed	• Array cable sandwave levelling = **27,293,114m^3** Array cable burial = 170km length with an average 1m trench width x average 1.2m burial depth = **204,000m^3** • Platform interconnector cable sandwave levelling = 1,436,480m^3 • Platform interconnector cable burial – 20km length with average 1m trench width x average 1.2m burial depth = 24,000m^3 Worst case scenario volume for array and interconnector platform cables = 28.96Mm^3 • A pre-grapnel run would be required during cable installation, however this is run along the surface of the seabed and would have minimal SSC volume.	Sandwave levelling may be required prior to offshore cable installation. Any excavated sediment due to sandwave levelling would be disposed of within the North Falls offshore project area, meaning there will be no net loss of sediment from the site. Sediment displacement assumes a box shaped dimension.
Impact 6: Changes in seabed level due to offshore array and platform interconnector cables installation	As Construction Impact 5	As Construction Impact 5.	As Construction Impact 5.

Potential impact	Parameter	Worst case	Notes
Impact 7: Interruptions to bedload sediment transport due to sandwave levelling for offshore export cable and array cable installation	Volume of sediment disturbed	As Construction Impact 5.	As Construction Impact 5.
Impact 8: Indentations on the seabed	Seabed disturbance footprint	• Vessel jack up assuming six jack up locations per wind turbine/OSP (275m^2 per jack up leg x six legs x six locations x 354 jack up operations) = **584,100m^2** • Anchoring during wind turbine/OSP installation = **274,704m^2** (based on vessels with eight anchors, each with 116.4m^2 footprint and five anchoring events per wind turbine/OSP) • Anchoring during array/ platform interconnector cable installation = **235,878m^2** (based on nine anchors per vessel, each with 61m^2 footprint; and 432 anchoring events • Anchor during offshore export cable installation = **297,850m^2** (based on nine anchors per vessel, each with 61m^2 footprint; and 546 anchoring events) • Boulder clearance = **295m^2** (up to 15 boulders of 5m diameter in the offshore cable corridor) • Boulder clearance= **491m^2** (up to 25 boulders of up to 5m diameter in the array area) • Array area UXO clearance = **1025m^2**. Crater areas reported from other offshore wind farms range from approximately 2 to 25m^2, whereas the largest predicted in Ørdtek (2018) is around 350m^2. It is estimated 13 of the UXO craters would be of 25m^2 or less and two craters of up to 350m^2. Up to 15 UXO clearance operations are predicted along the array area. • Offshore cable corridor UXO clearance = **1600m^2**. It is estimated 22 of the UXO craters would be of 25m^2 or less and three craters of up to 350m^2. Up to 25 UXO clearance operations are predicted along the export cable route. Worst case scenario seabed indentations = **1.38km^2**	Temporary disturbance relates to seabed preparation and installation activities. The persistent/ permanent footprint of infrastructure is assessed as an operation phase impact.

Potential impact	Parameter	Worst case	Notes
Operation and maintenance			
Impact 1: Changes to the tidal regime due to the presence of structures on the seabed (wind turbines and OSP/OCP foundations)	Cross sectional area within the water column	Worst case wind turbine cross-sectional area based on GBS with 65m diameter base, 15m diameter top at 15m above the seabed = **600m^2.** Monopile would continue as a 15m diameter column to the water surface. Total worst case scenario cross-sectional area based on 57 x 65m diameter GBS = **34,200m^2**	GBS are the worst-case foundation types for effects on tidal currents. This is based on GBS having the greatest cross-sectional area within the water column (compared to other foundation types) representing the greatest physical blockage to tidal currents. Therefore, a larger number of GBS with minimum wind turbine and OSP spacing is the worst case scenario. The worst case scenario for changes to the tidal regime does not include effects caused by cable protection. This is because, although flows would tend to accelerate over the protection and then decelerate on the 'down-flow' side, they would return to baseline values a very short distance from the structure. Hence, the effect on tidal currents would be very small.
Impact 2: Changes to the wave regime due to the presence of structures on the seabed (wind turbines and OSP/OCP foundations)	Cross sectional area within the water column	As Operational Impact 1.	GBS are the worst-case foundation types for effects on waves due to the height of the foundation above the seabed. Wind turbine spacing can be described in general terms at this stage.
Impact 3: Changes to the sediment transport regime due to the presence of structures on the seabed (wind turbines and	Cross sectional area within the water column	As Operational Impact 1.	GBS are the worst-case foundation types for effects on the sediment transport regime due to the height of the foundation above the seabed.

Potential impact	Parameter	Worst case	Notes
OSP/OCP foundations)			
Impact 4: Loss of seabed area due to infrastructure footprint within the array area	Loss of seabed area	Total worst case wind turbine footprint based on 57 x 65m diameter GBS = **189,144m²** Scour protection assumes that all turbines have scour protection of up to 83,774m² (excluding wind turbine foundation footprint) = **4,775,118m²** Two offshore electrical platforms with scour protection = **174,184m²** (87,092m² each) Up to 34km of array cable protection may be required in the unlikely event that the array cables cannot be buried (based on 20% of the length) x 6m cable protection width = 204,000m² Worst case scenario total persistent footprint in the array area = **5.37km²**	GBS are the worst-case foundation types for loss of seabed area due to the size of the base that will be present on the seabed.
Impact 5: Morphological and sediment transport effects due to cable protection measures within the array area	Length of cable protection	Array cable protection – Up to 34km of cable protection may be required in the unlikely event that array cables cannot be buried (based on 20% of the length) x 6m cable protection width = 204,000m² Platform interconnector cable protection – Up to 4km of cable protection may be required in the unlikely event that array cables cannot be buried (based on 20% of the length) x 6m cable protection width = 24,000m² Height of cable protection = up to 1.4m	
Impact 6: Morphological and sediment transport effects due to cable protection measures within the offshore cable corridor	Length of cable protection	Up to 12.5km of cable protection may be required in the unlikely event that export cables cannot be buried (based on 10% of the length) x 6m cable protection width = 75,240m²	
Impact 7: Changes in SSC due to cable repairs and reburial	Volume of sediment disturbed	Unplanned repairs and reburial of cables may be required during O&M, the following estimates are included: • Reburial of about 2.75% of array/platform interconnector cable is estimated over the life of the Project (24m disturbance width) x average 1.2m depth = 150,480m³ • Reburial of 4% of offshore export cable is estimated over the life of the Project (24m disturbance width) x average 1.2m depth = 144,461m³	Each O&M activity would be relatively short term and it is likely that the requirements for maintenance would be spread over the Project life, with suspended sediments becoming rapidly redeposited.

<table>
<tr><th>Potential impact</th><th>Parameter</th><th>Worst case</th><th>Notes</th></tr>
<tr><td></td><td></td><td>• Five array/platform interconnector cable repairs are estimated over the Project life. 600m section removed x 24m disturbance width x average 1.2m depth = 86,400m^3
• Four export cable repairs are estimated over the Project life. 600m section removed x 24m disturbance width x average 1.2m depth = 69,120m^3</td><td></td></tr>
<tr><td>Impact 8: Indentations on the seabed</td><td>Seabed disturbance footprint</td><td>Anchored vessels placed during the cable repairs included above = 4,914m^2
Maintenance of offshore infrastructure would be required during O&M. An estimated 177 major component replacement activities may be required per year, using jack up vessels and/or anchoring = 292,050m^2
One UXO clearance operation per year over the lifetime of the Project with a crater footprint estimate of up to 350m^2</td><td>This represents the maximum estimated total area of seabed disturbance from unplanned repairs and reburial of cables that may be required during O&M.</td></tr>
<tr><td colspan="4">Decommissioning</td></tr>
<tr><td>Impact 1: Changes in SSCs due to foundation removal</td><td rowspan="2">Volume of sediment disturbed</td><td rowspan="2">Cutting of piles below the seabed surface:
• 480 pin-piles of 6m diameter
  ○ 57 wind turbines x eight piles
  ○ Two OSPs x 12 piles
Or
• 59 monopiles of 17m diameter (57 wind turbines + two OSPs/OCP)
Or
Removal of largest foundations (GBS):
• 57 WTG x 65m diameter
• Two OSPs x 65m diameter
Or
A mixture of the above foundation types.</td><td rowspan="4">No decision has yet been made regarding the final decommissioning arrangements for the offshore project infrastructure. It is also recognised that legislation and industry best practice change over time. However, the following infrastructure is likely to be removed, reused or recycled where practicable:
• Turbines including monopile, steel jacket and GBS foundations;
• OSPs/OCP including topsides and steel jacket foundations; and
• Offshore cables may be removed or left in situ depending on available information at the time of decommissioning.
The following infrastructure is likely to be decommissioned in situ depending on available information at the time of decommissioning. However, where it represents the worst case scenario (e.g. for disturbance), removal is assessed:
• Scour protection;
• Offshore cables may be removed or left in situ; and</td></tr>
<tr><td>Impact 2: Changes in seabed level due to foundation removal</td></tr>
<tr><td>Impact 3: Changes in SSCs due to removal of parts of the export cable</td><td>As Construction Impact 1</td><td rowspan="2">Up to 125.4km of export cable, two cables of 62.7km each, (removal to be determined in consultation with key stakeholders as part of the decommissioning plan)</td></tr>
<tr><td>Impact 4: Changes in seabed level due</td><td>As Construction Impact 1</td></tr>
</table>

Potential impact	Parameter	Worst case	Notes
to removal of parts of the export cable			• Crossings and cable protection. The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and will be agreed with the regulator. Decommissioning arrangements will be detailed in a Decommissioning Plan, which will be prepared in accordance with the Energy Act 2004.
Impact 5: Changes in SSCs due to removal of parts of the array and interconnector cables	Volume of sediment disturbed	Up to 190km of array/platform interconnector cable (removal to be determined in consultation with key stakeholders as part of the decommissioning plan)	
Impact 6: Changes in seabed level due to removal of parts of the array and platform interconnector cables	As Construction Impact 3		
Impact 7: Indentations on the seabed due to decommissioning vessels	Volume of sediment disturbed	• Vessel jack up assuming six jack up locations per wind turbine (275m^2 per jack up leg x six legs x six locations) = 564,300m^2 • Jack up vessel footprints for OSPs/OCP = 19,800m^2 • Anchoring during wind turbine and OSP/OCP decommissioning = 274,704m^2 (based on vessels with eight anchors, each with 116.4m^2 footprint; and five anchoring events per wind turbine/OSP/OCP) • Anchoring during array/platform interconnector cables removal (if required) = 235,878m^2 (based on nine anchors per vessel, each with 61m^2 footprint; and 432 anchoring events) • Anchor placement for export cable removal (if required) = 297,850m^2 (based on nine anchors per vessel, each with 61m^2 footprint; and 546 anchoring events)	

8.3.3 Summary of mitigation embedded in the design

17. This section outlines the embedded mitigation relevant to the Marine Geology, Oceanography and Physical Processes assessment, which has been incorporated into the design of North Falls (Table 8.3). Where other mitigation measures are proposed, these are detailed in the impact assessment (Section 8.6).

Table 8.3 Embedded mitigation measures

Parameter	Mitigation measures embedded into North Falls design
Turbine Spacing	Wind turbine spacing can be described in general terms at this stage. A minimum separation distance of: • 5 x the rotor diameter (i.e. 1180m for the smallest turbines with 236m rotor diameter or 1,685m for the largest turbines with 337m rotor diameter) in the downwind direction; and • 4 x the rotor diameter (i.e. 944m for the smallest turbines with 236m rotor diameter or 1,348m for the largest turbines with 337m rotor diameter) in the cross wind direction. This will minimise the potential for interaction between adjacent wind turbines with respect to marine physical process.
Foundations	Micro-siting will be used where practicable to minimise the requirements for seabed preparation prior to foundation installation.
Cables	Micro-siting will be used where practicable to minimise the requirements for seabed preparation prior to cable installation.
	Cables will be buried where practicable, minimising the requirement for cable protection measures and thus effects on sediment transport.

8.4 Assessment methodology

8.4.1 Legislation, guidance and policy

8.4.1.1 National Policy Statements

18. The assessment of likely significant effects upon Marine Geology, Oceanography and Physical Processes has been made with specific reference to the relevant NPS. These are the principal policy documents with respect to Nationally Significant Infrastructure Projects (NSIPs). Those relevant to the Project are:

- Overarching NPS for Energy (EN-1) (Department for Energy Security and Net Zero (DESNZ) 2023a);
- NPS for Renewable Energy Infrastructure (EN-3) (DESNZ 2023b);
- NPS for Electricity Networks Infrastructure (EN-5) (DESNZ 2023c).

19. The specific assessment requirements for Marine Geology, Oceanography and Physical Processes, as detailed in the NPS, are summarised in Table 8.4 together with an indication of the section of the ES chapter where each is addressed.

Table 8.4 NPS assessment requirements

NPS Requirement	NPS Reference	ES Reference (Volume 3.1)
Overarching NPS for Energy (EN-1)		
'Where relevant, applicants should undertake coastal geomorphological and sediment transfer modelling to predict and understand impacts and help identify relevant mitigating or compensatory measures.'	Section 5.6, paragraph 5.6.10	The approach adopted in this ES for all impacts apart from waves is conceptual and evidence-based using data from GWF and GGOW as a suitable analogue (see Section 8.4.6). Numerical modelling of waves has been completed for potential operational impacts due to the presence of the foundation structures
'The ES (see Section 4.3) should include an assessment of the effects on the coast, tidal rivers and estuaries. In particular, applicants should assess: • the impact of the proposed project on coastal processes and geomorphology, including by taking account of potential impacts from climate change. If the development will have an impact on coastal processes the applicant must demonstrate how the impacts will be managed to minimise adverse impacts on other parts of the coast • the implications of the proposed project on strategies for managing the coast as set out in Shoreline Management Plans (SMPs)207 (which are designed to identify the most sustainable approach to managing flood and coastal erosion risks from short to long term and are long term non-statutory plans which set out the agreed high-level objective for coastal flooding and erosion management for each SMP area), any relevant Marine Plans, River Basin Management Plans, and capital programmes for maintaining flood and coastal defences and Coastal Change Management Areas • the effects of the proposed project on marine ecology, biodiversity, protected sites and heritage assets • how coastal change could affect flood risk management infrastructure, drainage and flood risk • the effects of the proposed project on maintaining coastal recreation sites and features • the vulnerability of the proposed development to coastal change, taking account of climate change, during the Project's operational life and any decommissioning period'	Section 5.6, paragraph 5.6.11	The assessment of potential construction and operation and maintenance impacts and likely significant effects are described in Section 8.6.2 and Section 8.6.3, respectively. North Falls will not affect the Shoreline Management Plan and allowance has been made for predicated erosion rates during North Falls design (further detail is provided in Chapter 4 Site Selection and Assessment of Alternatives). Embedded mitigation to minimise likely significant effects at the coast of cable installation and operation are described in Section 8.3.3. Effects on marine ecology biodiversity and protected sites are assessed in Chapter 12 Benthic and Intertidal Ecology, Chapter 13 Fish and Shellfish Ecology, Chapter 14 Marine Mammal Ecology and Chapter 15 Offshore Ornithology. Potential flood risk impacts are considered in Chapter 23 Water Resources and Flood Risk. Effects on recreation are assessed in Chapter 34 Tourism and Recreation. As described above, North Falls has been designed so that it is not vulnerable to coastal change or climate change.
'The applicant should be particularly careful to identify any effects of physical changes on the integrity and special features of Marine Protected Areas (MPAs). These could include MCZs, habitat sites including Special Areas of Conservation and Special Protection Areas with marine features, Ramsar Sites, Sites of Community Importance, and SSSIs with marine features. Applicants should also identify any	Section 5.6, paragraph 5.6.13	The potential receptors to morphological change are the Suffolk coast, Essex coast and designated sites including Margate and Long Sands SAC, KKE MCZ and Annex I sandbanks. The likelihood of affecting their integrity is assessed with respect to changes in seabed level caused by foundation and cable installation (Section 8.6.2.1– Section

NPS Requirement	NPS Reference	ES Reference (Volume 3.1)
effects on the special character of Heritage Coasts[209].' .		8.6.2.8) and interruption to bedload sediment transport by cable protection (Section 8.6.3.5 and Section 8.6.3.6).
NPS for Renewable Energy Infrastructure (EN-3)		
The construction, operation and decommissioning of offshore energy infrastructure (including the preparation and installation of the cable route) can affect the following elements of the physical offshore environment, which can have knock on impacts on other biodiversity receptors: • water quality – disturbance of the seabed sediments or release of contaminants can result in direct or indirect effects on habitats and biodiversity, as well as on fish stocks thus affecting the fishing industry • waves and tides – the presence of the turbines can cause indirect effects through change to wave climate and tidal currents on flood defences, marine ecology and biodiversity, marine archaeology and potentially coastal recreation activities • scour effect – the presence of wind turbines and other infrastructure can result in a change in the water movements within the immediate vicinity of the infrastructure, resulting in scour (localised seabed erosion) around the structures. This can indirectly affect navigation channels for marine vessels, marine archaeology and impact biodiversity and seabed habitats • sediment transport – the resultant movement of sediments, such as sand across the seabed or in the water column, can indirectly affect navigation channels for marine vessels, could affect sediment supply to sensitive coastal sites and impact biodiversity and seabed habitats • suspended solids – the release of sediment during construction, operation and decommissioning can cause indirect effects on marine ecology and biodiversity; • sandwaves – the modification/clearance of sandwaves can cause direct physical and ecological effects both at the seabed and within the water column due to disturbance and suspension of sediment, and potentially indirect effects (e.g. changes to seabed morphology in water depths where waves can influence the seabed, which can in turn affect wave climate and sediment transport; and • water column – wind turbine structures can also affect water column features such as tidal mixing fronts or stratification due to a change in hydrodynamics and turbulence around structures.	Paragraph 2.8.111	Effects on water quality are covered in Chapter 9 Marine water and sediment quality. Effects on waves and tides induced by the physical presence of infrastructure during the operation phase are considered in Section 8.6.3.1 and Section 8.6.3.2. Assessment of the potential for seabed scour and the potential for effects on the form and function of bedload sediment transport processes due to the physical presence of foundations are described in Section 8.6.3.3. Consideration of the risk of increased suspended sediments is described in Section 8.6.2.1 and Section 8.6.2.2. Potential increases in suspended sediment concentrations due to sandwave clearance are assessed in Section 8.6.2.5. Effects on water column stratification are scoped out of this EIA
'Applicant assessments are expected to include predictions of the physical effects arising from modifications to hydrodynamics (waves and	Section 2.8, paragraphs	Each of the impacts and effects in Section 8.6.3.1 – Section 8.6.3.3 cover the potential magnitude and

NPS Requirement	NPS Reference	ES Reference (Volume 3.1)
tides), sediments and sediment transport, and sea bed morphology that will result from the construction, operation and decommissioning of the required infrastructure.' 'Assessments should also include effects such as the scouring that may result from the proposed development and how that might impact sensitive species and habitats.'	2.8.112 and 2.8.113	significance of the physical (waves, tides and sediments) effects upon the baseline conditions resulting from the construction, operation and maintenance, and decommissioning of North Falls. Scour resulting from the Project is not assessed because scour protection will be used wherever scour is likely to occur, reducing sediment release to negligible quantities.
'Applicant assessment of the effects of installing offshore transmission infrastructure across the intertidal/coastal zone should demonstrate compliance with mitigation measures in any relevant plan-level Habitat Regulations Assessment (HRA) including those prepared by The Crown Estate as part of its leasing round, and include information, where relevant, about: • any alternative landfall sites that have been considered by the applicant during the design phase and an explanation for the • final choice; • any alternative cable installation methods that have been considered by the applicant during the design phase and an explanation for the final choice; • potential loss of habitat; • disturbance during cable installation, maintenance/repairs and removal (decommissioning); • increased suspended sediment loads in the intertidal zone during installation and maintenance/repairs; • potential risk from invasive and non-native species; • predicted rates at which the intertidal zone might recover from temporary effects, based on existing monitoring data; and • protected sites.'	Section 2.8, paragraph 2.8.119	Landfall Site Selection and Assessment of Alternatives are provided in Chapter 4 Site Selection and Assessment of Alternatives HDD will be used to install the export cables at the landfall and will exit in the subtidal zone. Therefore, there will be no direct impacts on the intertidal zone. A range of cable installation methods are required, and these are detailed in Chapter 5 Project Description. The worst case scenario for marine geology, oceanography and physical processes is provided in Section 8.3.2. Potential habitat loss in the intertidal zone is covered in Chapter 12 Benthic and Intertidal Ecology. Assessment of the potential disturbance and increased SSCs in the nearshore (including the intertidal zone) due to cable installation is provided in Section 8.6.3.6. Potential risks from invasive non-native species are assessed in Chapter 12 Benthic and Intertidal Ecology. The recoverability of the coastal receptors (Suffolk coast and Essex coast) is assessed for morphological and sediment transport effects due to cable protection measures at the coast (Section 8.6.3.6). The Margate and Long Sands SAC and KKE MCZ have been included as receptors within this chapter and so likely significant effects on protected sites has been considered.
'Applicant assessment of the effects on the subtidal environment should include: • loss of habitat due to foundation type including associated seabed preparation, predicted scour, scour protection and altered sedimentary processes, e.g. sandwave/boulder/UXO clearance; • environmental appraisal of inter-array and other offshore transmission and installation/maintenance methods, including	Section 2.8, paragraph 2.8.126	An assessment of likely significant effects of the installation and maintenance of cable infrastructure (including consideration of the potential impact of cable protection measures) is undertaken for the relevant construction and operation impacts in Section 8.6.2 and 8.6.2.5 respectively.

NPS Requirement	NPS Reference	ES Reference (Volume 3.1)
predicted loss of habitat due to predicted scour and scour/cable protection and sandwave/boulder/UXO clearance; • habitat disturbance from construction and maintenance/repair vessels' extendable legs and anchors; • increased suspended sediment loads during construction and from maintenance/repairs; • predicted rates at which the subtidal zone might recover from temporary effects; • potential impacts from EMF on benthic fauna; • potential impacts upon natural ecosystem functioning; • protected sites; and • potential for invasive/non-native species introduction.'		See above for scour. The quantification and likely significant effect of seabed loss due to the footprints of North Falls infrastructure is covered in Section 8.6.3.4. A worst case scenario of all foundations having scour protection is considered to provide a conservative assessment. The worst case scenario cable-laying techniques are jetting, ploughing or cutting and are considered in all the cable construction assessments. The disturbance to the subtidal seabed caused by indentations due to installation vessels is assessed in Section 8.6.2.10. The potential increase in suspended sediment concentrations and change in seabed level is assessed in Section 8.6.2.1– Section 8.6.2.8. The recoverability of receptors is assessed for all the relevant impacts, particularly those related to changes in seabed level due to export cable installation (Section 8.6.2.6) and morphological and sediment transport effects due to cable protection measures for export cables (Section 8.6.3.6). Assessment of likely significant effects and identification of mitigation for the marine ecosystem are discussed is the following ES chapters: • Chapter 10 Benthic and intertidal ecology • Chapter 11 Fish and shellfish ecology • Chapter 12 Marine mammals • Chapter 13 Offshore ornithology Potential risks from EMF and invasive non-native species are assessed in Chapter 12 Benthic and Intertidal Ecology. Effects on protected sites are assessed in the MCZ Assessment (document reference 7.3) and Report to Inform Appropriate Assessment (Document Reference: 7.1)

8.4.1.2 Other legislation, guidance and policy

20. In addition to the NPS, there are several pieces of legislation, policy and guidance applicable to the assessment of marine geology, oceanography and physical processes. These include (discussed further in ES Chapter 3 Policy and Legislative Context (Document Reference: 3.1.5):

- The Marine Policy Statement (MPS, HM Government, 2011; discussed further in ES Chapter 3 Policy and Legislative Context (Document Reference: 3.1.5)) provides the high-level approach to marine planning and general principles for decision making that contribute to achieving this vision. It also sets out the framework for environmental, social and economic considerations that need to be considered in marine planning. Regarding the topics covered by this chapter the key reference is in section 2.6.8.6 of the MPS which states:

  "…Marine plan authorities should not consider development which may affect areas at high risk and probability of coastal change unless the impacts upon it can be managed. Marine plan authorities should seek to minimise and mitigate any geomorphological changes that an activity or development will have on coastal processes, including sediment movement."

- The MPS is also the framework for preparing individual Marine Plans and taking decisions affecting the marine environment. The Marine Plans relevant to the Project are:
  - the North Falls array area and offshore section of the offshore cable corridor are located within the remit of the East Inshore and East Offshore Marine Plans (HM Government, 2014;). Objective 6 "*To have a healthy, resilient and adaptable marine ecosystem in the East Marine Plan areas*" is of relevance to this chapter as it covers policies and commitments on the wider ecosystem, including those related to the Marine Strategy Framework Directive and the Water Framework Directive (see ES Chapter 3 Policy and Legislative Context (Document Reference: 3.1.5)), as well as other environmental, social and economic considerations. Elements of the ecosystem considered by this objective include: "*coastal processes and the hydrological and geomorphological processes in water bodies and how these support ecological features*".
  - The nearshore section of the offshore cable corridor is in the area covered by the South East Inshore Marine Plan (MMO, 2021). Policies SE-CC-2 and SE-CC-3 are of relevance to this chapter:

SE-CC-2 – "*Proposals in the south east marine plan area should demonstrate for the lifetime of the project that they are resilient to the impacts of climate change and coastal change."*

SE-CC-3 – "*Proposals in the south east marine plan area, and adjacent marine plan areas, that are likely to have significant adverse impacts on coastal change, or on climate change adaptation measures inside and outside of the proposed project areas, should only be supported if they can demonstrate that they will, in order of preference:*

a) avoid

b) minimise

c) mitigate

- adverse impacts so they are no longer significant."

21. In addition to NPS, MPS, the East Inshore and East Offshore Marine Plans, and South East Inshore Marine Plan, guidance on the generic requirements, including spatial and temporal scales, for Marine Geology, Oceanography and

Physical Processes studies associated with offshore wind farm developments is provided in five main documents:

- Offshore wind farms: guidance note for Environmental Impact Assessment in respect of Food and Environmental Protection Act (FEPA) and Coast Protection Act (CPA) requirements: Version 2 (Cefas, 2004).
- Coastal Process Modelling for Offshore Wind Farm Environmental Impact Assessment (Lambkin et al., 2009).
- Review of Cabling Techniques and Environmental Effects applicable to the Offshore Wind Farm Industry (BERR, 2008).
- General advice on assessing potential impacts of and mitigation for human activities on MCZ features, using existing regulation and legislation (JNCC and Natural England, 2011).
- Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects (Cefas, 2011).

22. Further detail is provided in ES Chapter 3 Policy and Legislative Context (Document Reference: 3.1.5).

8.4.2 Data sources

8.4.2.1 Site specific surveys

23. To provide site specific and up to date information to support the impact assessment, geophysical (multibeam echosounder for bathymetry, side-scan sonar for seabed texture and sub-bottom profiling for shallow geology) surveys of the array area and offshore cable corridor were completed between May and August 2021 (Fugro, 2021a, b). A benthic survey of the offshore project area was also undertaken between May and August 2021 (Fugro, 2021c). The data collected during these surveys are described in Table 8.5 and are used to characterise the existing environment.

Table 8.5 Site-specific survey data

Dataset	Spatial coverage	Year	Notes
Geophysical survey	Array area	May to August 2021	High-resolution seabed bathymetry, seabed texture, morphological features, and shallow geology
Geophysical survey	Offshore cable corridor	May to August 2021	High-resolution seabed bathymetry, seabed texture, morphological features, and shallow geology
Benthic survey	Array area	May to August 2021	Grab sampling and particle size analysis
Benthic survey	Offshore cable corridor	May to August 2021	Grab sampling and particle size analysis at 19 sampling stations

8.4.2.2 Numerical modelling of waves

24. To investigate waves and provide a baseline for prediction of changes due to North Falls, a wave model was run. Wave conditions were simulated using the two-dimensional spectral MIKE21-SW wave transformation model. The model simulates the growth, decay and transformation of wind-generated waves and swell in offshore and coastal areas. MIKE21-SW is a state-of-the-art numerical

tool for prediction and analysis of wave climates in offshore and coastal areas (Appendix 8.1).

25. The wave model has been successfully calibrated against measured data recorded at waverider buoys West Gabbard 2 and South Knock (data and locations are provided in Appendix 8.1). For each of these buoys, the largest storm waves approaching from six primary directions (north, north-east, east, south-east, south-west and south) were selected for the model calibration.

26. The worst potential impacts in terms of wave direction are waves from the north-north-west (330ºN), north (0ºN), east (90ºN) and south-south-west (210ºN). Hence, model runs were completed for each of these directions for three return periods (1 in 1 year, 1 in 50 year and 1 in 100 year). Simulations were completed for the effect of North Falls both individually and cumulatively with other wind farm developments (either in the planning phase or constructed, see Appendix 8.1).

27. Model outputs with the Project in place (either alone or cumulatively with other nearby wind farms) were compared against the model outputs from the baseline model runs (without the Project) to quantify the changes in wave height and direction at the location of sensitive receptors (coast, sandbanks or conservation features sensitive to changes in the wave regime). The individual or cumulative impacts on waves at sensitive receptors should be less than 5% to be considered negligible. This threshold is widely used in several sectors and is based on a pragmatic and risk-based approach to changes in the wave climate that reflects the dynamic nature of the marine environment and the inherent uncertainties in terms of both measurement and modelling accuracies.

8.4.2.3 Other available sources

28. Information to support this ES has also been drawn from a series of data collection exercises and associated studies, including desk-top assessment and numerical modelling, which were undertaken to inform the GGOW and GWF ESs (Greater Gabbard Offshore Winds Ltd., 2005, Galloper Wind Farm Limited, 2011) (Table 8.6):

- collection of metocean data (wind, waves, water levels and currents) at the existing wind farms;
- a desk study to determine the existing tidal and sedimentary processes within the GGOW and GWF wind farm sites and surrounding sea area, along their offshore cable corridors and at the adjacent coast;
- an assessment of the effects on the physical environment resulting from the construction, operation and decommissioning of the existing wind farms, including the effects of the wind turbine foundations on waves, tidal currents and sediment transport; and
- modelling of baseline tidal currents and sediment plume dispersion during cable installation and assessment of foundation scour potential for different areas of the wind farms.

Table 8.6 Other available data and information sources from GGOW and GWF

Data Set	Spatial Coverage	Year
Geophysical survey - bathymetry, seabed features and shallow geology (Titan)	GGOW array area and offshore cable route	June to July 2004
Geophysical survey - bathymetry, seabed features and shallow geology (EMU)	GGOW array area extra seabed after a boundary change	May 2005
Geotechnical survey - sample boreholes, Standard Penetration Tests (SPT) and Cone Penetrometer Test (CPT) at each location (Hydro Soil Services)	GGOW array area - two locations on the Inner Gabbard and two on The Galloper sandbanks.	September 2004
Benthic survey – grab samples and particle size analysis (Centre for Marine and Coastal Studies)	GGOW array area and offshore cable route	November 2004 and April 2005
Metocean survey - waves, water levels, currents and SSCs (EMU)	GGOW array area	November 2004 to March 2005
Coastal processes assessment (ABPmer)	GGOW array area	2005
Geophysical survey - bathymetry, seabed features and shallow geology (Osiris)	GWF array area and offshore cable route	August to December 2009
Benthic survey – grab samples and particle size analysis (Centre for Marine and Coastal Studies)	GWF array area and offshore cable route	December 2009
Coastal processes assessments (ABPmer)	GWF array area which includes an area overlapping the North Falls array area	2011

29. In addition to the numerical modelling data from GGOW and GWF, analytical assessments of SSCs using spreadsheet based numerical models from the Five Estuaries PEIR (Five Estuaries Wind Farm Ltd, 2023) have been used.

30. In addition to the site-specific surveys for North Falls and the data collected for GGOW, GWF and Five Estuaries, a range of other data sources are available including:

- Marine Renewable Atlas (BERR, 2008);
- National Tide and Sea Level Forecasting Service;
- United Kingdom Hydrographic Office (UKHO) tidal diamonds and historical charts;
- Numerical modelling studies undertaken by HR Wallingford for the Outer Thames MAREA;
- United Kingdom Climate Projections 2018 (UKCP18) (Palmer *et al.* 2018);
- British Geological Survey 1:250,000 seabed sediment mapping;
- British Geological Survey bathymetric contours and paper maps;
- Admiralty Charts and United Kingdom Hydrographic Office survey data;
- Marine Aggregate Levy Sustainability Fund (MALSF);

- Regional Environmental Characterisation (REC) study for the Outer Thames Estuary (MALSF);
- SeaZone seabed bathymetry data. This data can be used to inform the far-field model domain and to provide base mapping;
- Wavenet Data. On behalf of Defra, Cefas operates a strategic wave monitoring network for England and Wales that provides a single source of real time wave data from a network of wave buoys located offshore from areas at risk from flooding. One of the buoys is located offshore at West Gabbard;
- TotalTide tidal level data. The TotalTide numerical modelling package can been used to synthetically generate astronomical tidal level data and current speed so that measured data from the metocean surveys can be compared against the model data for an assessment of consistency; and
- Met Office data. Wind and wave time series to provide details on the longer-term offshore wave climate.

8.4.3 Impact assessment methodology

31. ES Chapter 6 EIA Methodology (Document Reference: 3.1.8) explains the general impact assessment methodology applied to North Falls. The following sections describe the methods used to assess the likely significant effects on Marine Geology, Oceanography and Physical Processes.

32. The assessment of effects on tidal current and sediment transport processes are predicated on a S-P-R conceptual model, whereby the source is the initiator event, the pathway is the link between the source and the potentially impacted receptor, and the receptor is the receiving entity. An example of the S-P-R conceptual model is provided by cable installation which disturbs sediment on the seabed (source). This sediment is then transported by tidal currents until it settles back to the seabed (pathway). The deposited sediment could change the composition and elevation of the seabed (receptor). Numerical modelling of these processes effects of North Falls would be disproportionate to the potential impacts described in Section 8.6 and a conceptual evidence-based assessment is preferred (see further justification provided in Section 8.4.6). However, numerical modelling of waves has been completed for the assessment of operational impacts due to the presence of the foundation structures (ES Appendix 8.1 (Document Reference: 3.3.3)).

33. Consideration of the likely significant effects of North Falls on the marine geology, oceanography and physical processes is carried out over the following spatial scales:

    - near-field: the area within the immediate vicinity (tens or hundreds of metres) of the array area and along the offshore cable corridor; and
    - far-field: the wider area that might also be affected indirectly by the Project (e.g. due to disruption of waves, tidal currents or sediment pathways passing through the site).

34. For the effects on marine geology, oceanography and physical processes, the assessment follows two approaches. The first type of assessment is impacts on

marine geology, oceanography and physical processes whereby several discrete direct receptors can be identified. These include certain morphological features with an inherent geological or geomorphological value or function which may potentially be affected by North Falls such as Annex I sandbanks, MCZ features, and beaches and sea cliffs at the coast.

35. The impact assessment incorporates a combination of the sensitivity of the receptor, its value (if applicable) and the magnitude of the change to determine a significance of effect.

36. In addition to identifiable receptors, the second type of assessment covers changes to marine geology, oceanography and physical processes represent impacts which may manifest themselves as an effect upon other receptors, most notably marine water and sediment quality, benthic ecology, and fish and shellfish ecology (e.g. in terms of increased SSCs, or erosion or smothering of habitats on the seabed). Hence, the two approaches to the assessment of marine geology, oceanography and physical processes are:

- Situations where potential impacts can be defined as directly affecting receptors which possess their own intrinsic morphological value. In this case, the significance of the effect is based on an assessment of the sensitivity of the receptor and magnitude of impact, by means of a significance of effect matrix.
- Situations where impacts (or changes) in the baseline marine geology, oceanography and physical processes may occur which could manifest as effects upon receptors other than marine geology, oceanography and physical processes. In this case, the magnitude of impact is determined in a similar manner to the first assessment method but the significance of effects on other receptors is made within the relevant chapters of the ES pertaining to those receptors.

8.4.3.1 Definitions

37. For each potential impact, the assessment identifies the sensitivity of the receptors within the study area and implements a systematic approach to understanding the impact pathways and the level of impacts (i.e. magnitude) on given receptors.

38. In addition, the 'value' of the receptor forms an important element within the assessment, for instance if the receptor is a protected habitat. It is important to understand that high value and high sensitivity are not necessarily linked within a particular effect. A receptor could be of high value (e.g. Annex I habitat) but have a low or negligible sensitivity. Similarly, low value does not equate to low sensitivity and is judged on a receptor-by-receptor basis. The value will be considered, where relevant, as a modifier for the sensitivity assigned to the receptor, based on expert judgement.

39. The definitions of sensitivity, value and magnitude for the purpose of the Marine Geology, Oceanography and Physical Processes assessment are provided in 8.7, Table 8.8 and Table 8.9, respectively. These expert-based judgements of receptor sensitivity, value and magnitude of impact will be closely guided by the conceptual understanding of baseline conditions.

Table 8.7 Definition of sensitivity for a morphological receptor

Sensitivity	Definition
High	Tolerance: Receptor has very limited tolerance of impact Adaptability: Receptor unable to adapt to impact Recoverability: Receptor unable to recover resulting in permanent or long-term (>10 years) change.
Medium	Tolerance: Receptor has limited tolerance of impact Adaptability: Receptor has limited ability to adapt to impact Recoverability: Receptor able to recover to an acceptable status over the medium term (5-10 years).
Low	Tolerance: Receptor has some tolerance of impact Adaptability: Receptor has some ability to adapt to impact Recoverability: Receptor able to recover to an acceptable status over the short term (1-5 years).
Negligible	Tolerance: Receptor generally tolerant of impact Adaptability: Receptor can completely adapt to impact with no detectable changes. Recoverability: Receptor able to recover to an acceptable status near instantaneously (<1 year).

Table 8.8 Definitions of value for a morphological receptor

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

Table 8.9 Definition of magnitude for a morphological receptor

Magnitude	Definition
High	Scale: A change which would extend beyond the natural variations in background conditions. Duration: Change persists for more than ten years. Frequency: The effect would always occur. Reversibility: The effect is irreversible.
Medium	Scale: A change which would be noticeable from monitoring but remains within the range of natural variations in background conditions. Duration: Change persists for five to ten years. Frequency: The effect would occur regularly but not all the time. Reversibility: The effect is very slowly reversible (five to ten years).
Low	Scale: A change which would barely be noticeable from monitoring and is small compared to natural variations in background conditions. Duration: Change persists for one to five years. Frequency: The effect would occur occasionally but not all the time. Reversibility: The effect is slowly reversible (one to five years).
Negligible	Scale: A change which would not be noticeable from monitoring and is extremely small compared to natural variations in background conditions. Duration: Change persists for less than one year.

Magnitude	Definition
	Frequency: The effect would occur highly infrequently. Reversibility: The effect is quickly reversible (less than one year).

40. The establishment of an overall magnitude is based on a combination of the individual magnitudes for scale, duration, frequency, and reversibility. If all four individual magnitudes are negligible, then the overall magnitude is negligible. If three of the parameters are negligible with a single low magnitude, then the overall magnitude is still negligible because most of the individual magnitudes are negligible, and the single parameter is only one level above negligible. If one of the parameters is medium or high, with the other three negligible then the overall magnitude is raised to low or medium, respectively, to reflect the significance of the higher individual magnitude. If more than one parameter is medium or high with the others negligible then the overall magnitude is adjusted accordingly to represent the worst case scenario. If there is a range of individual magnitudes across scale, duration, frequency, and reversibility, the overall magnitude is estimated based on an 'average' of the individual magnitudes, assuming that the weighting is even across the four parameters.

8.4.3.2 Significance of effect

41. The assessment of significance of an effect is a function of the sensitivity of the receptor and the magnitude of the impact (see ES Chapter 6 EIA Methodology (Document Reference: 3.1.8) for further details). The determination of significance is guided using a significance of effect matrix, as shown in Table 8.10. Definitions of each level of significance are provided in Table 8.11.

42. Likely significant effects identified within the assessment as major or moderate are regarded within this chapter as significant. Appropriate mitigation has been identified, where practicable, in consultation with the regulatory authorities and relevant stakeholders. The aim of mitigation measures is to avoid or reduce the overall significance of effect to determine a residual effect upon a given receptor.

Table 8.10 Significance of effect matrix

		Adverse Magnitude				Beneficial Magnitude			
		High	Medium	Low	Negligible	Negligible	Low	Medium	High
Sensitivity	High	*Major*	*Major*	*Moderate*	*Minor*	*Minor*	*Moderate*	*Major*	*Major*
	Medium	*Major*	*Moderate*	*Minor*	*Minor*	*Minor*	*Minor*	*Moderate*	*Major*
	Low	*Moderate*	*Minor*	*Negligible*	*Negligible*	*Negligible*	*Minor*	*Minor*	*Moderate*
	Negligible	*Minor*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Minor*

Table 8.11 Definition of effect significance

Significance	Definition
Major	Very large or large change in receptor condition, both adverse or beneficial, which are likely to be important considerations at a regional or district level because they contribute

Significance	Definition
	to achieving national, regional or local objectives, or could result in exceedance of statutory objectives and / or breaches of legislation.
Moderate	Intermediate change in receptor condition, which are likely to be important considerations at a local level.
Minor	Small change in receptor condition, which may be raised as local issues but are unlikely to be important in the decision making process.
Negligible	No discernible change in receptor condition.
No change	No effect, therefore no change in receptor condition.

8.4.4 Cumulative effects assessment methodology

43. The cumulative effects assessment (CEA) considers other plans, projects and activities that may interact cumulatively with North Falls. ES Chapter 6 EIA Methodology (Document Reference: 3.1.8) provides further details of the general framework and approach to the CEA.

44. For marine geology, oceanography and physical processes, these activities include construction and operation of other offshore wind farms and large coastal defence/ protection works.

8.4.5 Transboundary effects assessment methodology

45. The transboundary assessment considers the potential for transboundary effects to occur on marine geology, oceanography and physical processes receptors as a result of North Falls; either those that might arise within the Exclusive Economic Zone (EEZ) of European Economic Area (EEA) states or arising on the interests of EEA states (e.g. a non UK fishing vessel). ES Chapter 6 EIA Methodology (Document Reference: 3.1.8) provides further details of the general framework and approach to the assessment of transboundary effects.

46. For marine geology, oceanography and physical processes, the potential for transboundary effects were considered in the Scoping Report and it was concluded that transboundary effects could be scoped out of assessment. This was based on the findings of the transboundary assessment for GWF (ABPmer, 2011a; Royal Haskoning, 2011) which found no potential for significant transboundary effects. As North Falls is further from the EEZ boundary than GWF and the ZoI from North Falls is likely to be similar to GWF, transboundary effects are scoped out.

8.4.6 Justification for why a conceptual approach is appropriate for tidal currents and sediment transport

47. Previous numerical modelling has been undertaken specifically for the Greater Gabbard and Galloper offshore wind farms located adjacent to (and east to south-east of) North Falls. In addition, numerical modelling of tidal currents and spreadsheet based analytical assessments of SSCs have been completed at Five Estuaries. Given the availability of relevant information from these other projects, it would be disproportionate to run a bespoke tidal current model for North Falls. Hence, the results of this modelling and theoretical approaches are

used as part of the expert-based assessment and judgement to evaluate the potential construction and operational effects of North Falls on the identified marine geology, oceanography and physical processes receptors.

48. Following Section 42 consultation and feedback received from Natural England and the MMO through the EPP, bespoke numerical modelling of waves has been completed for North Falls to assess potential operational impacts due to the presence of the foundation structures (both individually and cumulatively with other offshore wind farms).

8.4.6.1 Physical environment basis

49. The physical basis for using the modelling for tidal currents and sediment transport is that the GGOW, GWF and Five Estuaries designs and marine geology, oceanography and physical processes operating at these sites are like North Falls and therefore provide suitable evidence (and are suitable analogues) to support the assessment of impacts and effects at North Falls. The location of the landfall for North Falls will be the Tendring peninsula at Kirby Brook on Frinton-on-Sea, coast of Essex. This is different to the landfall for GGOW and GWF, and so a bespoke desk based assessment of the offshore cable corridor and the landfall area is provided in Sections 8.6.2.5, 8.6.2.6, 8.6.2.9, 8.6.3.6 and 8.6.3.7.

50. Justification for using the modelling results from GGOW, GWF and Five Estuaries as the principal evidence of potential impacts to inform an assessment of likely significant effects at North Falls is provided below, which includes the similarities (and dissimilarities) of the existing physical and sedimentary conditions (water depths, tidal currents, seabed sediments, and suspended sediment) at each of the sites. In addition, the western part of the originally assessed GWF which was not constructed now forms part of the eastern part of North Falls (ES Figure 8.1 (Document Reference: 3.2.4)).

51. The range of water depths at GGOW and GWF are comparable to those at North Falls (ES Figure 8.1 (Document Reference: 3.2.4)). However, they are slightly different in their distribution of water depths. This is because the two parts of GGOW that are similar in elevation to North Falls are located either side of the north-north-east to south-south-west oriented linear Galloper sandbank, which is shallower than most parts of North Falls (apart from a small area in the southeast occupied by North Falls sandbank). The bathymetry of the southern array of GWF is similar in both range and distribution to most of North Falls. However, North Falls does contain an area of deeper bathymetry at its southwest, which is deeper than any part of the adjacent GGOW and GWF.

52. Although there are no sandbanks in the proposed North Falls array area, the water depths surrounding the sandbanks (which extends into North Falls and includes the western part of the originally assessed GWF) are about 20 to 50m below Chart Datum (CD) with a maximum depth of about 60m below CD in the south-east part of GWF. These are like the water depths at North Falls which range from approximately 10m to 50m below CD.

53. Tidal currents demonstrate similar directions and velocities on the flood tide and ebb tide. For all sites, the main axis for tidal flows is rectilinear and directed to the north-east during the ebb tide and to the south-west during the flood tide. Modelled current velocities are similar on both states of the tide, ranging from

0.9m/s to 1.3m/s (ABPmer, 2005; PMSS, 2005). Six metocean devices were deployed between November 2004 and March 2005 to measure current flows and wave heights and directions for GGOW. Although there was minor variability in current speeds between the different deployments, in general surface currents peaked at approximately 1.8m/s, bed currents were about 0.7 to 1.7m/s, and the currents were aligned with the local seabed topography. Average bed speeds recorded were approximately 0.4m/s at the GGOW offshore wind farm sites, whilst average surface speeds were approximately 0.7m/s. The same data were used to support the EIA for GWF (ABPmer, 2011a; Royal Haskoning, 2011), and it is anticipated that, given the similar water depths (apart from local variations caused by interactions with the sandbanks) the current conditions across North Falls are similar.

54. Other than the Inner Gabbard and Galloper sandbanks, the seabed sediments at all sites are broadly similar. For GGOW grab sampling was undertaken during November 2004 and April 2005. The seabed at GGOW comprises medium sand in the banks surrounded by a more mixed sediment composed of mainly sandy gravel with areas of muddy sandy gravel and gravelly sand. The GWF seabed is dominated by gravelly sand or sandy gravel (which is consistent with the dominant seabed types found at the adjacent GGOW) (ABPmer, 2011a; Royal Haskoning, 2011). Broad-scale sediment mapping by the British Geological Survey shows that the North Falls array area is dominated by sandy gravel with gravelly sand in the south.

55. Average baseline SSCs at GGOW and GWF are comparable to those at North Falls. The average SSC was approximately 10-22mg/l in the vicinity of GGOW and 7-21mg/l in the vicinity of GWF (Cefas, 2016). As described in Section 8.5.8, average SSCs in the vicinity of North Falls was approximately 7-15mg/l at the array area. SSCs across Five Estuaries are slightly less (7-10mg/l) than across North Falls, as Five Estuaries is further offshore.

8.4.6.2 Design basis

56. The modelling for GGOW and GWF assessed 140 wind turbines each with a diameter of 36m and 35m, respectively, for GBS (worst case scenario). The assessment of tidal currents at Five Estuaries was completed on 79 smaller WTGs on conical gravity bases, and two OSP/OCP multi-leg jacket foundations with suction buckets. North Falls will comprise up to 57 turbines with GBS foundations of 65m diameter. This means the North Falls design is a more conservative design compared to the modelled GGOW, GWF and Five Estuaries designs. Whilst it is recognised that there are small differences in physical and sedimentary conditions and project parameters between the sites, the numerical modelling conducted for GGOW, GWF and Five Estuaries allows for these differences in the effect that may arise due to these factors.

8.4.7 Assumptions and limitations

57. Due to the large amount of data that has been collected for the site-specific surveys for North Falls, and those at GWF, GGOW and Five Estuaries, as well as other available data, there is a good understanding of the existing marine geology, oceanography and physical processes environment at the Project and its adjacent areas.

8.5 Existing environment

8.5.1 Bathymetry and bedforms

8.5.1.1 Array area

58. Water depths in the array area range from 5m below LAT at the site of two large shallow banks in the extreme north-east and south-east of the array area, to 58m in the far east of the array area (ES Figure 8.1 (Document Reference: 3.2.4)). The seabed in the west of the array area is predominantly flat and featureless, whilst the east contains large sandwaves with megaripples. The average seabed gradient across the featureless seabed is on average 0.2°, with average gradients of 1.0° observed on the flanks of the megaripples and 3.7° on the flanks of the sandwaves. A maximum gradient of 31.2° was observed on the flank of a sandwave within the array area.

8.5.1.2 Offshore cable corridor

59. Water depths along the offshore cable corridor are 1.5m above LAT closer to the coast, gradually deepening to 42.4m below LAT in the east (ES Figure 8.2 (Document Reference: 3.2.4)). The west of the offshore cable corridor exhibits outcropping bedrock between flat and featureless seabed (Fugro, 2020b). Towards the centre of the offshore cable corridor, the seabed is characterised by large sandwaves and megaripples (Fugro, 2020b). In the east of the offshore cable corridor, the seabed is flat and featureless with isolated areas of seabed ripples (Fugro, 2020b).

8.5.2 Offshore geology

60. The geology of North Falls is predominantly Eocene to Holocene, generally consisting of Holocene deposits overlying Pleistocene channel complexes and infill deposits, which overlie the London Clay Formation and the Harwich Formation. Table 8.12 outlines each formation, with their geophysical description, expected geological condition and coverage (Fugro, 2021a, b).

Table 8.12 Geological formations present at the North Falls array area and offshore cable corridor (Fugro, 2021a, b)

Formation	Geophysical description	Expected geological condition	Coverage
Recent	Low to medium amplitude, discontinuous reflectors.	Includes surficial sediments (veneer of sediment overlying London Clay) and bedforms such as megaripples and Sandwaves.	Throughout offshore project area
Holocene	Distinctive high-amplitude internal reflectors throughout much of the unit	Comprises clay and peat sediments up to 6m thick, rich in woody debris.	Array area
Pleistocene	Variety of channel complexes and infill deposits of varying sizes	Very dense, silty gravelly sand and silty sandy gravel, occasionally interbedded with stiff to very stiff sandy gravelly clay.	Throughout offshore project area
London Clay Formation	Low to moderate amplitude subparallel internal reflectors, with occasional prominent fault offsets with throws up to 3 m.	Marine, clayey silt, silty clay and silt.	Throughout offshore project area

Formation	Geophysical description	Expected geological condition	Coverage
Harwich Formation	Sequence of high amplitude, chaotic reflectors at the base, passing upwards into a 2-3m thick layer with weak reflectors and finally into a sequence of strong sub-parallel reflectors	Cross-bedded, glauconitic sand and silty facies, varying in depth between 2m below the seabed to more than 78m below the seabed.	Throughout offshore project area

8.5.2.1 Array area

61. The bedrock across the array area is dominated by the Harwich Formation, which is conformably overlain by the London Clay Formation (Fugro, 2021a). The top of the Harwich Formation deepens from approximately 2m below the seabed in the south-west of the array area, to more than 78m below the seabed in the north of the array area.

62. London Clay is present below most of the seabed, overlain by only a thin veneer of Holocene sediments. There are two exceptions to this; in the east of the array area, where thicker Holocene sediment such as sandbanks and sandwaves occur and in locations where the London Clay has been eroded to expose the underlying Harwich Formation (Fugro, 2021a).

63. The London Clay is overlain by Pleistocene sediments, which are interpreted to be part of a variety of channel complexes and infill deposits of varying sizes where the London Clay Formation has been eroded (Fugro, 2021a). The thickest area of Pleistocene deposits is in the south of the array area (up to 20m below the seabed), which coincides with a large channel (Fugro, 2021a). A meandering Pleistocene channel is interpreted in the north-west of the array area (Plate 8.1).

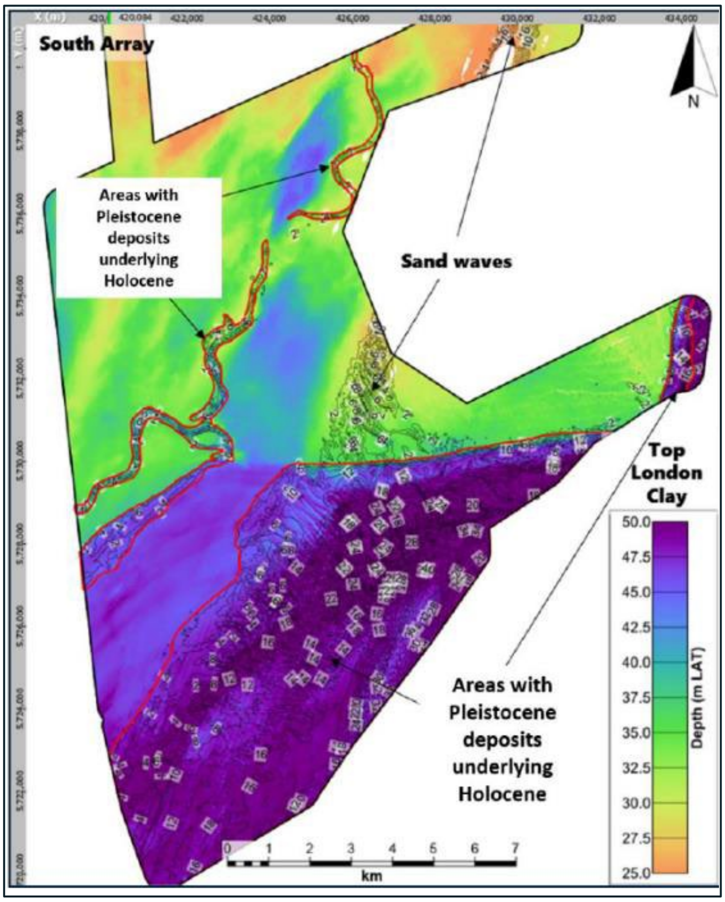

Plate 8.1 Pleistocene deposits in the former North Falls south array area (Fugro, 2021a). Note that the survey was completed using the original Project boundary (discussed in the PEIR)[1]

64. The youngest units are associated with the Holocene. They comprise two principal subunits: reworked modern Holocene (Recent) and early Holocene (Fugro, 2021a). A thin veneer of Recent sediment overlies the London Clay throughout the array area. This unit is also associated with megaripples and sandwaves (Fugro, 2021a). Reworked Recent sediments occur throughout the array area (Fugro 2021a). The early Holocene subunit is up to 6m thick in the southern part of the array area (Plate 8.2). There is a complex range of seabed sediments present around the outer edges of the early Holocene subunit, caused by the erosion and recent reworking of sediments (Fugro, 2021a).

[1] The North Falls array area is similar to the former south array, with the western boundary moved further east, as described in Chapter 4 Site selection and assessment of alternatives

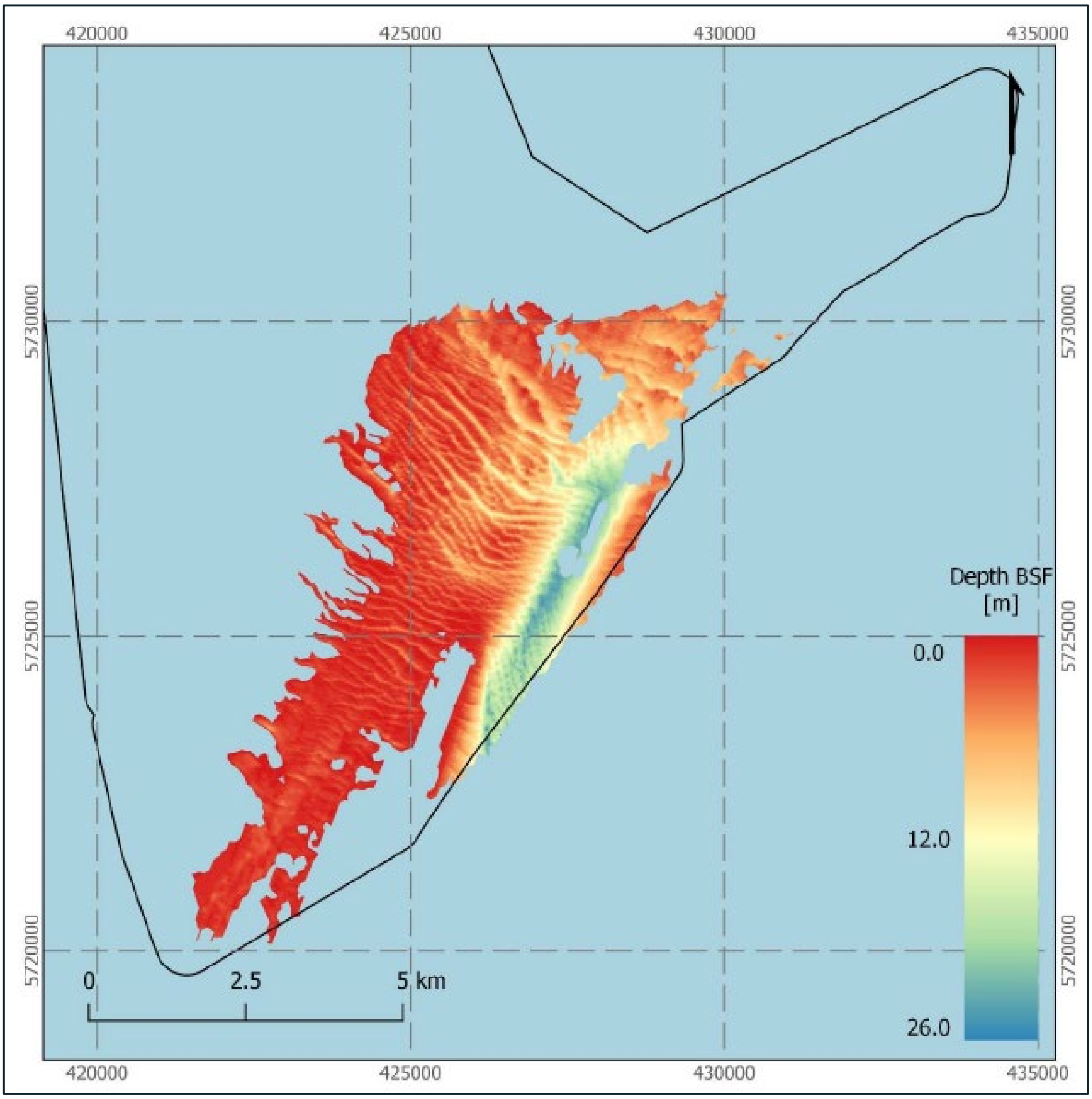

Plate 8.2 The extent of the early Holocene subunit in southern part of the array area (Fugro, 2021a). Note that the survey was completed using the original Project boundary (discussed in the PEIR)[2]

8.5.2.2 Offshore cable corridor

65. The Harwich Formation was interpreted to be present between kilometre posts (KP) 14.00 and 26.00 along the offshore cable corridor (ES Figure 8.3 (Document Reference: 3.2.4)) (Fugro, 2021b). The top of the unit is located between 0 and 14.4m below the seabed, with two outcrops along the cable corridor (Fugro, 2021b).

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[2] The North Falls array area is similar to the former south array, with the western boundary moved further east, as described in Chapter 4 Site selection and assessment of alternatives

66. London Clay is present along the entire offshore cable corridor overlying the Harwich Formation (Fugro, 2021b). The depth of the London Clay remains within 2m of the seabed across most of the corridor, with deeper areas caused by the cutting of Pleistocene channels where it reaches a maximum depth of 14.4m below the seabed (Fugro, 2021b). There are also several outcrops of London Clay at the seabed (ES Figure 8.4 (Document Reference: 3.2.4)) (Fugro, 2021b).

67. Pleistocene channels of varying sizes are interpreted as cutting through the London Clay Formation (and occasionally the Harwich Formation) along the offshore cable corridor (Fugro, 2021b). Pleistocene channels range from less than 50m wide and 2 – 4m deep, to greater than 1km wide and up to 15m deep (Fugro, 2021b). The base of the Pleistocene unit ranges in depth from 0 to 14.4m below the seabed (ES Figure 8.5 (Document Reference: 3.2.4)) (Fugro, 2021b).

68. Holocene sediments overlie the London Clay Formation, or the Pleistocene unit in places, along the offshore cable corridor (Fugro, 2021b). An isolated area of unknown origin was observed overlying the Holocene sediments towards the landfall of the offshore cable corridor between KP 0.6 and 1.38 (Fugro, 2021b). The package increases in thickness and lateral extent towards the landfall. Its extent is delineated by the Base Shore Unit, which is elevated above the surrounding seabed and is only located on top of Pleistocene channels (Plate 8.3 and ES Figure 8.6 (Document Reference: 3.2.4)). Plate 8.4 illustrates a profile along the offshore cable corridor (Fugro, 2021b).

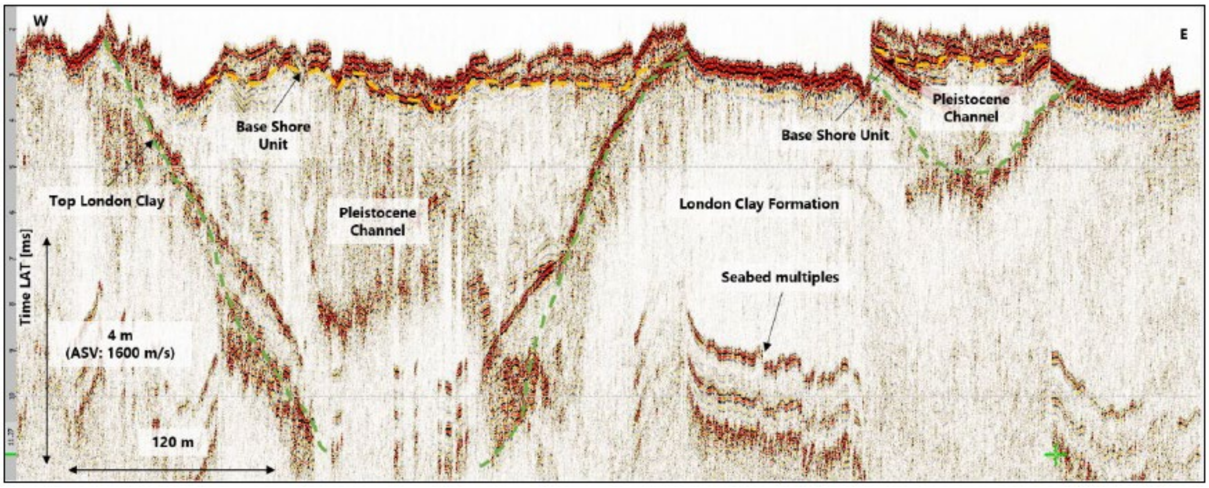

Plate 8.3 Interpreted Base Shore Unit observed in the nearshore of the offshore cable corridor

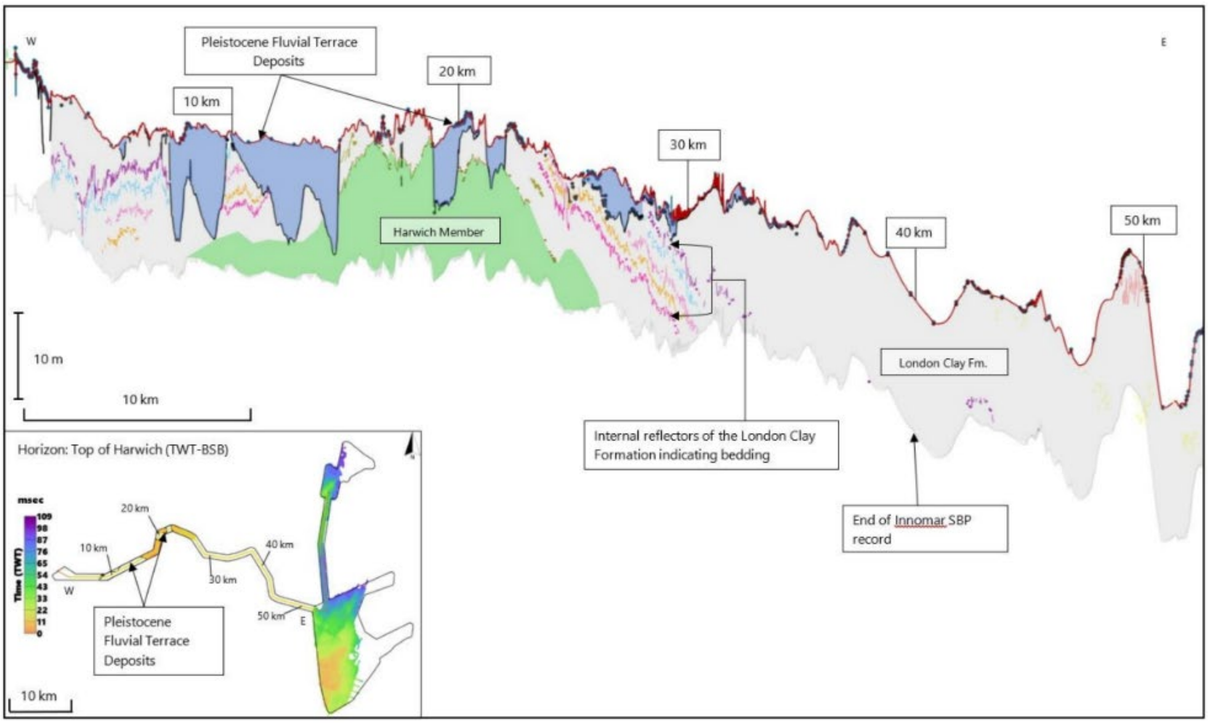

Plate 8.4 Schematic of the shallow geology of the offshore cable corridor (Fugro, 2021b)

8.5.3 Water levels

8.5.3.1 Regional summary

69. The astronomical tidal range in the southern North Sea and along the Essex and Suffolk coast varies according to the position of an amphidromic point between the east of England and the Netherlands. At the amphidromic point, the tidal range is near zero and then increases with radial distance from this point. Due to the regional tidal regime being influenced by the amphidromic point, the tidal range gradually increases with progression south across the study area (ES Figure 8.7 (Document Reference: 3.2.4)).

8.5.3.2 Array area

70. The array area experiences a mesotidal regime with a mean spring tidal range of about 3.0m at its northern boundary and 3.5m at its southern boundary.

8.5.3.3 Offshore cable corridor

71. Along the offshore cable corridor, the tidal range is about 3.0-3.5m at its eastern end increasing to 3.5-4.0m close to the landfall.

8.5.3.4 Storm Surge

72. The North Sea is particularly susceptible to storm surges, and water levels at North Falls could become elevated several metres by these meteorological effects. The coast can also be subject to significant surge activity which may raise water levels above those of the predicted tide. Predicted extreme water levels can exceed predicted mean high-water spring levels by more than 1m. Environment Agency (2018) calculated one in one-year water levels of 2.68m above MHWS at Felixstowe. The 1 in 50-year water levels are predicted to be 3.43m above MHWS at Felixstowe.

8.5.4 Tidal currents

73. Using a hindcast dataset covering a 42-year period between 1979 and 2020, Metoceanworks (2022) derived the average annual tidal currents at the North Falls array area (Plate 8.4). ABPmer (2005) and PMSS (2005) also modelled tidal currents on flood and ebb tides at North Falls and surrounding areas. The main axes for tidal flows are rectilinear and are directed to the north-north-east during the ebb tide and to the south-south-west during the flood tide. Modelled current velocities are similar on both states of the tide, ranging from 0.9m/s to 1.3m/s (Plate 8.5 and Plate 8.6). Tidal currents closer to the coast (i.e., Clacton-on-Sea) are approximately 0.26m/s during peak flood spring tide and 0.10m/s during peak ebb spring tide (East Anglia Coastal Group (EACG), 2010).

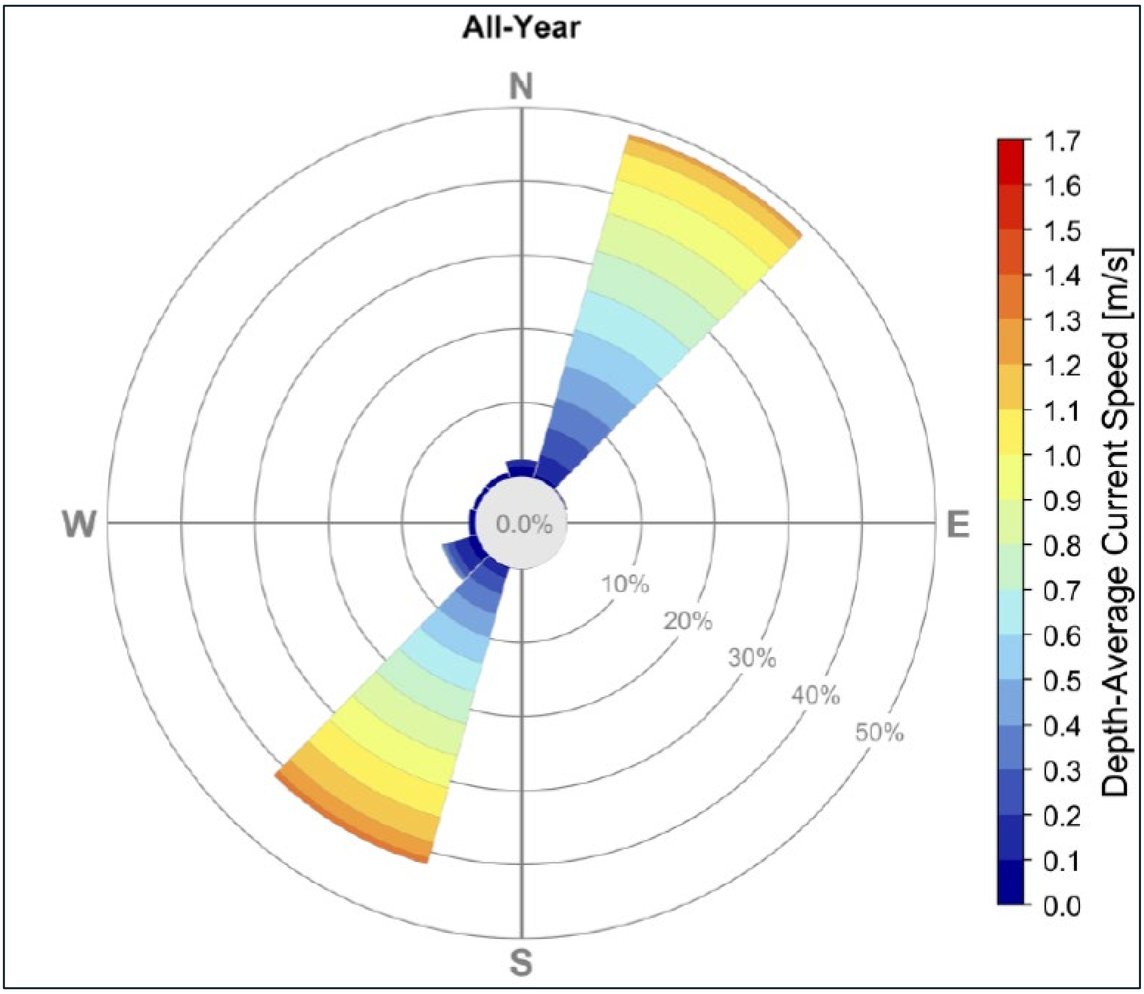

Plate 8.5 Tidal current conditions at the North Falls array area derived from hindcast data (Metoceanworks, 2022)

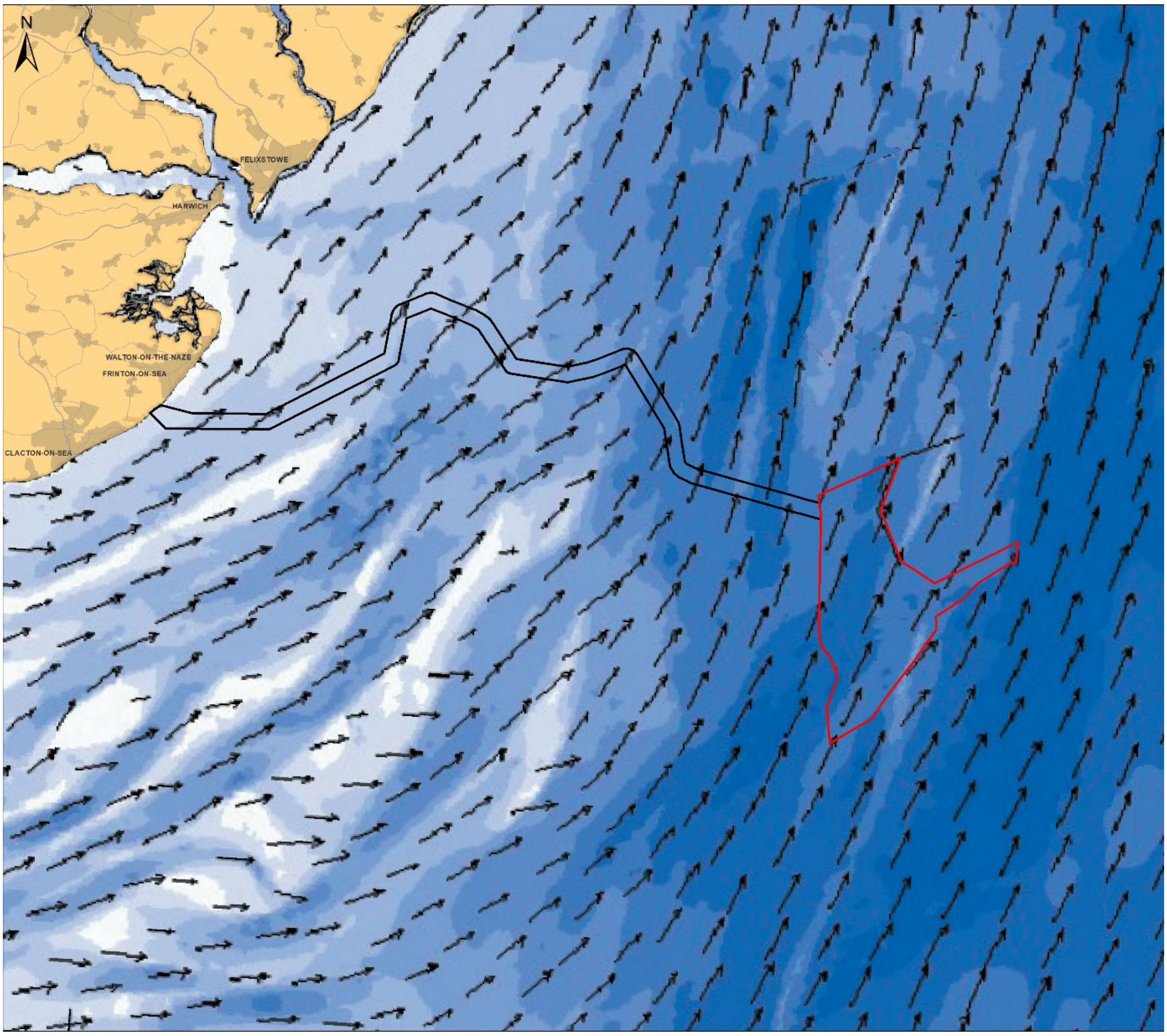

Plate 8.6 Modelled tidal flows in the southern North Sea for Greater Gabbard Offshore Wind Farm during an ebb tide (PMSS, 2005)

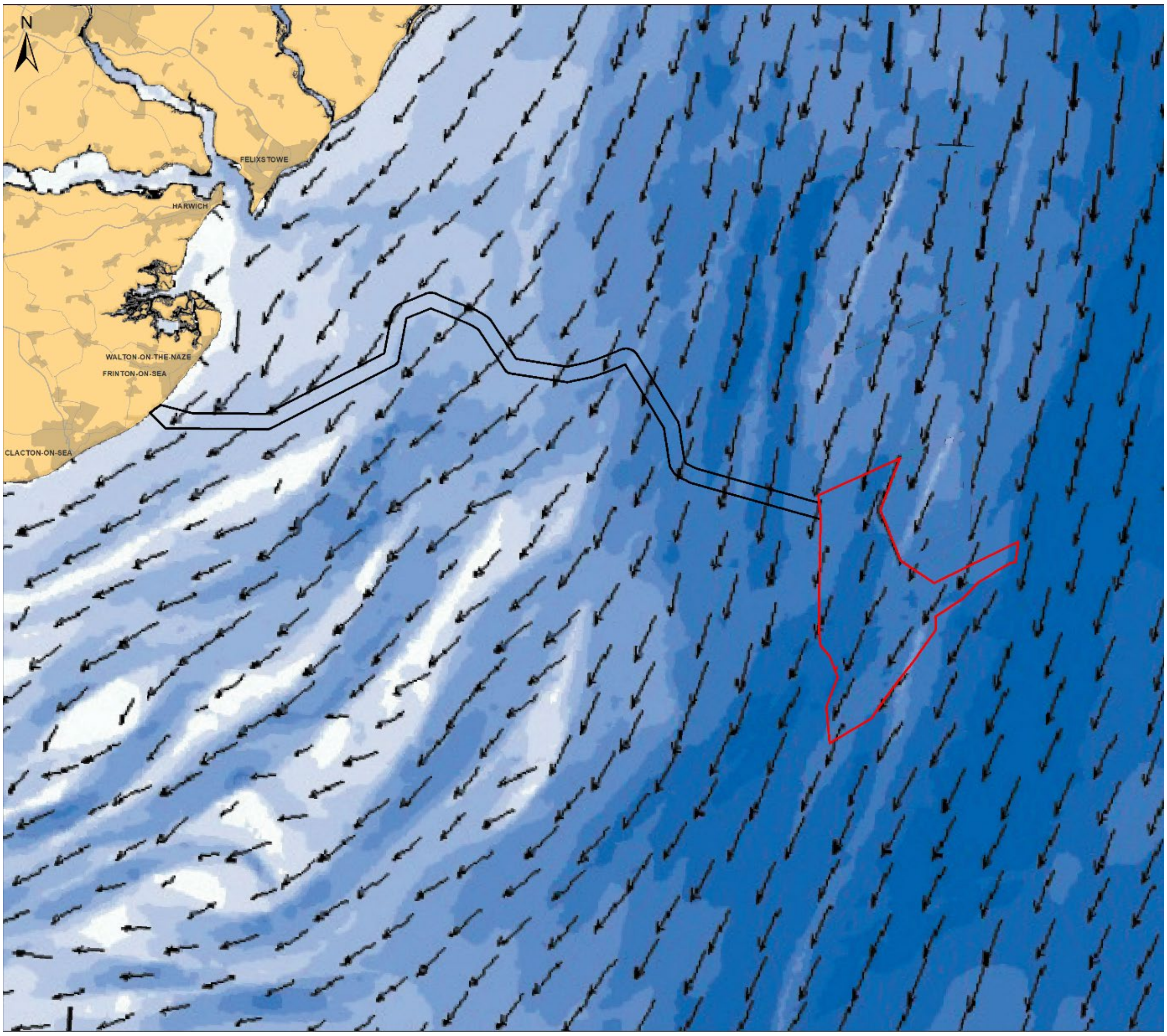

Plate 8.7 Modelled tidal flows in the southern North Sea for Greater Gabbard Offshore Wind Farm during a flood ebb tide (PMSS, 2005)

8.5.5 Waves

74. North Falls is exposed to wave conditions generated within the North Sea, with the most severe conditions arriving from the north-east due to long fetch lengths. Hindcast data collected over a 42-year period between 1979 and 2020 at the North Falls array area, measured wave data from a wave buoy at West Gabbard, and data collected between November 2004 and March 2005 from GGOW all shows that the primary wave directions are from the north-north-east and south-south-west (ABPmer, 2005; PMSS, 2005) (Plate 8.8, Plate 8.9 and Plate 8.10).

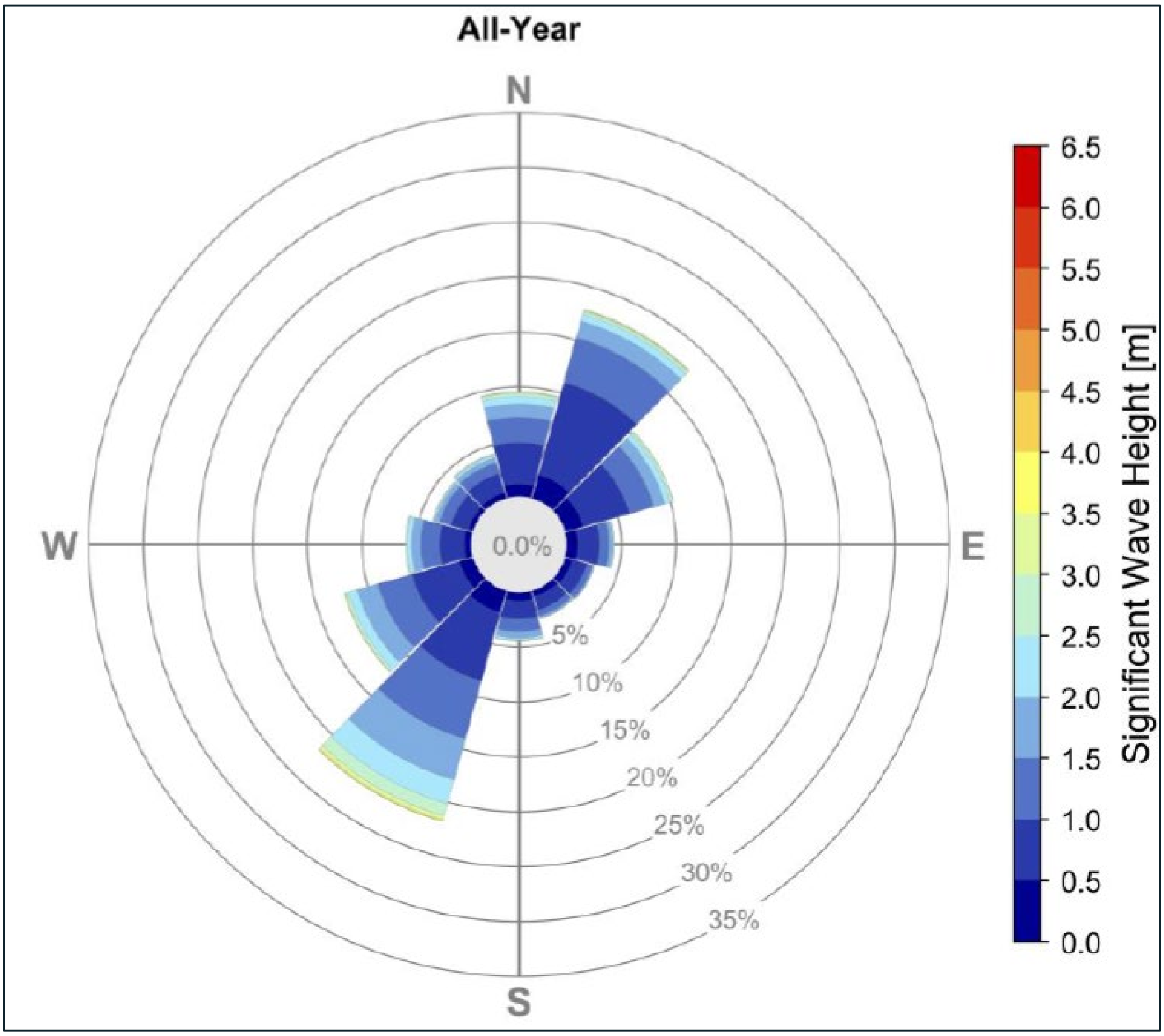

Plate 8.8 Wave conditions at the North Falls array area derived from hindcast data (Metoceanworks, 2022)

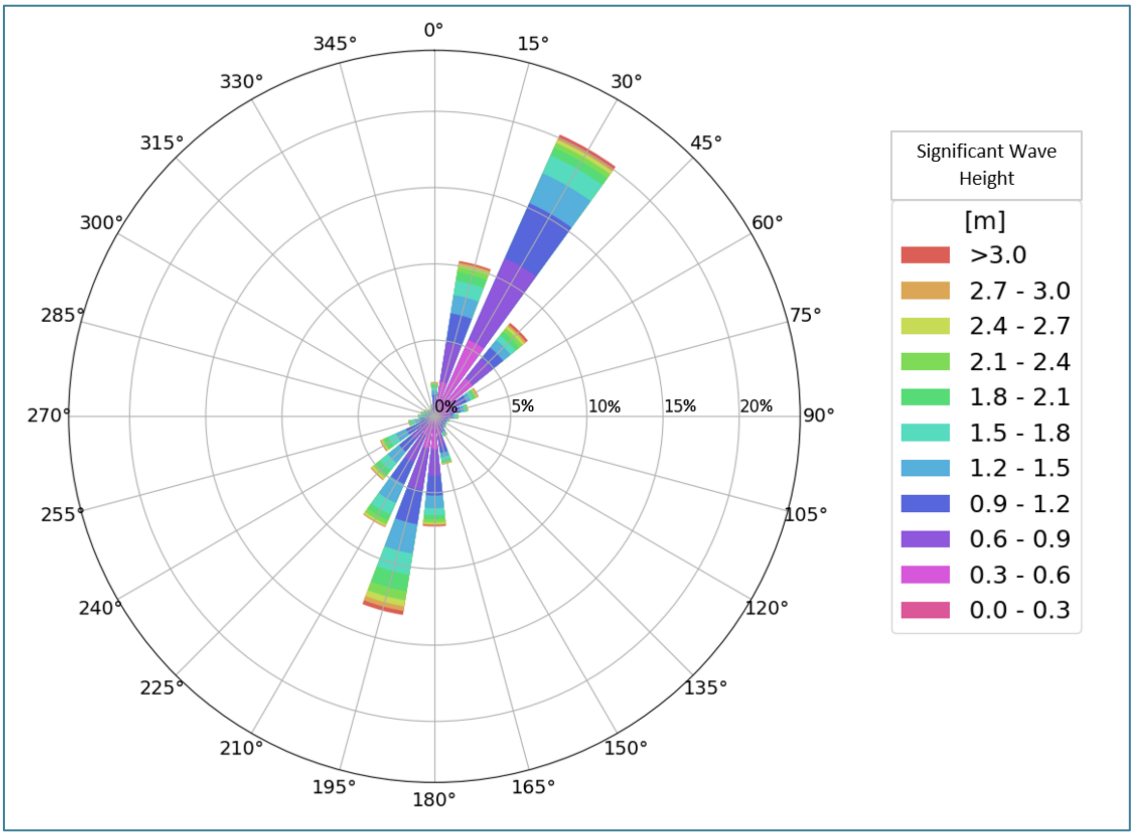

Plate 8.9 Measured wave conditions at the CEFAS West Gabbard 2 wave buoy

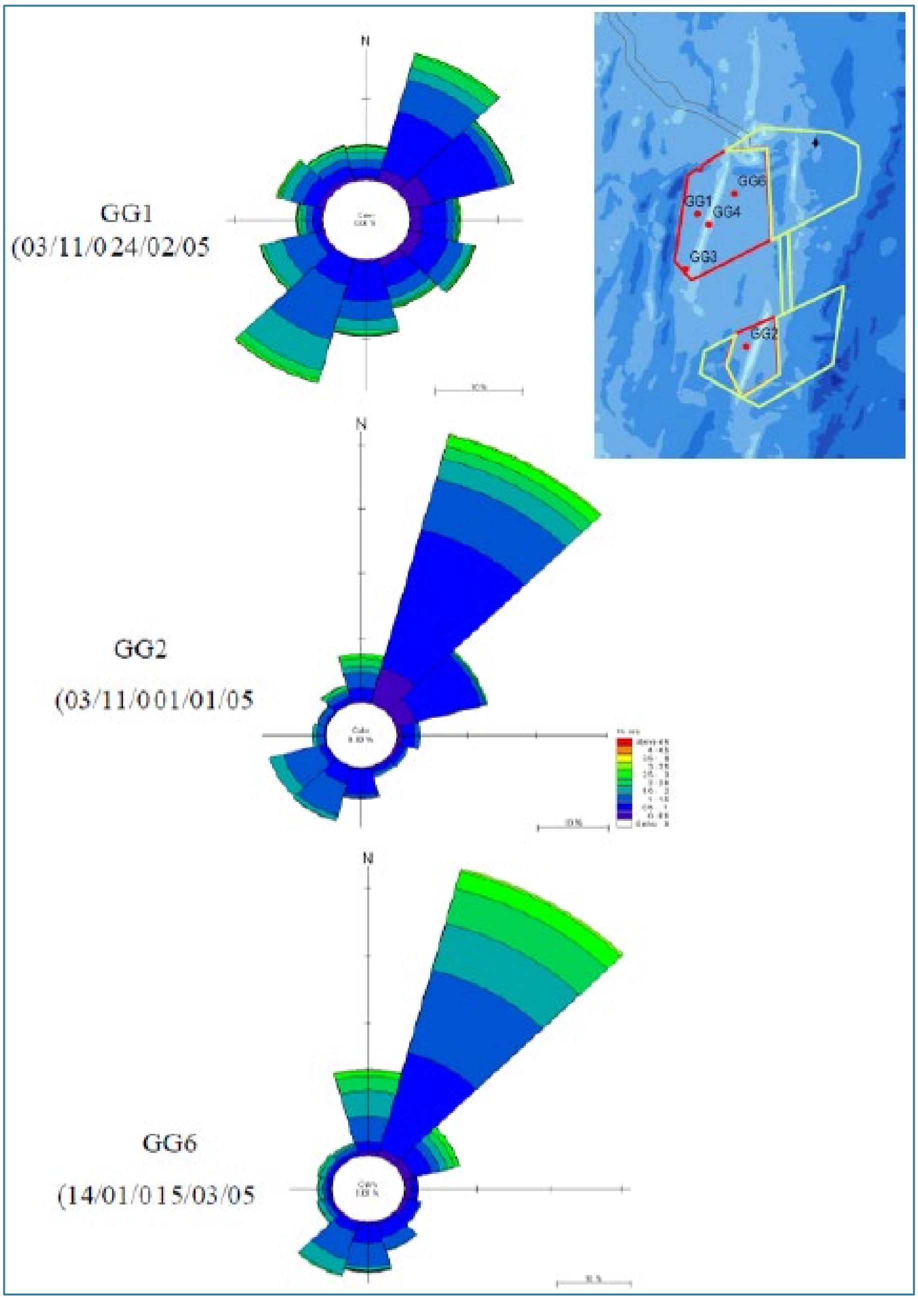

Plate 8.10 Near field wave conditions at GGOW in 2005 (ABPmer, 2011a)

75. The larger waves normally propagate from the north-north-east although these are rarely greater than 4m in height with typical significant wave heights about 3.6m (ABPmer, 2005; PMSS, 2005). The most common wave heights were between 0.5m and 1.5m approaching along the dominant north-north-east to south-south-west axis.

76. Wave conditions towards the landfall will be less severe due to the protection afforded by numerous sandbanks and the presence of East Anglia to the north (EACG, 2010). Sandbanks can provide a physical barrier or refract incoming waves which reduces the wave energy reaching the coast. A wave rose from modelled wave hindcast databases shows that the most common wave

directions close to landfall are from the north-east and south-west. Significant wave heights range between 0.25 and 0.5m (Plate 8.11) (ABPmer, 2018).

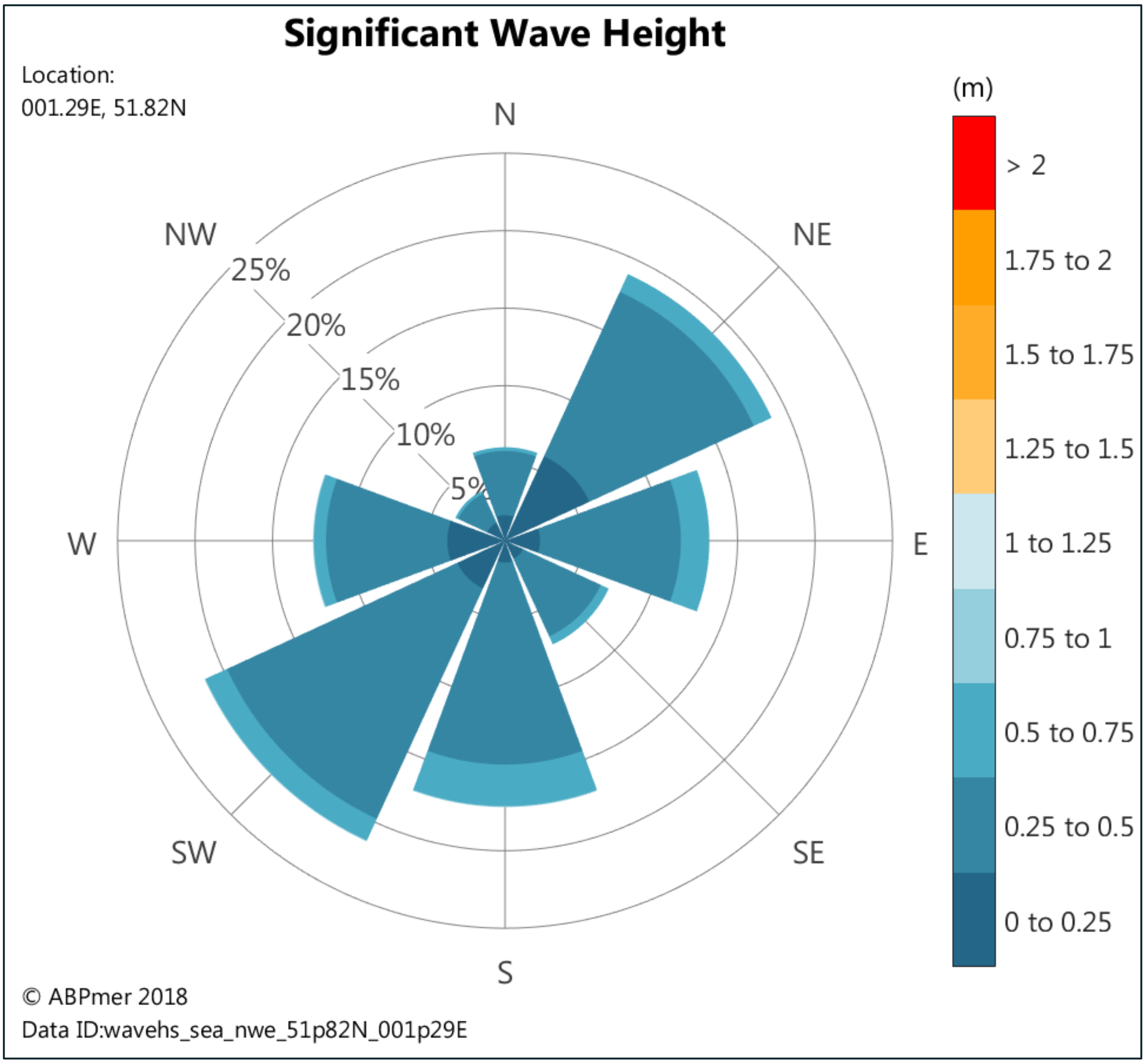

Plate 8.11 Significant wave heights closer to the landfall over the period 1979 to 2009 (ABPmer, 2018)

8.5.6 Seabed sediment distribution

8.5.6.1 Regional summary

77. The regional seabed and coast have been strongly influenced by deposition of sediment during the Pleistocene and Holocene periods (Section 8.5.2). Large quantities of sediment were deposited on the underlying chalk by retreating glaciers and associated rivers. The sediment was reworked by fluvial processes while sea level was low, and then by waves and currents during the Holocene (last 10,000 years) rise in sea level and up to the present day creating numerous bedforms including megaripples, sandwaves and sandbanks.

78. A site-specific seabed sediment grab sampling campaign with particle size distribution analysis totalling 27 samples was completed by Fugro from May to August 2021 (Fugro, 2021a). Samples with particle size analysis were recovered from the following areas (ES Figure 8.8 (Document Reference: 3.2.4)):

- Array area (8 samples); and
- Offshore cable corridor (19 samples).

79. ES Figures 8.9 and ES Figure 8.10 (Document Reference: 3.2.4) provides an overview of the interpreted seabed sediment distribution across the array area and offshore cable corridor.

8.5.6.2 Array area

80. The dominant sediment type in the array area is medium sand (16-83% in all samples) with median particle sizes (d_{50}) between 0.34mm and 0.92mm (medium to coarse sand) (Plate 8.12). The mud content is zero in five of the eight samples and less than 15% in 100% of the samples. The samples with the highest gravel content (37-42%) are ST33, ST36 and ST40 which are all located in the northern part of the array area (ES Figure 8.9 (Document Reference: 3.2.4)). Samples in the south and north-east of the array area are dominated by sand.

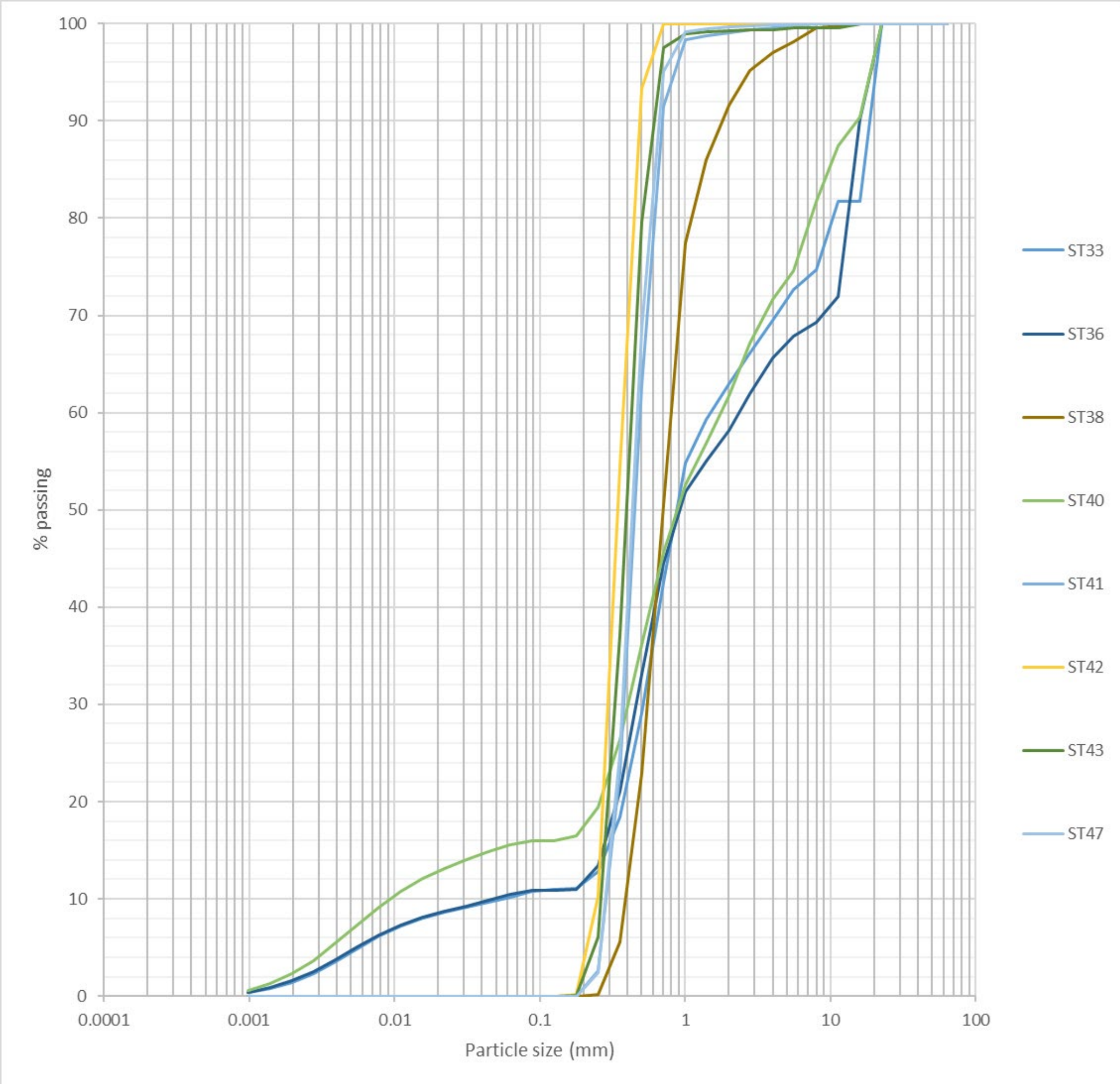

Plate 8.12 Cumulative particle size distribution curves of the eight seabed sediment samples collected in the array area

8.5.6.3 Offshore cable corridor

81. The dominant sediment type in the offshore cable corridor is medium sand (2-51% in all samples) with variable median particle sizes (d_{50}) between 0.012mm and 11.72mm (silt/clay to pebble) (Plate 8.13). The mud content is less than 5% in 26% of the samples and less than 78% in 100% of the samples. The samples with the highest mud content are located at ST02, ST03, ST04 and ST05 with an average of 59.4%. These samples are located closest to the landfall (ES Figure 8.10 (Document Reference: 3.2.4)).

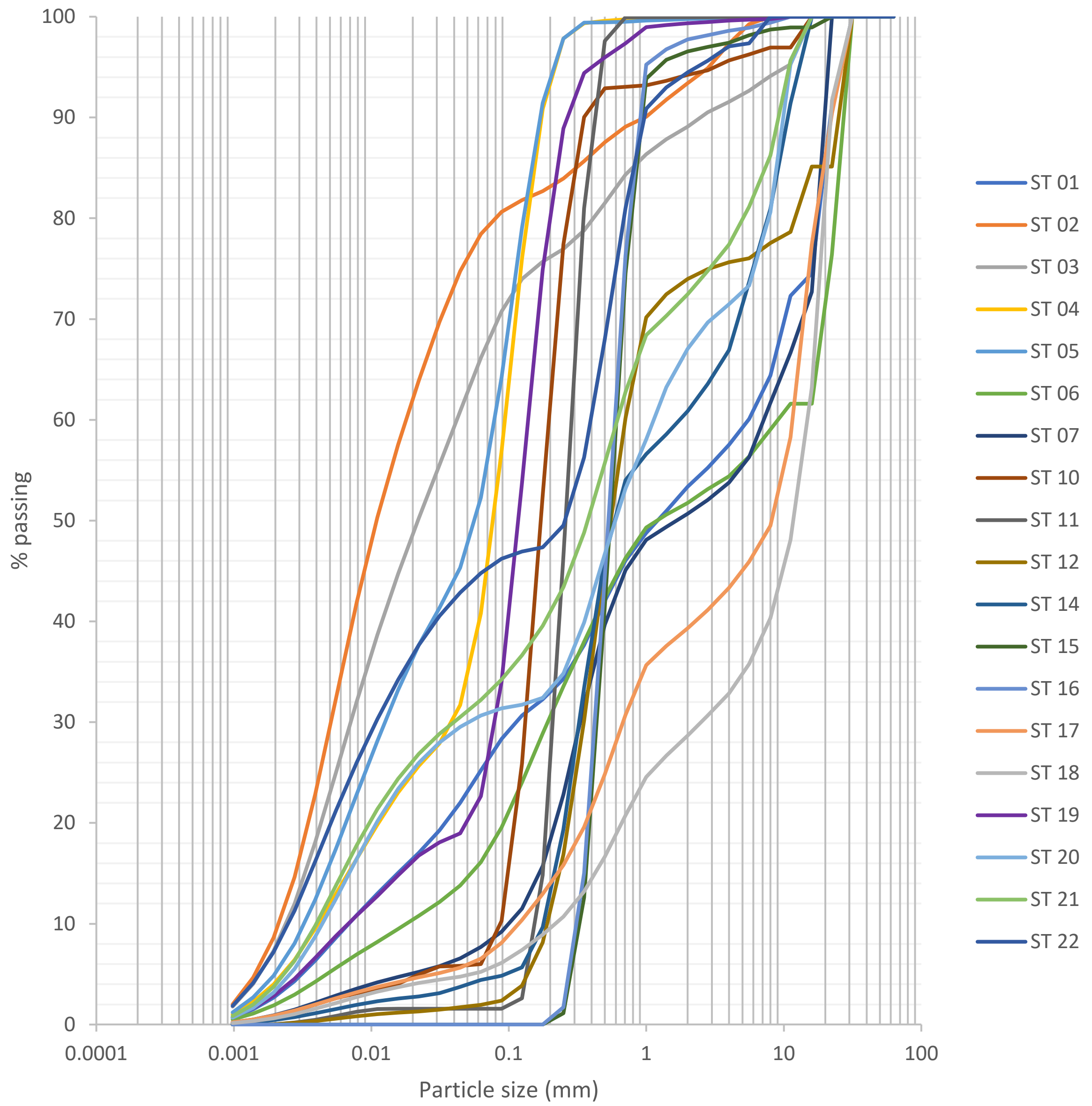

Plate 8.13 Cumulative particle size distribution curves of the 19 seabed sediment samples collected in North Falls offshore cable corridor

8.5.7 Bedload sediment transport

82. Regional bedload sediment transport pathways in the southern North Sea have been investigated by Kenyon and Cooper (2005). They analysed the results of modelling studies and bedform indicators and showed that tidal currents are the dominant mechanism responsible for bedload transport. The dominant regional bedload transport vectors are to the south-south-west across North Falls and to the north-north-east further offshore. Between these opposing directions of transport is a bedload transport parting (Reynaud and Dalrymple, 2012) (ES Figure 8.11 (Document Reference: 3.2.4)).

83. Sediment transport pathways within North Falls have been analysed using the orientation of bedforms. Sandwaves are present across the south, south-east

and extreme north-east of the array area and approximately half-way along the offshore cable corridor (ES Figures 8.12 and ES Figure 8.13 (Document Reference: 3.2.4)). The crests of the sandwaves in these areas exhibit a consistent north-west to south-east orientation that indicates a net direction of transport to the south-west and north-east. Tidal currents are the main driving force of sediment transport across sandwaves and as a result, move sediment in a south-westerly direction during a flow tide and a north-easterly direction during an ebb tide. The net direction of sediment transport across areas that are not characterised by migrating bedforms (adjacent to the sandwaves) is likely to be the same.

8.5.8 Suspended sediment concentrations

84. SSCs were measured at four locations as part of the metocean data collection at GGOW between 3rd November 2004 and 24th March 2005. The maximum SSC was 85mg/l with a mean concentration of 20mg/l (Emu Ltd, 2005).

85. Cefas (2016) published average SSCs between 1998 and 2015 for the seas around the UK (ES Figure 8.14 (Document Reference: 3.2.4)). The average SSC in the vicinity of the array area for the period 1998-2015 was approximately 7-15mg/l. The average SSC in the vicinity of the offshore cable corridor is 15mg/l offshore, ranging to 100mg/l close to the landfall location.

8.5.9 Coastal processes along the Tendring peninsula

86. The exposed coast of the Tendring peninsula, composed of gravel and sand beaches, dunes, and cliffs, is shaped by waves approaching from the north-east but is more vulnerable to storms approaching from the east (EACG, 2010). The potential net longshore sediment transport rates in the region range from 1,950 to 254,900m^3/year (Posford Duvivier, 2001, HR Wallingford, 1997) and are directed towards the south-south-west (Plate 8.14). Potential longshore sediment transport rates between Frinton-On-Sea and Clacton-on-Sea range from 16,350 to 21,000m^3/year (Posford Duvivier, 2001, Onyett and Simmonds, 1983).

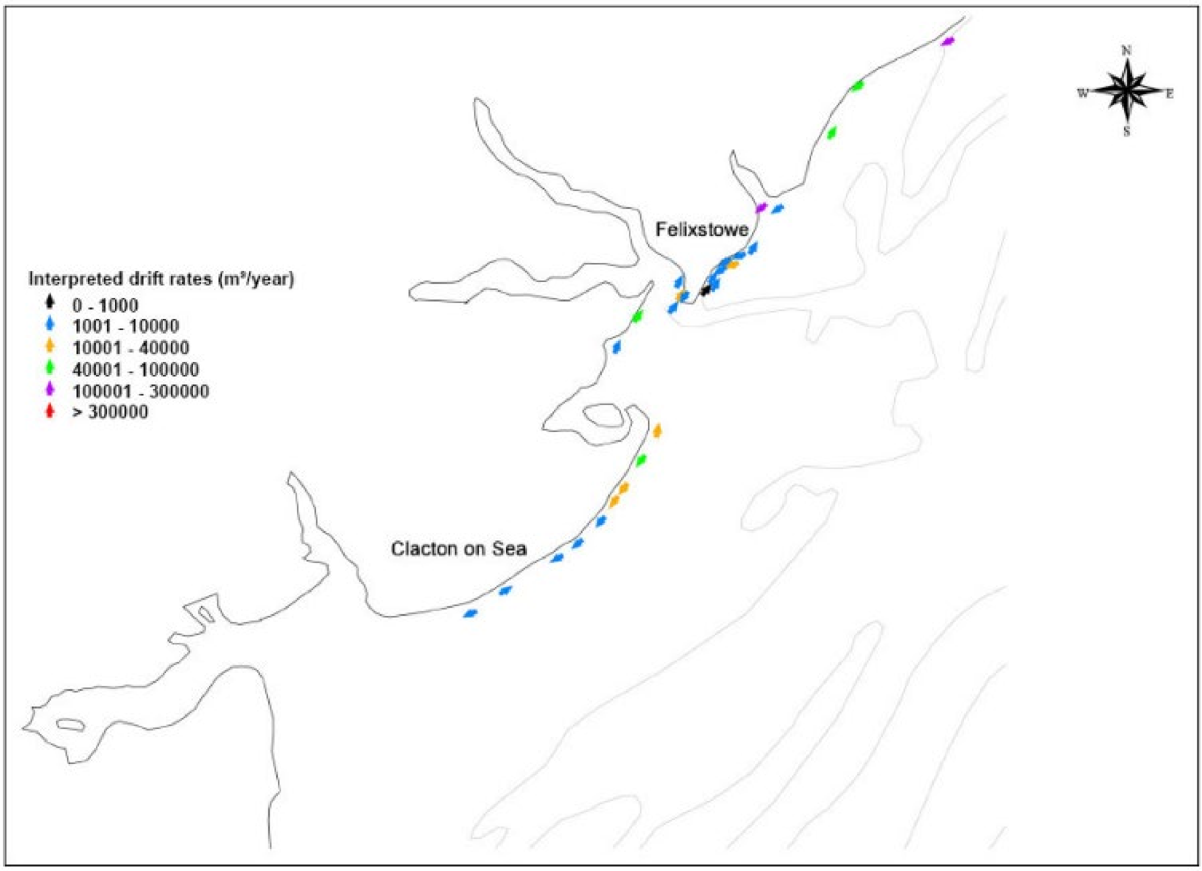

Plate 8.14 Potential longshore sediment transport rates (HR Wallingford et al., 2002)

87. The Shoreline Management Plan (SMP) (EACG, 2010) states that the intended management along this frontage up to 2055 is 'hold the line' and would '*sustain and support its viability of the seaside towns and their communities, tourism and commercial activities*'. From 2055 to 2105, the management policy is 'hold the line / managed realignment' with low-lying ground around the landfall at flood risk.

8.5.10 Future trends in baseline conditions

88. The baseline conditions for marine geology, oceanography and physical processes will continue to be controlled by waves and tidal currents driving changes in sediment transport and then seabed morphology. However, the long-term established performance of these drivers may be affected by environmental changes including climate change driven sea-level rise. The effect of these broadscale environmental changes will occur regardless of the presence or absence of North Falls.

89. This will have the greatest impact at the coast where more waves will impinge on the low-lying beaches and estuaries, potentially increasing their rate of erosion. Climate change will have little effect offshore where landscape-scale changes in water levels (water depths) far outweigh the effect of minor changes due to sea-level rise.

90. In their response to inform the scoping opinion and in their response to PEIR, Essex County Council state that coastal protection works at Clacton-on-Sea, to the south of the landfall area, are reliant on ongoing maintenance for which funding may be challenging. Therefore, while the current shoreline management plan is to hold the line, this could change in future to include managed realignment, subject to a revised strategy (the Planning Inspectorate, 2021). If a managed realignment option were to be implemented the siting of the Project would not be an issue because the landfall transition jointing bays would be c. 400m from the shoreline behind golf course/ SSSI and so set back from potential managed realignment with HDD to route cabling underneath the site.

8.6 Assessment of significance

8.6.1 Receptors

91. The principal receptors with respect to marine geology, oceanography and physical processes are those features with an inherent geological or geomorphological value or function which may potentially be affected by North Falls. These are Annex I sandbanks, Margate and Long Sands SAC, KKE MCZ, and the Suffolk and Essex coasts (gravel and sand beaches, dunes and cliffs) (ES Figure 8.15 (Document Reference: 3.2.4)). The specific features defined within these receptors as requiring assessment are listed in Table 8.13.

Table 8.13 Marine geology, oceanography and physical processes receptors relevant to the Project

Receptor Group	Extent of coverage	Description of features	Closest distance from array area	Closest distance from offshore cable corridor
Suffolk Coast	Lowestoft to Felixstowe	Gravel and sand beaches, dunes and cliffs	39km	11.1km
Essex Coast (including landfall)	Harwich to Canvey Island (Kirby Brook at the landfall)	Gravel and sand beaches, dunes and cliffs	43km	0km (overlapping)
Designated sites and features	Annex I Sandbank (Annex I Reef will be addressed in the benthic ecology section)	Sublittoral sandbanks permanently submerged, and associated sandwaves	0km (overlapping)	0km (adjacent)
	Margate and Long Sands SAC	Sandbanks which are slightly covered by sea water all the time	10.9km	0km (adjacent)
	KKE MCZ	Subtidal sand, subtidal coarse sediment, subtidal mixed sediments	0km (adjacent)	6.2km

92. The impact assessment sections (Section 8.6.2 and Section 8.6.3) assess the likely significant effects on the wave, current and sediment transport regimes on the receptor groups outlined in Table 8.13.

93. Further to the receptors described above, changes to physical processes can impact other receptors and therefore the magnitude of impact on physical processes is considered in the following chapters, where applicable:

- Chapter 9 Marine water and sediment quality;
- Chapter 10 Benthic and intertidal ecology;
- Chapter 11 Fish and shellfish ecology;
- Chapter 14 Commercial fisheries; and
- Chapter 16 Offshore archaeology and cultural heritage.

8.6.1.1 The Suffolk and Essex coast

94. The Suffolk coast, between Lowestoft and Felixstowe, falls under SMP 7 (Suffolk Coastal District Council, 2010). The Suffolk coast is characterised by soft eroding cliffs, shingle beaches and coastal lagoons, and includes the Blyth, Alde/Ore, Deben, Orwell, and Stour estuaries (Environment Agency, 2011). This coast is predominantly undefended and is therefore prone to roll back in response to wave attack and sea-level rise (Environment Agency, 2011). Features formed by longshore sediment transport dominate much of the Suffolk coast, including Orfordness (a 16km shingle spit) and Benacre Ness (a large mobile shingle beach which is migrating northwards) (Environment Agency, 2011). The two main urban areas along the Suffolk coast are Lowestoft and Felixstowe, which are defended by sea walls and groynes. The SMP notes that there is a lack of sediment supply from the north (EACG, 2010).

95. The Essex coast, encompassing the landfall on the Tendring Peninsula, falls under SMP 8 Essex and South Suffolk (EACG, 2010). The beach frontage along the Tendring Peninsula is composed of a mixture of shingle and/or sand and muddy shores. The erosion of this frontage is primarily due to its vulnerability to wave pressure, orientation and landward constraints imposed by coastal and sea defences (EACG, 2010). It is protected by a combination of sea walls, promenades, wave return walls and a range of other beach control measures including groynes and breakwaters (Plate 8.15). Additional coastal defence works have been undertaken since the SMP, including the following:

- works to reinforce and improve a section of seawall along York Road, Holland on Sea; and
- a major coastal protection scheme covering 5km of coast between Clacton and Holland on Sea to protect the cliff and promenade. The scheme cost £36M and was opened to the public in 2015 (Tendring Council, undated).

96. There is a concern that the saltmarsh and mudflats along the Essex and South Suffolk coast and estuaries have been progressively eroding in response to sea-level rise (EACG, 2010). A study of saltmarsh coverage between 1973 and 1998 showed a loss of 1,000 ha in Essex, primarily due to coastal erosion (Cooper et al., 2001).

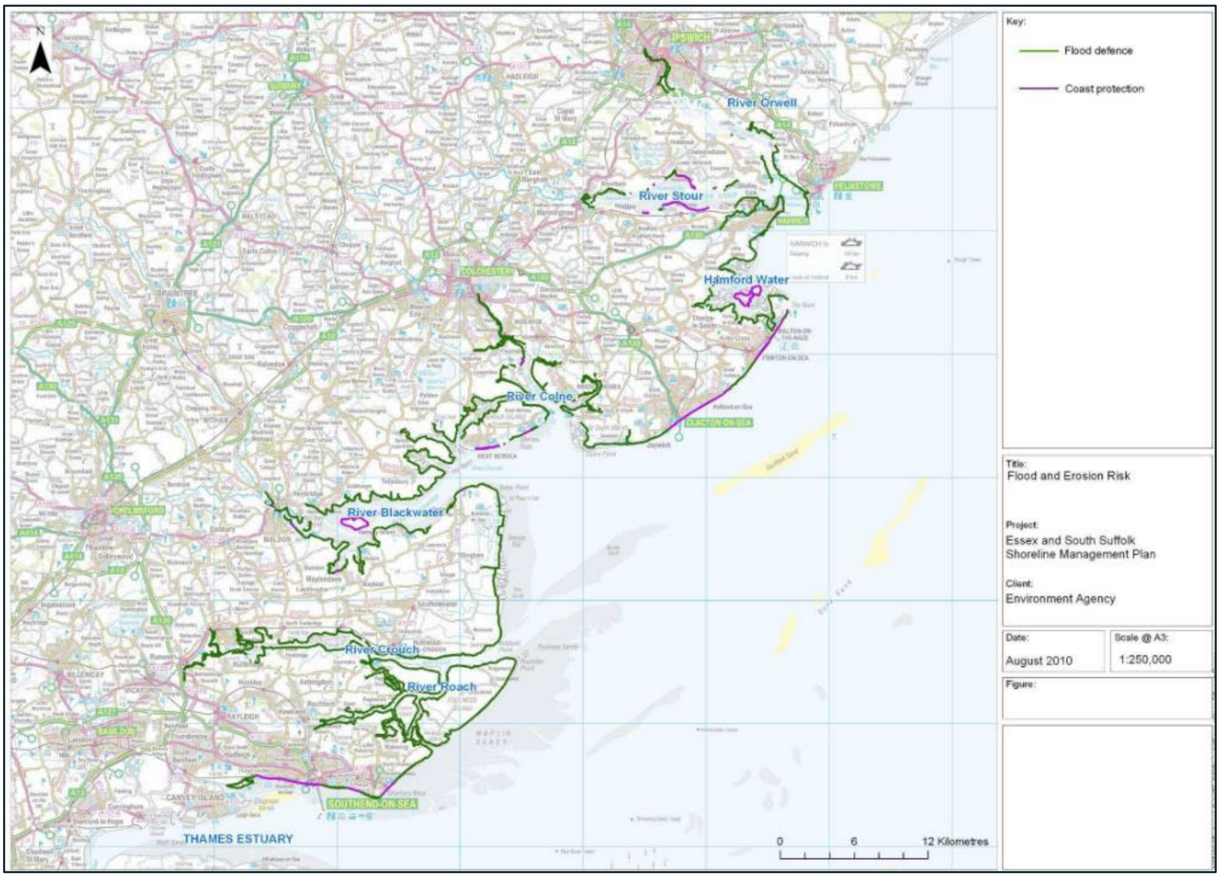

Plate 8.15 Flood defence and coast protection measures in Essex (EACG, 2010)

8.6.1.2 Annex I sandbanks

97. Annex I sandbanks are distributed widely around the UK coast. They are characterised as distinct ‘banks’ (elongate / rounded mounds) associated with horizontal or sloping plains of sand (JNCC, unknown). The ‘Annex I’ types are associated with areas of horizontal or sloping sandy habitat that are closely associated with the banks. Annex I sandbanks occur on the east of the array area and adjacent to the offshore cable corridor (ES Figure 8.15 (Document Reference: 3.2.4)).

8.6.1.3 Margate and Long Sands SAC

98. The Margate and Long Sands SAC is located approximately 22km off the Suffolk coast, covering an area of 649km^2. The conservation objective for the SAC is to ‘ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring:

- the extent and distribution of qualifying natural habitats;
- the structure and function (including typical species) of qualifying natural habitats; and
- the supporting processes on which the qualifying natural habitats rely’.

The North Falls offshore cable corridor lies adjacent to the SAC.

8.6.1.4 KKE MCZ

99. The KKE MCZ is located approximately 35km off the Essex coast, covering an area of 96km^2. The conservation objectives for the MCZ's protected features are that they are 'maintained in favourable condition if they are already in favourable condition or recovered to a favourable condition if they are not already in favourable condition'.

8.6.2 Likely significant effects during construction

100. During the construction phase of North Falls, there is the potential for foundations and cable installation activities to disturb sediment, potentially resulting in changes in SSCs and/or seabed level or, in the case of nearshore cable installation, shoreline morphology due to deposition or erosion. These are considered as Construction Impacts 1 to 8. The worst case scenario is discussed in Section 8.3.2.

8.6.2.1 Impact 1a: Changes in SSCs due to seabed preparation for installation of turbine and OSP/OCP foundations

101. Seabed sediments and shallow near-bed sediments within the array area would be disturbed during dredging activities to create a suitable base prior to foundation installation. The worst case scenario assumes that sediment would be dredged and returned to the water column at the sea surface as overflow from a dredger vessel. This process would cause local and short-term increases in SSCs both at the point of dredging at the seabed and, more importantly, at the point of its discharge back into the water column. The disposal of any sediment that would be disturbed or removed during foundation installation would occur within the offshore project area.

102. Mobilised sediment from these activities may be transported by wave and tidal action in suspension in the water column. The disturbance effects at each wind turbine location are likely to last for no more than a few days, within an overall foundation installation programme of approximately six months in total.

103. The median particle sizes of seabed sediments are predominantly 0.34 to 0.92mm (medium to coarse sand) across the array area. Most seabed samples contain no mud. As outlined in Section 8.5.8, average SSCs at North Falls are up to 15mg/l across the array area (Cefas, 2016). These concentrations may increase significantly during storm events (HR Wallingford *et al.*, 2002).

104. For the total volume released during the construction phase, the worst case scenario is associated with the maximum number of GBS foundations (57) and two OSPs/OCP, with a 70m preparation diameter dredged to 5m (Table 8.2).

105. Conceptual evidence-based assessment suggests that due to the predominance of medium and coarse sand across the array area, the sediment disturbed by the drag head of the dredger at the seabed would remain close to the bed and rapidly settle back to the bed. Most of the sediment released at the water surface from the dredger vessel would fall rapidly (minutes or tens of minutes) to the seabed as a highly turbid dynamic plume immediately upon its discharge (within a few tens of metres along the axis of tidal flow).

106. Some of the finer sand fraction from this release and the very small proportion of mud that is present are likely to stay in suspension for longer and form a

passive plume which would become advected by tidal currents. Due to the sediment sizes present, this is likely to exist as a measurable but modest concentration plume (tens of mg/l) for around half a tidal cycle (up to six hours). Sediment would eventually settle to the seabed in proximity to its release (within a few hundred metres up to around a kilometre along the axis of tidal flow) within a short period of time (hours to days). Whilst lower SSCs would extend further from the dredged area, along the axis of predominant tidal flows, the magnitudes would be indistinguishable from background levels.

107. Five Estuaries Wind Farm Ltd (2023) assessed sediment dispersion in the water column due to seabed preparation for foundation installation at Five Estuaries using spreadsheet based numerical models. The total volume of sediment released during seabed preparation was estimated as 1.19Mm^3 which is conservative compared to the estimated release of 1.14Mm^3 at North Falls.

108. The results were summarised into four main zones of effect, based on the distance from the seabed preparation causing the sediment disturbance. Given the similar sediment compositions, and the higher volumes released at Five Estuaries, these results provide a conservative analogy for the likely significant effects at North Falls:

- 0 to 50m: This is the zone of highest SSC increase. All gravel would likely be deposited in this zone, along with a large proportion of sands that are not suspended higher into the water column. Although plume dimensions and SSC would primarily be controlled by the volume of sediment released and the way it settles, this zone would have very high SSC increase (tens to hundreds of thousands of mg/l) lasting for the duration of active disturbance plus up to 30 minutes following the end of disturbance. After more than one hour after the end of active disturbance there would be no change to SSC;
- 50 to 100m: This is the zone of measurable SSC increase. Sands would likely be deposited in this zone. SSC increases would be high (hundreds to low thousands of mg/l) lasting for the duration of active disturbance plus up to 30 minutes following the end of disturbance. After more than one hour after the end of active disturbance there would be no change to SSC;
- 500m to the tidal excursion buffer distance: This is the zone of lesser but measurable SSC increase. The increase in SSC would be mainly fines that are maintained in suspension for more than one tidal cycle and are advected by ambient tidal currents. The plume dimensions and SSC would be primarily controlled by the volume of sediment released, the patterns of current speed and direction at the place and time of release and where the plume moves to over the following 24 hours. At the time of active disturbance there would be low to intermediate SSC increase (tens to low hundreds of mg/l) because of any remaining fines in suspension. This would occur within a narrow plume (tens to a few hundreds of metres wide with SSC decreasing rapidly by dispersion to ambient values within one day after the end of active disturbance. From one to six hours after the end of active disturbance, the SSC increase would decrease to tens of mg/l, and from six to 24 hours decrease gradually to background values (no measurable local increase). After 24 to 48 hours following cessation of activities there would be no measurable change from baseline SSC; and

- Beyond the tidal excursion buffer distance or anywhere not tidally aligned to the active sediment disturbance activity, there is no expected impact or change to SSC.

109. This conceptual evidence-based assessment is supported by the findings of a review of the evidence base into the physical impacts of marine aggregate dredging on sediment plumes and seabed deposits (Whiteside et al., 1995; John et al., 2000; Hiscock and Bell, 2004; Newell et al., 2004; Tillin et al., 2011; Cooper and Brew, 2013).

110. Modelling simulations undertaken for GWF using the Delft3D plume model (ABPmer, 2011b) support the expert-based assessments of SSCs arising from disturbance of near-surface sediments during seabed preparation for GBS foundations at North Falls. Sediment types and distributions across the North Falls and GWF sites are similar, as are water depths across both sites. Therefore, the modelling studies for GWF represent a suitable analogue for verifying the conclusions of the more qualitative expert-based assessment at North Falls.

111. For GWF, the simulation was carried out on installation of ten GBS foundations (45m diameter) on the Galloper sandbank, with two foundations installed simultaneously and a seabed sediment release volume of 7,200m^3 (ABPmer, 2011b). Given that the water depths were less than other locations within the GWF array site and that sediment release volumes were more likely to be in the region of 4,750m^3 (following design project optimisation), this was considered a highly conservative scenario.

112. The model results predicted that increased SSCs due to seabed preparation would extend over a larger area for smaller sized sediment given its greater mobility under the tidal regime. Simulations predicted a maximum dispersion distance of 15km and 11km from the point of release for both coarse silt and fine sand at peak ebb flow (ABPmer, 2011b). Within the passive plume, SSCs were low (less than 0.2mg/l above background levels) and within the range of natural variability. The dispersal of fine sediment retained within the passive plume was in accordance with the main axis of the tidal flow (along a north-east to south-west axis). For larger sized sediment, SSCs are greater close to the point of release (0.5mg/l and 1.4mg/l above background levels for silt and fine sand, respectively at high water) (ABPmer, 2011b). A plume with concentrations greater than 1mg/l above background levels was predicted to be isolated to within 2 to 3km of the point of release, beyond which SSCs are less than 1mg/l (ABPmer, 2011b).

113. Given the similarity in the physical environments of North Falls and GWF, it is expected that effects from installation across the whole of the North Falls array area would be similar, although with the point of release moving across the area with progression of the construction sequence.

8.6.2.1.1 Sensitivity

114. Due to the nature of the pressure (increase in SSCs due to seabed preparation for foundation installation) there is no pathway for impact to all the identified receptors so therefore they are not sensitive to this pressure. This is because the receptors are dominated by processes that are active along the seabed and not affected by suspended sediment in the water column.

8.6.2.1.2 Magnitude

115. The worst case changes in SSCs due to seabed preparation for GBS foundation installation are likely to have the magnitudes of impact shown in Table 8.14.

Table 8.14 Magnitude of impact on SSCs under the worst case scenario for GBS foundation installation

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Near-field*	High	Negligible	Negligible	Negligible	Medium
Far-field	Low	Negligible	Negligible	Negligible	Negligible

*The near-field impacts are confined to a small area, likely to be up to a kilometre from each foundation location.

8.6.2.1.3 Effect significance

116. The impacts on SSCs due to foundation installation at North Falls do not directly affect the identified receptor groups for marine geology, oceanography and physical processes. This is because the receptors are dominated by processes that are active along the seabed and not affected by suspended sediment in the water column. However, there may be impacts arising from subsequent deposition of the suspended sediment on the seabed and these are discussed under Construction Impact 2a (Section 8.6.2.3). Hence, there are no changes to the identified receptor groups associated with the suspended sediment generated by North Falls and no significant effect will occur.

117. The impact on SSCs does have the potential to affect other receptors and the assessment of effect significance is addressed within the relevant chapters of this ES (Section 8.10).

8.6.2.2 Impact 1b: Changes in SSCs due to drill arisings for installation of piled foundations for wind turbines and OSP/OCPs

118. Sediments below the seabed within North Falls would become disturbed during any drilling activities that may be needed at the location of piled foundations. The ambient SSCs across North Falls range from less than 10mg/l to about 15mg/l (Section 8.5.8) mean that the transient impact of sediment plumes arising from installation of the wind farm foundations may be significant (although temporally limited) under specific circumstances. The disposal of any sediment that would be disturbed or removed during foundation installation would occur within the North Falls array area close to each foundation. The worst case scenario for a release from an individual wind turbine assumes a monopile foundation for the largest wind turbine. In this case, a 18m drill diameter would be used from the seabed to a depth of 45m, releasing a maximum of 11,451m^3 of sediment per monopile foundation into the water column.

119. It is estimated that the maximum number of foundations that would require drilling would be 10%, based on engineering experience. Taking a precautionary worst case approach, it has therefore been assumed that 10% of the 34 largest wind turbines in North Falls and one OSP/OCP would require drilling. The total volume of drill arisings would be up to 46,179m^3 (Table 8.2).

120. The drilling process would cause local and short-term increases in SSCs at the point of discharge of the drill arisings at 10% of 34 wind turbine locations and

one OSP/OCP foundation. Released sediment may then be transported by tidal currents in suspension in the water column. Due to the small quantities of fine-sediment released (most of the sediment will be sand or aggregated clasts, see Section 8.5.7), the fine-sediment is likely to be widely and rapidly dispersed, and would result in only low SSCs. The disturbance effects at each wind turbine location are only likely to last for a few days of construction activity within the overall construction programme lasting up to two years in total.

121. The conceptual evidence-based assessment suggests that away from the immediate release locations, elevations in SSC above background levels for only 10% of 34 foundations and one OSP/OCP foundation would be very low (less than 10mg/l) and within the range of natural variability. Net movement of fine sediment retained within a plume would be to the south-west or north-east, depending on state of the tide at the time of release. Sediment concentrations arising from one foundation installation are unlikely to persist for sufficiently long for them to interact with subsequent operations, and therefore no cumulative effect is anticipated from multiple installations.

8.6.2.2.1 Sensitivity

122. Due to the nature of the pressure (increase in SSCs due to drill arisings for installation of piled foundations) there is no pathway for effect to any of the identified receptor groups so therefore they are not sensitive to this pressure. This is because the receptors are dominated by processes that are active along the seabed and not affected by suspended sediment in the water column.

8.6.2.2.2 Magnitude

123. The worst case changes in SSCs due to the installation of the maximum number of the largest monopile foundations are likely to have the magnitudes of impact shown in Table 8.15.

Table 8.15 Magnitude of impact on SSCs under the worst case scenario for piled foundation installation

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Near-field*	Low	Negligible	Negligible	Negligible	Negligible
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible

* The near-field impacts are confined to a small area likely to be up to a kilometre from each foundation location and would not cover the North Falls array area.

8.6.2.2.3 Effect significance

124. The impacts on SSCs due to foundation installation for North Falls do not directly affect the identified receptor groups for marine geology, oceanography and physical processes, so there is no change associated with the proposed North Falls project. No significant effect will occur. However, the impacts on SSC have the potential to affect other receptors and the assessment of effect significance is addressed within the relevant chapters of this ES (see Section 8.10).

8.6.2.3 Impact 2a: Changes in seabed level due to seabed preparation for installation of turbine and OSP/OCP foundations

125. The increased SSCs associated with construction Impact 1a (Section 8.6.2.1) have the potential to deposit sediment and raise the seabed elevation slightly.

126. The conceptual evidence-based assessment suggests that coarser sediment disturbed during seabed preparation would fall rapidly to the seabed (minutes or tens of minutes) as a highly turbid dynamic plume immediately after it is discharged. Deposition of this sediment would form a 'mound' local to the point of release. Due to the coarser sediment particle sizes observed across the array area (predominantly medium to coarse sand), a large proportion of the disturbed sediment would behave in this manner.

127. The resulting mound would be a measurable protrusion above the existing seabed (likely to be tens of centimetres to a few metres high) but would remain local to the release point. The geometry of each of these mounds would vary across North Falls, depending on the prevailing physical conditions, but in all cases the sediment within the mound would be similar to (but not the same as) both the seabed that it has replaced and the surrounding seabed. The baseline particle size distribution data for the North Falls array area shows that the seabed is dominated by medium and coarse sand with overall compositional variations related to the volumes of coarser sand and gravel. Mud content is always less than 5%. This would mean that there would be a small but insignificant change in seabed sediment type, likely to be caused by differences in the volume of the coarser fraction in the mound compared to the natural seabed, but this would have little effect on the benthic communities that inhabit this type of seabed.

128. This type of behaviour has been predicted using spreadsheet based numerical models at Five Estuaries (Five Estuaries Wind Farm Ltd, 2023). Within 50m of each foundation, coarser sediment (gravel and coarser sands) was predicted to deposit with local thicknesses of tens of centimetres to several metres. In the zone 50 to 100m from the foundation, sand and gravel would deposit in local thicknesses up to tens of centimetres. In both zones, there would be no measurable ongoing deposition after more than one hour from cessation of active disturbance. Beyond 100m, there was predicted to be no measurable thickness of deposition from the beginning of disturbance.

129. Also, the overall changes in elevation of the seabed would be small compared to the absolute depth of water (up to 55m below LAT). The changes in seabed elevation are within the natural change to the bed caused by sandwaves and sand ridges and hence the effect on physical processes would be negligible.

130. The mound will be mobile and be driven by the physical processes, rather than the physical processes being driven by it. This means that over time the sediment comprising the mound will gradually be re-distributed by the prevailing waves and tidal currents.

131. In addition to local mounds, the very small proportion of mud that forms the passive plume would become more widely dispersed before settling on the seabed. The worst-case thickness of sediment deposited from the plume would not likely exceed a maximum of 1mm and be less than 0.1mm over larger areas of the seabed.

132. This theoretical assessment is supported by modelling results for GWF, which shows seabed thickness changes simulated for fine sand of less than 0.035mm following seabed preparation for ten GBS (equivalent to one grain of fine silt)

(ABPmer, 2011b). The maximum area of deposition was between 4km^2 and 15km^2 for very fine sand and fine sand, respectively (ABPmer, 2011b).

133. This assessment is further supported by an extended evidence-base obtained from research into the physical impacts of marine aggregate dredging on sediment plumes and seabed deposits (Whiteside et al., 1995; John et al., 2000; Hiscock and Bell, 2004; Newell et al., 2004; Tillin et al., 2011; Cooper and Brew, 2013).

8.6.2.3.1 Sensitivity

134. The sensitivity and value of all relevant receptors are presented in Table 8.16.

Table 8.16 Sensitivity and value assessment of receptors

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Suffolk coast	Negligible	Negligible	Negligible	High	Negligible
Essex coast	Negligible	Negligible	Negligible	High	Negligible
Annex I sandbank	Negligible	Negligible	Negligible	High	Negligible
Margate and Long Sands SAC	Negligible	Negligible	Negligible	High	Negligible
KKE MCZ	Negligible	Negligible	Negligible	High	Negligible

8.6.2.3.2 Magnitude

135. The changes in seabed level due to foundation installation under the worst-case sediment dispersal scenario are likely to have the magnitudes of impact shown in Table 8.17.

Table 8.17 Magnitude of impact on seabed level changes due to deposition under the worst case scenario for sediment dispersal following GBS foundation installation

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Near-field*	High	Negligible	Negligible	Negligible	Medium
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible

*The near-field impacts are confined to a small area of seabed likely to be up to a kilometre from each foundation location and would not cover the whole of North Falls.

8.6.2.3.3 Effect significance

136. The overall likely effect of seabed preparation for foundation installation activities for North Falls on seabed level changes for the Suffolk coast, Essex coast, Margate and Long Sands SAC is of negligible adverse significance (no significant effect). This is because there is a separation distance of at least 10.9km between the nearest sediment release point and the receptors noted above.

137. The overall likely effect of seabed preparation for foundation installation activities under a worst case scenario on seabed level changes on the Annex I sandbanks and KKE MCZ is negligible adverse significance (no significant effect). This is because the predicted thickness of sediment resting on the

seabed would be a maximum of 1mm. After this initial deposition, this sediment will be continually re-suspended to reduce the thickness even further to a point where it will be effectively zero. This will be the longer-term outcome once the sediment supply from foundation installation has ceased.

138. The effects on seabed level have the potential to affect other receptors and the assessment of effect significance is addressed within the relevant chapters of this ES (Section 8.10).

8.6.2.4 Impact 2b: Changes in seabed level due to drill arisings for installation of piled foundations for wind turbines and OSP/OCPs

139. The combined increases in SSCs and creation of aggregated clasts of mud associated with Construction Impact 1b (see Section 8.6.2.2) have the potential to deposit sediment and raise the seabed elevation.

140. Drilling of piled foundations could potentially occur through four different geological units (Table 8.12); Holocene deposits, underlying Pleistocene channel complexes and infill deposits, London Clay Formation, and the Harwich Formation. The coarser sediment fractions (silty gravelly sand and silty sandy gravel) of the Pleistocene would settle out of suspension near to the point of release (up to thicknesses of approximately 40mm over a seabed area of 300m). For the most part, the deposited sediment layer across the wider seabed area would be very thin and confined to an area around a maximum of 10% of 34 wind turbine foundations and one OSP/OCP foundation (see Table 8.2 for worst case drill arisings).

141. If the drilling penetrates the underlying mud deposits, then a worst case scenario is considered whereby the sediment released from the drilling is assumed to be wholly in the form of larger aggregated ‘clasts’ which would settle rapidly. These clasts would remain on the seabed (at least initially), rather than being disaggregated into their individual fine sediment grains immediately upon release. Under this scenario, the worst case scenario assumes that a ‘mound’ would reside on the seabed near the site of release.

142. These mounds would be composed of sediment with a different particle size and would behave differently (they would be cohesive) to the surrounding sandy seabed, and therefore represent the worst case scenario for mound formation during construction.

143. For an individual wind turbine, the worst case assumes that each mound would contain a maximum volume of 10,214m^3 of sediment (assumes that all the drill arisings are in the form of aggregated clasts). A mound for a single monopile for OSP/OCP would contain a maximum volume of 11,451m^3. For drill arisings from the Project as a whole, the worst-case is for 10% of 34 of the largest turbines and one OSP/OCP, which equates to 46,179m^3.

144. The method for calculating the footprint of each mound follows that which was developed and agreed with Natural England for earlier major offshore wind farm projects at Dogger Bank Creyke Beck (Forewind, 2013), Dogger Bank Teesside (Forewind, 2014), East Anglia THREE (East Anglia Three Limited (EATL), 2015), Norfolk Vanguard (Royal HaskoningDHV, 2018) and Norfolk Boreas (Royal HaskoningDHV, 2019). The methodology involves the following stages:

- Calculate the maximum potential width of a mound (for the given volume) based on the diameter of an assumed idealised cone on the seabed. This was based on simple geometric relationships between volume, height, radius, and side-slope angle of a cone. The latter parameter was taken as a maximum of 30°, which is a suitable representation for an angle of friction of clasts of sediment.
- Calculate the maximum potential length of the mound (for the given volume and maximum potential width). The assumed height of the mound was 'fixed' in the calculation as being equivalent to the average height of the naturally occurring sandwaves on the seabed within the site. This calculation was based on simple geometric relationships between volume, height, width and length and assumed that, when viewed in side elevation, the mound would be triangular in profile but that its length is greater than its width, thus forming a 'ramp' shape.
- Based on the newly calculated width and length of the mound, a footprint area on the seabed could then be calculated.

145. Based on this approach, the footprint of an individual 2m-high mound arising from the installation of the largest wind turbine monopile would be 10,214m^2 (or a total footprint of 46,179m^2, assuming a worst case scenario of 10% of 34 of the largest turbines and one OSP/OCP are drilled).

146. Because of their potentially large particle sizes, future transport of the aggregated clasts would be limited, and most would remain static within the mound. However, over time the flow of tidal currents over the mound would gradually winnow (there would be a gradual disaggregation of the clasts into their constituent particle sizes) the topmost clasts and over time the mound would lower through erosion.

8.6.2.4.1 Sensitivity

147. The sensitivity and value of all relevant receptors are presented in Table 8.18.

Table 8.18 Sensitivity and value assessment of relevant receptors

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Suffolk coast	Negligible	Negligible	Negligible	High	Negligible
Essex coast	Negligible	Negligible	Negligible	High	Negligible
Annex I sandbank	Negligible	Negligible	Negligible	High	Negligible
Margate and Long Sands SAC	Negligible	Negligible	Negligible	High	Negligible
KKE MCZ	Negligible	Negligible	Negligible	High	Negligible

8.6.2.4.2 Magnitude

148. The changes in seabed level due to foundation installation under the worst case sediment dispersal scenario and sediment mound scenario are likely to have the magnitudes of impact shown in Table 8.19 and Table 8.20, respectively.

Table 8.19 Magnitude of impacts on seabed level changes due to deposition under the worst case scenario for sediment dispersal following piled foundation installation

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Near-field*	Low	Negligible	Negligible	Negligible	Negligible
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible

*The near-field impacts are confined to a small area of seabed likely to be up to a kilometre from each foundation location and would not cover the whole of North Falls.

Table 8.20 Magnitude of impacts on seabed level changes due to deposition under the worst case scenario for sediment mound creation following piled foundation installation

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Near-field*	Low	Low-Medium	Low-Medium	Medium	Medium
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible

*The near-field impacts are confined to a small area of seabed (likely to be immediately adjacent to each wind turbine location) and would not cover the whole of North Falls.

8.6.2.4.3 Effect significance

149. The overall effect of foundation installation activities for the Project under a worst case scenario on seabed level changes for the Suffolk coast, Essex coast and Margate and Long Sands SAC is negligible adverse significance. This is because there is a separation distance of at least 10.9km between the nearest sediment release point and the receptors noted above. Also, transport of the aggregated clasts in the mounds would be limited, and so there would be no pathway between the source (mounds) and the receptors (Margate and Long Sands SAC and Essex coast and Suffolk coast).

150. The array area is located outside and adjacent to the KKE MCZ. The layout of turbines will be decided post consent, however as the rotors must be within the array area boundary, the centre point of the platform foundations will at least the distance of a rotor radius (minimum 118m) from the MCZ. The deposited sediment layer across the wider seabed area, including the MCZ, would be approximately 40mm over a seabed area within 300m of each foundation. After this initial deposition, this sediment will be continually re-suspended to reduce the thickness even further to a point where it will be effectively zero. This will be the longer-term outcome once the sediment supply from foundation installation has ceased. The worst case scenario assumes that piles would be drilled to their full depth for the given water depth. In practice, the volumes of sediment released would be lower than the worst case because the detailed design process would optimise the foundation type and installation method to the site conditions. The overall significance of effect associated with sediment dispersal would be no greater than negligible adverse.

151. Impacts on seabed level have the potential to affect other receptors and the assessment of effect significance is addressed within the relevant chapters of this ES (see Section 8.10).

8.6.2.5 Impact 3: Changes in SSCs due to export cable installation

152. The detail of the export cabling is dependent upon the final project design, but present estimates are that the maximum length of export cable could be up to 125.4km (two cables of 62.7km each).

153. Sandwave levelling (pre-sweeping) may be required along the offshore cable corridor prior to installation. The worst case scenario assumes that sediment would be dredged and returned to the water column at the sea surface as overflow from a dredger vessel. This process would cause local and short-term increases in SSCs both at the point of dredging at the seabed and, more importantly, at the point of its discharge back into the water column.

154. Mobilised sediment from these activities may be transported by wave and tidal action in suspension in the water column. The sediment released at any one time would depend on the capacity of the dredger. Any sediment excavated during sandwave levelling would be disposed of within the North Falls offshore project area, meaning there will be no net loss of sand from the site.

155. The installation of the export cable has the potential to disturb the shallow sub-seabed down to an average of 1.2m (depending on the area) and a width of up to 1m. A trench will also be required at the HDD exit location, which will be located on the seabed at approximately 1 to 8m depth. Table 8.2 summarises the worst case scenario sediment releases.

156. The types and magnitudes of impacts that could be caused have previously been assessed within industry best-practice documents on cabling techniques (BERR, 2008; The Crown Estate/RPS, 2019). These documents have been used in the conceptual evidence-based assessment of site conditions to inform the assessment.

157. Also, although SSCs will be elevated they are likely to be lower than concentrations that would develop in the water column during storm conditions, including the December 2013 storm surge and other recent events. Storms can rapidly change seabed sediment distribution through re-suspension and re-deposition. They are short-term natural phenomenon that are likely to drive greater changes to the seabed than the changes that would occur due to the presence of the wind farm infrastructure. Also, once jetting is completed, tidal currents are likely to rapidly disperse the suspended sediment (i.e. over a period of a few hours) in the absence of any further sediment input.

158. It is likely that the increase in concentrations would be greatest in the shallowest sections of the offshore cable corridor, but in these locations the background concentrations are also greater than in deeper waters, with values of about 100mg/l (Cefas, 2016).

159. Modelling simulations undertaken for GWF confirm the evidence-based assessment. The model assumed a continuous installation of a 240km export cable (0.5m wide and buried at a depth of 1.5m) by jetting over a ten-day period. Results predicted increased SSC up to 14km from the offshore cable corridor. However, SSCs at this distance were typically less than 0.2mg/l (ABPmer, 2011b). Over the entire simulation period, SSCs at peak flow were predicted to be less than 0.5mg/l above natural background levels (ABPmer, 2011b). Elevated SSCs were dispersed by tidal currents along the dominant north-east

to south-west axis and were a short-term effect. Elevated SSCs were not expected over a wider coastal area.

160. As described in Section 8.4.6, there are similarities in water depth, sediment types, metocean conditions and length of the offshore cable corridor for GWF and the proposed North Falls project. This makes the GWF modelling study a suitable analogue for the present assessment.

161. The HDD exit point will be in the subtidal zone seaward of the low water mark. The cable exit point would require excavation of a trench to bury the nearshore portion of the offshore cable. This excavation has the potential to increase SSCs close to shore.

162. During the excavation process the SSCs will be elevated above prevailing conditions but are likely to remain within the range of background nearshore levels (which will be high close to the coast because of increased wave activity) and lower than those concentrations that would develop during storm conditions. Also, once jetting is completed, the conditions in the high energy nearshore zone are likely to result in rapid dispersal of the suspended sediment (i.e. over a period of a few hours) in the absence of any further sediment input.

163. Excavated sediment would be backfilled into the trench by mechanical means (within a few days of excavation) and the nearshore zone re-instated close to its original morphology. This activity would result in some local and short-term disturbance to the beach and nearshore zone, but there would be no long-term effect on sediment transport processes.

8.6.2.5.1 Sensitivity

164. Due to the nature of the pressure (increase in SSCs due to export cable installation) there is no pathway for effect to all identified receptors so therefore they are not sensitive to this pressure.

8.6.2.5.2 Magnitude

165. The worst case changes in SSCs due to export cable installation are likely to have the magnitudes of impact shown in Table 8.21. This is applicable to grid connection Options 1 and 2 only.

Table 8.21 Magnitude of impacts on SSCs under the worst case scenario for export cable installation

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Near-field* (nearshore)	Low	Negligible	Negligible	Negligible	Negligible
Near-field* (offshore)	Low	Negligible	Negligible	Negligible	Negligible
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible

* The near-field impacts are confined to a small area likely to be of the order up to a kilometre from the offshore cable corridor and would not cover the whole offshore cable corridor.

8.6.2.5.3 Effect significance

166. The effects on SSCs due to export cable installation would have no change upon the identified receptor groups for marine geology, oceanography and physical processes and no significant effect will occur. This is because the

receptors are dominated by processes that are active along the seabed and are not affected by sediment suspended in the water column. However, there may be effects arising from subsequent deposition of the suspended sediment on the seabed and these are discussed under construction Impact 4 (Section 8.6.2.6).

167. The impact on SSC in the offshore cable corridor (for Options 1 and 2) does have the potential to affect other receptors and therefore the assessment of effect significance is addressed within the relevant chapters of this ES (see Section 8.10).

8.6.2.6 Impact 4: Changes in seabed level due to offshore export cable installation

168. The assessment of changes in seabed level due to offshore export cable installation has been considered separately from those for the array and platform interconnector cables.

169. The increases in SSCs associated with offshore export cable installation have the potential to result in changes in seabed level as the suspended sediment deposits.

170. The plume modelling simulations undertaken for offshore export cable installation for GWF indicated that the larger sediment sizes (fine sand) would result in the greatest bed thickness changes, although the maximum seabed thickness change simulated is less than 0.015mm (ABPmer, 2011b). The sand was deposited over an area of less than 30m^2 (ABPmer, 2011b). Should any sediment deposition occur along the coast, it will be rapidly dispersed by wave action. As there is already significant ambient sand transport in the vicinity, the small amounts of additional re-settled sand will not significantly change the local transport. The coarse sediment observed across the offshore cable corridor would behave in this manner.

171. The mud-sized sediment present along the offshore cable corridor close to shore and at the eastern end of the offshore cable corridor close to the array area (Section 8.5.6) would be advected a greater distance and persist in the water column for hours to days, before depositing to form a thin a layer on the seabed. However, it is anticipated that under the prevailing hydrodynamic conditions, this sediment would be readily re-mobilised, especially in the shallow inshore area where waves would regularly agitate the bed. Accordingly, outside the immediate vicinity of the offshore cable trench, bed level changes and any changes to seabed character are expected to be immeasurable in practice.

8.6.2.6.1 Sensitivity

172. The sensitivity and value of all relevant receptors are presented in Table 8.22.

Table 8.22 Sensitivity and value assessment of relevant receptors

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Suffolk coast	Negligible	Negligible	Negligible	High	Negligible
Essex coast	Negligible	Negligible	Negligible	High	Negligible
Annex I sandbanks	Negligible	Negligible	Negligible	High	Negligible

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Margate and Long Sands SAC	Negligible	Negligible	Negligible	High	Negligible
KKE MCZ	Negligible	Negligible	Negligible	High	Negligible

8.6.2.6.2 Magnitude

173. The worst case changes in seabed level due to export cable installation are likely to have the magnitudes of impact described in Table 8.23. This is applicable to grid connection Options 1 and 2 only.

Table 8.23 Magnitude of impact on seabed level changes due to export cable installation under the worst case scenario for SSCs

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Near-field*	Low	Negligible	Negligible	Negligible	Negligible
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible

*The near-field impacts are confined to a small area of seabed likely to be up to a kilometre from each foundation location and would not cover the whole of North Falls.

8.6.2.6.3 Effect significance

174. Based on the GWF plume modelling simulations, conceptual evidence-based assessment of deposition from the plume generated from cable installation indicates that the changes in seabed elevation are effectively immeasurable within the accuracy of any numerical model or bathymetric survey. This means that given these very small magnitude changes in seabed level arising from offshore export cable installation, the effects on the identified morphological receptors would not be significant. Hence, the overall effect of offshore cable installation activities under a worst case scenario on seabed level changes for the identified morphological receptor groups is negligible adverse (no significant effect) for Essex coast, Margate and Long Sands SAC, Annex I sandbanks and KKE MCZ receptors. Given the bedload sediment transport direction is to the south-west (Section 8.5.7), and the distance between the closest sediment release point and the Suffolk coast is 11.1km, there is no change on this receptor.

175. In many parts of the offshore cable corridor, export cable installation is unlikely to result in the release of the volumes of sediment considered under this worst case scenario. In addition, the optimisation of the offshore cable route selection within the corridor, and the depth and installation methods during detailed design would ensure that effects are minimised.

176. The impacts on seabed level also have the potential to affect other receptors and therefore the assessment of effect significance is addressed within relevant chapters of this ES (see Section 8.10).

8.6.2.7 Impact 5: Changes in SSCs due to offshore array and platform interconnector cable installation

177. Sandwave levelling (pre-sweeping) may be required for the array/platform interconnector cable prior to installation. The worst case scenario assumes that

sediment would be dredged and returned to the water column at the sea surface as overflow from a dredger vessel. This process would cause local and short-term increases in SSCs both at the point of dredging at the seabed and more importantly, at the point of its discharge back into the water column. Table 8.2 summarises the worst case scenario volume of sediment disturbed.

178. Mobilised sediment from these activities may be transported by wave and tidal action in suspension in the water column. The disturbance effects at each location are likely to last for no more than a few days. The sediment released at any one time would depend on the capacity of the dredger. Any sediment excavated during sandwave levelling would be disposed of within the North Falls offshore project area, meaning there will be no net loss of sand from the site.

179. The types and magnitudes of impacts that could be caused have previously been assessed within an industry good practice document on cabling techniques (BERR, 2008). This document has been used to support the evidence-based assessment of site conditions to inform the below.

180. Conceptual evidence-based assessment indicates that the changes in SSCs due to array cable installation would be like those that have been assessed in relation to the disturbance of near-surface sediments during foundation installation activities (see Construction Impact 1a – Section 8.6.2.1).

8.6.2.7.1 Sensitivity

181. Due to the nature of the pressure (increase in SSCs due to array cable installation) there is no pathway for effect to all identified receptors so therefore they are not sensitive to this pressure. This is because the receptors are dominated by processes that are active along the seabed and are not affected by sediment suspended in the water column.

8.6.2.7.2 Magnitude

182. The worst case changes in SSCs due to the installation of the array and platform interconnector cables are likely to have the magnitudes of impact shown in Table 8.24.

Table 8.24 Magnitude of impact on SSCs under the worst case scenario for array and platform interconnector cable installation

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Near-field*	High	Negligible	Negligible	Negligible	Medium
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible

* The near-field impacts are confined to a small area likely to be up to a kilometre from the cable and would not cover the entirety of the seabed within the North Falls array area.

8.6.2.7.3 Effect significance

183. The effects on SSCs due to array and platform interconnector cable installation (including that from any seabed preparation) will have no change (i.e. no significant effect) upon the identified receptor groups for marine geology, oceanography and physical processes. This is because the receptors are dominated by processes that are active along the seabed and are not affected by sediment suspended in the water column. However, there may be effects

arising from subsequent deposition of the suspended sediment on the seabed and these are discussed under Construction Impact 6 (Section 8.6.2.8).

184. The impact on SSC does have the potential to affect other receptors and the assessment of effect significance is addressed within the relevant chapters of this ES (see Section 8.10).

8.6.2.8 Impact 6: Changes in seabed level due to offshore array and platform interconnector cable installation

185. The increases in SSCs associated with Construction Impact 5 (Section 8.6.2.7) have the potential to result in changes in seabed level as the suspended sediment deposits.

186. The evidence-based assessment suggests that coarser sediment disturbed during cable installation would fall rapidly to the seabed (minutes or tens of minutes) as a highly turbid dynamic plume immediately after it is discharged. Deposition of this sediment would form a linear mound (likely to be tens of centimetres high) parallel to the cable as the point of release moves along the excavation. The coarse sediment particle sizes observed across the array area would behave in this manner and be similar in composition to the surrounding seabed. This would mean that there would be no significant change in seabed sediment type.

187. Mud-sized sediment would also be released to form a passive plume and become more widely dispersed before settling on the seabed. The conceptual evidence-based assessment suggests that due to the dispersion by tidal currents, and subsequent deposition and re-suspension, the deposits across the wider seabed would be very thin (millimetres).

188. This theoretical assessment is supported by modelling results for GBS foundation installation for GWF (considered a highly conservative worst case scenario), which predicted bed thickness changes of 0.03mm (ABPmer, 2011b). This is within the natural variation in bed level change for the area.

8.6.2.8.1 Sensitivity

189. The sensitivity and value of all relevant receptors are presented in Table 8.25.

Table 8.25 Sensitivity and value assessment of relevant receptors

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Suffolk coast	Negligible	Negligible	Negligible	High	Negligible
Essex coast	Negligible	Negligible	Negligible	High	Negligible
Annex I sandbanks	Negligible	Negligible	Negligible	High	Negligible
Margate and Long Sands SAC	Negligible	Negligible	Negligible	High	Negligible
KKE MCZ	Negligible	Negligible	Negligible	High	Negligible

8.6.2.8.2 Magnitude

190. Evidence-based assessment indicates that changes in seabed level due to array and platform interconnector cable installation (including any deposition arising from sandwave levelling) would be minor and are likely to have the magnitudes of impact shown in Table 8.26.

Table 8.26 Magnitude of impact on seabed level changes due to deposition under the worst case scenario for sediment dispersal following array and platform interconnector cable installation (including sandwave levelling)

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Near-field*	Low	Negligible	Negligible	Negligible	Negligible
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible

*The near-field impacts are confined to a small area of seabed likely to be up to a kilometre from the cable and would not cover the whole of North Falls.

8.6.2.8.3 Effect significance

191. The impact on seabed level is highly unlikely to have the potential to directly affect the identified receptor groups for marine geology, oceanography and physical processes. Consequently, the overall effect significance of array and platform interconnector cable installation on seabed level changes for the Essex coast, Suffolk coast, and Margate and Long Sands SAC is negligible adverse (no significant effect) due to the separation distance between these receptors and the array and platform interconnector cables. The overall effect significance of array and platform interconnector cable installation under a worst case scenario on seabed level changes for Annex I sandbanks and KKE MCZ is negligible adverse (no significant effect).

192. The impacts on seabed level also have the potential to affect other receptors and the assessment of impact significance is addressed within the relevant chapters of this ES (see Section 8.10).

8.6.2.9 Impact 7: Interruptions to bedload sediment transport due to sandwave levelling for offshore export cable, array cable and platform interconnector cable installation

193. Sandwave levelling (pre-sweeping) may be required prior to export cable and offshore array cable installation. The removal of sandwaves could potentially interfere with sediment transport pathways that supply sediment to the local sandbank systems, including those designated under the Margate and Long Sands SAC.

194. Any excavated sediment due to sandwave levelling would be disposed of within the North Falls offshore project area so there will be no net loss of sand from the site. Tidal currents would, over time, re-distribute the sand back over the levelled area (as re-formed sandwaves). The extent of sandwave levelling required and specific disposal locations within the offshore project area would be determined post consent following detailed geophysical surveys. However, given the relatively low volumes of sand likely to be affected, the overall effect of changes to the seabed would be minimal.

195. The dynamic nature of the sandwaves in this area means that any direct changes to the seabed associated with sandwave levelling are likely to recover

over a short period of time due to natural sand transport pathways. This conceptual evidence-based assessment is supported by the findings of a review of the evidence base into the recovery of sandwaves at the similarly dynamic areas of Race Bank and Haisborough, Hammond and Winterton SAC (ABPmer, 2018b).

196. To install parts of the array and export cables for Race Bank Offshore Wind Farm, the crests of sandwaves were reduced in elevation. Ørsted (2018) reported the results of multibeam echosounder monitoring of pre- (2015/2016), during (2017) and post- (2018) sandwave levelling (pre-sweeping) to assess the level of disturbance and the rate of natural recovery (restoration) of seabed morphology. Nine areas were chosen (seven array cables routes and two areas along the offshore cable corridors) where significant sediment mobility was expected. The results showed that along most of the nine study areas, the seabed had completely or nearly completely recovered to pre-construction levels (greater than 75% recovery of sandwaves in all areas).

197. ABPmer (2018b) completed a sandwave study in relation to cable installation activities in the Haisborough, Hammond and Winterton SAC which has informed the impact assessments for the Norfolk Projects. They showed that the cable corridor is in an active and highly dynamic environment governed by current flow speeds, water depth and sediment supply, all of which are conducive to the development and maintenance of sandbanks. Therefore, despite the disturbance to sandwaves intersecting the cable corridor, the Haisborough, Hammond and Winterton SAC sandbank system would remain undisturbed as new sandwaves will continue to be formed. They concluded that the overall form and functioning of any sandwave, or the SAC sandbank system, is not disrupted by levelling of the sandwaves.

8.6.2.9.1 Sensitivity

198. The sensitivity and value of all relevant receptors are presented in Table 8.27.

Table 8.27 Sensitivity and value assessment of relevant receptors

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Suffolk coast	Negligible	Negligible	Negligible	High	Negligible
Essex coast	Negligible	Negligible	Negligible	High	Negligible
Annex I sandbanks	Negligible	Negligible	Negligible	High	Negligible
Margate and Long Sands SAC	Negligible	Negligible	Negligible	High	Negligible
KKE MCZ	Negligible	Negligible	Negligible	High	Negligible

8.6.2.9.2 Magnitude

199. The worst case changes in bedload sediment transport due to sandwave levelling within the offshore export cable and offshore array cables are likely to have the magnitudes of impact described in Table 8.28.

Table 8.28 Magnitude of impact on bedload sediment transport under the worst case scenario for sandwave levelling within the offshore export cable and offshore array cables

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Near-field*	Medium	Negligible	Negligible	Negligible	Low
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible

*The near-field impacts are confined to a small area of seabed (likely to be of the order of several hundred metres up to a kilometre from the cable corridor) and would not cover the whole cable corridor.

8.6.2.9.3 Effect significance

200. Keeping the dredged sand within the sandbank system enables the sand to become re-established within the local sediment transport system by natural processes and encourages the re-establishment of the bedforms. Given the local favourable conditions that enable sandwave development, the sediment would be naturally transported back into the levelled area within a short period of time. The levelled area will naturally act as a sink for sediment in transport and will be replenished in the order of a few days to a year. The overall effect significance of sandwave levelling activities within the offshore cable corridor (for Options 1 and 2) on the Suffolk coast and KKE MCZ is no change due to the separation distance between these receptors and the offshore array cables. The overall effect significance for the array cables and platform interconnector cable (all Options) on the Suffolk and KKE MCZ is negligible. The overall effect significance of sandwave levelling activities on the Essex coast, Annex I sandbanks and Margate and Long Sands SAC is negligible adverse (no significant effect).

201. The impacts on bedload sediment transport also have the potential to affect other receptors and the assessment of effect significance is addressed within relevant chapters of this ES (see Section 8.10).

8.6.2.10 Impact 8: Indentations on the seabed

202. There is potential for UXO clearance and certain vessels used during installation of foundations and cable infrastructure to directly impact the seabed.

203. This applies for those vessels that utilise jack-up legs or several anchors to hold station and to provide stability for a working platform. Where legs or anchors (and associated chains) have been inserted into the seabed and then removed, there is potential for an indentation to remain, proportional to the dimensions of the object. The worst case scenario corresponds to the use of jack-up vessels, since the depressions would be greater than the anchor scars.

204. As the leg is inserted, the seabed sediments would primarily be compressed vertically downwards and displaced laterally. This may cause the seabed around the inserted leg to be raised in a series of concentric pressure ridges. As the leg is retracted, some of the sediment would return to the hole via mass slumping under gravity until a stable slope angle is achieved. Over the longer term, the hole would become shallower and less distinct due to infilling with mobile seabed sediments. Post-construction monitoring of indentations on the seabed caused by jack-ups during the installation of Dudgeon Offshore Wind Farm (DOW) indicate that natural processes are restoring local areas of seabed affected by the construction works.

205. A six-legged jack-up barge used for the installation of turbines/OSP/OCPs would have a footprint of 1,650m². Each leg could penetrate 5 to 15m into the seabed and may be cylindrical, triangular, truss leg or lattice. The worst case scenario assumes that six jack-up events will be required at each turbine/OSP/OCP (Table 8.2).

206. Vessels may also require anchoring during turbine and OSP/OCP installation. Anchor footprints of 116.4m² are assumed, with eight anchors per vessel and five placements per turbine/OSP/OCP. The total footprint of anchoring during turbine/OSP/OCP installation is 344,529m² (Table 8.2).

207. Cable installation vessels will also be required to anchor. Anchor footprints of 61m² are assumed, with nine anchors per vessel and 432 placements during array and platform interconnector cable installation and 545 during export cable installation. The total footprint of anchoring is 533,728m² (Table 8.2).

208. Craters formed during UXO clearance are reported from other offshore wind farms to range from approximately 2m² to 25m². A review of potential UXO in the southern North Sea (Ørdtek, 2018) estimates the largest predicted crater is around 350m². Up to 15 UXO clearance operations are predicted in the array area and 25 in the offshore cable corridor.

8.6.2.10.1 Sensitivity

The sensitivity and value of all relevant receptors are presented in Table 8.29.

Table 8.29 Sensitivity and value assessment of relevant receptors

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Essex coast	Negligible	Negligible	Negligible	High	Negligible
Suffolk coast	Negligible	Negligible	Negligible	High	Negligible
Annex I sandbanks	Negligible	Negligible	Negligible	High	Negligible
Margate and Long Sands SAC	Negligible	Negligible	Negligible	High	Negligible
KKE MCZ	Negligible	Negligible	Negligible	High	Negligible

8.6.2.10.2 Magnitude

209. The worst case changes in terms of indentations on the seabed due to installation vessels and UXO clearance are likely to have the magnitudes of impact described in (Table 8.30).

Table 8.30 Magnitude of impact on seabed level changes under the worst case scenario for installation vessel indentations and UXO clearance

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Near-field (footprint of leg/anchor/crater)	High	Negligible	Negligible	Medium	Medium
Near-field (beyond the footprint of leg/anchor)	No change	-	-	-	No change

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Far-field	No change	-	-	-	No change

8.6.2.10.3 Effect significance

210. The footprint of jack-ups and mooring lines used during the installation of turbines/OSPs/OCP and platform interconnector cables and the craters formed during UXO clearance in the array area would not extend beyond the direct footprint. Therefore, there is no change from these activities on the Suffolk and Essex coasts since these receptors are located remotely from the zone of influence.

211. The layout of turbines and offshore cables will be decided post consent. However, if it is not possible for jack-up vessel legs, vessel anchors, or UXO clearance, to avoid Annex I sandbanks, there is potential for indentations to occur. However, any disturbance footprint would be limited in scale (see Table 8.2) and any impacts would be temporary in nature with indentations infilling through natural processes over the course of a few days to months. Therefore, the likely effect of these activities is negligible adverse which is not significant.

212. Installation of the offshore export cable and cable protection measures at the HDD exit point may involve an anchor footprint. These activities will be local and temporary and therefore a negligible adverse effect which is deemed to be not significant will occur on the nearshore area of the Essex coast.

213. The significance of the effects on other receptors is addressed within the relevant chapters of this ES (see Section 8.10).

8.6.3 Likely significant effects during operation

214. During the operation phase, there is potential for the presence of foundations to cause changes to the tidal and wave regimes due to physical blockage effects. These changes could potentially affect the sediment regime and/or seabed morphology. These potential impacts are considered as Operational Impacts 1 to 6. In addition, there is potential for disturbance of the seabed during maintenance activities. These potential impacts are considered as Operational Impact 7.

8.6.3.1 Impact 1: Changes to the tidal current regime due to the presence of structures on the seabed (wind turbines and OSP/OCP foundations)

215. The presence of the worst case GBS wind turbine foundations and OSP/OCP foundation structures on the seabed within North Falls has the potential to alter the baseline tidal current regime. Any changes to the tidal current regime have the potential to contribute to changes in seabed morphology due to alteration of sediment transport patterns (see Operational Impact 3, Section 8.6.3.3).

216. The conceptual evidence-based assessment suggests that each foundation would present an obstacle to the passage of currents locally, causing a small modification to the height and/or phase of the water levels and a wake in the current flow. This latter process involves a deceleration of flow immediately upstream and downstream of each foundation and an acceleration of flow

around the sides of each foundation. Current speeds return to baseline conditions with progression downstream of each foundation and generally do not interact with wakes from adjacent foundations due to the relatively large separation distances.

217. The assessment of tidal currents was undertaken at Five Estuaries on 79 smaller WTGs on conical gravity bases, and two OSP/OCP multi-leg jacket foundations with suction buckets. This means the North Falls design (57 GBS wind turbine foundations) is a more conservative design compared to Five Estuaries (Section 8.4.6). The Five Estuaries assessment showed that changes to current speed would be less than 0.05 m/s (Five Estuaries Wind Farm Ltd, 2023). These changes are very small, both in absolute and relative terms, within the range of natural variability, and not measurable in practice. Corresponding changes to current direction are less than one degree.

218. The assessment of tidal currents at the adjacent GWF (Section 8.4.6), concluded that there would be no significant changes to the broad-scale flow regime, with a reduction in the overall flow within the wind farm boundary of 5% at peak flood and 4% at peak ebb, and an increase in flow between the turbine rows (ABPmer, 2011a). The changes modelled only last a maximum of ten minutes at one time (ABPmer, 2011a). No significant impact on the tidal current regime was predicted for GWF, and the same conclusion (based on the similarities between GWF and North Falls, see Section 8.4.6) is reached for North Falls.

219. In addition, there is a pre-existing scientific evidence base which demonstrates that changes in the tidal regime due to the presence of foundation structures are both small in magnitude and local in spatial extent. This is confirmed by existing guidance documents (ETSU, 2000, 2002; Lambkin et al., 2009) and numerous Environmental Statements for a range of existing and planned offshore wind farms.

8.6.3.1.1 Sensitivity

220. The sensitivity and value of all relevant receptors are presented in Table 8.31.

Table 8.31 Sensitivity and value assessment of relevant receptors

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Suffolk coast	Medium	Low	Negligible	High	Low
Essex coast	Medium	Low	Negligible	High	Low
Annex I sandbanks	Negligible	Negligible	Negligible	High	Negligible
Margate and Long Sands SAC	Negligible	Negligible	Negligible	High	Negligible
KKE MCZ	Negligible	Negligible	Negligible	High	Negligible

8.6.3.1.2 Magnitude

221. The worst case changes to tidal currents due to the presence of GBS wind turbine foundations and OSPs/OCP are likely to have the magnitudes of impact shown in Table 8.32.

Table 8.32 Magnitude of impact on tidal currents under the worst case scenario for the presence of GBS foundations and OSPs/OCP

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Near-field	Low	High	Medium	Negligible	Medium
Far-field	Negligible	High	Medium	Negligible	Low

222. The effects on the tidal current regime have been translated into a 'zone of potential influence' (ZoI) based on an understanding of tidal ellipses. The ZoI is based on the knowledge that effects arising from wind turbine and OSP/OCP foundations on tidal currents are relatively small in magnitude, and local. It is expected that changes would return to background levels immediately outside the excursion of one tidal ellipse, and this threshold has been used to produce the maximum ZoI on the tidal current regime, as presented in ES Figure 8.16 (Document Reference: 3.2.4). The ZoI overlaps with the KKE MCZ and Annex I sandbanks. It does not overlap the Suffolk coast, Essex coast or Margate and Long Sands SAC.

8.6.3.1.3 Effect significance

223. The Suffolk coast, Essex coast and Margate and Long Sands SAC receptor groups for marine geology, oceanography and physical processes are remote from the ZoI on the tidal current regime. Due to this, no pathway exists between the source and these receptors, so in terms of effects on these receptor groups there is no change associated with North Falls.

224. The predicted ZoI for North Falls encompasses Annex I sandbanks and KKE MCZ. As outlined in Section 8.6.3.1, no significant impact on the tidal current regime is anticipated for North Falls and therefore the effect on the Annex I sandbanks and KKE MCZ is negligible adverse (not significant).

8.6.3.2 Impact 2: Changes to the wave regime due to the presence of structures on the seabed (wind turbine and OSP/OCP foundations)

225. The presence of GBS wind turbine foundations and OSP/OCP foundation structures on the seabed within North Falls has the potential to alter the baseline wave regime, particularly in respect of wave heights and directions. Any changes in the wave regime may contribute to changes in seabed morphology due to alteration of sediment transport patterns (see operational Impact 3, Section 8.6.3.3).

226. The wave modelling considered several wave and wind directions to determine the worst case direction, that is the direction that results in the worst-case nearshore wave conditions along the Essex and Suffolk coasts. The simulations predict that changes to 1 in 1 year return period waves approaching from the east resulted in the worst-case nearshore wave conditions. This combination of directional sector and return period was therefore used in the assessment of effects. All of the results from the modelling campaign are presented in Appendix 8.1.

227. ES Figure 8.17 (Document Reference: 3.2.4) shows the difference in significant wave height between the baseline condition and the North Falls foundation layout for the 1 in 1 year return period event. The results show that each foundation would present an obstacle to the passage of waves locally, causing

a small modification to the height and / or direction of the waves as they pass. Reflection from the wind turbines would result in a slight increase in wave conditions, up to about 2% of the significant wave height east of the array area.

228. Also, the presence of the foundations causes a wave shadow effect to be created by each foundation resulting in a slight reduction in wave conditions, up to about 2% of the significant wave height west of the array area. Wave heights return to baseline conditions with progression downstream of each foundation and generally do not interact with effects from adjacent foundations due to the separation distances. There is no change to the nearshore wave conditions along the Essex and Suffolk coasts.

229. ES Figure 8.18 (Document Reference: 3.2.4) describes the percentage difference in wave direction induced by the foundation layout. Predicted changes in direction are +/-0.8 degrees over limited footprints to the east and west of the array area.

8.6.3.2.1 Sensitivity

230. The sensitivity and value of all relevant receptors are presented in Table 8.33.

Table 8.33 Sensitivity and value assessment of relevant receptors

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Suffolk coast	Medium	Low	Negligible	Medium	Negligible
Essex coast	Medium	Low	Negligible	Medium	Negligible
Annex I sandbank	Negligible	Negligible	Negligible	High	Negligible
Margate and Long Sands SAC	Negligible	Negligible	Negligible	High	Negligible
KKE MCZ	Negligible	Negligible	Negligible	High	Negligible

8.6.3.2.2 Magnitude

231. The worst case changes to the wave regime due to the presence of GBS foundations are likely to have the magnitudes of impact shown in Table 8.34.

Table 8.34 Magnitude of impact on the wave regime under the worst case scenario for the presence of GBS foundations

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Effect
Near-field	Low	High	Medium	Negligible	Medium
Far-field	Negligible	High	Medium	Negligible	Low

8.6.3.2.3 Effect significance

232. The Essex coast, Suffolk coast and Margate and Long Sands SAC receptor groups for marine geology, oceanography and physical processes are remote from the zone of influence. Due to this, no pathway exists between the source and the receptor in these areas, and so in terms of effects on these receptor groups there is no change associated with the Project.

233. However, the zone of influence encroaches onto the KKE MCZ and Annex I sandbank receptor groups. The change in wave height would only be a few percent within these zones of encroachment. Hence the effect significance on these receptor groups would be negligible adverse.

8.6.3.3 Impact 3: Changes to the sediment transport regime due to the presence of structures on the seabed (wind turbine and OSP/OCP foundations)

234. Modifications to the tidal current regime and/or the wave regime due to the presence of the foundation structures during the operational phase may affect the sediment transport regime. This section addresses the broader patterns of suspended and bedload sediment transport across, and beyond, North Falls and sediment transport at the coast.

235. The predicted reductions in tidal currents (Operational Impact 1) and waves (Operational Impact 2) associated with the presence of the worst case GBS foundation structures would result in a reduction in the sediment transport potential across the areas where such changes are observed. Conversely, the areas of increased tidal flow around each wind turbine would result in increased sediment transport potential.

236. These changes to the marine geology, oceanography and physical processes would be both low in magnitude and largely confined to local wake or wave shadow effects attributable to individual wind turbine foundations and, therefore, would be small in geographical extent. In the case of wave effects, there would also be reductions due to a shadow effect across a greater seabed area, but the changes in wave heights across this wider area would be notably lower (typically less than 1%) than the changes local to each wind turbine foundation.

237. Five Estuaries Wind Farm Ltd (2023) assessed changes to tidally driven sediment transport at Five Estuaries and predicted no measurable change in residual sand transport rate or direction, either within the Five Estuaries array, or elsewhere. The effect on wave-driven transport was deemed not measurable in practice and within the range of natural variability (and would only add a small contribution to the tidally dominated transport).

238. ABPmer (2011a) assessed the potential impact to regional bedload transport processes caused by changes in flow vectors (speed and direction) and bed shear stress because of the installation of GWF. The numerical model showed that neither speed nor direction of the tidal currents was greatly affected by the installation of the wind farm.

239. A comparison of bed shear stress values before and after the GWF installation was undertaken during times of peak flow within the study area (ABPmer, 2011a). Changes in bed shear stress were typically restricted to within the GWF boundary, with some changes occurring to the north and south of the boundary depending on the tidal direction. Changes outside the array area were restricted to within 0.5km of the GWF boundary and were about -0.1 N/m^2. The centre of the array area was subject to local reductions in bed shear stress, whilst there were marginal increases (less than $0.25N/m^2$) in the east and west of the GWF array. It was considered unlikely that the changes simulated would result in a change in seabed form (ABPmer, 2011a).

240. The main concern with respect to seabed morphology was the potential change to the form and function of Outer Gabbard sandbank. This was also raised as a

concern during the GGOW consultation process (with respect to the Galloper and Inner Gabbard sandbanks), which resulted in the development of an exclusion zone around these sandbanks (ABPmer, 2011a). The position of these sandbanks with respect to North Falls is shown in ES Figure 8.14 (Document Reference: 3.2.4).

241. Numerical modelling predictions showed that reductions in bed shear stress occurred along and adjacent to Outer Gabbard sandbank during flood and ebb tidal conditions (ABPmer, 2011a). Changes only occurred in the lee of the turbines, with no bed shear stress changes noted alongside the main axis of flow through the GWF array. The maximum reduction in bed shear stress ($1N/m^2$) occurred in the shallow reaches of Outer Gabbard sandbank during both ebb and flood tides, with a larger spatial extent predicted during peak ebb tide. This may reduce the potential for mobilisation of larger sand fractions during neap tides but was not expected to be reduced during the spring tidal period.

242. The largest changes to bed shear stress were located at the GBS structures on Outer Gabbard sandbank and therefore an exclusion zone was placed around the bank. The layout of turbines for North Falls will be decided post consent.

243. A scour assessment was undertaken for GWF monopile, jacket and GBS foundations (ABPmer, 2011a). The predicted sediment volume released from scour development was found to be smaller than that released through seabed preparation activities for foundation installation ($4,163m^3$ compared to a maximum of $7,200m^3$ for a 45m GBS structure) (ABPmer, 2011a). As shown in Section 8.6.2.1 and Section 8.6.2.3, the likely significant effects of changes in suspended sediment and changes in seabed level associated with seabed preparation are negligible. Therefore, the magnitude of sediment released through scour development is also negligible. Although the affected area of the seabed is increased due to scour, it is still considered a small proportion of the overall array area.

8.6.3.3.1 Sensitivity

244. The sensitivity and value of all relevant receptors are presented in Table 8.35.

Table 8.35 Sensitivity and value assessment of relevant receptors

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Suffolk coast	Medium	Low	Negligible	Medium	Negligible
Essex coast	Medium	Low	Negligible	Medium	Negligible
Annex I sandbank	Negligible	Negligible	Negligible	High	Negligible
Margate and Long Sands SAC	Negligible	Negligible	Negligible	High	Negligible
KKE MCZ	Negligible	Negligible	Negligible	High	Negligible

8.6.3.3.2 Magnitude

245. Since it is expected that the changes in tidal flow and wave heights during the operational phase of North Falls would have no significant far-field impacts, then

the changes in sediment transport would be similar scale, with the likely magnitudes of impact shown in Table 8.36.

Table 8.36 Magnitude of effects on the sediment transport regime under the worst case scenario for the presence of GBS foundations

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Near-field	Low	High	Medium	Negligible	Medium
Far-field	Negligible	High	Medium	Negligible	Low

8.6.3.3.3 Effect significance

246. As outlined in Section 8.6.3.1 and Section 8.6.3.2, no significant effects on the wave or tidal current regimes are anticipated for North Falls and therefore the effect on the Suffolk coast, Essex coast, Annex I sandbanks, Margate and Long Sands SAC, and KKE MCZ is negligible adverse (not significant).

8.6.3.4 Impact 4: Loss of seabed area due to infrastructure within the array area

247. The seabed would be directly impacted by the footprint of each foundation structure and array cable protection within the North Falls array area. This would constitute a loss in natural seabed area during the operational life of the Project.

248. This direct footprint due to the presence of foundation structures could occur in one of two ways, without and with scour protection. Scour protection will be installed at locations where required, as determined by pre-construction surveys. A worst case scenario of all foundations and up to 20% of array cable length (38km) having scour protection is considered to provide a conservative assessment.

249. Under the worst case scenario, the seabed would be further occupied by material that is 'alien' to the baseline environment, such as concrete mattresses, fronded concrete mattresses, rock dumping, bridging or positioning of gravel bags.

250. The worst case is associated with the maximum number of 57 GBS wind turbine foundations and scour protection, two GBS OSP/OCP foundations with scour protection, and up to 20% of array cable protection (38km) (Table 8.2). This constitutes a seabed loss of 5.7% of the array area.

8.6.3.4.1 Sensitivity

251. The sensitivity and value of all relevant receptors are presented in Table 8.37.

Table 8.37 Sensitivity and value assessment of relevant receptors

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Suffolk coast	Medium	Low	Negligible	Medium	Negligible
Essex coast	Medium	Low	Negligible	Medium	Negligible
Annex I sandbank	Negligible	Negligible	Negligible	High	Negligible
Margate and Long Sands SAC	Negligible	Negligible	Negligible	High	Negligible

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
KKE MCZ	Negligible	Negligible	Negligible	High	Negligible

8.6.3.4.2 Magnitude

252. The worst-case loss of seabed due to the presence of foundation structures with scour protection and array cable protection is likely to have the magnitudes of impact shown in Table 8.38. It is likely that any secondary scour effects associated with scour protection would be confined within a few metres of the direct footprint of that scour protection.

Table 8.38 Magnitude of impacts on seabed morphology under the worst case scenario for the footprint of foundations and scour protection

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Near-field*	High	High	High	Negligible	High
Far-field	No change	-	-	-	No change

*The near-field impacts are confined to within the footprint of each foundation structure

8.6.3.4.3 Effect significance

253. The near-field impacts are confined to the footprint of each foundation structure, and therefore have no pathway to the Essex coast, Suffolk coast, Margate and Long Sands SAC and KKE MCZ receptors. There is therefore no change.

254. A loss of seabed will have a negligible adverse effect on sandbanks (and associated sandwaves) as sand will continue to be transported around the wind turbine foundations and over any scour protection due to the dynamic nature of the area. There is therefore a negligible adverse effect on Annex I sandbanks receptors which is not significant.

255. The significance of the effects on other receptors is addressed within the relevant chapters of this ES (see Section 8.10).

8.6.3.5 Impact 5: Morphological and sediment transport effects due to cable protection measures within the array area

256. As a worst case scenario, if the array and/or platform interconnector cables cannot be buried, they would be surface-laid and protected in some manner, and cable protection would also be required at any cable crossings. Cable protection will take the form of rock or concrete mattresses.

257. The impacts that such works may have on marine geology, oceanography and physical processes primarily relate to the potential for interruption of sediment transport processes and the footprint they present on the seabed. In areas of active sediment transport, any linear protrusion on the seabed may interrupt bedload sediment transport processes. There is unlikely to be any significant impact on suspended sediment processes since armoured cables or cable protection works (including where the cable crosses other sub-marine infrastructure such as pipelines and other cables) are relatively low above the seabed (a maximum of 1.4m).

258. The worst case scenario length of cable protection for the array and platform interconnector cables and crossings is 38km (Table 8.2).

259. The presence of sandwaves across the array area indicates that some bedload sediment transport exists, with a net direction from south-west to north-east (see Section 8.5.7). Protrusions from the seabed are unlikely to significantly affect the migration of sandwaves, since their heights (typically between 1m and 15m, with average wavelengths of between 25m and 37m, Fugro, 2021a) would exceed the height of cable protection works and the sandwaves would pass over them. There may be local interruptions to bedload transport in other areas, but the gross patterns across the North Falls array area would not be affected significantly.

260. Secondary scour may occur around the edge of cable protection, dependent upon the cable protection material. Once scour has developed, continuation of suspension of sediments is unlikely. It is unlikely that any impacts will occur on sediment transport because of scour around cable protection.

8.6.3.5.1 Sensitivity

261. The sensitivity and value of all relevant receptors are presented in Table 8.39.

Table 8.39 Sensitivity and value assessment of relevant receptors

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Suffolk coast	Medium	Low	Negligible	Medium	Negligible
Essex coast	Medium	Low	Negligible	Medium	Negligible
Annex I sandbank	Negligible	Negligible	Negligible	High	Negligible
Margate and Long Sands SAC	Negligible	Negligible	Negligible	High	Negligible
KKE MCZ	Negligible	Negligible	Negligible	High	Negligible

8.6.3.5.2 Magnitude

262. The worst case changes to the seabed morphology and sediment transport due to cable and crossing protection measures for array and platform interconnector cables are likely to have the magnitudes of impact shown in Table 8.40.

Table 8.40 Magnitude of impacts on seabed morphology and sediment transport under the worst case scenario for cable and crossing protection measures for array and platform interconnector cables

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Near-field*	Medium	Low	Low	Negligible	Low
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible

* The near-field impacts are confined to a small area (likely to be within the footprint of cable protection works), and would not cover the whole North Falls

8.6.3.5.3 Effect significance

263. The effects on seabed morphology and sediment transport arising from the presence of array cables and platform interconnector cables and cable protection measures would not extend far beyond the direct footprint. Therefore, there is no change associated with the Project on the Essex coast, Suffolk coast

and Margate and Long Sands SAC since these are located remotely from this zone of potential impact. If cable protection does present an obstruction to bedload transport, then it is likely that sandwaves would pass over them. Gross patterns of bedload transport would not be affected significantly, and therefore there would be a negligible adverse effect on Annex I sandbanks (and associated sandwaves) and KKE MCZ which is not significant.

264. The significance of the effects on other receptors is addressed within the relevant chapters of this ES (see Section 8.10).

8.6.3.6 Impact 6: Morphological and sediment transport effects due to cable protection measures within the offshore cable corridor

265. As a worst case scenario, it has been assumed that burial of the export cables would not practicably be achievable within some areas of the offshore cable corridor and, instead, cable protection measures would need to be provided to surface-laid cables in these areas. The locations where cable protection measures are most likely to be required are areas of cable crossings and in areas of seabed characterised by exposed bedrock. An estimate of 10% of the cable length (12.5km) requiring cable protection is included in the worst case scenario (Table 8.2). Cable protection may take the form of rock or concrete mattresses.

266. The impacts that export cable protection may have on marine geology, oceanography and physical processes primarily relate to the potential for interruption of sediment transport processes and the footprint they present on the seabed.

267. In areas of active sediment transport, any linear protrusion on the seabed may interrupt bedload sediment transport processes during the operational phase. There is likely to be a difference in impact depending on whether the cable protection works are in 'nearshore' or 'offshore' areas within the offshore cable corridor. Any works in areas close to the coast have the potential to affect wave-driven longshore sediment transport processes and circulatory pathways across any nearshore banks.

268. The seaward limit which marks the effective boundary of wave-driven sediment transport is called the 'closure depth' and is estimated to be approximately 1.5km from the coast, in about 5m water depth.

269. Any protrusions from the seabed associated with cable protection measures could potentially influence sediment transport in the nearshore and along the coast. Any interruptions to sediment transport locally within this zone could, in turn, affect the morphological response of wider areas (e.g. frontages along the sediment transport pathway) due to reductions in sediment supply to those areas.

270. The potential magnitude of the impact will depend on the local sediment transport rates. A lower rate would reduce the potential impact on sediment supply to wider areas. There are likely to be a range of sediment transport potentials across the export cables. If Pleistocene geological units are exposed at the seabed or covered by a thin lag, then they are static and have zero transport potential (i.e. no mobile sediment). If the cable protection is laid in these areas, then sediment transport is not an issue as no sediment is being transported.

271. Where the seabed is composed of mobile sand, it can be transported under existing tidal conditions. If the cable protection does present an obstruction to this bedload transport the sediment would first accumulate one side or both sides of the obstacle (depending on the gross and net transport at that location) to the height of the protrusion. With continued build-up, it would then form a 'ramp' over which sediment transport would eventually occur by bedload processes, thereby bypassing the protection. The gross patterns of bedload transport across the export cables would therefore not be impacted significantly.

272. In recognition of these potential impacts, the site selection process will consider an appropriate landfall location and offshore cable corridor which aims to minimise the need for cable protection and therefore sediment transport effects will be minimised, as far as practicably possible.

273. The presence of cable protection works on the seabed would represent the worst case in terms of a direct loss of seabed area (Table 8.2).

274. A commitment has been made to install the export cable at the landfall using HDD techniques, thus avoiding direct disturbance in the intertidal zone.

8.6.3.6.1 Sensitivity

275. The sensitivity and value of all relevant receptors are presented in Table 8.41.

Table 8.41 Sensitivity and value assessment of relevant receptors

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Suffolk coast	Medium	Low	Negligible	High	Medium
Essex coast	Medium	Low	Negligible	High	Medium
Annex I sandbank (outside SACs)	Negligible	Negligible	Negligible	High	Negligible
Margate and Long Sands SAC	Negligible	Negligible	Negligible	High	Negligible
KKE MCZ	Negligible	Negligible	Negligible	High	Negligible

8.6.3.6.2 Magnitude

276. The worst case changes to seabed morphology and sediment transport due to cable protection measures for export cables would have the magnitudes of impact shown in Table 8.42.

Table 8.42 Magnitude of impact on seabed morphology and sediment transport under the worst case scenario for cable protection measures for export cables

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Landfall intertidal zone	Negligible	High	High	Negligible	Medium
Shallower than 5m water depth	Medium	High	High	Negligible	Medium

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Deeper than 5m water depth	Low	High	High	Negligible	Medium

8.6.3.6.3 Effect significance

277. Offshore of the closure depth, the effects on seabed morphology and sediment transport arising from the presence of export cable protection measures would not extend far beyond the direct footprint. Therefore, there is no change associated with the Project on the Suffolk coast, KKE MCZ and Annex I sandbanks outside SACs since these receptors are located remotely from this zone of potential impact.

278. The Margate and Long Sands SAC is adjacent to the offshore cable corridor and therefore within the zone of influence. The low impact magnitude and negligible sensitivity outlined above would result in a negligible effect significance on the Margate and Long Sands SAC. The significance of effects on the biological receptors of the SAC are assessed in ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12).

279. Inshore of the closure depth, the placement of cable protection could result in a medium impact magnitude within the zone of influence (the Tendring Peninsula). While the sensitivity of the Essex coast is predominantly medium, the presence of coastal protection along the Tendring Peninsula (the most likely section of the Essex coast to be a receptor) means that changes to the sediment transport regime would have a realistic effect of negligible significance. In reality, cable protection could form a similar beneficial function to the existing groynes, which are aimed at restricting the flow of sediment to protect the coast.

280. The significance of the effects on other receptors is addressed within the relevant chapters of this ES (see Section 8.10).

8.6.3.7 Impact 7: Changes in SSC due to cable repairs and reburial

281. Cable repairs and reburial could be needed over the operational lifetime of North Falls.

282. The maximum disturbance volume for a cable repair is predicted to be 18,720m^3 (based on 24m width, 600m repair length and average 1.2m depth). Five repairs of the array and platform interconnector cables and four repairs of the offshore export cables are estimated over the Project life. The location of these repairs is unknown.

283. In addition, as a worst case scenario, it is estimated that 2.75% of the array and platform interconnector cables and 4% of the offshore export cables could require reburial over the Project life. The disturbance width of reburial would be 24m and average burial depth 1.2m and therefore the volume of SSC from reburial would be 150,480m^3 for array and platform interconnector cables and 144,461m^3 for offshore export cables.

284. The sediment volumes arising from repair and reburial would be small in magnitude and cause an insignificant impact in terms of enhanced SSCs and deposition elsewhere.

285. There is potential for the temporary physical disturbance associated with maintenance and repair operations to be located within the Annex I sandbanks in the array area and adjacent to KKE MCZ. In addition, export cable repairs and/or reburial could be adjacent to the Margate and Long Sands SAC.

8.6.3.7.1 Sensitivity

286. Due to the nature of the pressure (increase in SSCs due to cable repairs or reburial) there is no pathway for effect to all the identified receptors so therefore they are not sensitive to this pressure. This is because the receptors are dominated by processes that are active along the seabed and are not affected by sediment suspended in the water column.

8.6.3.7.2 Magnitude

287. The worst case changes in terms of indentations on the seabed due to maintenance vessels and cable repair and reburial footprints would have the magnitudes of impact shown in Table 8.43.

Table 8.43 Magnitude of impact on the seabed under the worst case scenario for cable repairs and reburial

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Near-field	Low	Negligible	Negligible	Negligible	Negligible
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible

8.6.3.7.3 Effect significance

288. The assessment indicates that temporary physical disturbance may occur to Annex I sandbanks in the array area (Table 8.2). Although temporary physical disturbance may occur, the need for cable repairs and/or reburial is likely to be intermittent in nature. In addition, no sediment would be removed from the array area during maintenance activities. Due to the short duration and small scale of any maintenance works (if required) there will be negligible impact on the form or function of the site. Therefore, the significance is assessed as negligible adverse (not significant).

289. The impact on SSCs does have the potential to affect other receptors and the assessment of effect significance is addressed within the relevant chapters of this ES (Section 8.10).

8.6.3.8 Impact 8: Indentations on the seabed due to O&M vessels and UXO clearance

290. For cable repair, anchor placement may be required with a total footprint of 4,914 m^2. Wind turbines and OSP/OCP maintenance may also need to be carried out, requiring the use of jack up or anchored vessels. The worst case scenario disturbance areas during maintenance are presented in Table 8.2.

291. Where legs or anchors are temporarily placed on the seabed, there is potential for an indentation to remain that is proportional in size to the dimensions of the object. There is also potential for local effects on waves, tidal currents and sediment transport and for local scour around the legs or anchors while they remain in place for the duration of the maintenance works.

292. As with UXO clearance during construction, craters may range from approximately $2m^2$ to $350m^2$. One UXO clearance operation per year is predicted during the operational life of the Project.

293. There is potential for the temporary physical disturbance associated with maintenance and repair operations to be located within the Annex I sandbanks in the array area. All other receptors listed in Table 8.13 are beyond the zone of influence of seabed indentations from O&M vessels.

8.6.3.8.1 Sensitivity

294. The sensitivity and value of all relevant receptors are presented in Table 8.44.

Table 8.44 Sensitivity and value assessment of the relevant receptor

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Annex I sandbank	Negligible	Negligible	Negligible	High	Negligible

8.6.3.8.2 Magnitude

295. The worst case changes in terms of indentations on the seabed due to maintenance vessels and UXO clearance would have the magnitudes of impact shown in Table 8.45.

Table 8.45: Magnitude of impact on the seabed under the worst case scenario for maintenance vessel indentations

Location	Scale	Duration	Frequency	Reversibility	Magnitude
Near-field (footprint of leg/anchor)	High	Negligible	Negligible	Medium	Medium
Near-field (beyond the footprint of the leg/anchor)	No change	-	-	-	No change
Far-field	No change	-	-	-	No change

8.6.3.8.3 Effect significance

296. The near-field impacts are confined to the footprint of each vessel, and therefore have no pathway to the Essex coast, Suffolk coast, Kentish Knock MCZ and Margate and Long Sands SAC receptors. There is therefore no change.

297. The assessment indicates that temporary physical disturbance may occur to Annex I sandbanks in the array area (Table 8.2). Although temporary physical disturbance may occur, the need for cable repairs is likely to be intermittent in nature. In addition, no sediment would be removed from the array area during maintenance activities. Due to the short duration and small scale of any maintenance works (if required) there will be no effect on the form or function of the site. Therefore, it is assessed as negligible adverse effect (not significant).

298. Due to the dynamic nature of sandbanks and sandwaves in this area, indentations directly impact on this receptor during the operational phase will be

of short duration and small-scale and therefore there will be a negligible adverse effect to Annex I sandbanks which is not significant.

299. The significance of the effects on other receptors is addressed within relevant chapters of this ES (see Section 8.10).

8.6.4 Likely significant effects during decommissioning

300. The scope of the decommissioning works would most likely involve removal of the accessible installed components. This is outlined in Section 5.5.16 of ES Chapter 5 Project Description (Document Reference: 3.1.7) and the detail would be agreed with the relevant authorities at the time of decommissioning. Offshore, this is likely to include removal of all the wind turbine components and part of the foundations (those above seabed level). Some or all of the array cables, platform interconnector cables, and offshore export cables may also be removed. Scour and cable protection would likely be left in situ. Table 8.2 provides an indicative worst case scenario for decommissioning.

301. During the decommissioning phase, there is potential for wind turbine foundation and cable removal activities to cause changes in SSCs and/or seabed or shoreline levels because of sediment disturbance effects. The types of effect would be comparable to those identified for the construction phase:

- Impact 1 Changes in SSCs due to foundation removal;
- Impact 2 Changes in seabed level due to foundation removal;
- Impact 3 Changes in SSCs due to removal of parts of the offshore export cable;
- Impact 4 Changes in seabed level due to removal of parts of the offshore export cable;
- Impact 5 Changes in SSCs due to removal of parts of the array and platform interconnector cables;
- Impact 6 Changes in seabed level due to removal of parts of the array and platform interconnector cables; and
- Impact 7 Indentations on the seabed due to decommissioning vessels. No UXO clearance is predicted during decommissioning as any UXO in proximity to infrastructure would have been cleared during construction and operation.

302. The magnitude of impacts would be comparable to or less than those identified for the construction phase. Accordingly, given the construction phase assessments concluded “no change” or “negligible adverse effects” for marine geology, oceanography and physical processes receptors, the same would be valid for the decommissioning phase regardless of the final decommissioning methodologies.

303. The significance of effects on other receptors is addressed within relevant chapters of this ES (ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11), ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12), ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13), ES Chapter 12 Marine Mammals (Document

Reference: 3.1.14) and ES Chapter 13 Offshore Ornithology (Document Reference: 3.1.15)).

8.7 Potential monitoring requirements

304. No further monitoring is proposed in relation to marine geology, oceanography and physical processes. This is because the outcomes of the assessment have concluded that all of the potential impacts considered will result in either no change or, at worse, negligible adverse effects (i.e. no significant effects). The conclusions have a high degree of certainty on account of an accumulation of evidence from a range of studies and other existing wind farms (details in Section 8.4.2). However, as is typical for development projects of this nature, a range of geophysical surveys will be carried out both before and after construction both for engineering / asset integrity purposes and to feed into the requirements for other environmental topics such as benthic ecology and archaeology.

8.8 Cumulative effects

8.8.1 Identification of potential cumulative effects

305. The first step in the CEA process is the identification of which residual effects assessed for North Falls on their own have the potential for a cumulative effect with other plans, projects, and activities. This information is set out in Table 8.46. Only potential impacts assessed in Section 8.6.2 as negligible adverse or above are included in the CEA (i.e. those assessed as 'no change' are not taken forward as there is no potential for them to contribute to a cumulative impact).

Table 8.46 Potential cumulative effects

Impact	Relevant receptors	Potential for cumulative effect	Rationale
Construction			
Construction Impact 2a: Changes in seabed level due to seabed preparation for installation of turbine and OSP/OCP foundations	• Annex I sandbanks; and • KKE MCZ	Yes	There is a potential temporal overlap in installation activities with the Projects screened in (Table 8.47) which could cause a cumulative effect with regards to changes in seabed level.
Construction Impact 2b: Changes in seabed level due to drill arisings for installation of piled foundations for wind turbines and OSPs/OCP	• Annex I sandbanks; and • KKE MCZ		
Construction Impact 4: Changes in seabed level due to deposition from the suspended sediment plume during offshore export cable installation	• Essex coast; • Margate and Long Sands SAC;		

Impact	Relevant receptors	Potential for cumulative effect	Rationale
	• Annex I sandbanks;		
Construction Impact 6: Changes in seabed level due to the deposition from the suspended sediment plume during array and platform interconnector cable installation.	• Annex I sandbanks; and • KKE MCZ		
Construction Impact 7: Interruptions to bedload sediment transport due to sandwave levelling for offshore export cable and array cable installation	• Essex coast; • Margate and Long Sands SAC; • Annex I sandbanks; and • KKE MCZ	No	Impacts occur at discrete locations for a time-limited duration and are local in nature with a low impact magnitude.
Construction Impact 8: Indentations on the seabed due to installation vessels	• Margate and Long Sands SAC; • Annex I sandbanks; and • KKE MCZ	No	Impacts occur at discrete locations for a time-limited duration and are local in nature with a low impact magnitude.
Operation			
Operational Impact 1: Changes to the tidal regime due to the presence of structures on the seabed (wind turbines and OSP/OCP foundations)	• Annex I sandbanks; and • KKE MCZ	Yes	Impacts could occur and potentially coalesce with those arising from other wind farms which could cause a cumulative effect with regards to tidal currents, wave and sediment transport.
Operational Impact 2: Changes to the wave regime due to the presence of structures on the seabed (wind turbine and OSP/OCP foundations)	• Annex I sandbanks; and • KKE MCZ	Yes	Impacts could occur and potentially coalesce with those arising from other wind farms which could cause a cumulative effect with regards to tidal currents, wave and sediment transport.
Operational Impact 3: Changes to the sediment transport regime due to the presence of structures on the seabed (wind turbine and OSP/OCP foundations)	• Annex I sandbanks; and • KKE MCZ	Yes	Impacts could occur and potentially coalesce with those arising from other wind farms which could cause a cumulative effect with regards to tidal currents, wave and sediment transport.
Operational Impact 4 Loss of seabed area due to	• Annex I sandbanks.	No	Impacts occur at discrete locations within the North Falls array area and

Impact	Relevant receptors	Potential for cumulative effect	Rationale
infrastructure within the array area			therefore there will be no cumulative impact.
Operational Impact 5: Morphological and sediment transport effects due to cable protection measures within the array area	• Annex I sandbanks; and • KKE MCZ	No	Impacts occur at discrete locations within the North Falls offshore cable corridor and therefore there will be no cumulative impact.
Operational Impact 6: Morphological and sediment transport effects due to cable protection measures within the offshore cable corridor	• Essex coast; • Margate and Long Sands SAC; • Annex I sandbanks;	No	Impacts occur at discrete locations within the North Falls offshore cable corridor and therefore there will be no cumulative impact.
Operational Impact 8: Indentations on the seabed due to O&M and UXO vessels [negligible adverse effect applies to the Annex I sandbanks receptor]	• Annex I sandbanks.	No	Impacts will be highly local around the vessels anchoring locations and therefore there will be no cumulative impact.
Decommissioning			
Decommissioning Impact 2 Changes in seabed level due to foundation removal	• Annex I sandbanks; and • KKE MCZ	Yes	There is a potential temporal overlap in decommissioning activities with other projects screened in (Table 8.47).
Decommissioning Impact 4 Changes in seabed level due to removal of parts of the export cable	• Essex coast; • Margate and Long Sands SAC; • Annex I sandbanks;		
Decommissioning Impact 6 Changes in seabed level due to removal of parts of the array and platform interconnector cables	• Annex I sandbanks; and • KKE MCZ		
Decommissioning Impact 7 Indentations on the seabed due to decommissioning vessels	• Annex I sandbanks.		

8.8.2 Other plans, projects, and activities

306. The second step in the cumulative assessment is the identification of the other plans, projects and activities that may result in cumulative effects for inclusion in the CEA (described as 'project screening'). This information is set out in Table 8.47, together with a consideration of the relevant details of each, including current status (e.g. under construction), planned construction period, closest distance to North Falls, status of available data and rationale for including or excluding from the assessment.

307. The project screening has been informed by the development of a CEA project list which forms an exhaustive list of plans, projects, and activities within the study area (Section 8.3.1) relevant to North Falls. For the CEA, a range of 30km from the North Falls offshore project area has been used to provide a conservative search area for the screening of plans and projects which have potential to interact with the impacts of North Falls. The list has been appraised, based on the confidence in being able to undertake an assessment from the information and data available, enabling individual plans, projects, and activities to be screened in or out.

Table 8.47 Summary of projects considered for the CEA in relation to marine geology, oceanography and physical processes (project screening)

Plan or project	Status	Construction period	Closest distance from the Project	Closest distance from the offshore cable corridor	Confidence in Data	Included in the CEA (Y/N)	Rationale
NeuConnect Interconnector	Pre-construction	2023-2028	2.5km	0km	High	Yes	The NeuConnect Interconnector bisects the North Falls offshore cable corridor and there is potential for temporal overlap of cable installation activities.
BritNed Interconnector	Operational since 2009	N/A	0 km	9.3km	High	No	The BritNed Interconnector passes through the south of the array area but has been operational since 2009. There is therefore no potential for cumulative impact on the identified receptors.
Nautilus Interconnector	Pre-application	2025-2028	Cable route currently unknown		Low	Yes	The offshore study area for Nautilus intersects with the North Falls offshore project area. Therefore, there is potential for cumulative effects, subject to the final location and programme for the interconnector
South & East Anglia (SEA) Link	Pre-application	2026-2030	5.4km	0km	High	Yes	The emerging preferred and alternative routes for Sea Link intersect with the North Falls offshore cable corridor. Therefore, there is potential for cumulative effects.
Tarchon Energy Interconnector	Pre-planning	2027-2030	Cable route currently unknown		Low	Yes	Interconnector between UK and Germany with potential to be in proximity to the North Falls

Plan or project	Status	Construction period	Closest distance from the Project	Closest distance from the offshore cable corridor	Confidence in Data	Included in the CEA (Y/N)	Rationale
							offshore project area. Therefore, there is potential for cumulative effects, subject to the final location and programme for the interconnector.
Greater Gabbard offshore wind farm	Operational since 2012	N/A	0 km	3.9km	Medium	Yes	Potential cumulative effects on the wave and tidal regimes, and from ongoing maintenance activities.
Galloper offshore wind farm	Operational since 2018	N/A	0 km	6.4km	Medium	Yes	
Five Estuaries offshore wind farm	In Planning	Late 2020s	0km	12.9km	Medium	Yes	Potential for some interaction between the dredging plumes from the cable/foundation installation from Five Estuaries with North Falls. During operation, there is potential for cumulative effects on the wave and tidal regimes, and from ongoing maintenance activities.
Thanet offshore wind farm	Operational since 2010	N/A	24.9km	36.2km	Medium	No	Any ongoing effects of maintenance activity from these offshore wind farms will be highly localised and therefore, given the distance from the North Falls offshore project area, there is no pathway for significant cumulative effects. This approach is in keeping with the Galloper EIA, where it was
London Array offshore wind farm	Operational since 2013	N/A	20.6km	15.5km	Medium		
Gunfleet Sands offshore wind farm	Operational since 2010	N/A	39km	6km	Medium		

Plan or project	Status	Construction period	Closest distance from the Project	Closest distance from the offshore cable corridor	Confidence in Data	Included in the CEA (Y/N)	Rationale
							agreed with Cefas and Defra that no assessment of cumulative effects was required with other Round 2 sites in the Thames strategic area (except GGOW).
Outer OTE aggregate exploration and option area 528/2	Unknown	2016-2024	9.4km	14km	Low	No (Subject to operational status)	There is potential for some interaction between the dredging plumes from the aggregate exploration and option areas and plumes from cable/foundation installation / decommissioning and operation and maintenance activities. The operational status of the Outer OTE aggregate exploration and option area 528/2 is unknown, therefore, it is not currently included in the CEA.
Thames D aggregates production agreement area 524	Production agreement secured 2022	2022-2036	0km	10.3km	Low	Yes	
Southwold East aggregates production agreement area 430	Operational since 2012	2012-2025	50.1km	48.4km	Medium	No	Aggregate sites which were operational at the time of the North Falls characterisation surveys are a component of the baseline environment.
North Inner Gabbard aggregate production agreement area 498	Operational since 2015	2015-2030	24.7km	24km	Medium	No	

Plan or project	Status	Construction period	Closest distance from the Project	Closest distance from the offshore cable corridor	Confidence in Data	Included in the CEA (Y/N)	Rationale
Shipwash aggregate production agreement area 507	Operational since 2016	2016-2031	19.6km	9.8km	Medium	No	
Longsand aggregate production agreement area 508	Operational since 2014	2014-2029	13.9km	5.8km	Medium	No	
Longsand aggregate production agreement area 509	Operational since 2015	2015-2030	13.8km	2.1km	Medium	No	
Longsand aggregate production agreement area 510	Operational since 2015	2015-2030	9.5km	3.5km	Medium	No	
North Falls East production agreement area and option area 501	Operational since 2017	2017-2032	13.2km	25.3km	Medium	No	

8.8.3 Assessment of cumulative impacts

8.8.3.1 Cumulative Impact 1: Changes in seabed level

8.8.3.1.1 Plans and projects considered

308. Changes in seabed level caused by temporary physical disturbance and increased sediment concentrations has been assessed as a cumulative effect.

309. There is potential for works associated with all phases of North Falls to be conducted at the same time, or similar time, to works associated with all phases of Five Estuaries, as well as maintenance works at GGOW and GWF. There is also potential for overlap with the installation activities of the NeuConnect, Nautilus and SEA Link Interconnector cables and dredging works from the Thames D aggregates production agreement area 524.

310. The worst-case scenario for marine geology, oceanography and physical processes would be for the Interconnector cables, Five Estuaries and North Falls to be constructed at the same time, alongside ongoing dredging works from the Thames D aggregates production agreement area 524 and maintenance works at GGOW and GWF. This would provide the greatest opportunity for interaction of sediment plumes and a larger change in seabed level during construction. The combined change in seabed level from foundations and/or cable installation could potentially have greater spatial and vertical extents than individual projects.

8.8.3.1.2 Interactions with adjacent wind farms

311. The North Falls array area and offshore cable corridor are located to the west of the Five Estuaries array areas, perpendicular to the tidal axis, which means that overlap and interaction of changes in seabed level created by activities at Five Estuaries and activities in the North Falls array area are very unlikely.

312. Also, combined changes in seabed level caused by maintenance activities over the operational lifespan of North Falls, Five Estuaries, GWF and GGOW will be minimal and considerably less than any generated during construction. Hence, overall, the potential cumulative effect in all cases would be negligible adverse.

8.8.3.1.3 Interactions with marine aggregate dredging and cable installation

313. To assess the potential for cumulative effects between the installation of offshore cables (NeuConnect, Nautilus and SEA Link Interconnector cables and Five Estuaries offshore export cables) and marine aggregate dredging activities (Thames D aggregates production agreement area 524) in adjacent areas of the seabed, reference has been made to the GWF EIA and supporting technical appendix (ABPmer 2011a). Although the GWF cable corridor route is different, the results provide an appropriate analogy for North Falls due to similarities across the study area.

314. The CEA for GWF determined that based on previous modelling investigations undertaken for dredging areas (which were closer to GGOW), no cumulative impact was predicted. This was supported by results from monitoring of plume dispersal from dredging activities undertaken by Oakwood Environmental (1999) and numerical modelling studies undertaken for the Outer Thames MAREA, which concluded that SSCs outside the licensed dredging areas were less than 20mg/l above background levels (except at the boundary, where they were within the range of natural variability) (HR Wallingford, 2010). Due to the

similar physical conditions of GWF and GGOW, an assessment of ongoing dredging activities and foundation/cable installation for GWF was not necessary (ABPmer, 2011a).

315. Changes in seabed morphology following aggregate dredging would be limited to very restricted parts of the seabed adjacent to the licenced or proposed dredging areas (HR Wallingford, 2010). Therefore, negligible cumulative effects are expected.

8.8.3.1.4 Interactions during decommissioning

316. The magnitudes of cumulative impact during decommissioning would be comparable to or less than those identified above. Accordingly, given the construction phase assessment concluded negligible adverse effects the same would be valid for the decommissioning phase.

8.8.3.1.5 Overall effect significance

317. The receptors potentially affected by the cumulative change in seabed level are the Essex coast, Suffolk coast, Margate and Long Sands SAC, Annex I sandbanks and KKE MCZ. They will not experience a significant cumulative effect either during construction or decommissioning. The impact on the receptors will be negligible adverse.

8.8.3.2 Cumulative Impact 2: Changes in operational tidal currents

8.8.3.2.1 Plans and projects considered

318. The operational phases of GGOW, GWF and Five Estuaries are likely to overlap with the North Falls operational phase. The combined physical obstruction of foundations may have a potential impact on tidal current velocities.

319. Additionally, the Thames D aggregates production agreement area 524 is located less than 0.5km from the array area. This could also potentially have a cumulative effect on the hydrodynamic regime, combined with the adjacent wind farms and North Falls.

320. Once installed, the interconnector cables would have no predicted effect on tidal currents.

8.8.3.2.2 Interactions with adjacent wind farms

321. The overlap of the individual 'zones of influence' effectively represents the enlargement of four separate zones into a single 'zone of influence'. The pre-existing scientific evidence base and the results of the GWF modelling (Sections 8.6.3.1 and 8.6.3.2) demonstrate that cumulative changes in tidal currents due to the presence of foundation structures are both small in magnitude and local in spatial extent. Hence, the potential cumulative effect between GWF, GGOW, Five Estuaries and North Falls is negligible adverse.

322. This is supported by modelling undertaken for East Anglia ONE North and TWO (located approximately 32m north-east of the North Falls array area), which demonstrated no significant impact on the tidal regime caused by the wind farms.

8.8.3.2.3 Interactions with marine aggregate dredging

323. HR Wallingford (2010) found that changes in current speeds of greater than 5% did not extend outside the boundaries of the Thames D aggregates production agreement area 524. Given that the impact on the hydrodynamic regime from aggregate dredging is restricted to the boundaries of the licenced or proposed

dredge area, the cumulative effect is expected to be minimal. Therefore, the effect significance is negligible adverse which is not significant.

8.8.3.2.4 Overall impact significance

324. The receptors potentially affected by the cumulative change in operational tidal currents are Annex I sandbanks and KKE MCZ. They will not experience a significant cumulative effect. The impact on the receptors will be negligible adverse. There will be no cumulative effects on the nearshore tidal regime along the Essex and Suffolk coasts.

8.8.3.3 Cumulative Impact 3: Changes in operational waves

8.8.3.3.1 Plans and projects considered

325. During the operational phase of North Falls, it is highly likely the adjacent wind farms will also be in their operational phases. This could have a potential impact through combined changes to wave heights and direction.

8.8.3.3.2 Interactions with adjacent wind farms

326. Modelling of the potential cumulative effects on waves of the simultaneous operation of North Falls and adjacent wind farms shows that the worst-case direction is for waves approaching from the east for a 1 in 1 year return period. The predicted changes in wave height and direction are shown in ES Figure 8.20 (Document Reference: 3.2.4) and ES Figure 8.21 (Document Reference: 3.2.4), respectively. All the results from the modelling campaign are presented in ES Appendix 8.1 (Document Reference: 3.3.3).

327. The model predicts that each foundation in North Falls array and adjacent wind farm arrays would present an obstacle to the passage of waves locally, causing a small modification to the height and / or direction of the waves as they pass. Reflection from the wind turbines would result in a slight increase in wave conditions, up to about 2% of the significant wave height east of the combined wind farms. In addition, wave shadowing by each foundation would result in a reduction in wave conditions, up to about 2% of the significant wave height west of the combined wind farms. Predicted changes in direction are +/-1.0 degrees over limited footprints to the east and west of the array area. The extent and strength of changes caused by obstructing wave activity is very limited and will likely remain within the range of natural background variation.

8.8.3.3.3 Overall impact significance

328. The receptors potentially affected by the cumulative change in operational waves are Annex I sandbanks and KKE MCZ. They will not experience a significant cumulative effect. The effect on the receptors will be negligible adverse. There will be no cumulative effects on the nearshore wave conditions along the Essex and Suffolk coasts.

8.8.3.4 Cumulative Impact 4: Changes in operational sediment transport

8.8.3.4.1 Plans and projects considered

329. The combined physical obstruction of foundations and associated scour at GGOW, GWF, Five Estuaries and North Falls may have a potential impact on tidal currents and waves that drive sediment transport.

330. Due to the spatial limitations of cumulative effects generated by the Thames D aggregates production agreement area 524 (discussed in sections 8.8.3.1.3 and 8.8.3.2.3) this plan/project is not considered for Cumulative Impact 4.

8.8.3.4.2 Interactions with adjacent wind farms

331. Alterations to sediment transport during the operational phase would largely be driven by changes in tidal currents (Cumulative Impact 2) and waves (Cumulative Impact 3). Cumulative changes in tidal currents and waves with the adjacent wind farms would be negligible in magnitude due to the localised spatial extent. Since it is expected that the changes in tidal flow and wave heights would have no significant far-field impacts, then the changes in sediment transport would be of similar scale.

8.8.3.4.3 Overall impact significance

332. The receptors potentially affected by the cumulative change in operational sediment transport are Essex coast, Suffolk coast, Margate and Long Sands SAC, Annex I sandbanks and KKE MCZ receptors. They will not experience a significant cumulative effect. The effect on the receptors will be negligible adverse.

8.8.4 Summary of cumulative effects

333. Given the local nature of the cumulative impacts described, the overall cumulative effect significance is predicted to be negligible adverse (not significant).

8.9 Transboundary impacts

334. Given that there will be negligible to no change in the hydrodynamic and sedimentary regime because of North Falls, and the distance between North falls and the outer limit of the EEZ, transboundary impacts are unlikely to occur, or are unlikely to be significant. Transboundary impacts are scoped out of further assessment in accordance with the scoping opinion (Planning Inspectorate, 2021).

8.10 Interactions

335. There are clear interactions between the marine geology, oceanography and physical processes topic and several other topics that have been considered within this ES. Table 8.48 provides a summary of the principal interactions and sign-posts to where those issues have been addressed in the relevant chapters.

Table 8.48 Marine Geology, Oceanography and Physical Processes interactions

Topic and description	Related chapter (Volume 3.1)	Where addressed in this chapter	Rationale
Construction			
Effects on water column (SSCs)	Chapter 9 Marine Water and Sediment Quality Chapter 11 Fish and Shellfish Ecology Chapter 14 Commercial Fisheries	Section 8.6.2.1 and Section 8.6.2.2 (foundation installation) Section 8.6.2.5 (export cable installation)	Suspended sediment could be contaminated and could cause disturbance to fish and benthic species through smothering.

Topic and description	Related chapter (Volume 3.1)	Where addressed in this chapter	Rationale
	Chapter 10 Benthic and Intertidal Ecology	Section 8.6.2.7 (array cable installation)	
Effects on seabed (morphology / sediment composition)	Chapter 10 Benthic and Intertidal Ecology Chapter 11 Fish and Shellfish Ecology Chapter 14 Commercial Fisheries Chapter 15 Shipping and Navigation Chapter 16 Offshore Archaeology and Cultural Heritage	Section 8.6.2.1 and Section 8.6.2.2 (foundation installation) Section 8.6.2.5 (export cable installation) Section 8.6.2.7 (array cable installation) Section 8.6.2.10 (installation vessels)	Disruption to seabed morphology and sediment composition could affect these receptors by altering the existing sedimentary environment, however this is unlikely to be to levels which are significant.
Operation			
Effects on shoreline (morphology / sediment transport / sediment composition)	Chapter 10 Benthic and Intertidal Ecology Chapter 21 Water Resources and Flood Risk Chapter 29 Seascape and Visual Impact Assessment Chapter 30 Landscape and Visual Amenity		Disruption to shoreline morphology could potentially impact on these chapters through a change to the existing shoreline environment which could have implications for the receptors associated with these chapters.
Effects on seabed (sediment transport processes / morphology)	Chapter 10 Benthic and Intertidal Ecology Chapter 11 Fish and Shellfish Ecology Chapter 14 Commercial Fisheries Chapter 15 Shipping and Navigation Chapter 16 Offshore Archaeology and Cultural Heritage	Section 8.6.3.3 (sediment transport regime) Section 8.6.3.4 (loss of seabed area) Section 8.6.3.5 (array cable protection) Section 8.6.3.6 (export cable protection in the offshore zone)	Disruption to sediment transport processes or loss of seabed area could affect these receptors by altering the existing sedimentary environment, however this is unlikely to be to levels which are significant.

Topic and description	Related chapter (Volume 3.1)	Where addressed in this chapter	Rationale
Decommissioning			
Interactions of impacts during the decommissioning phase will be the same as those outlined above for the construction phase.			

8.11 Inter-relationships

336. The impacts identified and assessed in this chapter have the potential to inter-relate with each other. The areas of potential inter-relationships between impacts are presented in Table 8.49. This provides a screening tool for which impacts have the potential to inter-relate. Table 8.49 provides an assessment for each receptor (or receptor group) as related to these impacts.

337. Within Table 8.50 the impacts are assessed relative to each development phase (i.e. construction, operation or decommissioning) to see if (for example) multiple construction impacts affecting the same receptor could increase the significance of effect upon that receptor. Following this, a lifetime assessment is undertaken which considers the potential for impacts to affect receptors across all development phases (Table 8.50).

338. The impacts listed in Table 8.49 are expressed on the following receptors in Table 8.50:

- Essex coast;
- Suffolk coast;
- Annex I sandbanks;
- Margate and Long Sands SAC; and
- KKE MCZ.

Table 8.49 Inter-relationships between impacts – screening

Construction										
	Impact 1a: Changes in SSCs due to seabed preparation for installation of turbine and OSP/OCP foundations	**Impact 1b: Changes in SSCs due to drill arisings for installation of piled foundation for wind turbines and OSP/OCPs**	**Impact 2a: Changes in seabed level due to seabed preparation for installation of turbine and OSP/OCP foundations**	**Impact 2b: Changes in seabed level due to drill arisings for installation of piled foundations and OSP/OCPs**	**Impact 3: Changes in SSCs due to offshore export cable installation**	**Impact 4: Changes in seabed level due to deposition from the suspended sediment plume during offshore export cable installation**	**Impact 5: Changes in SSCs due to array/ platform interconnector cable installation**	**Impact 6: Changes in seabed level due to array/ platform interconnector cable installation**	**Impact 7: Interruptions to bedload sediment transport due to sandwave levelling for offshore export cable, array cable and platform interconnector cable installation**	**Impact 8: Indentations on the seabed**
Impact 1a: Changes in SSCs due to seabed preparation for installation of turbine and OSP/OCP foundations	-	No	Yes	No	Yes (Options 1 and 2 only)	Yes (Options 1 and 2 only)	Yes	Yes	No	No
Impact 1b: Changes in SSCs due to drill arisings for installation of piled foundations for wind turbines and OSP/OCPs	No	-	No	Yes	Yes (Options 1 and 2 only)	Yes (Options 1 and 2 only)	Yes	Yes	No	No
Impact 2a: Changes in seabed level due to seabed preparation for installation of turbine and	Yes	No	-	No	Yes (Options 1 and 2 only)	Yes (Options 1 and 2 only)	Yes	Yes	No	Yes

Construction	Impact 1a: Changes in SSCs due to seabed preparation for installation of turbine and OSP/OCP foundations	Impact 1b: Changes in SSCs due to drill arisings for installation of piled foundation for wind turbines and OSP/OCPs	Impact 2a: Changes in seabed level due to seabed preparation for installation of turbine and OSP/OCP foundations	Impact 2b: Changes in seabed level due to drill arisings for installation of piled foundations and OSP/OCPs	Impact 3: Changes in SSCs due to offshore export cable installation	Impact 4: Changes in seabed level due to deposition from the suspended sediment plume during offshore export cable installation	Impact 5: Changes in SSCs due to array/ platform interconnector cable installation	Impact 6: Changes in seabed level due to array/ platform interconnector cable installation	Impact 7: Interruptions to bedload sediment transport due to sandwave levelling for offshore export cable, array cable and platform interconnector cable installation	Impact 8: Indentations on the seabed
OSP/OCP foundations										
Impact 2b: Changes in seabed level due to drill arisings for installation of piled foundations and OSP/OCPs	No	Yes	No	-	Yes (Options 1 and 2 only)	Yes (Options 1 and 2 only)	Yes	Yes	No	Yes
Impact 3: Changes in SSCs due to offshore export cable installation	Yes (Options 1 and 2 only)	Yes (Options 1 and 2 only)	Yes (Options 1 and 2 only)	Yes (Options 1 and 2 only)	-	Yes (Options 1 and 2 only)	Yes (Options 1 and 2 only)	Yes (Options 1 and 2 only)	No	No
Impact 4: Changes in seabed level due to deposition from the suspended sediment plume during offshore export cable installation	Yes (Options 1 and 2 only)	Yes (Options 1 and 2 only)	Yes (Options 1 and 2 only)	Yes (Options 1 and 2 only)	Yes (Options 1 and 2 only)	-	Yes (Options 1 and 2 only)	Yes (Options 1 and 2 only)	No	Yes (Options 1 and 2 only)

Construction	Impact 1a: Changes in SSCs due to seabed preparation for installation of turbine and OSP/OCP foundations	Impact 1b: Changes in SSCs due to drill arisings for installation of piled foundation for wind turbines and OSP/OCPs	Impact 2a: Changes in seabed level due to seabed preparation for installation of turbine and OSP/OCP foundations	Impact 2b: Changes in seabed level due to drill arisings for installation of piled foundations and OSP/OCPs	Impact 3: Changes in SSCs due to offshore export cable installation	Impact 4: Changes in seabed level due to deposition from the suspended sediment plume during offshore export cable installation	Impact 5: Changes in SSCs due to array/ platform interconnector cable installation	Impact 6: Changes in seabed level due to array/ platform interconnector cable installation	Impact 7: Interruptions to bedload sediment transport due to sandwave levelling for offshore export cable, array cable and platform interconnector cable installation	Impact 8: Indentations on the seabed
Impact 5: Changes in SSCs due to array/ platform interconnector cable installation	Yes	Yes	Yes	Yes	Yes (Options 1 and 2 only)	Yes (Options 1 and 2 only)	-	Yes	No	No
Impact 6: Changes in seabed level due to array/ platform interconnector cable installation	Yes	Yes	Yes	Yes	Yes (Options 1 and 2 only)	Yes (Options 1 and 2 only)	Yes	-	Yes	Yes
Impact 7: Interruptions to bedload sediment transport due to sandwave levelling for offshore export cable, platform interconnector cable and array cable installation	No	No	No	No	No	No	No	Yes	-	No

Construction	Impact 1a: Changes in SSCs due to seabed preparation for installation of turbine and OSP/OCP foundations	Impact 1b: Changes in SSCs due to drill arisings for installation of piled foundation for wind turbines and OSP/OCPs	Impact 2a: Changes in seabed level due to seabed preparation for installation of turbine and OSP/OCP foundations	Impact 2b: Changes in seabed level due to drill arisings for installation of piled foundations and OSP/OCPs	Impact 3: Changes in SSCs due to offshore export cable installation	Impact 4: Changes in seabed level due to deposition from the suspended sediment plume during offshore export cable installation	Impact 5: Changes in SSCs due to array/ platform interconnector cable installation	Impact 6: Changes in seabed level due to array/ platform interconnector cable installation	Impact 7: Interruptions to bedload sediment transport due to sandwave levelling for offshore export cable, array cable and platform interconnector cable installation	Impact 8: Indentations on the seabed
Impact 8: Indentations on the seabed	No	No	Yes	Yes	No	Yes (Options 1 and 2 only)	No	Yes	No	-

Operation	Impact 1: Changes to the tidal current regime due to the presence of structures on the seabed (wind turbines and OSP/OCP foundations)	Impact 2: Changes to the wave regime due to the presence of structures on the seabed (wind turbines and OSP/OCP foundations)	Impact 3: Changes to the sediment transport regime due to the presence of structures on the seabed (wind turbines and OSP/OCP foundations)	Impact 4: Loss of seabed area due to infrastructure within the array area	Impact 5: Morphological and sediment transport effects due to cable protection measures within the array area	Impact 6: Morphological and sediment transport effects due to cable protection measures within the offshore cable corridor	Impact 7: Changes in SSC due to cable repairs and reburial	Impact 8: Indentations on the seabed due to O&M vessels and UXO clearance
Impact 1: Changes to the tidal current regime due to the presence of structures on the seabed (wind turbines and OSP/OCP foundations)	-	Yes	No	No	No	No	No	No
Impact 2: Changes to the wave regime due to the presence of structures on the seabed (wind turbines and OSP/OCP foundations)	Yes	-	No	No	No	No	No	No
Impact 3: Changes to the sediment transport regime due to the presence of structures on the seabed (wind turbines and OSP/OCP foundations)	No	No	-	No	Yes	Yes (Options 1 and 2 only)	No	No

Operation	Impact 1: Changes to the tidal current regime due to the presence of structures on the seabed (wind turbines and OSP/OCP foundations)	Impact 2: Changes to the wave regime due to the presence of structures on the seabed (wind turbines and OSP/OCP foundations)	Impact 3: Changes to the sediment transport regime due to the presence of structures on the seabed (wind turbines and OSP/OCP foundations)	Impact 4: Loss of seabed area due to infrastructure within the array area	Impact 5: Morphological and sediment transport effects due to cable protection measures within the array area	Impact 6: Morphological and sediment transport effects due to cable protection measures within the offshore cable corridor	Impact 7: Changes in SSC due to cable repairs and reburial	Impact 8: Indentations on the seabed due to O&M vessels and UXO clearance
Impact 4: Loss of seabed area due to infrastructure within the array area	No	No	No	-	No	No	No	No
Impact 5: Morphological and sediment transport effects due to cable protection measures within the array area	No	No	Yes	No	-	Yes (Options 1 and 2 only)	No	No
Impact 6: Morphological and sediment transport effects due to cable protection measures within the offshore cable corridor	No	No	Yes (Options 1 and 2 only)	No	Yes (Options 1 and 2 only)	-	No	No
Impact 7: Changes in SSC due to cable repairs and reburial	No	No	No	No	No	No	-	No
Impact 8: Indentations on the seabed due	No	No	No	No	No	No	No	-

Operation	Impact 1: Changes to the tidal current regime due to the presence of structures on the seabed (wind turbines and OSP/OCP foundations)	Impact 2: Changes to the wave regime due to the presence of structures on the seabed (wind turbines and OSP/OCP foundations)	Impact 3: Changes to the sediment transport regime due to the presence of structures on the seabed (wind turbines and OSP/OCP foundations)	Impact 4: Loss of seabed area due to infrastructure within the array area	Impact 5: Morphological and sediment transport effects due to cable protection measures within the array area	Impact 6: Morphological and sediment transport effects due to cable protection measures within the offshore cable corridor	Impact 7: Changes in SSC due to cable repairs and reburial	Impact 8: Indentations on the seabed due to O&M vessels and UXO clearance
to O&M and UXO vessels								

Decommissioning	Impact 1 Changes in SSCs due to foundation removal	Impact 2 Changes in seabed level due to foundation removal	Impact 3 Changes in SSCs due to removal of parts of the export cable	Impact 4 Changes in seabed level due to removal of parts of the export cable	Impact 5 Changes in SSCs due to removal of parts of the array cables	Impact 6 Changes in seabed level due to removal of parts of the array cables	Impact 7 Indentations on the seabed due to decommissioning vessels
Impact 1 Changes in SSCs due to foundation removal	-	No	No	No	Yes	Yes	Yes
Impact 2 Changes in seabed level due to foundation removal	No	-	No	No	Yes	Yes	Yes
Impact 3 Changes in SSCs due to removal of parts of the offshore export cable	No	No	-	Yes (Options 1 and 2 only)	No	No	Yes (Options 1 and 2 only)
Impact 4 Changes in seabed level due to removal of parts of the export cable	No	No	Yes (Options 1 and 2 only)	-	No	No	Yes (Options 1 and 2 only)

Decommissioning	Impact 1 Changes in SSCs due to foundation removal	Impact 2 Changes in seabed level due to foundation removal	Impact 3 Changes in SSCs due to removal of parts of the export cable	Impact 4 Changes in seabed level due to removal of parts of the export cable	Impact 5 Changes in SSCs due to removal of parts of the array cables	Impact 6 Changes in seabed level due to removal of parts of the array cables	Impact 7 Indentations on the seabed due to decommissioning vessels
Impact 5 Changes in SSCs due to removal of parts of the array cables	Yes	Yes	No	No	-	Yes	Yes
Impact 6 Changes in seabed level due to removal of parts of the array cables	Yes	Yes	No	No	Yes	-	Yes
Impact 7 Indentations on the seabed due to decommissioning and UXO vessels	Yes	Yes	Yes (Options 1 and 2 only)	Yes(Options 1 and 2 only)	Yes	Yes	-

Table 8.50 Inter-relationships between impacts – phase and lifetime assessment

Receptor		Highest significance level Construction	Operation	Decommissioning	Phase assessment	Lifetime assessment
Suffolk Coast	Southwold to Clacton-on- Sea	Negligible	Negligible	Negligible	No greater impact than individually assessed impact. The impacts have negligible adverse magnitude of impact on the receptor. Given that that each impact will be managed with standard and good practice methodologies there would either be no interactions or that these would not result in greater impact than assessed individually.	No greater than individually assessed impact

Receptor		Highest significance level Construction	Operation	Decommissioning	Phase assessment	Lifetime assessment
Essex Coast (Landfall location)	Coast between Clacton-on-Sea and Frinton-on-Sea, Essex	Negligible	Negligible	Negligible	No greater impact than individually assessed impact. The impacts have negligible adverse magnitude of impact on the receptor. Given that that each impact will be managed with standard and good practice methodologies there would either be no interactions or that these would not result in greater impact than assessed individually.	No greater than individually assessed impact
Designated sites and features	Annex I Sandbank (Annex I Reef will be addressed in the benthic ecology section)	Negligible	Negligible	Negligible	No greater impact than individually assessed impact. The impacts have negligible adverse magnitude of impact on the receptor. Given that that each impact will be managed with standard and good practice methodologies there would either be no interactions or that these would not result in greater impact than assessed individually.	No greater than individually assessed impact
	Margate and Long Sands SAC	Negligible	Negligible	Negligible	No greater impact than individually assessed impact. The impacts have negligible adverse magnitude of impact on the receptor. Given that that each impact will be managed with standard and good practice methodologies there would either be no interactions or that these would not result in greater impact than assessed individually.	No greater than individually assessed impact
	KKE MCZ	Negligible	Negligible	Negligible	No greater impact than individually assessed impact. The impacts have negligible adverse magnitude of impact on the receptor. Given that that each impact will be managed with standard and good practice methodologies there would either be no interactions or that these would not result in greater impact than assessed individually.	No greater than individually assessed impact

8.12 Summary

339. This chapter has provided a characterisation of the existing environment for marine geology, oceanography and physical processes based on both existing and site-specific survey data, which has informed the impact assessment and established that the likely significant effects on the identified receptors during construction, operational and decommissioning phases of North Falls are 'negligible adverse' or 'no change' and therefore not significant.

340. The specific receptors that have been identified in relation to this topic are Annex I Sandbanks, Margate and Long Sands SAC, KKE MCZ, and the Suffolk and Essex coasts.

341. The overall cumulative effect significance of the Project over these receptors is predicted to remain negligible adverse (not significant in EIA terms).

342. Transboundary impacts are scoped out of further assessment in accordance with the scoping opinion (Planning Inspectorate, 2021).

343. The impacts that have been assessed are mostly anticipated to result in no change to the identified receptors because they are located remotely from the zones of influence and no pathway has been identified that can link the source to the receptor. A summary of impacts to these receptors are listed in Table 8.51.

Table 8.51 Summary of likely significant effects on marine geology, oceanography and physical processes

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation significance	Additional mitigation measures proposed	Residual significance
Construction						
Impact 1a: Changes in SSCs due to seabed preparation for installation of turbine and OSP/OCP foundations	Essex coast	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
	Suffolk coast	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
	Annex I sand banks	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
	Margate and Long Sands SAC	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
	KKE MCZ	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
Impact 1b: Changes in SSCs due to drill arisings for installation of piled foundations for wind	Essex coast	N/A	Negligible (near-field) Negligible (far-field)	No change	N/A	No change
	Suffolk coast	N/A	Negligible (near-field)	No change	N/A	No change

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation significance	Additional mitigation measures proposed	Residual significance
turbines and OSPs/OCP			Negligible (far-field)			
	Annex I sand banks	N/A	Negligible (near-field) Negligible (far-field)	No change	N/A	No change
	Margate and Long Sands SAC	N/A	Negligible (near-field) Negligible (far-field)	No change	N/A	No change
	KKE MCZ	N/A	Negligible (near-field) Negligible (far-field)	No change	N/A	No change
Impact 2a: Changes in seabed level due to seabed preparation for installation of turbine and OSP/OCP foundations	Essex coast	Negligible	Medium (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Suffolk coast	Negligible	Medium (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Annex I sand banks	Negligible	Medium (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Margate and Long Sands SAC	Negligible	Medium (near-field) Negligible (far-field)	Negligible	N/A	Negligible

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation significance	Additional mitigation measures proposed	Residual significance
	KKE MCZ	Negligible	Medium (near-field) Negligible (far-field)	Negligible	N/A	Negligible
Impact 2b: Changes in seabed level due to drill arisings for installation of piled foundations for wind turbines and OSP/OCPs	Essex coast	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Suffolk coast	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Annex I sand banks	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Margate and Long Sands SAC	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	KKE MCZ	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
Impact 3: Changes in SSCs due to offshore export cable installation	Essex coast	N/A	Negligible (near-field (nearshore)) Negligible (near-field (offshore)) Negligible (far-field)	No change	N/A	No change

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation significance	Additional mitigation measures proposed	Residual significance
	Suffolk coast	N/A	Negligible (near-field (nearshore)) Negligible (near-field (offshore)) Negligible (far-field)	No change	N/A	No change
	Annex I sand banks	N/A	Negligible (near-field (nearshore)) Negligible (near-field (offshore)) Negligible (far-field)	No change	N/A	No change
	Margate and Long Sands SAC	N/A	Negligible (near-field (nearshore)) Negligible (near-field (offshore)) Negligible (far-field)	No change	N/A	No change
	KKE MCZ	N/A	Negligible (near-field (nearshore)) Negligible (near-field (offshore)) Negligible (far-field)	No change	N/A	No change
Impact 4: Changes in seabed level due to offshore export cable installation	Essex coast	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Suffolk coast	Negligible	Negligible (near-field)	No change	N/A	No change

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation significance	Additional mitigation measures proposed	Residual significance
			Negligible (far-field)			
	Annex I sand banks	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Margate and Long Sands SAC	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	KKE MCZ	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
Impact 5: Changes in SSCs due to offshore array cable installation	Essex coast	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
	Suffolk coast	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
	Annex I sand banks	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
	Margate and Long Sands SAC	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation significance	Additional mitigation measures proposed	Residual significance
	KKE MCZ	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
Impact 6: Changes in seabed level due to offshore array cable installation	Essex coast	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Suffolk coast	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Annex I sand banks	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Margate and Long Sands SAC	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	KKE MCZ	Negligible	Low (near-field) Negligible (far-field)	Negligible	N/A	Negligible
Impact 7: Interruptions to bedload sediment transport due to sandwave levelling for offshore export cable and offshore	Essex coast	Negligible	Low (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Suffolk coast	Negligible	Low (near-field) Negligible (far-field)	No change	N/A	No change

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation significance	Additional mitigation measures proposed	Residual significance
array cable installation	Annex I sand banks	Negligible	Low (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Margate and Long Sands SAC	Negligible	Low (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	KKE MCZ	Negligible	Low (near-field) Negligible (far-field)	No change	N/A	No change
Impact 8: Indentations on the seabed	Essex coast	Negligible	Medium (near field (footprint of leg/anchor)) No change (near field (beyond the footprint of leg/anchor)) No change (far field)	No change	N/A	No change
	Suffolk coast	Negligible	Medium (near field (footprint of leg/anchor)) No change (near field (beyond the footprint of leg/anchor)) No change (far field)	No change	N/A	No change
	Annex I sand banks	Negligible	Medium (near field (footprint of leg/anchor))	Negligible	N/A	Negligible

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation significance	Additional mitigation measures proposed	Residual significance
			No change (near field (beyond the footprint of leg/anchor)) No change (far field)			
	Margate and Long Sands SAC	Negligible	Medium (near field (footprint of leg/anchor)) No change (near field (beyond the footprint of leg/anchor)) No change (far field)	Negligible	N/A	Negligible
	KKE MCZ	Negligible	Medium (near field (footprint of leg/anchor)) No change (near field (beyond the footprint of leg/anchor)) No change (far field)	Negligible	N/A	Negligible
Operation						
Impact 1: Changes to the tidal current regime due to the presence of structures on the seabed (wind turbines and	Essex coast	Low	Medium (near-field) Low (far-field)	No change	N/A	No change
	Suffolk coast	Low	Medium (near-field) Low (far-field)	No change	N/A	No change

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation significance	Additional mitigation measures proposed	Residual significance
OSP/OCP foundations)	Annex I sand banks	Negligible	Medium (near-field) Low (far-field)	Negligible	N/A	Negligible
	Margate and Long Sands SAC	Negligible	Medium (near-field) Low (far-field)	No change	N/A	No change
	KKE MCZ	Negligible	Medium (near-field) Low (far-field)	Negligible	N/A	Negligible
Impact 2: Changes to the wave regime due to the presence of structures on the seabed (wind turbines and OSP/OCP foundations)	Essex coast	Negligible	Medium (near-field) Low (far-field)	No change	N/A	No change
	Suffolk coast	Negligible	Medium (near-field) Low (far-field)	No change	N/A	No change
	Annex I sand banks	Negligible	Medium (near-field) Low (far-field)	Negligible	N/A	Negligible
	Margate and Long Sands SAC	Negligible	Medium (near-field) Low (far-field)	No change	N/A	No change
	KKE MCZ	Negligible	Medium (near-field) Low (far-field)	Negligible	N/A	Negligible
Impact 3: Changes to the sediment transport regime	Essex coast	Negligible	Medium (near-field) Low (far-field)	Negligible	N/A	Negligible

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation significance	Additional mitigation measures proposed	Residual significance
due to the presence of structures on the seabed (wind turbines and OSP/OCP foundations)	Suffolk coast	Negligible	Medium (near-field) Low (far-field)	Negligible	N/A	Negligible
	Annex I sand banks	Negligible	Medium (near-field) Low (far-field)	Negligible	N/A	Negligible
	Margate and Long Sands SAC	Negligible	Medium (near-field) Low (far-field)	Negligible	N/A	Negligible
	KKE MCZ	Negligible	Medium (near-field) Low (far-field)	Negligible	N/A	Negligible
Impact 4: Loss of seabed area due to infrastructure within the array area	Essex coast	Negligible	High (near-field) No change (far-field)	No change	N/A	No change
	Suffolk coast	Negligible	High (near-field) No change (far-field)	No change	N/A	No change
	Annex I sand banks	Negligible	High (near-field) No change (far-field)	Negligible	N/A	Negligible
	Margate and Long Sands SAC	Negligible	High (near-field) No change (far-field)	No change	N/A	No change
	KKE MCZ	Negligible	High (near-field) No change (far-field)	No change	N/A	No change

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation significance	Additional mitigation measures proposed	Residual significance
Impact 5: Morphological and sediment transport effects due to cable protection measures within the array area	Essex coast	Negligible	Low (near-field) Negligible (far-field)	No change	N/A	No change
	Suffolk coast	Negligible	Low (near-field) Negligible (far-field)	No change	N/A	No change
	Annex I sand banks	Negligible	Low (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Margate and Long Sands SAC	Negligible	Low (near-field) Negligible (far-field)	No change	N/A	No change
	KKE MCZ	Negligible	Low (near-field) Negligible (far-field)	Negligible	N/A	Negligible
Impact 6: Morphological and sediment transport effects due to cable protection measures within the offshore cable corridor	Essex coast	Medium	Medium (landfall) Medium (shallower than 5m) Medium (deeper than 5m)	Negligible	N/A	Negligible
	Suffolk coast	Medium	Medium (landfall)	No change	N/A	No change
	Annex I sand banks	Negligible	Medium (shallower than 5m)	No change	N/A	No change
	Margate and Long Sands SAC	Negligible	Medium (deeper than 5m)	Negligible	N/A	Negligible
	KKE MCZ	Negligible	Medium (landfall)	No change	N/A	No change

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation significance	Additional mitigation measures proposed	Residual significance
Impact 7: Changes in SSC due to cable repairs and reburial	Essex coast	N/A	Negligible (near-field) Negligible (far-field)	No change	N/A	No change
	Suffolk coast	N/A	Negligible (near-field) Negligible (far-field)	No change	N/A	No change
	Annex I sand banks	N/A	Negligible (near-field) Negligible (far-field)	No change	N/A	No change
	Margate and Long Sands SAC	N/A	Negligible (near-field) Negligible (far-field)	No change	N/A	No change
	KKE MCZ	N/A	Negligible (near-field) Negligible (far-field)	No change	N/A	No change
Impact 8: Indentations on the seabed due to O&M and UXO vessels	Annex I sand banks	Negligible	Medium (near-field (footprint of leg/anchor)) No change (near-field (beyond the footprint of the leg/anchor)) No change (far-field)	Negligible	N/A	Negligible

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation significance	Additional mitigation measures proposed	Residual significance
Decommissioning						
Impact 1: Changes in SSCs due to foundation removal	Essex coast	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
	Suffolk coast	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
	Annex I sand banks	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
	Margate and Long Sands SAC	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
	KKE MCZ	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
Impact 2: Changes in seabed level due to foundations removal	Essex coast	Negligible	Medium (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Suffolk coast	Negligible	Medium (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Annex I sand banks	Negligible	Medium (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Margate and Long Sands SAC	Negligible	Medium (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	KKE MCZ	Negligible	Medium (near-field) Negligible (far-field)	Negligible	N/A	Negligible
Impact 3: Changes in SSCs due removal of parts of the export cable	Essex coast	N/A	Negligible (near-field (nearshore)) Negligible (near-field (offshore))	No change	N/A	No change

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation significance	Additional mitigation measures proposed	Residual significance
			Negligible (far-field)			
	Suffolk coast	N/A	Negligible (near-field (nearshore)) Negligible (near-field (offshore)) Negligible (far-field)	No change	N/A	No change
	Annex I sand banks	N/A	Negligible (near-field (nearshore)) Negligible (near-field (offshore)) Negligible (far-field)	No change	N/A	No change
	Margate and Long Sands SAC	N/A	Negligible (near-field (nearshore)) Negligible (near-field (offshore)) Negligible (far-field)	No change	N/A	No change
	KKE MCZ	N/A	Negligible (near-field (nearshore)) Negligible (near-field (offshore)) Negligible (far-field)	No change	N/A	No change
Impact 4: Changes in seabed level due to removal of parts of the export cable	Essex coast	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Suffolk coast	Negligible	Negligible (near-field) Negligible (far-field)	No change	N/A	No change
	Annex I sand banks	Negligible	Negligible (near-field)	Negligible	N/A	Negligible

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation significance	Additional mitigation measures proposed	Residual significance
			Negligible (far-field)			
	Margate and Long Sands SAC	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	KKE MCZ	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
Impact 5: Changes in SSCs due to removal of parts of the array cables	Essex coast	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
	Suffolk coast	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
	Annex I sand banks	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
	Margate and Long Sands SAC	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
	KKE MCZ	N/A	Medium (near-field) Negligible (far-field)	No change	N/A	No change
Impact 6: Changes in seabed level due to removal of parts of the array cables	Essex coast	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Suffolk coast	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	Annex I sand banks	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation significance	Additional mitigation measures proposed	Residual significance
	Margate and Long Sands SAC	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
	KKE MCZ	Negligible	Negligible (near-field) Negligible (far-field)	Negligible	N/A	Negligible
Impact 7: Indentations on the seabed due to decommissioning vessels	Essex coast	Negligible	Medium (near field (footprint of leg/anchor)) No change (near field (beyond the footprint of leg/anchor)) No change (far field)	No change	N/A	No change
	Suffolk coast	Negligible	Medium (near field (footprint of leg/anchor)) No change (near field (beyond the footprint of leg/anchor)) No change (far field)	No change	N/A	No change
	Annex I sand banks	Negligible	Medium (near field (footprint of leg/anchor)) No change (near field (beyond the footprint of leg/anchor))	Negligible	N/A	Negligible

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation significance	Additional mitigation measures proposed	Residual significance
			No change (far field)			
	Margate and Long Sands SAC	Negligible	Medium (near field (footprint of leg/anchor)) No change (near field (beyond the footprint of leg/anchor)) No change (far field)	Negligible	N/A	Negligible
	KKE MCZ	Negligible	Medium (near field (footprint of leg/anchor)) No change (near field (beyond the footprint of leg/anchor)) No change (far field)	Negligible	N/A	Negligible

Table 8.52 Summary of cumulative effects on marine geology, oceanography and physical processes

Cumulative Effects	Receptor	Sensitivity	Magnitude	Pre-mitigation significance	Additional mitigation measures proposed	Residual significance
Cumulative						
Cumulative changes in seabed level	Essex coast	Negligible	Negligible to Medium	Negligible	N/A	Negligible
	Suffolk coast,	Negligible	Negligible to Medium	Negligible	N/A	Negligible
	Margate and Long Sands SAC	Negligible	Negligible to Medium	Negligible	N/A	Negligible
	Annex I sandbanks	Negligible	Negligible to Medium	Negligible	N/A	Negligible
	KKE MCZ	Negligible	Negligible to Medium	Negligible	N/A	Negligible
Cumulative changes in operational tidal currents	Annex I sandbanks	Negligible	Medium to Low	Negligible	N/A	Negligible
	KKE MCZ	Negligible	Medium to Low	Negligible	N/A	Negligible
Cumulative changes in operational waves	Annex I sandbanks	Negligible	Medium to Low	Negligible	N/A	Negligible
	KKE MCZ	Negligible	Medium to Low	Negligible	N/A	Negligible
Cumulative changes in operational sediment transport	Essex coast	Negligible	Medium to Low	Negligible	N/A	Negligible
	Suffolk coast	Negligible	Medium to Low	Negligible	N/A	Negligible
	Margate and Long Sands SAC	Negligible	Medium to Low	Negligible	N/A	Negligible
	Annex I sandbanks	Negligible	Medium to Low	Negligible	N/A	Negligible
	KKE MCZ	Negligible	Medium to Low	Negligible	N/A	Negligible

8.13 References

ABPmer (2011a). The Galloper Wind Farm: Baseline Coastal Processes. ABPmer Report R.1782, March 2011.
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HARNESSING THE POWER OF NORTH SEA WIND

North Falls Offshore Wind Farm Limited

A joint venture company owned equally by SSE Renewables and RWE.

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