RWE Renewables UK Dogger Bank South (West) Limited

RWE Renewables UK Dogger Bank South (East) Limited

Dogger Bank South Offshore Wind Farms

Preliminary Environmental Information Report

Chapter 8 – Marine Physical Environment

24/04/2023

Document Reference: 004300115

Revision: 04

Unrestricted

Company:	**RWE Renewables UK Dogger Bank South (West) Limited and RWE Renewables UK Dogger Bank South (East) Limited**	Asset:	**Development**
Project:	**Dogger Bank South Offshore Wind Farms**	Sub Project/Package:	**Consents**
Document Title or Description:	Preliminary Environmental Information Report – Chapter 8 – Marine Physical Environment		
Document Number:	004300115-04	Contractor Reference Number:	PC2340-RHD-OF-ZZ-RP-Z-0048

The document Originator shall complete this Cover Sheet and may give guidance below on any actions required by the recipient(s). The document Checker and Approver must not be the same person. The Document Author and Approver must not be the same person. The Approver must not be less senior than the Author.

Rev No.	Date	Status/Reason for Issue	Author	Checked by	Approved by
01	22/02/2023	First Issue	CM / CP	HC	AP
02	24/03/2023	Second Issue	CM / CP	CC	HC
03	05/04/2023	Third Issue	CP	CC	HC
04	24/04/2023	Fourth Issue	CP	CC	DB

Unrestricted

Contents

Tables

Dogger Bank South Offshore Wind Farms

Volume 2 - Figures

Plates

Dogger Bank South Offshore Wind Farms

Volume 3 – Appendices

Appendix 8.1 Marine Physical Processes Technical Note

Appendix 20.2 Water Environment Regulations Compliance Assessment

Unrestricted

004300115-04

Glossary

Term	Definition
Accommodation Platform	An offshore platform (situated within either the DBS East or DBS West array area) that will provide accommodation and mess facilities for staff when carrying out maintenance activities for the Projects.
Amphidromic Point	The centre of an amphidromic system; a nodal point around which a standing-wave crest rotates once each tidal period.
Array Areas	The DBS East and DBS West offshore array areas, where the wind turbines and array cables will be located. The array areas do not include the offshore export cable corridor.
Array Cables	Cables which link the wind turbine generators to the offshore substation/converter/collector platform(s).
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. sand waves, ripples) resulting from the movement of sediment over it.
Clay	Fine-grained 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.

Term	Definition
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.
Current	Flow of water generated by a variety of forcing mechanisms (e.g. waves, tides, wind).
Dogger Bank South (DBS) Offshore Wind Farms	The collective name for the two Projects, DBS East and DBS West.
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).
Electrical Switching Platform (ESP)	The electrical switching platform (if required) will provide a link to a co-ordinated east coast transmission system which is planned to run from Scotland to England, as per National Grid ESO's Holistic Design Network. This platform may be located either within one of the array areas (alongside a converter station) or mid-way along the export cable corridor (likely next to the Reactive Compensation Platform if required).
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.

Term	Definition
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).
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.
Inter-Platform Cables	Cables linking offshore platforms.
Intertidal	Area on a shore that lies between Lowest Astronomical Tide (LAT) and Highest Astronomical Tide (HAT).
Landfall	The point at the coast at which the offshore export cables are brought onshore, connecting to the onshore cables at the transition joint bay above mean high water.
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 sand waves 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 (~20m).

Term	Definition
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 Converter Platforms (OCPs)	Offshore Converter Platforms (OCPs) will be required for the HVDC option. The OCPs are fixed structures located within the array area that collect the AC power generated by the wind turbines and convert the power to DC, before transmission through the offshore export cables to the Project's onshore grid connection points.
Offshore Development Area	The Offshore Development Area encompasses the wind farm site and the options for the offshore transmission works.
Offshore Export Cable Corridor	This is the area which will contain the offshore export cables (and potentially the ESP and / or RCP) between the offshore substation/converter platforms and Transition Joint Bays at the landfall.
Offshore Substation Platforms (OSPs)	Offshore Substation Platforms (OSPs) will be required for the HVAC option. These are fixed structures located within the array areas that contain electrical equipment to aggregate the power from the wind turbines, followed by conversion into a more suitable voltage for transmission through the offshore export cables to the Project's onshore grid connection points.
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.
Reactive Compensation Platform (RCP)	A Reactive Compensation Platform (RCP) will be required for a HVAC solution. The RCP will host the shunt reactors required to provide reactive compensation, in order to limit the electrical losses which occur with HVAC transmission over long distances.

Term	Definition
Sand	Sediment particles, mainly of quartz with a diameter of between 0.063mm and 2mm. Sand is generally classified as fine, medium or coarse.
Sand Wave	Bedforms with wavelengths of 10 to 100m, with amplitudes of 1 to 10m.
Scoping Opinion	The report adopted by the Planning Inspectorate on behalf of the Secretary of State.
Scoping Report	The report that was produced in order to request a Scoping Opinion from the Secretary of State.
Scour Protection	Protective materials to avoid sediment erosion from the base of the wind turbine foundations and offshore platform foundations due to water flow.
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.

Term	Definition
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.
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.
The Applicant	RWE Renewables UK Dogger Bank South (West) Limited and RWE Renewables UK Dogger Bank South (East) Limited as the owners of DBS West and DBS East respectively are the named undertakers that will have the benefit of the Development Consent Order. References in this document to obligations on, or commitments by, 'the Applicant' are given on behalf of RWE Renewables UK Dogger Bank South (West) Limited and RWE Renewables UK Dogger Bank South (East) Limited.
The Projects	DBS East and DBS West (collectively referred to as the Dogger Bank South offshore wind farms).

Term	Definition
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.
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.
Wavelength	The horizontal distance between consecutive wave crests (or alternative troughs).

Acronyms

Term	Definition
ADCP	Acoustic Doppler Current Profiler
BAC	Background Assessment Concentration
BEIS	Department of Business, Energy and Industrial Strategy
BGS	British Geological Survey
CD	Chart datum
CEA	Cumulative Effects Assessment
Cefas	Centre for Environment, Fisheries and Aquaculture
CFB	Coastal Flood Boundaries
CPA	Coast Protection Act 1949
DBS	Dogger Bank South
DCO	Development Consent Order
DECC	Department of Energy and Climate Change
EAC	European Assessment Criteria
ECC	Export Cable Corridor
EEA	European Economic Area
EEZ	Exclusive economic zone
EIA	Environmental Impact Assessment
EMF	Electro Magnetic Field
EPA	Environmental Protection Agency
EPP	Evidence Plan Process

Term	Definition
EQS	Environmental Quality Standard
ERL	Effects Range-Low
ES	Environmental Statement
ETG	Expert Topic Groups
EYRC	East Riding of Yorkshire Council
FEPA	Food and Environment Protection Act 1985
GBS	Gravity Base Structures
HDD	Horizontal Directional Drilling
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
ICES	International Council for the Exploration of the Sea
JNCC	Joint Nature Conservation Committee
LAT	Lowest astronomical tide
MBES	Multi-beam echosounder
MCZ	Marine Conservation Zone
MMO	Marine Management Organisation
MPCP	Marine Pollution Contingency Plan
MPS	Marine Policy Statement
MSR	Mean Spring Range
MW	Mega Watt
NCERM	National Coastal Erosion Risk Mapping

Term	Definition
NPS	National Policy Statement
NSIP	Nationally significant infrastructure project
OD	Ordnance datum
OSP	Offshore substation platform
OSPAR Convention	Convention for the Protection of the Marine Environment of the North-East Atlantic
OWF	Offshore Windfarm
PAH	Polyaromatic hydrocarbons
PCB	Polychlorinated biphenyls
PDE	Project Design Envelope
PEIR	Preliminary Environmental Information Report
PINS	Planning Inspectorate
PSA	Particle Size Analysis
QSR	Quality Status Reports
RCP	Representative Concentration Pathway
SAC	Special Area of Conservation
SBP	Sub bottom profiler
SCAPE	Soft Cliff and Platform Erosion
SCI	Sites of Community Importance
SPA	Special Protection Area
S-P-R	Source-pathway-receptor

Term	Definition
SSS	Side Scan Sonar
SSSI	Site of Special Scientific Interest
Term	Definition
UKCP	UK Climate Projections

8 Marine Physical Environment

8.1 Introduction

1. This chapter of the Preliminary Environmental Information Report (PEIR) considers the likely significant effects of the Projects on the marine physical environment (which includes marine sediment and water quality). The chapter provides an overview of the existing environment for the proposed Offshore Development Area, followed by an assessment of likely significant effects for the construction, operation, and decommissioning phases of the Projects.

2. The assessment should be read in conjunction with the following linked chapters:

- **Chapter 9 Benthic Habitats**;
- **Chapter 10 Fish and Shellfish Ecology**; and
- **Chapter 17 Offshore Archaeology and Cultural Heritage**.

8.2 Consultation

3. Consultation with regard to the marine physical environment has been undertaken in line with the general process described in **Chapter 6 EIA Methodology**. The key elements of consultation to date have included scoping and the ongoing Evidence Plan Process (EPP) via the seabed Expert Topic Group (ETG). The feedback received has been considered in preparing the PEIR. **Table 8-1** provides a summary of how the consultation responses received to date have influenced the approach that has been taken. Note that marine sediment and water quality was originally presented as a separate chapter in the Scoping Report therefore consultation responses specific to scoping are presented separately in **Table 8-2**. From this point on, however, the two topics are combined under the heading 'marine physical environment'.

4. This chapter will be updated following consultation on PEIR in order to produce the final assessment that will be submitted with the Development Consent Order (DCO) application. Full details of the consultation process will also be presented in the Consultation Report alongside the DCO application.

Table 8-1 Consultation Responses Related to Marine Physical Processes

Comment	Project Response
PINS scoping response 02/09/2022	
The Inspectorate agrees that the effects on waves and tidal currents from equipment during construction can be scoped out in relation to the offshore environment. However, the ES should consider whether nearshore / cable landfall works may impact on waves and tidal currents, and subsequently other coastal processes including geomorphological changes and processes, and surge water levels.	An assessment of the impact of cable installation in the nearshore and at the possible landfall location is considered in sections 8.7.4.3 and 8.7.4.4. Changes to wave and tide regime due to the presence of cable protection measures in the nearshore during operation is considered in section 8.7.5.5. As the cable will be installed using HDD, there will be no impact on coastal geomorphology, surge water levels or coastal erosion during operation.
In view of the information in the Scoping Report the Inspectorate appreciates that physical alterations to the seabed topography caused by installation techniques are expected to infill naturally, the Scoping Report stating a timescale of 'a few days to months'. In the absence of site-specific information on the seabed	Physical changes to the seabed due to installation vessels during construction are scoped in and assessed in section 8.7.4.10. The worst case assumes scour protection is required for all foundations. The impact of scour protection is assessed in relation to loss of seabed area in section 8.7.5.8. It is assumed that the design of scour

Comment	Project Response
conditions the extent of scour/secondary scour effects cannot be understood. The Inspectorate does not agree to scope this matter out at this stage, and advises that this matter is assessed within the ES, or evidence provided to demonstrate that significant effects will not occur.	protection will mitigate any impact of scour on the seabed with secondary effects of scour being limited to within a few meters of the protection.
Table 2-3 states that impacts arise from the presence of large foundations will be assessed in the operational phase. The information relating to the impact-effect pathways lacks necessary detail in order to understand why construction processes could not also result in impacts to Flamborough Front. The Inspectorate does not agree to scope this matter out and advises that this matter is addressed within the Evidence Plan Process (EPP) referred to in Paragraph 174.	The main impacts in relation to the construction phase are due to disturbance of the seabed. The Flamborough Front is not sensitive to changes in bedload sediment transport or to changes in seabed level and morphology. Therefore, no effects from construction activities are anticipated. This will be discussed within the EPP, if required. Instead, the main potential impact on the Flamborough Front would be changes in water column mixing due to the presence of foundations (the wake effect) during the operation phase. This impact has been scoped in and is considered in section 8.7.5.3.
The Scoping Report states that "There is an extensive and robust evidence base on the previous Dogger Bank wind farms work to negate the need for numerical modelling to support the assessment of the Projects.". No evidence is presented within the Scoping Report to support this statement, and as such at present the Inspectorate cannot comment on the requirement for numerical modelling. The ES should present a detailed methodology for the assessment, and include relevant information to inform the assessment such as numerical modelling, as necessary.	A note outlining the results of previous modelling undertaken in the Dogger Bank region and its relevance to DBS offshore wind farms has been prepared and provided to ETG members for review (**Appendix 8-1**). A summary of this information is provided in 8.7.3. Following consultation via the marine physical environment ETG, Project-specific modelling of changes to the marine physical environment will be undertaken and included as part of the ES.
The Scoping Report refers (Paragraph 163) to the potential for the nearshore to be affected as a result of the cable landfall. Table 2-4 does not identify whether there are any onshore designated features (such	A full list of receptors considered in the PEIR is given in **Table 8-21** and includes the undesignated Flamborough Front which is assessed in section 8.7.5.3.

Comment	Project Response
as coastal Sites of Special Scientific Interest (SSSIs)) that may be impacted as a result of the Proposed Development. It is also noted that Flamborough Front is omitted from the Table. While the Inspectorate understands this is an undesignated feature it is nevertheless considered to be of high value and is likely to experience impacts from the Proposed Development. The ES should provide an assessment of the impacts likely to result in significant effects for all relevant receptors.	
Section 2.1 of the Scoping Report does not refer to the potential effects of encountering unexploded ordnance (UXO), and the potential for accidental or planned detonation, in relation to marine physical processes. The Inspectorate considers that the ES should assess the likely significant effects which could occur in this regard.	The impact of accidental or planned UXO detonation on the marine physical environment has not been assessed as a separate impact as the worst case for seabed preparation for foundation and cable installation (section 8.7.4.1) will disturb a greater volume of sediment in total when compared with the likely number and size of detonations across the Project. Furthermore, the worst case for indentations on the seabed caused by installation vessels (section 8.7.4.10) will be greater in number, and cumulative seabed footprint than from than any impact from localised UXO detonations. A separate marine licence application will be made for any UXO clearance works which would be subject to its own environmental assessment. Furthermore, in all cases where UXO are found, UXO health and safety procedures take precedence.
Paragraph 39 (Scoping Report Section 1.5) indicates that scour protection installation may involve seabed preparation (levelling and gravel installation). The Scoping Report chapter for marine physical processes does not state whether this is to be assessed as a potential impact. The Inspectorate considers that the installation (and	Changes in suspended sediment concentration due to seabed preparation for foundation installation are assessed in section 8.7.4.1. The presence of scour protection measures during operation is assessed in relation to loss of seabed area in section 8.7.5.8.

Comment	Project Response
subsequent presence) of scour protection should be assessed for all project phases.	
Environment Agency Scoping Response 08/12/2021	
Do you agree with the characterisation of the existing environment? Broadly yes. The characterisation here is at a very high level, which is understandable for these early stages of planning, although there are some areas that we would comment on: Cliff recession: We note that linear extrapolation of averaged recession rates is used to provide indicative recession distances over the next 60 years, albeit with an accompanying caveat that future rates may be higher. We would encourage a most robust approach to forecasting future trends within the Environmental Statement in order to consider the reasonable worst case scenario at the potential landfall locations. The Environment Agency is currently funding a research project examining projections of future cliff recession rates and the application of regionally specific multipliers to account for accelerated erosion due to climate change, which could be useful for this work (unless similar bespoke work is planned).	Predictions of cliff erosion rates have been made using empirical equations in section 8.6.2. The suitability of the outputs of the Environment Agency funded research project to the Skipsea coastline was discussed at the marine physical processes ETG (held on 20th January 2023) and it was agreed that the use of the SCAPE modelling tool would not be suitable over the timeframe of the DBS Projects.
Do you agree with the approach to data collection? Yes.	Noted
Have all the potential impacts on the marine physical processes resulting from the Projects been identified in the Scoping Report? Largely, yes. Could construction activities / any structures remaining during the operational period result in changes to physical processes, or scour/erosion, in	Scour around foundations during the operational phase is scoped in. The effect on physical processes will incrementally increase as the wind farms are constructed with the greatest potential impacts resulting from the completed wind farms. These impacts are therefore covered under operational effects, and are scoped out of

Comment	Project Response
inshore and intertidal areas in the vicinity of the landfall area? It may be necessary to scope in the risk of localised or temporary changes at this stage because the different assessments (Environmental Impact Assessment (EIA) / Habitat Regulations Assessment / Water Environment Regulations assessment) will require impacts to be assessed at different scales.	further consideration in relation to the construction phase. Changes in the marine physical environment due to installation of the Horizontal Directional Drilling (HDD) exit pits (including potential temporary installation of cofferdams) are scoped in to the construction phase (see sections 8.7.4.4 and 8.7.4.9)
Do you agree with the impacts which have been scoped in (or scoped out) of further assessment? Largely yes, but we question the decision to scope out the potential for impacts on bedload sediment transport and seabed morphological change during construction. Until a final design is agreed on, we would consider there to be a risk that the construction of landfall infrastructure could impact on coastal processes and geomorphology (e.g. if coffer dams are required). We therefore suggest that this should be scoped in.	An assessment of changes to sediment transport processes at the landfall are now scoped in (see sections 8.7.4.4 and 8.7.4.9)
Do you agree with the proposed approach to assessment? Yes, although having not had the opportunity to review the modelling and assessment work undertaken for all the offshore wind farms mentioned, we are unable at this time to comment on how appropriate it is to re-use this work for this project. In particular, we are keen to ensure that modelling and assessment relating to coastal processes and geomorphology impacts at the landfall locations is appropriate for the specific frontage(s) selected, which may differ from previous offshore wind projects. The assessment should show that the development will not have a negative	The assessment of effects at the landfall will be conceptual and based on the evidence base that exists for the Holderness coast from previous wind farms landing here, but also the significant research base that exists. There was no coastal modelling completed for the previous wind farms. The evidence base further offshore will provide the necessary baseline information to determine potential impact at the coast from the Projects array sites. Given the large distance from the coast, at this stage, there is considered to be no impact at the coast from the array site. The assessment has considered implications for coastal change and flood

Comment	Project Response
impact on coastal processes and should consider the impact now and in the future. It will also need to consider the implications of coastal change and flood risk on the development, as well as from the development. The Shoreline Management Plan (SMP) should form the basis for the assessment. If further coastal interventions or mitigation is required, this should be in line with the SMP. It should be noted that some SMP Policy Units contain different options over the epochs included. In such cases, the approach will need to be justified. Where interventions are required / possible, the assessment should set out the requirements and dependencies. Where existing flood or coastal risk management assets exist, we would wish to see that the interests of the relevant management authority are protected. For example, access for operational or maintenance purposes. We may seek legal agreements to protect the interests of the Environment Agency, where appropriate.	risk in line with the SMP as outlined in sections 8.5.15 and 8.6. Details on the modelling undertaken for Dogger Bank A & B and why it is a suitable proxy for DBS offshore wind farms have been provided to the seabed ETG as part of the marine physical processes method statement to seek agreement on this (See **Appendix 8.1** and section 8.7.3).
Cumulative Impacts Assessment: We welcome the acknowledgement of a cumulative impacts assessment to be undertaken as part of the final EIA with an offshore focus. A number of similar projects have been completed in recent years, as well as other similar schemes currently being advanced. However, we are not clear if the offshore focus overlooks activities/impacts in the Humber.	Impacts in the Humber will be included in the Cumulative Effect Assessment (CEA), as required, which will be included in the ES.
The SMP (2010) Flamborough Head to Gibraltar Point identifies policy units based on the intended management approach to the shoreline. In brief, large areas of the coastline are undefended, and natural erosion will occur. This section of the coast	An assessment of coastal erosion has been undertaken (section 8.5.15) which considers historic monitoring of coastal retreat undertaken by East Rising of Yorkshire Council and the National Coastal Erosion Risk Mapping (NCERM) risk

Comment	Project Response
has some of the fastest rates of erosion in Europe. If a landfall option is chosen within the undefended sections of the SMP, the applicant should consider the implications of this on their infrastructure over its lifetime. Please note that coastal erosion is often unpredictable and non-linear (as per para. 144). The assessment should consider the uncertainties and be precautionary. Coastal erosion advice is contained within the Planning Practice Guidance and also the relevant National Policy Statements. We recommend that as part of your assessment you consider a range associated with coastal erosion. The National Coastal Erosion Risk Mapping (https://data.gov.uk/dataset/7564fcf7-2dd2-4878-bfb9-11c5cf971cf9/national-coastal-erosion-risk-mapping-ncerm-national-2018-2021) may be of relevance to your assessment."	mapping. These data have been compared to predicted rates of cliff retreat in section 8.6.2 to highlight the range and uncertainty in rates depending on the tools used for predictions.
Historic England Scoping Response 23/08/2022	
Section 2.1 (Marine Physical Processes) – it is our advice that changes, as proposed by this project arising from 'construction' should be considered as likely to give rise to significant impacts on seabed features and morphology. In reference to the explanation provided about mitigation (section 1.7.2.4) it is a relevant matter that the applicant demonstrates a "commitment" to conduct geophysical, geotechnical survey and other seabed intrusive investigations, as part of the preparation of any Environmental Statement (ES) produced for this proposed project.	Assessment of changes to sediment transport processes and morphology during construction are now scoped in. Geophysical surveys, grab sampling and metocean surveys are being carried out. Initial metocean results are presented in section 8.5.6 and a review of intrusive boreholes acquired during 2022 are given in section 8.5.2. Limited geotechnical studies have been undertaken within the array areas to date. Further studies will be on-going along the offshore ECC and within the array areas throughout 2023 and 2024. The results are not likely to be available to inform the consents application process.

Comment	Project Response
Natural England Scoping Response 23/08/2022	
Existing Environment. We advise that baseline information on the following; regional solid geology, regional Quaternary geology, bedform mapping, seabed mobility, sediment transport rates and pathways, site-specific geotechnical data, coastal cells and sub-cells should be taken into consideration in the ES to provide environmental context.	Noted. These have been considered in sections 8.5.1, 8.5.2, 8.5.3, 8.5.7, 8.5.8, 8.5.12 and 8.5.13. These sections will be updated with Project-specific survey data at ES.
We advise the Applicant considers surge water levels.	Extreme water levels have not been considered as trenchless techniques such as HDD will be used at the landfall location. This means the cables will pass below the cliff and will not be influenced by surges. Offshore, storm surges were included in the analogues numerical modelling undertaken for the Dogger Bank A & B and Dogger Bank C and Sofia Offshore Wind Farms (see **Appendix 8-1**).
It is noted that at the proposed landfall locations close to Skipsea, there is regional net sediment transport predominantly to the south. The presence of any temporary infrastructure in the nearshore zone, such as access ramps or cofferdams, may interfere with the longshore transport of material along the coastline. Longshore transport rates and directions at the landfall/in the nearshore zone should, therefore, be considered and assessed, to determine if there if there is the potential for the development and associated infrastructure to interact with the coast. And any mitigation measures that may be required.	Baseline coastal sediment transport processes have been assessed in section 8.5.15 and potential changes to these processes due to construction at the landfall are considered in section 8.7.4.9.
Coastal Erosion. There are no site-specific data for the proposed landfall locations at Skipsea. This is an undefended stretch of	Trenchless installation techniques, such as HDD, will be used at the landfall. This means the cables will pass beneath the cliff

Comment	Project Response
coast which experiences high rates of cliff erosion, including episodic events of high cliff retreat. The evolution of the coast at landfall and implications to longshore sediment transportation will need to be taken into account for the lifetime of the development, this is particularly important to cable burial and siting of jointing bay infrastructure and maintaining designated site features further south. We would advise that site-specific cliff height, cliff erosion data and shore platform down wearing data be included in the baseline characterisation for the landfall environment. Cliff erosion data and beach profile data are available from East Riding of Yorkshire Council (ERYC). We would also advise that the Applicant considers how the coast at landfall will alter throughout the lifetime of the development, both in terms of vertical change in beach profile and coastal retreat and the changes this has on longshore sediment transport.	system emerging on the onshore side of the cliff top. Historical and future coastal (cliff and shore platform) erosion rates have been considered (see sections 8.6 and 8.5.16) in relation to the onshore entrance pit. The location of the offshore exit pit is to be determined but may be within the intertidal zone. Changes in the vertical beach profile in relation to the location of the offshore HDD exit pit will be considered in the ES.
There are other existing primary data which the Applicant should consider in the baseline environment characterisation, such as: bedform distribution across the study area, seabed mobility, sediment transport pathways, littoral sub-cell boundaries, and any available site specific geotechnical data. This may be in the form of existing data from other OWF projects including those that are operational where appropriate.	Project-specific bathymetric survey data will be assessed at ES to characterise the seabed and identify bedforms and sediment mobility. Site-specific geotechnical data have been assessed in section 8.5.2.Tidal ellipse data are being acquired and the full analysis will be incorporated at ES. This will be used alongside data from adjacent wind farms, where relevant. The results from a Project-specific sediment mobility study will also be included at ES.
The Cefas suspended sediment concentration data are now old (i.e. 1998-2015). NE best practice advises that, as a general benchmark, care should be taken when considering datasets which are older than five years. Ideally, simultaneous records of SSC, water levels, currents and	Two wave buoys have been deployed, one in DBS East and one in DBS West. These wave buoys include downward facing Acoustic Doppler Current Profilers (ADCPs) that measure current speed and direction. Initial wave results from these buoys are

Comment	Project Response
waves should be obtained to help form a better understanding of the process controls on sediment mobilisation events and subsequent transport across the project study area.	given in section 8.5.6 and the full data set will be included at ES.
We advise that a baseline understanding of Smithic Bank needs to be established in order to understand the potential impact of the Dogger Bank South cable installation, cable repair/replacement, and cable protection alone, or in-combination with other developments.	Available information from Smithic Bank is provided in sections 8.5.1 and 8.5.7. It is also considered as a key receptor in the impact assessment in section 8.7.4.9.
Other data sources. Bathymetric data/comparative studies are available as follows: • Brew and Cooper (2022) • Ørsted (2022) • Pye et al. (2015)	Noted, these will be considered where relevant.
Other impacts due to construction activities at landfall may include the use of a temporary beach access ramp, construction vehicle/plant traffic across the beach, ancillary infrastructure (e.g. cofferdams) and seabed excavation within shallow nearshore areas. We advise that these potential impacts on the local wave regime and/or coastal morphology may also need to be considered by the Applicant. It would also be appropriate to consider adoption of successful landfall operations undertaken by other OWF developers along this coast.	Trenchless installation techniques, such as HDD, will be used at the landfall. This will require an entrance (landward) and exit (seaward) pit. The worst case assumes the exit pit will be in the intertidal area and may require temporary structures such as cofferdams. This has been considered in the impact assessment in sections 8.7.4.9 and 8.7.5.5.
Impacts on seabed morphology due to indentations on the seabed from installation vessels have been scoped out of further consideration. Until site-specific evidence of the subseabed conditions becomes available, there exists the potential for anchoring or jack-up vessel	Indentations on the seabed due to installation vessels have now been scoped in and are assessed in section 8.7.5.9.

Comment	Project Response
legs to penetrate the seabed, cause scour/secondary scour, and to impact the morphology and features of the seabed both during both construction and operation. We advise that this impact be scoped in for construction and operation/maintenance vessels until further evidence becomes available on the nature of the seabed and its mobility.	
Scour at each foundation. Consider modelling of scour around foundations, evaluating scour potential and thus, scour protection requirements. Consider including a seabed sediment mobility study.	Scour around foundations will be based on empirical data, and existing 'generic' modelling that has been carried out. A seabed mobility study has been undertaken and will be incorporated into any assessments in relation to scour protection.
Flamborough Front. We advise that careful consideration should be given to potential enhanced mixing of the water column due to the Dogger Bank South arrays both alone, and in-combination, with the other Dogger Bank OWF developments. Baseline characterisation surveys should include the natural cycle of water column stratification, biogeochemical fluxes, and primary productivity. The Applicant should also consider turbine spacing and potential wake-wake interactions. This should also be considered in the Outline Monitoring Plan.	The effects on the Flamborough Front are assessed in section 8.7.5.3. At a minimum turbine spacing of 830m, the potential for wake-wake effects is considered low.
Cumulative impacts of cable installation and cable repair/replacement/protection due to multiple developments making landfall across Smithic bank. We advise that this needs to be assessed.	This will be assessed at ES as part of the CEA.
Effects on bedload sediment transport and changes to seabed morphology – Construction. Seabed morphology should be scoped in.	This has been scoped in and is assessed in sections 8.7.4.6, 8.7.4.7, 8.7.4.8 and 8.7.4.9.

Comment	Project Response
Effects on bedload sediment transport and changes to seabed morphology – Decommissioning	This has been scoped in and is assumed to be comparable to effects during construction which is assessed in sections 8.7.4.6, 8.7.4.7, 8.7.4.8 and 8.7.4.9.
Impacts on waves and tidal currents for construction/decommissioning. These impacts be scoped in for the nearshore zone and landfall.	Any changes to waves/tidal current flows at the landfall due to temporary infrastructure would manifest as temporary changes to sediment transport, which is now scoped in for assessment at the landfall.
Impacts on seabed morphology due to indentations on the seabed from installation vessels. This impact should be scoped in for construction and operation, until there is a better understanding of the sub-seabed conditions.	Indentations on the seabed due to installation vessels have now been scoped in and are assessed in section 8.7.5.9.
Use of numerical modelling from other OWF projects. It will need to be robustly demonstrated why/how numerical data designed for other projects are directly relevant, and directly applicable, to Dogger Bank South. Moreover, the Applicant will also need to consider and provide evidence of the cumulative effect of Dogger Bank South and other nearby OWFs, on the hydrodynamic regime.	A method statement outlining the relevance of the results of previous modelling undertaken for the existing Dogger Bank offshore wind farms has been prepared as a separate supporting document (**Appendix 8-1)** The results from the previous modelling are discussed alongside conceptual understanding and the existing evidence base in section 8.7. Project-specific physical process modelling is being undertaken. The result will be available to inform the ES to be produced for the Projects The cumulative effect of DBS and other projects on the hydrodynamic regime will be included in the CEA at ES. A high-level list of Projects to be considered in the CEA at ES is detailed in section 8.8.2.
Lifetime of the project. Need to consider all stages of the development lifespan. This includes consideration of the potential	Noted. This is considered in section 8.7.6.

Comment	Project Response
impacts resulting from any infrastructure that may remain in situ after decommissioning.	
Receptors The list of receptors proposed for inclusion in the assessment does not include the following: • Holderness Coast (morphological feature) • Flamborough Front (water column feature) • Seabed sedimentary features such as The Hills • Geological SSSIs along the Holderness Coast • More distant receptors such as Spurn Head, Humber Estuary etc.	These have been considered as receptors as outlined in section 8.7.1. The location of seabed sedimentary features such as "The Hills" relative to the Projects will be determined at ES using Project-specific bathymetric survey data.

Table 8-2 Consultation Responses Related to Marine Sediment and Water Quality

Comment	Project Response
PINS scoping opinion 02/09/22	
The Inspectorate notes the brief commentary in the Scoping Report on the nature of the sediments in the study area and how this affects risk of potential impacts. Assessment of scour impacts during operation is proposed to be scoped out on the basis of the outcomes of previous assessment of Dogger Bank A and B, however this is not supported by any verified information e.g., monitoring data. In the absence of more project specific information on the receiving environment and details of construction and operation activities, the Inspectorate does not consider that the information in the Scoping Report is sufficient to scope these matters out at this stage. The ES should assess this matter or provide the information necessary to demonstrate that assessment is not required.	Scour protection is proposed (see **Chapter 5 Project Description**) which will minimise scour from the Projects. Scour effects are considered in Section 8.7.5.8.
The Inspectorate notes the information in the Scoping Report on the levels of contaminants in the study area based on Dogger Bank A and B studies. Information for the Proposed Development is not presented and site-specific analysis is not proposed. In the absence of this information, and details of construction and operation activities, the Inspectorate cannot agree to scope this matter out. The ES should assess this matter or provide the information necessary to demonstrate that assessment is not required.	Site specific data will be included with the ES – data was not available for the production of this PEIR chapter as such potential impacts from contaminants have been scoped in at this stage of the assessment.

Comment	Project Response
The Scoping Report does not provide any reasoning for scoping out accidental pollution during operation. Reference is made to the use of a Project Environmental Management Plan under the identified potential impact of pollution form construction vessels, however no other sources of accidental pollution are discussed. Decommissioning impacts are dismissed briefly with the reasoning that they are expected to be lesser than those for construction. The Inspectorate acknowledges that for all project phases the risk of significant effects from accidental pollution can generally be controlled by the use of mitigation plans and measures, and therefore accepts that significant effects are unlikely. Nevertheless, the ES must detail the potential sources and types of accidental pollution for all project phases and set out the proposed mitigation measures, including those to be included within the Project Environmental Management Plan, and indicate how these are to be secured.	An outline Project Environmental Management Plan will be provided with the DCO application which will detail potential sources and types of accidental pollution for all Project phases.
The Scoping Report states that cumulative effects are to be scoped out as all impacts have been scoped out. The Inspectorate considers that a pathway for effects may exist for each of the matters above, and that even if further consideration concludes that effects would be minor, they could combine with others to result in significant effects. Where a pathway for effects cannot be excluded the ES must assess the any likely significant cumulative effects that may occur.	Cumulative effects will be considered as part of the CEA as outlined in section 8.4.4.

Comment	Project Response
Figure 2.6 of the Scoping Report shows historical sample points (around Dogger Bank A and B and associated export cable route), but no coverage of the Dogger Bank South study area. It is not justified why this data can be relied upon to represent conditions within the Proposed Development and why site-specific contaminant analysis is not proposed. This analysis should be carried out and reported in the ES, or the ES should provide full reasoning as to why this is not required including the outcomes of consultation with the relevant stakeholders and consultation bodies.	Site specific data will be included with the ES – data was not available for the production of this PEIR chapter and therefore the same information as presented in the scoping report is included here in the interim.
Table 2-5 and 2-6 provide sediment contaminant analysis for the Dogger Bank A and B export cable corridor, and Tranche A windfarm array area, with reference to Cefas Action Levels. The Action Levels are not explained in the context of the rationale presented. The ES should include this information. In addition, data is only presented for the two datasets noted above, whereas Figure 2-6 indicates that data is available for the nearshore area. The data is also noted to date from 2013. The ES should ensure that data relied upon for the assessment of effects is both relevant and up to date.	An explanation regarding the use of Cefas Action Levels is provided in section 8.4.1. Site specific data will be included with the ES – data were not available for the production of this PEIR chapter and therefore the same information as presented in the scoping report is included here in the interim. Sample sites for the nearshore are presented in **Figure 8.8** and the data in **Table 8-16**.
Environment Agency Response 08/12/2021	
The assessment may need to use other sediment quality guidance in addition to Cefas Action Levels.	Additional assessment will be undertaken within the ES to include use of OSPAR sediment guidelines once site specific data is available.

Comment	Project Response
Water Framework Directive Water Bodies – various additional water bodies to be included.	Water Framework Directive (WFD) water bodies were identified purely to inform the water quality baseline for this topic. A full Water Environment Regulations Compliance Assessment is provided in Appendix 20.2 which includes rationale for water bodies identified to be at risk and considers all WFD compliance parameters, not just water quality.
Natural England Response 23/08/2022	
Increases in suspended sediment concentrations (SSC) during construction and operation (e.g. future dredging works) have the potential to smother sensitive habitats. The ES should include information on the sediment quality and potential for any effects on water quality through suspension of contaminated sediments. The EIA should also consider whether increased suspended sediment concentrations resulting are likely to impact upon the interest features and supporting habitats of the designated sites as listed above.	Increases in suspended sediment concentrations are considered in sections 8.7.4 and 8.7.5. Site specific data will be included with the ES – data were not available for the production of this PEIR chapter and therefore the same information as presented in the scoping report is included here in the interim. Effects on designated sites will be considered in the ES.
The ES should consider whether there will be an increase in the pollution risk as a result of the construction or operation of the development.	Noted. An outline Project Environmental Management Plan will be provided with the DCO application.
For activities in the marine environment up to 1 nautical mile out at sea, a Water Framework Directive (WFD) assessment is required as part of any application. The ES should draw upon and report on the WFD assessment considering the impact the proposed activity may have on the immediate water body and any linked water bodies.	A full Water Environment Regulations Compliance Assessment is provided in **Appendix 20.2**.

8.3 Scope

8.3.1 Study Area

5. The marine physical environment study area has been defined on the basis of the direct footprint of the Offshore Development Area (see **Chapter 5 Project Description**) (near-field) and wider areas of seabed and coastline that could potentially be affected (far-field).

8.3.2 Realistic Worst Case Scenario

8.3.2.1 General Approach

6. The realistic worst case design parameters for likely significant effects scoped into the EIA for the marine physical environment assessment are summarised in **Table 8-3**. These are based on the project parameters described in **Chapter 5 Project Description**, which provides further details regarding specific activities and their durations.

7. In addition to the design parameters set out in **Table 8-3**, consideration is also given to the different development scenarios still under consideration and the possible phasing of the construction as set out in sections 8.3.2.2 to 8.3.2.5.

Table 8-3 Realistic Worst Case Design Parameters

	Parameter			
	DBS East in isolation (HVDC only)	**DBS West in Isolation (HVAC only)**	**DBS East and DBS West concurrently (HVAC+HVDC)**	**Notes and rationale**
Construction In the instance of sequential development, up to a two year lag between construction activities is possible. The final overall footprint would be identical to the concurrent design scenario.				
Impact C1a: Changes in suspended sediment concentration and transport due to seabed preparation for foundation installation	Wind turbines Seabed preparation for 48 large suction bucket foundations with four x 25 m diameter buckets per pile = 94,247m^2 Offshore platforms Seabed preparation for six gravity base foundations = 338,460m² HVDC only option requires four offshore converter platforms (OCPs), one Electrical Switching Platform (ESP) and one accommodation platform.	Wind turbines Seabed preparation for 48 large suction bucket foundations with four x 25 m diameter buckets per pile = 94,247m^2 Offshore platforms Seabed preparation for six gravity base foundations = 338,460m² HVAC only option requires four offshore substation platforms (OSPs), one Reactive Compensation Platform (RCP) and one accommodation platform.	Wind turbines Seabed preparation for 95 large suction bucket foundations with four x 25 m diameter buckets per pile = 186,531m^2 Offshore platforms Seabed preparation for eleven gravity base foundations = 620,510m² HVDC + HVAC option requires eight OSP/OCPs, one ESP, one RCP and one accommodation platform.	Seabed footprint of suction bucket jacket foundations for large wind turbines = 1,964m^2 per structure Seabed footprint of gravity base foundations for offshore platforms = 56,410m^2 per foundation (including scour protection) The RCP and /or ESP, if required, will be located in the offshore export cable corridor.
Impact C1b: Changes in suspended sediment concentration and transport due to drill arisings from foundations	Wind turbines Drill arisings from 48 large wind turbines = 42,306m^3 OSPs Drill arising from 4 monopile foundations = 71,252m^3	Wind turbines Drill arisings from 48 large wind turbines = 42,306m^3 OSPs Drill arising from 4 monopile foundations = 71,252m^3	Wind turbines Drill arisings from 95 large wind turbines = 84,611m^3 OSPs Drill arising from 8 monopile foundations = 142,504m^3	Volume of drill arisings from large monopile foundations = 17,813m^3 per pile Assumes 5% of all wind turbines will be drilled. Monopile diameter for offshore platforms assumed the same as for wind turbines with the worst

	Parameter			
	DBS East in isolation (HVDC only)	**DBS West in Isolation (HVAC only)**	**DBS East and DBS West concurrently (HVAC+HVDC)**	**Notes and rationale**
	Other platforms Drill arising from 2 monopile foundations = 35,626m³	Other platforms Drill arising from 2 monopile foundations (HVAC only) = 35,626m3	Other platforms Drill arising from 3 monopile foundations = 53,439m³	case being 17 m diameter monopiles.
Impact C1c: Changes in suspended sediment concentration and transport due to array, inter platform and offshore export cable installation	Displaced sediment during cable installation Total offshore cable length per circuit = 198km Number of cables required = 2 Max. offshore cable length for all cable circuits = 396km Offshore export cable (trench width 1m x maximum cable length 396km x burial depth 1m) = 396,000m³ Array cables (trench width 1m x maximum cable length 325km x burial depth 1m) = 325,000m³ Inter-platform cables (trench width 1m x maximum cable length 55km x burial depth 1.5m) = 82,500m³	Displaced sediment during cable installation Total offshore cable length per circuit = 158km Number of cables required = 4 Max. offshore cable length for all cable circuits = 632km Offshore export cable (trench width 1m x maximum cable length 632km x burial depth 1m) = 632,000m³ Array cables (trench width 1m x maximum cable length 325km x burial depth 1m) = 325,000m³ Inter platform cables (trench width 1m x maximum cable length 99km x burial depth = 1.5m) = 148,500m³	Displaced sediment during cable installation Total offshore cable length per circuit = 158km for DBS West, 198km for DBS East. Number of cables required = 6 Max. offshore cable length for all cables = 1,028km Offshore export cable (trench width 1m x maximum cable length 1,028km x burial depth 1m) = 1,028,000m³ Array cables (trench width 1m x maximum cable length 650km x burial depth 1m) = 650,000m³ Inter platform cables (trench width 1m x maximum cable length 385km x burial depth = 1.5m) = 577,500m³	Assumes even split of total 650km array cable length between DBS East and DBS West. Assuming 6 separate cable trenches, for each cable circuit, a minimum of 50m apart. 2 export cables required for HVDC (per project), or up to 4 cables required for HVAC. Maximum export cable length assumes worst case that cable circuits are laid and buried in separate trenches rather than bundled. DBS West HVAC only would require inter-platform cables between the 4 OSPs , assumed no link to DBS East in this situation. Concurrent design assumes HVAC + HVDC design scenario. Requires inter-platform cables

	Parameter			
	DBS East in isolation (HVDC only)	**DBS West in Isolation (HVAC only)**	**DBS East and DBS West concurrently (HVAC+HVDC)**	**Notes and rationale**
	Seabed clearance area *Offshore export cables* Maximum seabed footprint disturbed by sand wave levelling = 2,047,002m² Maximum sand wave material to be dredged/relocated = 33,121,800m³ *Array and inter platform cables* Maximum seabed footprint disturbed by sand wave levelling = 950,000m² Maximum sandwave material to be dredged/relocated – 33,121,800m³	Seabed clearance area *Offshore export cable* Maximum seabed footprint disturbed by sand wave levelling = 1,060,000m² Maximum sand wave material to be dredged/relocated = 429,300m³ *Array and inter platform cables* Maximum seabed footprint disturbed by sand wave levelling = 4,094,004m² Maximum sand wave material to be dredged/relocated = 66,243,600m³	Seabed clearance area *Offshore export cable* Maximum seabed footprint disturbed by sand wave levelling = 6,141,005m² Maximum sand wave material to be dredged/relocated = 99,365,402m³ *Array and inter platform cables* Maximum seabed footprint disturbed by sandwave levelling – 6,141,005m² Maximum sandwave material to be dredged/relocated – 99,365,402m³	between the sites, hence the increase from 40km to 385km. Assumes jet trenching installation methods and a v-shape trench. Seabed clearance (levelling or pre-sweeping) is potentially required prior to cable installation.
Impact C1d: Changes in suspended sediment concentration and transport due to HDD exit cable installation	No. of horizontal directional drills (HDDs) = 5 Indicative depth of water at drill exit = 8m Indicative HDD length = 1400m Exit pit may be located within the intertidal area	No. of horizontal directional drills (HDDs) = 5 Indicative depth of water at drill exit = 8m Indicative HDD length = 1400m Exit pit may be located within the intertidal area	No. of horizontal directional drills (HDDs) = 9 Indicative depth of water at drill exit = 8m Indicative HDD length = 1400m Exit pit may be located within the intertidal area	If DBS East and DBS West are built in isolation there will be two separate phases of HDD installation. Total number of HDDs includes one spare for the in isolation scenario and two spare for the concurrent/sequential scenario..

	Parameter			
	DBS East in isolation (HVDC only)	**DBS West in Isolation (HVAC only)**	**DBS East and DBS West concurrently (HVAC+HVDC)**	**Notes and rationale**
Impact C1e: Deterioration in water quality associated with the release of sediment bound contamination (directly linked to changes in suspended sediment concentrations in impacts C1a to C1d)	As for Impacts C1a to C1d	As for Impacts C1a to C1d	As for Impacts C1a to C1d	The risk of releasing sediment bound contamination (if present) is directly linked to sediment disturbance and therefore the worst case relates to volumes of sediment potentially released into the water column.
Impact C2a: Changes in seabed level due to seabed preparation for foundation installation	As Impact C1a	As Impact C1a	As Impact C1a	As Impact C1a
Impact C2b: Changes to seabed level due to drill arisings from foundations	As Impact C1b	As Impact C1b	As Impact C1b	As Impact C1b
Impact C2c: Changes to seabed level due to array, inter platform and offshore export cable installation	As Impact C1c	As Impact C1c	As Impact C1c	As Impact C1c
Impact C3: Changes to bedload sediment transport due to HDD exit cable installation	As Impact C1d	As Impact C1d	As Impact C1d	Installation of temporary structures including cofferdams during construction of the HDD exit pit may affect wave and tidal currents which manifest as changes in bedload sediment

	Parameter			
	DBS East in isolation (HVDC only)	DBS West in Isolation (HVAC only)	DBS East and DBS West concurrently (HVAC+HVDC)	Notes and rationale
				transport and seabed morphology (scour). The size and orientation of the cofferdams relative to nearshore tidal, wave and sediment transport regime will determine how much blockage is created by the structures.
Impact C4: Indentations on the seabed due installation vessels	Jack-up vessels Up to 6 jack-up installations at each wind turbine (100 small turbines, 6 installations, 4 legs per installation, individual leg footprint 275m²) = 660,000m² Vessel jack-up footprint for all offshore platforms (1100m² combined leg area x 6 operations per offshore platform x 6 offshore platforms) = 33,000m² Anchoring Anchoring (116m² footprint x 4 anchors per activity x 5 activities requiring the deployment of anchors x 100 small turbines) = 233,000m²	Jack-up vessels Up to 6 jack-up installations at each wind turbine (100 small turbines, 6 installations, 4 legs per installation, individual leg footprint 1,100m²) = 660,000m² Vessel jack-up footprint for all offshore platforms (1100m² combined leg area x 5 operations per offshore platform x 6 offshore platforms) – 33,000m² Anchoring Anchoring (116m² footprint x 4 anchors per activity x 5 activities requiring the deployment of anchors x 100 small turbines) = 233,000m² Maximum total impacted area by anchoring – 44,091m²	Jack-up vessels Up to 6 jack-up installations at each wind turbine (200 small turbines, 6 installations, 4 legs per installation, individual leg footprint 1,100m²) = 1,320,000m² Vessel jack-up footprint for all offshore platforms (1100m² combined leg area x 1 operations per offshore platform x 7 offshore platforms) – 60,500m² Anchoring Anchoring (116m² footprint x 4 anchors per activity x 5 activities requiring the deployment of anchors x 200 small turbines) = 466,000m² Maximum total impacted area by anchoring – 66,136m²	In situations where a number does not divide equally between DBS East and DBS West (e.g. 95 large turbines), rounded up to higher number (e.g. 48 large turbines as opposed to 47.5). The greatest number of structures is for small turbines as they are greater in number.

	Parameter			
	DBS East in isolation (HVDC only)	DBS West in Isolation (HVAC only)	DBS East and DBS West concurrently (HVAC+HVDC)	Notes and rationale
	Maximum total impacted area by anchoring – 22,045m² *Note - 10km stretch along the offshore export cable corridor <10m Lowest Astronomical Tide (LAT), may require use of anchoring* Maximum area disturbed = 948,045m^2	*Note - 10km stretch along the offshore export cable corridor <10m LAT, may require use of anchoring* Maximum area disturbed = 970,045m^2	*Note - 10km stretch along the offshore export cable corridor <10m LAT, may require use of anchoring* Maximum area disturbed = 1,912,636m^2	
Operation				
Impact O1: Changes to the tidal regime due to the presence of infrastructure (wind turbine and offshore platform foundations)	<u>Wind turbines</u> Seabed preparation for 48 x large suction bucket foundations with 4 x 25 m diameter buckets per pile = **94,247m²** Minimum wind turbine spacing = 830m <u>Offshore platforms</u> Seabed preparation for 6 gravity base foundations = 338,460m² HVDC only option requires four offshore converter platforms (OCPs), one Electrical Switching Platform (ESP) and one accommodation platform.	<u>Wind turbines</u> Seabed preparation for 48 x large suction bucket foundations with 4 x 25 m diameter buckets per pile = **94,247m²** Minimum wind turbine spacing = 830m <u>Offshore platforms</u> Seabed preparation for 6 gravity base foundations = 338,460m² HVAC only option requires four offshore substation platforms (OSPs), one Reactive Compensation Platform (RCP) and one accommodation platform.	<u>Wind turbines</u> Seabed preparation for 95 x large suction bucket foundations with 4 x 25 m diameter buckets per pile = **186,531m²** Minimum wind turbine spacing = 830m <u>Offshore platforms</u> Seabed preparation for 11 gravity base foundations = 620,510m² HVDC + HVAC option requires eight OSP/OCPs, one ESP, one RCP and one accommodation platform.	Gravity based foundations are the worst-case foundation type for the offshore platforms, and suction bucket jacket foundations are the worst case foundation type for wind turbines as both these structures have the greatest cross-sectional area within the water column (compared to other foundation types) representing the greatest physical blockage to tidal currents. The worst case for suction bucket jacket foundations are small wind turbines as they are greater in number.

	Parameter			
	DBS East in isolation (HVDC only)	DBS West in Isolation (HVAC only)	DBS East and DBS West concurrently (HVAC+HVDC)	Notes and rationale
Impact O2: Changes to the wave regime due to the presence of infrastructure (wind turbine and offshore platform foundations)	Wind turbines 100 small suction bucket jacket foundations Wind turbine spacing = 830m Offshore platforms 6 gravity base foundations	Wind turbines 100 small suction bucket jacket foundations Wind turbine spacing = 830m Offshore platforms 6 gravity base foundations	Wind turbines 200 small suction bucket jacket foundations Wind turbine spacing = 830m Offshore platforms 11 gravity base foundations	As Impact O1 The gravity base and suction bucket jacket will protrude above the seabed by a maximum of 10 m. Gravity base foundations will create complete blockage in the water column (if conical in shape) Suction bucket jackets are above 10 m, suction bucket jacket foundations will be open allowing currents to pass through.
Impact O3: Changes to water circulation (Flamborough Front) due to the presence of infrastructure (wind turbine and offshore platform foundations)	As Impact O2	As Impact O2	As Impact O2	As Impact O2
Impact O4a: Changes to bedload sediment transport and seabed morphology due to the presence of infrastructure	Wind turbines 100 small turbines four-legged suction bucket jacket foundations with 15m diameter buckets, 10m	Wind turbines 100 small turbines four-legged suction bucket jacket foundations with 15m diameter buckets, 10m	Wind turbines 200 small turbines four-legged suction bucket jacket foundations with 15m diameter buckets, 10m	As Impact O2 Installed foundation, or other sub-sea structures proud of the seabed (e.g. rock berms), may lead to local scouring around

	Parameter			
	DBS East in isolation (HVDC only)	**DBS West in Isolation (HVAC only)**	**DBS East and DBS West concurrently (HVAC+HVDC)**	**Notes and rationale**
(wind turbine and offshore platform foundations)	proud of the seabed, with potential for group scour between legs <u>Offshore platforms</u> Seabed preparation for six gravity base foundations that protrude 10m above seabed = 338,460m²	proud of the seabed, with potential for group scour between legs <u>Offshore platforms</u> Seabed preparation for six gravity base foundations that protrude 10m above seabed = 338,460m²	proud of the seabed, with potential for group scour between legs <u>Offshore platforms</u> Seabed preparation for 11 gravity base foundations that protrude 10m above seabed= 620,510m²	their base if scour protection has not already pre-armoured the seabed. Depending on the seabed material, the scouring process may erode material into bedload and/or suspended load transport until an equilibrium condition is reached. In general, the largest foundation with the greatest solidity ratio will have the largest blockage effect on flows and will develop the most amount of scour.
Impact O4b: Changes to bedload sediment transport and seabed morphology due to the presence of cable protection measures	<u>Seabed footprint of cable protection</u> Total array and inter-platform cable protection – 656,512m² (488,400m² array cable protection + 168,112m² inter platform cable protection) Total footprint of pipeline / cable crossing material (array cables) – 61,310m² Total export cable protection – 1,089,660m²	<u>Seabed footprint of cable protection</u> Total array and inter-platform cable protection - 790,515m² (488,400m² array cable protection + 302,115m² inter-platform cable protection) Total footprint of pipeline / cable crossing material (array + inter-platform cables) = 73,539m² Total export cable protection – 1,642, 872m² Total worst case scour protection for ESP in offshore export cable corridor – 56,410m²	<u>Seabed footprint of cable protection</u> Total array and inter-platform cable protection - 2,139,904m² (976,800m² array cable protection + 1,163,104m² inter-platform cable protection) Total footprint of pipeline / cable crossing material (array + inter-platform cables) = 244,915m² Total export cable protection = 2,701,040m²	Cable protection measures will include a combination of rock or gravel burial (rock berms), concrete mattresses, protective aprons or coverings, bagged solutions and bridging. Assumes maximum array cable length of 325km if projects developed in isolation, 40km for inter platform cables (HVAC only) or 385km (HVAC+HVAC). The worst case will be for small wind turbines as they are greater in number and require a greater

	Parameter			
	DBS East in isolation (HVDC only)	**DBS West in Isolation (HVAC only)**	**DBS East and DBS West concurrently (HVAC+HVDC)**	**Notes and rationale**
	Total worst case scour protection for ESP in offshore export cable corridor – 56,410m² Total footprint of pipeline / cable crossing material – 122,611m²	Total footprint of pipeline / cable crossing material – 294,267m²	Total worst case scour protection for ESP & RCP in offshore export cable corridor – 112,821m² Total footprint of pipeline / cable crossing material = 441,403m²	length of cable which may require protection. Assumes 20% of the route will require remedial protection.
Impact O5: Cable repairs and reburial	Seabed footprint of repairs and reburial Total = 450,192m^2 (25% of area calculated for Impact O4b)	Seabed footprint of repairs and reburial Total = 615,016m^2 (25% of area calculated for Impact O4b)	Seabed footprint of repairs and reburial Total = 1,354,662m^2 (25% of area calculated for Impact O4b)	Remedial reburial and repair of cables may be required with up to 25% of original protection being replenished over its lifetime. As original protection will be repaired or replaced, there will be no changes to the total seabed footprint of cable protection measures.
Impact O6: Deterioration in water quality associated with the release of sediment bound contamination (directly linked to changes in suspended sediment concentrations in impacts O5)	As Impact O5	As Impact O5	As Impact O5	As Impact O5

	Parameter			
	DBS East in isolation (HVDC only)	**DBS West in Isolation (HVAC only)**	**DBS East and DBS West concurrently (HVAC+HVDC)**	**Notes and rationale**
Impact O7: Loss of seabed area due to the footprint foundations	As Impact C1a	As Impact C1a	As Impact C1a	As Impact C1a
Impact O8: Indentations on the seabed due to installation vessels	As Impact C4	As Impact C4	As Impact C4	As Impact C4
Landfall	Currently no available information on parameters for intertidal operation and maintenance activities			
Decommissioning				
No final decision regarding the final decommissioning policy for the onshore project infrastructure including landfall, onshore cable route and onshore substation has yet been made. It is also recognised that legislation and industry best practice change over time. However, it is likely that offshore project infrastructure will be removed above the seabed and reused or recycled where practicable. 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. It is anticipated that for the worst case scenario, the impacts will be no greater than those identified for the construction phase.				

8.3.2.2 Development Scenarios

8. There are currently two possible electrical solutions being considered for DBS West, HVAC or HVDC. Due to the distance of the array area offshore DBS East will be an HVDC project. Therefore, there are two possible electrical solutions for the Projects:

- One HVDC project and one HVAC project; or
- Two HVDC projects.

9. Offshore the most significant difference between an HVAC solution and an HVDC solution is that if an HVAC electrical solution is used an additional platform will be required along the offshore export cable. In addition, a HVAC solution will require two additional offshore export cables, over and above the four export cables that would be required for two HVDC projects.

10. In order to ensure that a robust assessment has been undertaken, all development scenarios and options have been considered to ensure the realistic worst-case scenario for each topic has been assessed. Further details are provided in **Chapter 5 Project Description**.

8.3.2.3 Construction Scenarios

11. The following principles set out the framework for how the Projects may be constructed (relating to both onshore and offshore works):

- DBS East and DBS West may be constructed at the same time, or at different times;
- If built concurrently, both Projects could be constructed in five years;
- If built non-concurrently, either Project could be built first;
- If built non-concurrently, each Project would require a five year period of construction;
- If built non-concurrently, it is anticipated that there would be up to a two year lag between the start of construction for the first project and the start of construction for the second project; and
- Assuming a maximum construction period per Project of five years, and taking the above into account, the maximum construction period over which the construction of both Projects could take place is seven years.

12. In order to determine which construction scenario presents the realistic worst case for each receptor and impact, the assessment considers both maximum duration effects and maximum peak effects, in addition to each Project being developed in isolation, drawing out any differences between each of the two Projects.

13. The three construction scenarios considered by the marine physical environment assessment are therefore:

- Build DBS East or build DBS West in isolation;
- Build DBS East and DBS West concurrently – reflecting the maximum peak effects; and
- Build the Projects sequentially with a lag of up to two years – reflecting the maximum duration of effects.

14. The individual, concurrent and sequential construction scenarios all allow for flexibility to build out the Projects using a phased approach. This will allow the Projects to adapt to National Grid Electricity Transmission Operator's development plans for the onshore grid connection points. Under a phased approach the maximum timescales for individual elements of the construction have been assessed.

15. Any differences between the Projects, or differences that could result from the manner in which the first and the second Projects are built (concurrent or sequential and the length of any gap) are identified and discussed where relevant in section 8.7. For each potential impact, only the worst case construction scenario for two Projects is presented, i.e. either concurrent or sequential. The justification for what constitutes the worst case is provided, where necessary, in section 8.7.

8.3.2.4 Operation Scenarios

16. Operation scenarios are described in detail in **Chapter 5 Project Description**. The assessment considers the following scenarios:

- Only DBS East in operation;
- Only DBS West in operation; and
- The two Projects operating concurrently, with a lag of two years between each Project commencing operation.

17. If the Projects are built out using a phased approach, there would also be a phased approach to starting the operational stage. The worst case scenario for the operational phases for the Projects have been assessed. See section 5.1.1 of **Chapter 5 Project Description** for further information on phasing scenarios for the Projects.

18. The operations lifetime of each Project is expected to be 30 years.

8.3.2.5 Decommissioning Scenarios

19. Decommissioning scenarios are described in **Chapter 5 Project Description**. Decommissioning arrangements will be agreed through the submission of a Decommissioning Programme prior to construction, however for the purpose of this assessment it is assumed that decommissioning of the Projects could be conducted separately, or at the same time.

8.3.3 Mitigation Embedded in the Design

20. This section outlines the embedded mitigation relevant to the marine physical environment assessment, which has been incorporated into the design of the Projects (**Table 8-4**). Where other mitigation measures are proposed, these are detailed in the impact assessment (section 8.7).

21. Due to the presence and movements of construction and operation and maintenance vessels/equipment there is the potential for spills and leaks which could result in changes to water quality. All vessels involved will be required to comply with the International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78.

22. An outline Project Environmental Management Plan (PEMP) will also be produced and implemented to cover the construction and, operation and maintenance and decommissioning phases of the Projects. This will set out all procedures and measures (in the form of a Marine Pollution Contingency Plan (MPCP)) to be followed during construction and, operation and maintenance and decommissioning phases to minimise the risk of, and effects in the event of an accidental spill. The PEMP will identify all potential sources and types of accidental pollution for all project phases and set out the proposed mitigation measures. This will be developed in consultation with key stakeholders for approval by the MMO. This potential risk to the marine environment is therefore not considered further within this Chapter (see **Table 8-2**).

Table 8-4 Embedded Mitigation Measures

Parameter	Mitigation Measures Embedded into the Project Design
Turbine spacing	A minimum separation distance of 830m has been defined between adjacent wind turbines, minimising the potential for interaction between adjacent wind turbines with respect to the marine physical environment.
Scour protection	Where necessary, foundations will include scour protection which will minimise the amount of scour and sediment released/transported due to scour.
Foundations	For piled foundation types, such as monopiles and jackets with pin piles, pile-driving will be used in preference to drilling where it is practicable to do so (i.e. where ground conditions allow). This would minimise the quantity of sub-surface sediment released into the water column from the installation process.
Cables	Cables will be buried where possible, minimising the requirement for external cable protection measures and thus effects on sediment transport.
	Route selection and micro-siting of the cables will be used to avoid areas of seabed that pose a significant challenge to their installation, including for example areas of sand waves and megaripples. This will minimise the requirement for seabed preparation (levelling) and the associated seabed disturbance. This is reflected in the allowances that have been made for these works as described in **Table 8-3**.
Horizontal Directional Drilling (HDD)	HDD, or other trenchless techniques, will be used to install the export cables at the landfall for the Projects. Whilst the exit pit location could be located within the intertidal zone, the use of HDD will prevent any impacts from occurring within the upper intertidal zone or the Holderness Cliffs. Cables will be buried at sufficient depth to have no effect on coastal erosion. Erosion would continue as a natural process driven by waves and subaerial processes.

Parameter	Mitigation Measures Embedded into the Project Design
Pollution Prevention Measures	All vessels involved will be required to comply with the International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78. An outline Pollution Environmental Management Plan (PEMP) will be produced to cover the construction and, operation and maintenance and decommissioning phases of the Projects and submitted with the DCO application. This will set out all procedures and measures (in the form of a Marine Pollution Contingency Plan (MPCP)) to be followed during construction and, operation and maintenance and decommissioning phases to minimise the risk of, and effects in the event of an accidental spill. The final PEMP will identify all potential sources and types of accidental pollution for all project phases and set out the proposed mitigation measures and will be developed in consultation with key stakeholders for approval by the MMO. This will be undertaken post-consent.

8.4 Assessment Methodology

8.4.1 Policy, Legislation and Guidance

8.4.1.1 National Policy Statements

23. The assessment of potential impacts upon the marine physical environment has been made with specific reference to the relevant National Policy Statements (NPS). The specific assessment requirements for the marine physical environment, as detailed in the NPS, are summarised in **Table 8-5** together with an indication of the section of this chapter where each is addressed.

24. It is noted that the NPS for Energy (EN-1), the NPS for Renewable Energy Infrastructure (EN-3) and the NPS for electricity networks infrastructure (EN-5) are in the process of being revised. Draft versions were published for consultation in September 2021 (BEIS, 2021a, BEIS 2021b and BEIS 2021c, respectively). A review of these draft versions has also been undertaken in the context of this PEIR chapter.

25. Where the draft versions of the NPS (EN-1 and EN-3) include relevant additional NPS requirements that are not presented within the current NPS (EN-1 and EN-3), these have been included in **Table 8-5**. Minor wording changes within the draft NPS, which do not materially influence the NPS (EN-1 and EN-3) requirements, have not been reflected.

26. Following the consultation in 2021 on the draft energy NPS, a new consultation opened on the 30th March 2023 on revised drafts of the energy NPSs, including EN1, EN3 and EN5. Due to the timing of this consultation, and finalisation of this PEIR we have been unable to review and take these revised draft NPS into account within these documents. However, these will be reviewed and incorporated into the final ES where relevant.

Table 8-5 NPS Assessment Requirements

NPS Requirement	NPS Reference	PEIR Section Reference
EN-1 NPS for Energy		
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 5.5, paragraph 5.5.6	An expert coastal geomorphological assessment has been undertaken as outlined in section 8.6.2.
The ES should include an assessment of the effects on the coast. 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) and any relevant Marine Plans (Objective 10 of the East Inshore and East Offshore Marine Plans is "To ensure integration with other plans, and in the regulation and management of key activities and issues, in the East Marine Plans, and adjacent areas" this therefore refers back to the objectives of the SMPs and capital programmes for maintaining flood and coastal defences;	Section 5.5, paragraph 5.5.7	Designated sites and coastal morphological features have been identified as receptors in section 8.7.1 and considered in the wider impact assessment (section 8.7). Potential changes resulting from climate change are presented in section 8.6. The existing coastal management strategies are presented in section 8.5.15 and the impact of the Projects in relation to these strategies is outlined in sections 8.7.4.4 and 8.7.4.9. The effects of the Projects on marine ecology and biodiversity are discussed in **Chapter 9 Benthic Habitats.**

NPS Requirement	NPS Reference	PEIR Section Reference
The effects of the proposed project on marine ecology, biodiversity and protected sites; 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.		
The applicant should be particularly careful to identify any effects of physical changes on the integrity and special features of Marine Conservation Zones, candidate marine Special Areas of Conservation (SACs), coastal SACs and candidate coastal SACs, coastal Special Protection Areas (SPAs) and potential SCIs and Sites of Special Scientific Interest (SSSI)[1]	Section 5.5, paragraph 5.5.9	Designated sites and coastal morphological features have been identified as receptors in section 8.7.1 and considered in the wider impact assessment (section 8.7).
Infrastructure development can have adverse effects on the water environment, including transitional waters and coastal waters. During the construction, operation and decommissioning phases, discharges would occur. There may also be an increased risk of spills and leaks of pollutants to the water environment. These effects could lead to adverse impacts on health	Paragraph 5.15.1	Potential effects of the Projects on Water Quality are assessed in section 8.7. Reference to accidental spills and proposed management is described in section 8.3.3. A WFD Assessment is provided in **Appendix 20.2**.

[1] Note that this has been amended in BEIS (2021a) to: 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, candidate marine Special Areas of Conservation (SACs), coastal SACs and candidate coastal SACs, coastal Special Protection Areas (SPAs) and potential coastal SPAs, Ramsar sites, Sites of Community Importance (SCIs) and potential SCIs and SSSIs

NPS Requirement	NPS Reference	PEIR Section Reference
or on protected species and habitats and could, in particular, result in surface waters and, ground waters of protected areas failing to meet environmental objectives established under the Water Framework Directive.		
Where the project is likely to have adverse effects on the water environment, the application should undertake an assessment of the existing status of, and impacts of the proposed project, on, water quality, water resources and physical characteristics of the water environment, as part of the Environmental Statement or equivalent.	Paragraph 5.15.2	The existing baseline is presented in section 8.5 to section 8.7.
EN-3 NPS for Renewable Energy Infrastructure		
The assessment should include predictions of physical effect that will result from the construction and operation of the required infrastructure and include effects such as the scouring that may result from the proposed development	Section 2.6, paragraph 2.6.193 and 2.6.194	Scour is considered in section 8.7.4.1 and 8.7.5.8.
Where necessary, assessment of the effects on the subtidal environment should include: Loss of habitat due to foundation type including associated sea bed preparation, predicted scour, scour protection and altered sedimentary processes; Environmental appraisal of inter-array and cable routes and installation methods;	Section 2.6, paragraph 2.6.113	Loss of seabed area is considered in section 8.7.5.8. Cable installation methods are considered in sections 8.7.4.3, 8.7.4.4, 8.7.4.5, 8.7.4.8, and 8.7.4.6 and 8.7.4.9. Increased suspended sediment loads are

NPS Requirement	NPS Reference	PEIR Section Reference
Habitat disturbance from construction vessels extendible legs and anchors; Increased suspended sediment loads during construction; Predicted rates at which the subtidal zone might recover from temporary effects.		considered in Impact C1 in section 8.7. Recovery rates from temporary effects at landfall are considered in sections 8.7.4.4 and 8.7.4.9.
An assessment of the effects of installing cable across the intertidal zone should include information, where relevant, about: Any alternative landfall sites that have been considered by the applicant during the design phase and an explanation of the final choice; Any alternative cable installation methods that have been considered by the applicant during the design phase and an explanation of the final choice; Potential loss of habitat; Disturbance during cable installation and removal (decommissioning); Increased suspended sediment loads in the intertidal zone during installation; Predicted rates at which the intertidal zone might recover from temporary effects.	Section 2.6, paragraph 2.6.81	See **Chapter 4 Site Selection and Assessment of Alternatives.**
The construction, operation and decommissioning of offshore energy infrastructure can affect marine water quality through the disturbance of seabed sediments or the release of contaminants with	Paragraph 2.6.189	Potential impacts during construction, operation and maintenance and decommissioning are assessed in section 8.7. Contaminant analysis of

NPS Requirement	NPS Reference	PEIR Section Reference
subsequent indirect effects on habitats, biodiversity and fish stocks.		samples collected from the seabed in the vicinity of the Projects windfarm site indicate very low levels of contaminants and further site specific data is to be collected for the ES.
Beyond 3nm, the MMO is the regulator. The applicant should consult the MMO and Cefas on the assessment methodology for impacts on the physical environment at the pre-application stage	Paragraph 2.6.192	The MMO and Cefas have been consulted through the EPP (see section 8.2).
EN-5 NPS for Electricity Networks Infrastructure		
Applicants should in particular set out to what extent the proposed development is expected to be vulnerable, and, as appropriate, how it has been designed to be resilient to: Coastal erosion – for the landfall of offshore transmission cables and their associated substations in the inshore and coastal locations respectively.	Section 2.6, paragraph 2.6.1	A coastal erosion assessment has been undertaken as outlined in section 8.6.2.
Draft Overarching NPS for Energy (EN-1) (BEIS, 2023)		
The ES should include an assessment of the effects on the coast. In particular, applicants should assess: How coastal change could affect flood risk management infrastructure, drainage and flood risk.	Section 2.30, Paragraph 2.30.2	A coastal erosion assessment has been undertaken as outlined in section 8.6.2.
Where the project is likely to have effects on the water environment,	Paragraph 5.16.2	The existing baseline is presented in section 8.5 to

NPS Requirement	NPS Reference	PEIR Section Reference
the applicant should undertake an assessment of the existing status of, and impacts of the proposed project on, water quality, water resources and physical characteristics of the water environment, as part of the Environmental Statement (ES) or equivalent.		section 8.6 and impacts on marine water quality are described and assessed in section 8.7.
The ES should in particular describe the existing quality of waters affected by the proposed project and the impacts of the proposed project on water quality, noting any relevant existing discharges, proposed new discharges and proposed changes to discharges	Paragraph 5.16.5	The existing baseline is presented in section 8.5 to section 8.6 and impacts on marine water quality are described and assessed in section 8.7.
The risk of impacts on the water environment can be reduced through careful design to facilitate adherence to good pollution control practice.	Paragraph 5.16.12	An outline Project PEMP which will include a MPCP will be submitted with the DCO application.
Draft NPS for Renewable Energy Infrastructure (EN-3) (BEIS, 2021b)		
Assessment of the effects on the subtidal environment should include: Environmental appraisal of inter-array and export cable routes and installation/maintenance methods, including predicted loss of habitat due to predicted scour and scour protection; Impacts on protected sites (e.g. HRA sites and MCZs); Potential impacts from EMF on benthic fauna.	Section 2.30, Paragraph 2.30.2	Impacts on protected sites are considered in the separate HRA Screening Report (ref: 004300176-01) and MCZ Assessment (to be completed for submission with the ES). The topic of EMF is not relevant to the marine physical environment. However, this is considered in **Chapter 9 Benthic Habitats.**

NPS Requirement	NPS Reference	PEIR Section Reference
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: 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. The release of sediment during construction, operation and decommissioning can cause indirect effects on marine ecology and biodiversity.	Paragraph 2.25.1	The existing baseline is presented in section 8.5 to section 8.6 and impacts on marine water quality are described and assessed in section 8.7. Effects on habitats are assessed in **Chapter 9 Benthic Habitats**, and on fish in **Chapter 10 Fish and Shellfish Ecology** and **Chapter 13 Commercial Fisheries.**

8.4.1.2 Other

27. In addition to the NPS, there a number of pieces of legislation, policy and guidance applicable to the assessment of marine physical environment. These include:

- The Marine Policy Statement (MPS, HM Government, 2011; discussed further in **Chapter 3, Policy and Legislative Context**) 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 East Inshore and the East Offshore Marine Plans and the North-East Inshore and Offshore Marine Plans (HM Government, 2014; discussed further in **Chapter 3 Policy and Legislative Context**). Objective 6 "*To have a healthy, resilient and adaptable marine ecosystem in the East Marine Plan areas*" is of relevance to the marine physical environment as this covers policies and commitments on the wider ecosystem, set out in the MPS including those to do with the Marine Strategy Framework Directive and the Water Framework Directive (see **Chapter 3 Policy and Legislative Context**), 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*".

28. Additional guidance on the generic requirements, including spatial and temporal scales, for marine physical environment studies associated with offshore wind farm developments is provided in the following main documents:

- Offshore wind farms (OWFs): 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).
- East Inshore and East Offshore Marine Plan Areas: Evidence and Issues (MMO, 2012).
- North-east Inshore and North-east Offshore Marine Plan Areas: Issues and Evidence Database (MMO 2017).

29. With respect to the assessment of sediment quality and potential risk to water quality, where available data supports it, sediment quality guidelines used by various organisations have been used. Within these Project assessments, Cefas Action Levels have been applied. These Action Levels are used by the MMO in relation to the assessment of dredge material and its suitability for disposal to sea) for contaminants on a primary list as part of an evidence based approach. There are two levels – Action Level 1 and Action Level 2. Contaminant levels below Action Level 1 are generally assumed to be of no concern and are unlikely to influence the licensing decision. Contaminant levels between Action Level 1 and Action Level 2 generally trigger further investigation of the material, and contaminants in dredged material above Action Level 2 are generally considered unsuitable for sea disposal (MMO, 2015).

30. Although the majority of the material assessed against these standards arises from a specific activity, i.e. dredging and disposal activities, they are also considered suitable for undertaking an initial risk assessment with respect to determining risks to marine waters from other marine activities, as part of EIA and associated WFD compliance assessments. If, overall, levels do not generally exceed AL1, then contamination levels are considered to be low risk in terms of the potential for impacts on water quality. Where concentrations fall close to, or above AL2, then more quantitative assessment regarding water quality effects might be required, which would consider the risk of breaching water quality Environmental Quality Standards (EQS). This approach is recommended by the Environment Agency in their WFD compliance assessment guidance 'Clearing the Waters for All' (Environment Agency, 2017). Relevant values are presented in **Table 8-6**.

Table 8-6 Cefas Action Levels

Contaminant	Units	Cefas Action Level 1	Cefas Action Level 2
Arsenic	mg/kg	20	100
Cadmium		0.4	5
Copper		40	400
Mercury		40	400
Nickel		20	200
Lead		50	500
Zinc		130	800
Polyaromatic Hydrocarbons (PAHS)	µg/kg	100	-
Polychlorinated biphenyls (PCBs) International Council for the Exploration of the Sea (ICES) 7	mg/kg	0.01	-

31. It is also proposed once site specific data is available that the data is compared to sediment guidelines used by OSPAR. The Convention for the Protection of the Marine Environment of the North-East Atlantic (the 'OSPAR Convention') is the mechanism by which 15 Governments and the EU cooperate to protect the marine environment of the North-East Atlantic. The convention requires that all contracting parties take all possible steps to prevent and eliminate pollution and protect the maritime area against the adverse effects of human activities. The aims are to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected.

32. Resulting from this cooperation are assessments, produced by the OSPAR commission, on the quality status of the marine environment for the maritime area, or for regions or sub-regions, thereof. These are presented in Quality Status Reports (QSRs). An element contributing to these assessments considers sediment quality data and uses Background Assessment Concentrations (BAC) and the US Environmental Protection Agency's (EPA) Effects Range-Low (ERL) to determine levels of contamination and trends over time. BACs are statistical tools, defined in relation to the background concentrations, which enable statistical testing of whether observed concentrations can be considered to be near background concentrations. The ERL value is defined as the lower tenth percentile of the data set of concentrations in sediments which were associated with biological effects. Adverse effects on organisms are rarely observed when concentrations fall below the ERL value.

8.4.2 Data and Information Sources

8.4.2.1 Site Specific Surveys

33. To provide site specific and up to date information on which to base the impact assessment, a marine geophysical survey including multi-beam echosounder (MBES), side scan sonar (SSS) and sub-bottom profiler (SBP) was conducted in 2022. A seabed grab sampling survey was also undertaken and the results from particle size analysis (PSA) and sediment contamination are expected in early 2023. These data will be provided for assessment and inclusion in the ES.

34. Metocean data is being collected for the Projects. Two metocean buoys were deployed in March 2022 in each of the array sites and the results to date used in this PEIR. The latest results will be incorporated into the ES.

8.4.2.2 Other Available Sources

35. Other sources that have been used to inform the assessment are listed in **Table 8-7**.

Table 8-7 Other Available Data and Information Sources

Data Set	Spatial Coverage	Year	Notes
EMODnet bathymetry	DBS array areas and offshore export cable corridor	2020	-
BERR Atlas tidal currents	DBS array areas and offshore export cable corridor	2007	-
BERR Atlas waves	DBS array areas and offshore export cable corridor	2001-2008	-
BGS seabed sediments	DBS array areas and offshore export cable corridor	Pre-1987	-
Cefas suspended sediment concentrations	DBS array areas and offshore export cable corridor	1998-2015	-
Physical and sedimentary processes data including numerical modelling	Dogger Bank A & B (formerly Creyke Beck A & B) and Dogger Bank C and Sofia (formerly Teesside A and B) Offshore Wind Farms	2011-2014	A note outlining the results of previous modelling undertaken in the Dogger Bank region and its relevance to DBS offshore wind farms has been prepared and provided to ETG members for review (**Appendix 8-1**). An outline of this information is provided in 8.7.3.`
CCO Bathymetry	Inshore waters	2011	-
Wave buoys	Inshore waters	2008-2022	Public data from the Hornsea wave buoy.
Cliff erosion rates	The Holderness coast	1852-2022	Provided by East Riding of Yorkshire Council

Data Set	Spatial Coverage	Year	Notes
Sediment contaminant data	Dogger Bank A & B (formerly Creyke Beck A & B) and Dogger Bank C and Sofia (formerly Teesside A and B) Offshore Wind Farms	2011 and 2012	-
OSPAR Quality Status Interim Assessment 2017	UK	Various	Chemical contamination review of region within which the Projects sit
Environment Agency data sources for inshore water quality – catchment data explorer and bathing waters database	Inshore area	2022	Water quality information for inshore waters (i.e. within 1 nautical mile)

8.4.3 Impact Assessment Methodology

36. **Chapter 6 EIA Methodology** provides a summary of the general impact assessment methodology applied. The following sections describe the methods used to assess the likely significant effects on the marine physical environment.

37. The assessment of effects on wave and tidal currents, and sediment transport processes are predicated 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 impacted by the effect, 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).

38. Consideration of the potential effects on the marine physical environment is carried out at the following spatial scales:

- Near-field: the area within the immediate vicinity (tens to hundreds of metres) of the Offshore Development Area; and
- Far-field: the wider area that may be affected indirectly by the Projects (e.g. due to the disruption of waves, tidal currents or sediment pathways passing through the Projects).

39. For the effects on the marine physical environment, the assessment follows two approaches. The first type of assessment is impacts on the marine physical environment whereby several discrete direct receptors can be identified. These include certain morphological features with ascribed inherent values, such as sand banks and other features of value, including beaches and sea cliffs along the Holderness coast.

40. 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.

41. The second type of assessment covers changes to the marine physical environment which in themselves are not necessarily impacts to which significance can be ascribed. Rather, these changes (such as a change in the wave climate, a change in the tidal regime or a change in suspended sediment concentrations) represent effects which may manifest themselves as an impact upon other receptors, most notably benthic ecology, and fish and shellfish ecology (e.g. in terms of increased suspended sediment concentrations, or erosion or smothering of habitats on the seabed). Hence, the two approaches to the assessment of the marine physical environment 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 effect is based on an assessment of the sensitivity of the receptor and magnitude of impact by means of an impact significance matrix.
- Situations where changes in the baseline marine physical environment may occur which could manifest as impacts upon receptors other than the marine physical environment. In this case, the magnitude of impact is determined in a similar manner to the first assessment method, but the significance of effect on other receptors is made within the relevant chapters of the ES pertaining to those receptors.

8.4.3.1 Definitions

42. For each potential impact, the assessment identifies receptors sensitive to that impact and implements a systematic approach to understanding the impact pathways and the level of impacts (i.e. magnitude) on given receptors. The definitions of sensitivity and magnitude for the purpose of the marine physical environment assessment are provided below.

8.4.3.1.1 Sensitivity

43. The sensitivity of a receptor to changes in the marine physical environment is dependent upon its tolerance and recoverability which are defined as:

- Tolerance: the extent to which the receptor is adversely affected by an effect; and
- Recoverability: a measure of a receptor's ability to return to a state at, or close to, that which existed before the effect caused a change.

44. A matrix approach is used to determine sensitivity as a function of tolerance and recoverability, as outlined in **Table 8-8** and **Table 8-9**.

Table 8-8 Sensitivity matrix

		Tolerance			
Recoverability		**None**	**Low**	**Medium**	**High**
	Very Low	High	High	Medium	Low
	Low	High	High	Medium	Low
	Medium	Medium	Medium	Medium	Low
	High	Medium	Low	Low	Negligible

Table 8-9 Definition of Sensitivity

Sensitivity	Definition
High	Tolerance: None, receptor has very limited tolerance of effect. Recoverability: Receptor unable to recover resulting in permanent or long-term (>10 years) change.
Medium	Tolerance: Receptor has limited tolerance of effect. Recoverability: Receptor able to recover to an acceptable status over the medium term (5-10 years).
Low	Tolerance: Receptor has some tolerance of effect. Recoverability: Receptor able to recover to an acceptable status over the short term (1-5 years).
Negligible	Tolerance: Receptor highly tolerant of effect. Recoverability: Receptor able to recover to an acceptable status near instantaneously (<1 year).

8.4.3.1.2 Value

45. In addition, a 'value' component may also be considered when assessing a receptor. This ascribes whether the receptor is rare, protected or threatened or otherwise. 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 physical sensitivity to an effect. 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. **Table 8-10** states the definitions of value levels for marine physical processes.

Table 8-10 Definition of Value

Value	Definition
High	Value: Receptor is designated and / or of national or international importance for marine geology, oceanography or physical processes and designation status relies on passing water EQS. Receptor is likely to be rare with minimal potential for substitution and may also be of significant wider-scale, functional or strategic importance.
Medium	Value: Receptor is not designated but is of local to regional importance for marine geology, oceanography or physical processes (including water quality).
Low	Value: Receptor is not designated but is of local importance for marine geology, oceanography or physical processes (including water quality).
Negligible	Value: Receptor is not designated and is not deemed of importance for marine geology, oceanography or physical processes (including water quality).

8.4.3.1.3 Magnitude

46. The magnitude of an impact is dependent upon its:

- Scale (i.e. size, extent or intensity);
- Duration;
- Frequency of occurrence; and
- Reversibility (i.e. the capability of the environment to return to a condition equivalent to the baseline after the effect ceases).

Table 8-11 Definition of Magnitude of Impacts

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 5-10 years. Frequency: The effect would occur regularly but not all the time. Reversibility: The effect is very slowly reversible (5-10 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 1-5 years. Frequency: The effect would occur occasionally but not all the time. Reversibility: The effect is slowly reversible (1-5 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. Frequency: The effect would occur highly infrequently. Reversibility: The effect is quickly reversible (less than one year).

8.4.3.2 Significance of Effect

47. The assessment of significance of an effect is informed by the sensitivity of the receptor and the magnitude of the impact (see **Chapter 6 EIA Methodology** for further detail). The determination of significance is guided by the use of a marine physical environment significance of effect matrix, as shown in **Table 8-12**. Definitions of each level of significance are provided in **Table 8-13**. For the purposes of this assessment, any effect that is of major or moderate significance is considered to be significant in EIA terms, whether this be adverse or beneficial. Any effect that has a significance of minor or negligible is not significant.

Table 8-12 Marine Physical Environment 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	Minor	Negligible	Negligible	Minor	Minor	Moderate
	Negligible	Minor	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Minor

Table 8-13 Definition of Effect Significance

Significance	Definition
Major	Very large or large change in receptor condition, which is likely to be an important consideration at a regional or district level because they contribute 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 is likely to be an important consideration 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 impact, therefore no change in receptor condition.

8.4.4 Cumulative Effect Assessment Methodology

48. The cumulative effect assessment (CEA) considers other plans, projects and activities that may result in cumulation with the Projects. **Chapter 6 EIA Methodology** provides further details of the general framework and approach to the CEA.

49. The final assessment of cumulative effects will be undertaken during the later stages of the EIA, once further information is available on a number of projects such as the Outer Dowsing Offshore Wind Farm, Hornsea Project Four decision and the Sheringham Shoal Extension Project and Dudgeon Extension Project examination. However, for the purposes of the PEIR, it is possible to identify a number of projects and plans which are likely to feature in that assessment and consider the extent to which cumulative effects might arise. Section 9.7 presents the following preliminary information regarding cumulative effects:

- Screening for cumulative effects; and
- A preliminary short list of plans and projects considered for CEA, including a brief description as to how projects have been screened in and the initial tier level they have been assigned.

8.4.5 Transboundary Effect Assessment Methodology

50. The transboundary assessment considers the potential for transboundary effects to occur on marine physical environment receptors as a result of the Projects; 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. **Chapter 6 EIA Methodology** provides further details of the general framework and approach to the assessment of the transboundary effects.

51. For both the marine physical environment and marine sediment and water quality topics, the potential for transboundary effects were considered in the respective chapters of the Scoping Report and it was concluded that given that the likely effects of the Projects will be restricted to near-field change, coupled with its location 40.82km from the EEZ boundary, there would be no pathway for transboundary impacts. The conclusion of the Scoping Report was accepted in the Scoping Opinion, and therefore, transboundary impacts are scoped out and are not considered further in this chapter.

8.4.6 Assumptions and Limitations

52. This preliminary assessment is considered to be an interim stage in the EIA process. The results presented in the following sections are based on early design assumptions and initial assessments which will be refined and presented in the final ES to be submitted as part of the DCO application.

53. Given the large amount of data that was collected for the Dogger Bank A, B and C, and Sofia offshore wind farms, there is a good baseline understanding of the marine physical environment at the Project sites and its adjacent areas. There is however, a limitation in offshore water quality data available. Therefore information from more general monitoring programmes such as those undertaken by the OSPAR Commission has been used to inform this assessment. This limitation is not, however, considered to significantly affect the certainty or reliability of the impact assessment given that existing sediment data in the vicinity of the Projects does not indicate significant levels of contamination. This will be confirmed once site specific data is available.

8.5 Existing Environment

8.5.1 Bathymetry and Seabed Features

54. The minimum and maximum water depths across the array areas are approximately 12m below Lowest Astronomical Tide (LAT) and 40m below LAT, respectively (**Figure 8-1**) (EMODnet, 2020). A bathymetric profile across the array areas (**Plate 8-1**) shows the seabed rises from north-west to south-east up the western flank of Dogger Bank and then becomes broadly flat across the top of the bank before falling again on the southern flank.

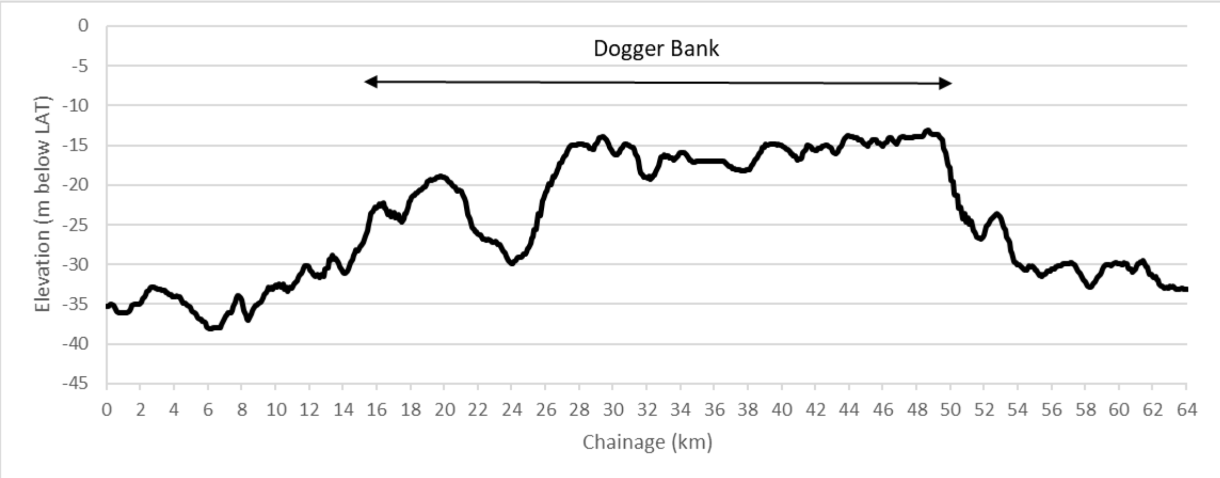

Plate 8-1 Seabed profile across the array areas, from north-west to south-east. Location of profile is shown on Figure 8-1.

55. The seabed along the offshore cable corridor gently slopes from the proposed landfall location where water depths are shallow to a maximum of 60m LAT about 8km offshore. Water depths then shallow to a minimum of 15m as the offshore export cable corridor approaches the array areas.

56. The construction buffer of offshore export cable corridor in the nearshore region, crosses the southern extremities of Smithic Bank (Southern Smithic), a north-east to south-west aligned offshore sand bank. South Smithic rises to a minimum depth of about 6m below Ordnance Datum (OD) (**Figure 8-2**). The western inshore flank of South Smithic is about 5km offshore from Bridlington before the bathymetry deepens down its eastern flank to its edge around 18m below OD. The inshore flank of the bank has a much steeper slope than that of the seaward flank.

57. At about 77km offshore, the offshore export cable corridor crosses an area of seabed covered by linear sand banks aligned north-west to south-east located in a region referred to as Sand Hills (**Figure 8-1**). These banks form longitudinal or sub-parallel to the dominant tidal currents and are considered to be static (over a period of decades), although they may be superimposed with other mobile bedforms such as megaripples or sand waves.

8.5.2 Marine Geology

58. The geology of the array areas is expected to comprise a sequence of Pleistocene sands and clays, overlain by Holocene marine sands (**Table 8-14**). The thickness of the Pleistocene and Holocene sediments beneath the DBS array areas exceeds 100m and bedrock is characterised by undifferentiated mudstone and sandstone (BGS Offshore Geoindex).

Table 8-14 Geological Formations Present Beneath the DBS Array Areas and Offshore Export Cable Corridor (Cotterill et al. 2017)

Era	BGS Formation	Expected geology
Holocene	Bligh Bank	Modern mobile sands (marine)
	Indefatigable Grounds	Gravelly sands and sandy gravel, lag deposit (marine)
	Nieuw Zeeland Gronden Terschellinger Bank	Muddy fine-grained sand (marine)
	Well Hole	Laminated sand and sandy mud, infills depressions (shallow marine)
	Elbow	Muddy sand and interbedded clay, and basal peat (transitional terrestrial to shallow marine)
Weichselian	Botney Cut	Stiff to soft glaciomarine to glaciolacustrine muds (glacial)
	Volans	Clay with variable silt, sand and gravel content (glacial)
	Bolders Bank	Firm to stiff silty sandy gravelly clay (glacial)
	Dogger Bank	Very heterogenous deposits. Includes clay with variable silt, sand and gravel content (glacial) and dense sand in areas (aeolian or periglacial). Organic matter has been recorded indicating possible sub-aerial exposure. Can contain shell fragments.
Eemian	Eem	Shelly sands, can be muddy in places (marine)
Saalian	Tea Kettle Hole	Fine-grained sand with organics (periglacial and aeolian)
	Cleaver Bank	Laminated clays and/or fine-grained sand (marine to proglacial)
Holstenian	Egmond Ground	Gravelly sands interbedded with silt and clay (marine)

59. A geotechnical survey undertaken within the DBS array areas in 2022 acquired five boreholes to depths of 55m below seabed. Analysis of these samples provides an initial understanding of the nature of the shallow geology of the study area and confirm the shallow geology is broadly the same as in the adjacent Dogger Bank A and B offshore wind farms (Forewind 2013a). This will be confirmed following interpretation of ground conditions from site specific marine geophysical and geotechnical surveys.

60. The lowermost deposits recovered in boreholes are silty sands that may have been deposited in a range of settings, including marine, terrestrial, periglacial and intertidal environments. The age of these deposits is unknown, but they may correlate to Eem, Tea Kettle Hole, Cleaver Bank or Egmond Ground formations which formed before the last glacial period (**Table 8-14**). They are present at a depth of 28m below seabed in the DBS West array area.

61. High strength, heterogenous clays with laterally discontinuous sand lenses are the dominant deposits in the DBS array areas and are encountered at depths between 3.6 and 19.5m below seabed and extend to depths greater than 55m below seabed. These deposits correlate to the Dogger Bank Formation which formed in a glacial environment during the last glacial period.

62. Elsewhere across Dogger Bank, the upper surface of the Dogger Bank Formation is cut by channel systems that can be tens of meters deep. These channels may be infilled with high strength silty clays laid down in a proglacial environment (Botney Cut Formation), or by clays and sands interbedded with peat (Elbow Formation) that formed as the climate warmed and sea-levels rose during the early Holocene.

63. A 11m thick sequence of soft clay and silt interbedded with a thin (0.28m) peat deposit was recorded in a borehole recovered from the DBS West array area which suggests in the past, river channels, lakes or estuaries would have been present.

64. The uppermost deposits recovered in the boreholes are slightly gravelly sands with shell fragments that represent deposition in the modern marine environment. These likely correlate to one or more of the Holocene formations; Bligh Bank, Indefatigable Grounds, Nieuw Zeeland Gronden Terschellinger Bank or Well Hole. They reach thicknesses of up to 9.5m in boreholes, but elsewhere across Dogger Bank can be greater than 10m thick.

65. The shallow geology along the offshore export cable corridor is expected to comprise glacial deposits of the Botney Cut Formation (**Table 8-14**), although a high degree of variability in the extent and thickness of these deposits is expected along the length of the corridor. The Botney Cut Formation may be overlain locally by younger soft clays, silts and sands with some potential for peat to be present (Elbow Formation). In the region of Sand Hills, up to ten metres of modern marine sands (Bligh Bank Formation) are expected. The thickness of Pleistocene and Holocene sediments are lower along the offshore export cable corridor compared to the array areas and Upper Cretaceous Chalk may be present at the seabed locally.

8.5.3 Seabed Sediments

66. Regional mapping of seabed sediments (BGS Offshore Geoindex) indicates the array areas are dominated by sandy sediments and mixed sediment (gravelly sand and sandy gravel) (**Figure 8-3**). The classification of these sediments implies the mud fraction would be low. This will be confirmed with project-specific particle size data that will be incorporated into the assessment at ES. BGS seabed sediment maps indicate a transition from coarser mixed sediments (sandy gravel and gravelly sand in the nearshore part of the offshore export cable corridor to sand-dominated sediments as the cable corridor approaches the array areas) (**Figure 8-3**).

8.5.4 Water Levels

67. The astronomical tidal range across the southern North Sea varies depending on location relative to an amphidromic point between East Anglia and the Netherlands. As a result, the mean spring range (MSR) gradually increases with progression west across the array areas (**Figure 8-4**) (DECC 2008). The DBS array areas experience a mesotidal range with a MSR of 2.0m at the south-east corner of the DBS East array area, increasing to 2.7m at the south-west corner of the DBS West array area. Along the offshore export cable corridor, the MSR increases from 4.9m at the possible landfall location to 2.4m at the seaward limit of the offshore export cable corridor (**Figure 8-4**).

68. The tidal regime at the possible landfall locations is semi-diurnal; the water level rises and falls twice a day. The water levels for the possible landfall locations have been estimated using the tide gauge at Bridlington (the closest reference location for tides). The mean spring tidal range for Bridlington is around 5m, with a mean neap range of around 2.4m.

69. These regular, predictable astronomical tides can be influenced by meteorological effects such as surge or wind set-up, causing extreme water levels. High waters on spring tides and positive surge influence enable waves to reach the base of the soft cliffs.

70. Latest available research from the UK Coastal Flood Boundaries (CFB) Project indicates that extreme water levels at Immingham (the nearest CFB site) during 1 in 1 year return period events are 4.17m above OD and during 1 in 200-year return period events are 5.06m above OD.

8.5.5 Tidal Currents

71. Across the DBS array areas, tidal flows are generally to the north-west on the flood tide and south-east on the ebb (**Figure 8-5**). The peak flows during spring tides range from 0.6 m/s to 0.3 m/s (DECC 2008).

72. Tidal current speeds in general reduce from west to east along the offshore export cable corridor (**Figure 8-5**) (DECC 2008). Peak spring current speeds are 1.0m/s at a point 22km along the offshore export cable corridor, east of Flamborough Head. Peak spring current speeds are lower to the west of this point, with a minimum of 0.5m/s in the nearshore area due to sheltering effects in the lee of the headland. Further offshore, peak spring current speeds reduce from west to east, to a minimum of 0.5m/s near the array areas.

8.5.6 Waves

73. In March 2022, waverider buoys were deployed in DBS East and DBS West array sites. The monthly average significant wave heights vary from a minimum of 0.8m in August 2022 to a maximum of 1.9m in November 2022. The predominant waves approach from the north to north north-east with a significant secondary component from the south to south south-west.

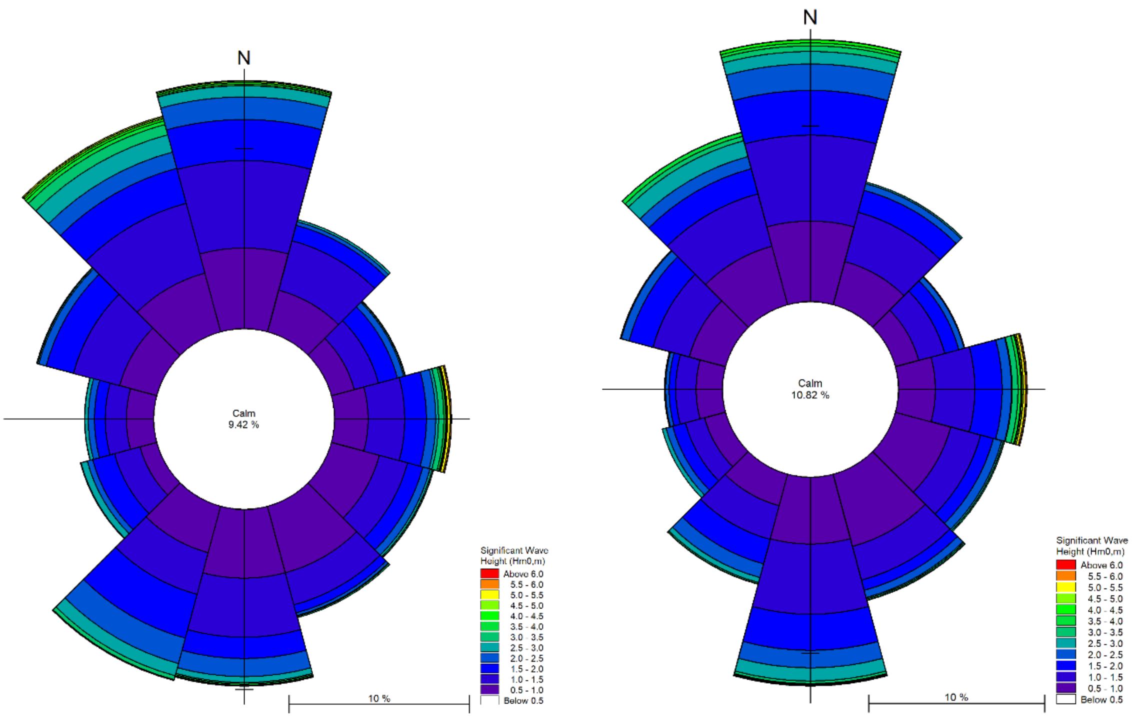

Plate 8-2 Wave roses for all waves from March 2022 to December 2022. Left is from the wave buoy deployed in DBS East and right from DBS West.

74. East Riding of Yorkshire Council deployed a nearshore waverider buoy near Hornsea (53.92°N, 0.07°E) in 10m (LAT) of water in June 2008. The Hornsea waverider buoy is located 7km south of the offshore export cable corridor and approximately 5km from the coast, providing information on wave climate in the nearshore.

75. Between June 2008 and December 2022, the monthly average significant wave heights varied from 0.57m to 1.02m and were generally higher during the winter months. The predominant waves approach from the north north-east sector (**Plate 8-3**). As they approach the coast they are modified by the bathymetry through the processes of refraction and shoaling, and by diffraction around Flamborough Head. These processes mean that as waves approach the coast at the proposed landfall locations they arrive from a more easterly direction, particularly those from the north and north-east, although they still exhibit a southwards component. There is a general increase in wave height with progression down the coast from Flamborough Head. This is due to the reduction in the sheltering effect of the headland of waves approaching from the north and north-east to the length of coast south of the headland (Holderness).

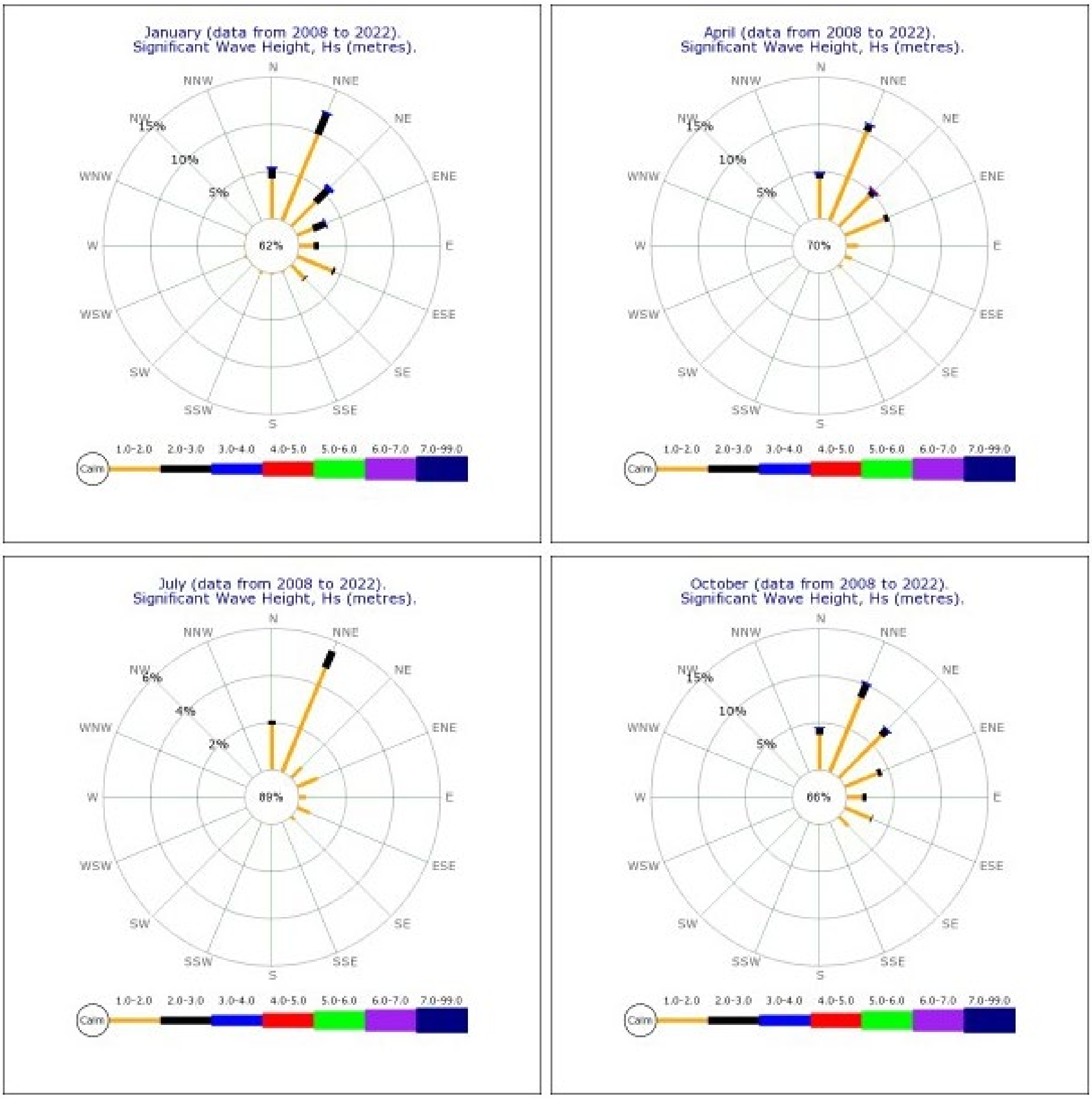

Plate 8-3 Wave roses for all years between 2008-2022 at the Hornsea waverider buoy for January (top left), April (top right), July (bottom left) and October (bottom right)

8.5.7 Bedload Sediment Transport

76. Tidal currents are the dominant driver of bedload sediment transport across the DBS array areas. The dominant sediment transport pathways are therefore expected to be towards the north-west.

77. The combination of water depth plus tidal variation means that waves are unlikely to be a major influence on bedload sediment transport along the offshore export cable corridor, apart from in shallower water approaching Smithic Sands.

78. Regional sediment transport pathways (Kenyon and Cooper, 2005) suggest sediment transport pathways in the nearshore part of the offshore export cable corridor are to the south to south-south-east whereas further offshore they are towards the north-northwest, with a bedload parting zone located about 30km from the coastline (**Figure 8-6**).

79. Sediment transport pathways in and around Smithic Bank are driven by a tidally generated gyre which creates rotational currents around the feature. Evidence of active bedload sediment transport is most prominent at the northern end of the bank (North Smithic) where large sand waves are observed (CCO 2014). This area is also associated with strongest tidal flows as water is forced past the headland. The asymmetric profile of these sand waves offers supporting evidence for net clockwise directions of bedload transport around the bank. On the eastern outer flank, the sand wave asymmetry is with the flood tide, moving sands to the south-west and onto the bank, whereas for the western inner flank the ebb tide dominates through a distinct channel between the bank and the headland to develop a net sediment pathway to the north-east (**Figure 8-2**). The tidal gyre provides a mechanism to maintain the morphology of Smithic Bank which is sheltered by Flamborough Head to the north.

80. The bank is shallowest (depths less than 3 m below CD) towards the northerly inshore flank where a steep slope drops around 6 m into the ebb tidal channel. The bank morphology shows evidence of responding to both waves and tides (CCO 2014). Tidal flows are a key influence on driving sand wave migration whereas wave attenuation through refraction and shoaling are likely to be a main cause of smoothing and broadening the profile of the southern extents of the bank. The shallow profile of Smithic Sands provides some sheltering to the leeward coastline around Bridlington, especially during periods of stormy waves (Scott Wilson 2010).

81. There are no bedforms between Smithic Bank and the Holderness coast which suggests there is relatively little sediment exchange between Smithic Bank and the Holderness coast to the south (and vice versa). This is supported by studies of sediment provenance undertaken by Pye and Blot (2015) who defined a boundary between a 'Flamborough' influence in and around Smithic Bank and a 'Holderness Cliffs' influence, located to the south of Smithic Bank (**Figure 8-2**).

8.5.8 Suspended Sediment Concentrations

82. Monthly mean variations in Suspended Sediment Concentrations have been derived from satellite observations from 1998 to 2015 (Cefas, 2016). Surface average suspended sediment concentrations are relatively low across the DBS array areas, with concentrations typically less than 3mg/l in DBS East reducing to below 2mg/l in DBS West (Cefas 2016) (**Figure 8-7**). The relatively low concentrations are due to both a low content of fine material in the seabed sediments and the area being distant from any terrestrial sources, such as the Humber Estuary and the Holderness cliffs.

83. Along the offshore export cable corridor, surface average suspended sediment concentrations are highest for around the first 10km from the coastline and around Flamborough Head where they may reach concentrations of 15mg/l (**Figure 8-7**). These concentrations may increase up to 300mg/l during storm events (Pye and Blott 2015). Further offshore the concentrations reduce to approximately 5mg/l. The higher concentrations in the nearshore region are likely driven by input of fine sediments from cliff erosion, shallower water depths, disturbance by waves and locally stronger wave-induced flows which keep sediment in suspension, inhibiting deposition locally.

8.5.9 Sediment quality

84. Studies undertaken in 2011 and 2012 as part of the Dogger Bank A & B (formerly Creyke Beck A & B) and Dogger Bank C and Sofia (formerly Teesside A and B) offshore wind farm developments revealed low levels of contamination in the sediments. This project data is considered relevant due to the close proximity of these projects to DBS and similarities in sediments likely to be found in the marine physical environment study area (see section 8.5.3). **Figure 8-8** shows the sample locations against the Offshore Development Area and BGS data. **Table 8-15** presents the data collected in the Tranche A area which included Dogger Bank A & B array areas and compares it to the Cefas Action Levels. **Table 8-16** presents the data collected at Dogger Bank A & B along their export cable corridor, which runs alongside the proposed cable corridor for the Projects (see **Figure 8-8**).

85. Only one site exceeded Cefas Action Level 1 for chromium and nickel in Tranche A and whilst a number of sites sampled along the Dogger Bank A & B export cable corridor exceeded Cefas Action Level 1, the majority of exceedances are marginal (i.e. only just over Action Level 1 concentrations). Site 23 appears to have generally higher levels of metals of which arsenic, chromium, copper and lead exceeded Action Level 1. All nearshore sites (34, 33, 32, 28, 21 and 8) appear to contain elevated levels of one or more metals; however, concentrations of contaminants did not exceed the Cefas Action Level 2. It was therefore concluded that sediment contamination was low for these projects (Forewind, 2013b).

86. It is expected that the seabed sediments within the Offshore Development Areas will be dominated by coarse fractions, with fines poorly represented. Assuming that these expectations are confirmed by primary survey data being acquired for the Projects, this significantly reduces the potential for contaminants to accumulate. This is reflected in the historical data collected for Dogger Bank A & B which is expected to support similar sediment types to DBS. It is therefore predicted that contaminant levels would be similar in the Offshore Development Area, but this will be confirmed with project-specific particle size data and chemistry data that will be incorporated into the assessment for the ES.

Table 8-15 Sediment Contaminant Sample Analysis Results Compared to the Cefas Action Levels for the Tranche A Windfarm Array Area. Yellow indicates an exceedance of Action Level 1. There were no exceedances of Action Level 2 (Forewind, 2013b).

Contaminant	**Site reference (array area – Tranche A)**															**Cefas Action Levels**	
	85	**8**	**4**	**5**	**23**	**41**	**49**	**94**	**45**	**74**	**58**	**61**	**17**	**82**	**40**	**Action Level 1**	**Action Level 2**
Arsenic (mg/kg)	1.64	1.13	2.69	1.86	0.85	0.72	3.22	1.37	3.36	<0.4	13.6	1.91	0.76	1.49	4.43	20	100
Cadmium (mg/kg)	0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.035	<0.03	<0.03	<0.03	0.131	0.032	<0.03	<0.03	<0.03	0.4	5
Chromium (mg/kg)	15.5	14.8	25.4	28.9	9.31	7.93	22.4	9.00	8.04	19.9	119	2.61	9.44	8.25	12.7	40	400
Copper (mg/kg)	4.12	3.86	3.32	3.54	2.7	2.04	3.26	1.39	2.07	2.14	36.3	3.55	2.19	2.5	2.83	40	400
Mercury (mg/kg)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.017	<0.002	<0.002	<0.002	<0.002	0.3	3
Lead (mg/kg)	8.18	6.38	6.6	5.89	8.17	5.79	6.52	3.99	4.44	3.56	23.6	7.72	5.45	6.36	6.80	50	500

Contaminant	Site reference (array area – Tranche A)															Cefas Action Levels	
	85	8	4	5	23	41	49	94	45	74	58	61	17	82	40	Action Level 1	Action Level 2
Nickel (mg/kg)	3.7	3.07	2.96	2.95	4.30	2.74	2.69	1.45	1.78	2.31	50.90	3.3	3.00	3.62	7.17	20	200
PCBs (sum ICES 7) (mg/kg)	Below level of detection																
Acenaphthene (µg/kg)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	100	-
Acenaphthylene (µg/kg)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	100	-
Anthracene (µg/kg)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	100	-
Benzo(a)anthracene (µg/kg)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	6.36	<2	<2	<2	<2	100	-
Benzo(a)pyrene (µg/kg)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	6.22	<2	<2	<2	<2	100	-

Contaminant	Site reference (array area – Tranche A)															Cefas Action Levels	
	85	8	4	5	23	41	49	94	45	74	58	61	17	82	40	Action Level 1	Action Level 2
Chrysene (μg/kg)	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	16.8	<3	<3	<3	<3	100	-
Dibenz(a,h)anthracene (μg/kg)	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	10	
Fluoranthene (μg/kg)	<2	3.25	<2	<2	<2	<2	<2	<2	<2	<2	7.17	<2	<2	<2	<2	100	-
Fluorene (μg/kg)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	100	-
Naphthalene (μg/kg)	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	100	-
Phenanthrene (μg/kg)	11.3	16.7	<10	13.1	10.2	<10	<10	<10	<10	<10	31.2	<10	<10	<10	<10	100	-
Pyrene (μg/kg)	5.28	3.97	<3	3.34	<3	<3	<3	<3	<3	<3	12.8	<3	<3	<3	<3	100	-

Table 8-16 Sediment Contaminant Sample Analysis Results Compared to the Cefas Action Levels for the Dogger Bank A & B Export Cable Corridor. Yellow indicates an exceedance of Action Level 1. There were no exceedances of Action Level 2 (Forewind, 2013b).

Contaminant	**Site reference (export cable corridor)**												**Cefas Action Levels**	
	23	**15**	**12**	**9**	**6**	**7**	**34**	**33**	**32**	**28**	**21**	**8**	**Action Level 1**	**Action Level 2**
Arsenic (mg/kg)	20.2	4.21	1.61	1.76	2.46	34.8	8.83	9.23	13.12	<0.4	2.84	41.7	20	100
Cadmium (mg/kg)	0.127	<0.03	<0.03	<0.03	<0.03	<0.03	0.234	0.827	0.827	0.476	0.585	0.077	0.4	5
Chromium (mg/kg)	158	11.4	8.81	12.3	11.9	10.7	142	135	104	64.3	138	77.9	40	400
Copper (mg/kg)	39.1	2.65	2.31	2.23	3.37	2.03	45.9	47.7	83	56.5	106	76.4	40	400
Mercury (mg/kg)	0.123	<0.002	0.002	0.002	0.002	0.003	0.016	0.012	0.025	0.047	0.107	0.018	0.3	3
Lead (mg/kg)	81.3	19.3	11.7	11.3	10.3	14.2	11.2	25	80.8	52.4	66.9	144	50	500
Nickel (mg/kg)	90.8	5.58	3.76	4.78	4.54	4.14	89.4	68	49.2	23.4	78	34.7	20	200
Polychlorinated biphenyls (PCBs) (sum ICES 7) (mg/kg)	Below level of detection where sampled (23, 15, 12, 9, 6, 7)													
Acenaphthene (µg/kg)	2.71	<2	<2	<2	<2	<2	2.22	15.2	11.1	12.6	10.9	<2	100	-

Contaminant	Site reference (export cable corridor)												Cefas Action Levels	
	23	15	12	9	6	7	34	33	32	28	21	8	Action Level 1	Action Level 2
Acenaphthylene (µg/kg)	<2	<2	<2	<2	<2	<2	<2	<2	<3	3.85	7.74	<2	100	-
Anthracene (µg/kg)	5.76	2.21	<2	<2	<2	<2	<2	6.84	14.4	43.2	21.1	<2	100	-
Benzo(a)anthracene (µg/kg)	11.2	<2	<2	<2	<2	3.28	2.43	22.4	31.7	140	55.5	4.34	100	-
Benzo(a)pyrene (µg/kg)	<2	<2	<2	<2	<2	2.88	<2	34.2	31.1	105	48.9	3.62	100	-
Chrysene (µg/kg)	11.3	>3	>3	>3	>3	3.74	4.89	28.9	61.2	128	65.3	8.41	100	-
Dibenz(a,h)anthracene (µg/kg)	<5	<5	<5	<5	<5	<5	<5	5.99	7.26	16.3	9.34	<5	10	
Fluoranthene (µg/kg)	26.2	10.7	<2	6.83	<2	4.83	5.22	26.8	59.5	228	89.3	9.59	100	-
Fluorene (µg/kg)	10.8	<10	<10	<10	<10	<10	<10	13.8	46.7	20.7	28.2	<10	100	-
Naphthalene (µg/kg)	<30	<30	<30	<30	<30	<30	<30	<30	152	45.4	118	<30	100	-

Contaminant	Site reference (export cable corridor)												Cefas Action Levels	
	23	15	12	9	6	7	34	33	32	28	21	8	Action Level 1	Action Level 2
Phenanthrene (µg/kg)	47	18.6	<10	12.7	<10	<10	15.2	40.6	182	160	129	17.1	100	-
Pyrene (µg/kg)	26.1	8.91	<3	6.05	<3	3.76	4.81	43.9	65	183	79.9	7.85	100	-

8.5.10 Water Quality - Chemical and Physico-chemical Parameters

87. Site specific water quality information is not available for the DBS array areas. However there are a number of more general monitoring programmes which provide an indication of current water quality trends. As outlined in section 8.4.1, the OSPAR Commission collates information and produces assessments regarding the state of the marine environment for five regions. The Projects are located in region II 'Greater North Sea'. In summary, the 2010 Quality Status Report states that eutrophication is still a problem in Regions II, III and IV. Reductions in phosphorus discharges exceed the OSPAR target of 50% compared to 1985, but nitrogen discharges are still the main problem, especially those from agriculture. With respect to hazardous substances, environmental concentrations of monitored chemicals are considered to have generally fallen, but are still above acceptable concentrations in many coastal areas of Regions II, III and IV. Contamination with persistent organic pollutants is widespread and their long-range air transport to the OSPAR area is of concern. It is also stated that historic pollution in aquatic sediments acts as a continued source for releases of persistent contaminants to the water column.

88. The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017, as amended by The Floods and Water (Amendment etc.) (EU Exit) Regulations 2019, continue to enforce the Directive of the European Parliament and of the Council 2000/60/EC establishing a framework for community action in the field of water policy (generally known as the WFD) following implementation of the European Union (Withdrawal) Act 2018. Water quality is an important component for compliance with the requirements of this Directive and therefore the information collected for the transitional and coastal water bodies is relevant to this section. The offshore export cable corridor in the nearshore area (i.e. 1 nm from the coast), passes through the Yorkshire South coastal WFD water body and within 8.5km of the Yorkshire North coastal WFD water body as shown in **Figure 8-9**. **Table 8-17** presents the details of current water quality status classification for these two coastal waterbodies.

Table 8-17 WFD Water Bodies (Environment Agency, 2021)

WFD Water Body	Water Body Type	Physico-Chemical Information (latest data from 2019)	Chemical Status (latest data from 2019)
Yorkshire South - **GB640402491000**	Coastal Water Body	**High**	**Fail** (Polybrominated diphenyl ethers (PBDE), Benzo(g-h-i) perylene, mercury and its compounds and tributyltin compounds)
Yorkshire North - **GB650401500004**	Coastal Water Body	**High**	**Fail** (PBDE, Benzo(g-h-i) perylene, mercury and its compounds

89. The following bathing waters are located on the coast in the region of the offshore export cable corridor (these are also protected areas designated under the WFD). They are classified over a four-year rolling period based on bacteriological parameters as either excellent, good, sufficient, or poor. The latest status classifications for each bathing water in 2022 were:

- Bridlington North – Good;
- Bridlington South – Poor;
- Danes Dyke, Flamborough – Excellent;
- Flamborough South Landing – Excellent;
- Fraisthorpe – Good;
- Hornsea – Excellent;
- Skipsea – Excellent; and
- Wilsthorpe – Good.

8.5.11 Flamborough Front

90. The Southern North Sea is generally described as a well-mixed water body. These well-mixed conditions are mainly due to relatively shallow depths and the ability of winds and tides to continually stir water sufficiently to prevent the onset of any stratification (DECC, 2016). In contrast, the Northern North Sea is relatively deeper with slightly weaker currents, this helps temperature stratification develop from the spring into the summer months. During this period, a transition between these two water bodies develops from about 10 km offshore of Flamborough Head in the form of a temperature front, known as the Flamborough Front. The deeper stratified water to the north tends to remain aligned with the 50m isobath (Hill, *et al.* 1993). The surface waters of the front tend to move around this alignment with the scale of tidal advection. The front becomes nutrient rich and is considered to be ecologically important. During autumn and winter the front dissipates due to increased wind and wave related stirring effects which are sufficient to overcome the stratification (i.e. increased mixing > buoyancy) and re-establish well-mixed conditions for this part of the Northern North Sea. The timing of the destabilisation will vary from year to year depending on the weather conditions at the time.

91. The Flamborough Front, when present, is a 320km-long zone located off the East Riding of Yorkshire coast (**Plate 8-4**). While the location and strength of the Flamborough varies on a seasonal and yearly basis, observations from between 1999 and 2008 suggest it is present in the DBS array areas and the offshore export cable corridor during summer 70-90% of the time. During autumn and spring, the front may be present in the DBS array areas between 30-50% of the time.

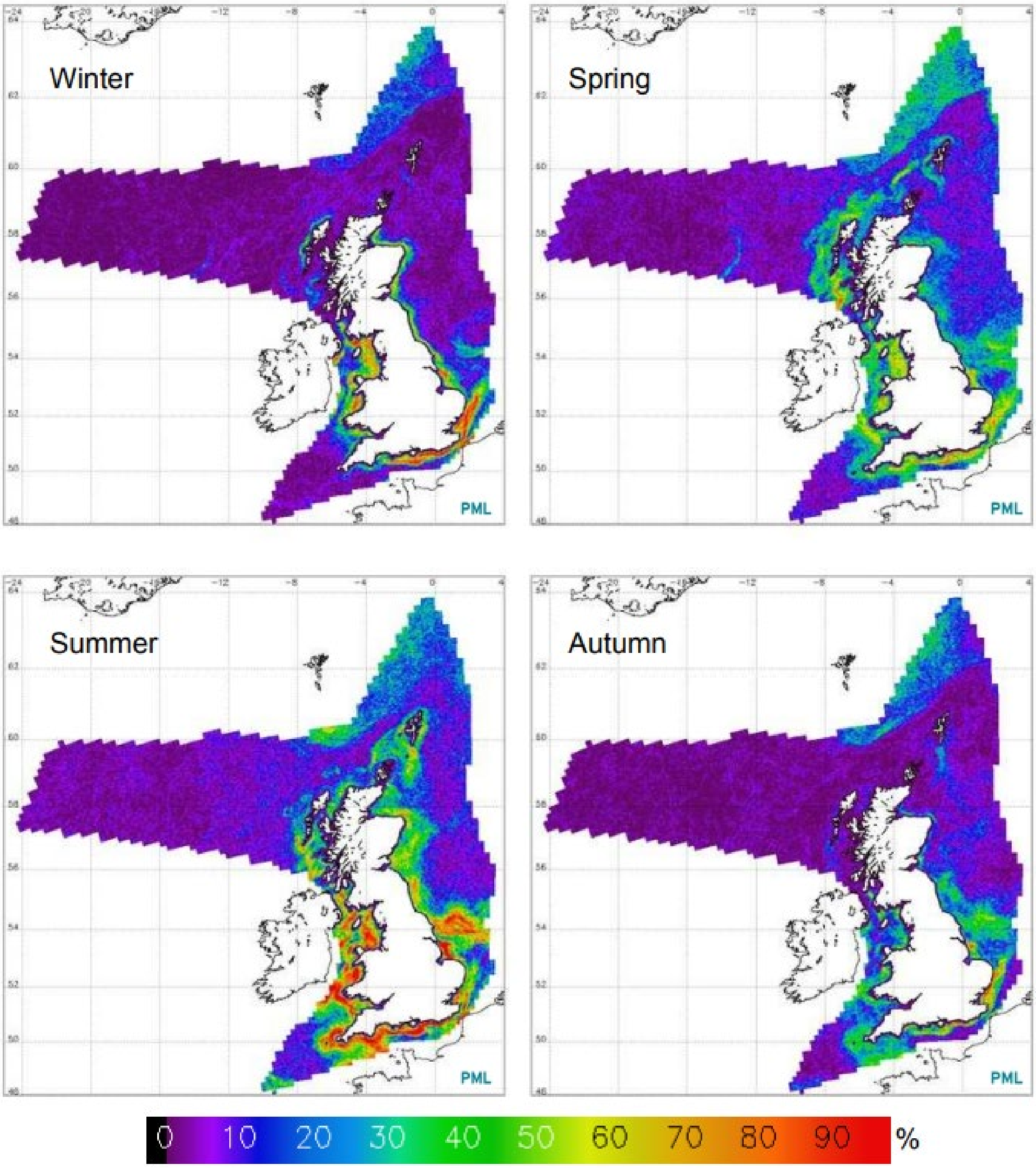

Plate 8-4 Seasonal frequent front maps, indicating the percentage of time a strong front was observed at each location based on 1999-2008 data (from Miller and Christodoulou 2014).

8.5.12 Coastal Geomorphology

92. The possible landfall locations are characterised by low cliffs composed of relatively soft clay (till), fronted by a highly dynamic sand and gravel beach that rests on a shore platform of till, which is exposed locally where beach deposits are thin. Cliffs along the Holderness coast range from 3m to 40m high (Scott Wilson, 2010). The coastal environment mainly responds to wave-driven processes which erode the beach and the base of the cliffs, and transport sediment along the beach.

93. The bathymetry in the nearshore zone is relatively shallow and gently sloping (**Figure 8-2**). Water depths reach 10m within 2km of Mean Low Water. No mobile bedforms have been identified in the nearshore data. However, a series of shore parallel, static ridge features are present at the possible landfall location. These may be relict glacial landforms that formed when sea levels were lower during the last glacial period.

8.5.13 Coastal Geology

94. The cliffs and shore platform along the Holderness coast are composed of Skipsea Till which formed in the late Devensian (18,000-13,000 years ago) and contains a high proportion of gravel and boulders. Lenses and thin sheets of silt, sand and gravel, and peat are present (Evans and Thomson, 2010) within the till which create planes of weakness that are more susceptible to erosion.

95. The till shore platform extends seaward into the subtidal zone where it is exposed at seabed locally. Seabed sediments in this highly dynamic zone are characterised by sand and mixed sediment (East Riding of Yorkshire Council, 2014).

8.5.14 Coastal Sediment Transport

96. Waves are the dominant driver of sediment transport along the Holderness coast with net transport at the possible landfall locations to the south towards Spurn Head (Pye and Blott 2015) (**Figure 8-6).**

97. Tidal and wave-induced currents acting across and along the relatively narrow beach fronting the coastal cliffs mobilise fine-grained sediment from the beach, exposed shore platform and the eroding cliffs, and transports it seaward creating a visible nearshore sediment plume.

8.5.15 Coastal Erosion

98. The Holderness coast is one of the fastest eroding coasts in Europe due to the combination of relatively soft till geology and a high energy wave environment. Cliff erosion rates along the coast are spatially and temporally complex which reflects the interaction between natural processes and human intervention in the form of coastal defences.

99. The SMP policy for this stretch of coast (Policy Unit C: Wilsthorpe to Atwick) is No Active Intervention for the Short Term (present day to 2025), Medium Term (2025 to 2055) and Long Term (2055 to 2105) (Scott Wilson, 2010). The NCERM identifies this frontage as natural defence and erodible.

100. East Riding of Yorkshire Council undertake routine monitoring of the Holderness coast in spring and autumn each year which includes topographic surveying of beach profiles from the top of the cliffs to low water. Cliff recession rates at profiles 24 to 31 (**Figure 8-10**), located in the immediate area surrounding the possible landfall locations, are summarised in **Table 8-18**.

Table 8-18 Cliff Recession Rates at Profiles 24 to 31.

Profile	Location	Erosion rate (m/year)		Height of cliff (m AODN)	Maximum annual recession (m)	Year of maximum
		Historic (1852 to 1989)	Recent (1989 to 2022)			
24	Between defences opposite South-field Lane, Ulrome	1.56	1.15	8.2	8.83	2016
25	North end of Green Lane, Skipsea	1.54	1.34	8.4	9.36	2007
26	South of Green Lane, Skipsea	1.58	0.92	10.6	10.17	2008
27	Opposite Skipsea village	1.33	1.06	13.0	10.95	2011
28	Opposite bunga-lows to south of Skipsea	1.19	1.41	12.9	11.60	2013
29	To south of Withow Gap, Skipsea	1.10	1.39	11.6	9.82	2020
30	Within golf course to north of Skirlington	1.07	1.14	14.6	7.86	2016
31	North end of Skirlington campsite	1.07	1.02	18.3	8.34	2018

101. The maximum annual recession at each of the profiles was recorded in the last 15 years, with the greatest of 11.6m recorded at Profile 28 in 2013.

102. Shore platform lowering contributes to coastal erosion as subaerial weathering and marine erosion break up the till allowing waves to transport it seaward. The beaches along the Holderness coast are covered by a relatively thin (less than 10cm in place) sand veneer which makes the shore platform extremely vulnerable to erosion.

8.5.16 Historic Sea-Level Rise

103. The erosion rates along the Holderness coast have been measured over the long term between 1852 and 1989, and more recently over the medium-term, between 1989-2022 (**Table 8-18**). The historic sea-level rise estimate that most closely covers this period of historic erosion is that of Woodworth (2017). Woodworth (2017) used recent mean sea level information from the UK tide gauge network along with short records of sea level measurements by the OS in 1859–1860, to estimate the average rates of sea-level change around the coast since the mid-19th century. The nearest historic data to the proposed landfall location analysed by Woodworth (2017) is at Scarborough, which includes OS data from 1859-1860 and tide gauge data for 24 of the years between 1955 and 2014 (with a central year of 1997). The estimated long-term rate of sea-level rise between mean sea level in 1859-1860 and the average mean sea level between 1955 and 2014 (1997) was 1.73mm/year.

8.6 Future Trends

104. In the event that the Projects are not developed, the baseline conditions for the marine physical environment will continue to be controlled by waves and tidal currents driving changes in sediment transport and then seabed morphology, but also anthropogenic influences in relation to water quality.

105. These long-term drivers may be affected by environmental changes including climate change driven sea-level rise. This will have the greatest impact at the coast where more waves will impinge on the cliffs, 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. With respect to water quality, continued improvements in inputs alongside continued legislative change could give rise to benefits in water quality in the long term.

8.6.1 Projected Sea-Level Rise

106. Historical data shows that the global temperature has risen since the beginning of the 20th century, and predictions are for an accelerated rise, the magnitude of which is dependent on the magnitude of future emissions of greenhouse gases and aerosols.

107. To determine a climate change sea-level allowance for the proposed landfall locations to cover the 30-year operational life of the wind farms and post-operation, this study uses the data of the UK Climate Projections (UKCP18) user interface for the model grid cell that covers the proposed landfall location (**Figure 8-11**). The UKCP18 outputs provide projections over three future greenhouse gas emissions scenarios, named Representative Concentration Pathways (RCPs). They are available for low (RCP2.6), medium (RCP4.5) and high (RCP8.5) emissions scenarios and presented by UKCP18 as central estimates of change (50% confidence level) in each scenario with an upper 95% confidence level and a lower 5% confidence level. For this study, RCP 4.5 and 8.5 has been used, representing the best estimate and highest of the three modelled RCPs. Outputs using the 50th percentile value are provided in **Table 8-19** and **Plate 8-5**, showing changes in mean sea level relative to a base date of 2023.

Table 8-19 UKCP18 Modelled Projections of Sea-level Rise at the Proposed Landfall Location

Year	Representative Concentration Pathway	Sea level rise relative to 2023 base date	Average rate of sea-level rise
2033 (10 years)	RPC 4.5	0.04m	4.7mm/year
	RPC 8.5	0.06m	6.5mm/year
2043 (20 years)	RPC 4.5	0.09m	5.0mm/year
	RPC 8.5	0.13m	6.4mm/year
2053 (30 years)	RPC 4.5	0.15m	5.1mm/year
	RPC 8.5	0.20m	6.8mm/year
2073 (50 years)	RPC 4.5	0.27m	5.4mm/year
	RPC 8.5	0.38m	7.5mm/year

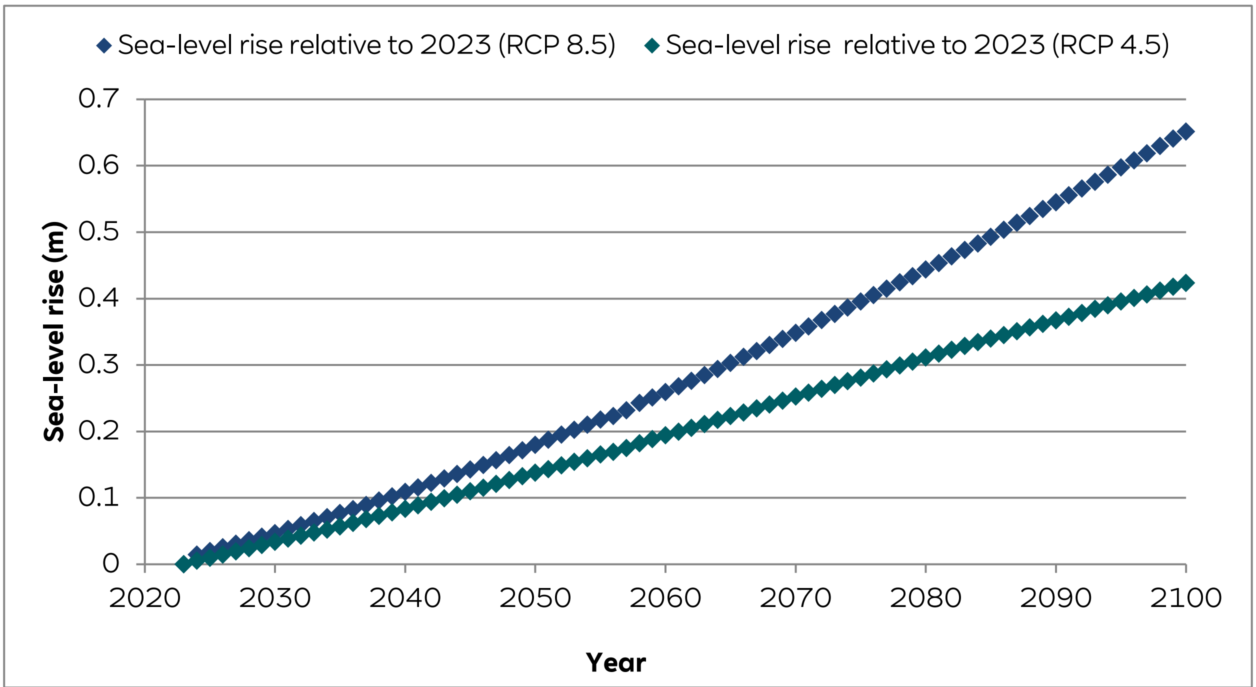

Plate 8-5 Projected changes in relative sea level (m) at the proposed landfall location under the 50% confidence level of the medium (RPC 4.5) and high (RCP 8.5) emissions scenarios using a 2023 baseline

8.6.2 Predicting Future Cliff Erosion

108. One of the most important long-term implications of climate change is the physical response of the coast to future sea-level rise. It is likely that the future erosion rate of the Holderness cliffs will be affected by the higher rates of sea-level rise. Higher baseline water levels would result in a greater occurrence of waves impacting the toes of the cliffs, increasing their susceptibility to erosion.

109. The most widely used models to forecast cliff-top erosion are empirical and use historical trend analysis from a knowledge of historic cliff erosion rates. Two methods of historical trend analysis have typically been adopted to predict future cliff erosion:

- Direct extrapolation of historic trends into the future without incorporating potential increases due to higher rates of relative sea-level rise (Lee and Clarke, 2002); and
- Forward projection including potential increases to account for higher rates of relative sea-level rise (Leatherman, 1990).

110. The extrapolation of historic trends involves analysing past data for average cliff erosion rate and adopting this rate for future years. The forward projection equation of Leatherman (1990) predicts future cliff erosion by using projected future relative sea-level rise scenarios and measured historic cliff erosion rates. The forward projection method involves multiplying historic cliff erosion rates with a factor derived from the ratio of future and historic rates of relative sea-level rise.

(Equation 1): $RP = RH.(SP/SH)$.

111. Where:

- RP = predicted erosion rate (m/year);
- RH = historic erosion rate (m/year) (**Table 8-18**);
- SP = predicted relative sea-level rise (mm/year); and
- SH = historic relative sea-level rise (mm/year).

112. The equation assumes that the main erosive factor is the rise of relative sea-level (the rate of cliff erosion is proportional to the change in rate of relative sea-level rise), the other influencing factors will remain constant, and that predictions of relative sea-level rise are reliable. The forward projection method is adopted here. The extrapolation method is likely to under-estimate future erosion.

113. Using values of historic sea-level rise and erosion rates, and projections of future sea-level rise (high emissions scenario), the predicted future cliff erosion rates at beach profiles 25-30 located in the vicinity of the possible landfall locations are shown in **Table 8-20**.

Table 8-20 Projected Cliff Erosion Rates of the Holderness Cliffs in the Vicinity of the Possible Landfall Locations

Erosion Profile Details		**Erosion rate (m/year)**				
		Historic	**Future**			
Profile	**Location**	**1852 to 2022**	**10 years**	**20 years**	**30 years**	**50 years**
24	Between defences opposite Southfield Lane, Ulrome	1.48	5.57	5.49	5.83	6.43
25	North end of Green Lane, Skipsea	1.50	5.65	5.56	5.91	6.52
26	South of Green Lane, Skipsea	1.45	5.46	5.38	5.72	6.31
27	Opposite Skipsea village	1.28	4.81	4.73	5.03	5.55
28	Opposite bungalows to south of Skipsea	1.37	5.15	5.07	5.38	5.94
29	To south of Withow Gap, Skipsea	1.33	5.02	4.94	5.25	5.79
30	Within golf course to north of Skirlington	1.13	4.24	4.17	4.44	4.89
31	North end of Skirlington campsite	1.06	3.99	3.93	4.17	4.60

114. Predictions of future coastal erosion using the UKCP18 high emission scenario (RCP8.5) at a 50% confidence level suggest the maximum cliff retreat distance at the possible landfall location will be 57m over the next 10 years, 111m over the next 20 years, 175m over the next 30 years and 326m over the next 50 years. These rates are the worst case and are overestimated when compared to the NCERM project which predicts a retreat distance of 33m for the short term (0 to 20 years) and 82m for the medium term (20 to 50 years) for this frontage which is classified as being erodible.

8.7 Assessment of Significance

8.7.1 Impact Receptors

115. The principal receptors with respect to the marine physical environment are coastal or marine features with an inherent geological or geomorphological value or function which may be affected by the Projects. For water quality, the receptor is generally the marine environment given that water quality EQS are applied regardless of designation status. However, it is acknowledged within this assessment that specific areas of marine waters are classified according to their water quality status or water quality contributes to their classification status, such as bathing waters and WFD water bodies for example therefore an additional value assessment is provided where activities could impact these designations.

116. The specific features requiring further assessment at the EIA stage are listed in **Table 8-21**. The impact assessment sections assess the significance of potential impacts on water quality, the wave and/or current and/or sediment transport regimes on these receptors.

Table 8-21 Marine Physical Environment Receptors Relevant to the Projects

Receptor group	Receptor	Description of features	Closest distance from projects
Designated sites and features	Dimlington Cliff SSSI	Geological Interest	36km south of the possible landfall locations
	Flamborough Head SAC and SSSI	Annex I habitat – Reefs, Vegetated sea cliffs of the Atlantic and Baltic Coasts and Submerged or partially submerged sea caves Shingle, Sea cliffs, Islets Improved grassland	9km north of the offshore ECC
	Flamborough and Filey Coast SPA	Wild birds	9km north of the offshore ECC
	Greater Wash SPA	Wild birds	Offshore ECC and possible landfall located within SPA
	Humber Estuary SPA	Wild birds	40km from possible landfall location
	Humber Estuary SAC	Estuaries Mudflats and sandflats not covered by seawater at low tide Sandbanks which are slightly covered by seawater all the time Coastal lagoons Salicornia and other annuals colonising mud and sand Atlantic salt meadows (*Glauco Puccinellietalia maritima*).	44.6km south of the landfall location

Receptor group	Receptor	Description of features	Closest distance from projects
	Holderness Inshore MCZ	Intertidal sand and muddy sand Moderate energy circalittoral rock High energy circalittoral rock Subtidal coarse sediment Subtidal mixed sediments Subtidal sand Subtidal mud Spurn head (subtidal)	Nearshore offshore ECC and one of the possible landfalls located within the MCZ
	Holderness Offshore MCZ	North Sea glacial tunnel valleys Subtidal coarse sediment Subtidal mixed sediment Subtidal sand	1km south of the offshore ECC, 12km from the coast
	Dogger Bank SAC	Annex I habitat – Sandbanks which are slightly covered by sea water all the time	DBS array areas and part of the offshore ECC are located within the SAC
	Southern North Sea SAC	Annex II species – Harbour porpoise	DBS array areas and part of the offshore ECC are located within the SAC
	Marine waters (offshore)	No specific features	Both DBS array areas and part of the offshore ECC
	Marine waters (inshore)	Marine waters within which the following designations are located:	ECC passes through the Yorkshire South coastal WFD water body and within 8.5km of the Yorkshire North coastal WFD water

Receptor group	Receptor	Description of features	Closest distance from projects
		WFD water bodies: Yorkshire South coastal WFD water body, Yorkshire North coastal WFD water body Bathing waters: Bridlington North, Bridlington South Danes Dyke, Flamborough, Flamborough South Landing, Fraisthorpe, Hornsea, Skipsea Wilsthorpe.	body as shown in **Figure 8-9.** Closest bathing water – Skipsea is on the border of the ECC boundary. All others are located at least 5km from the ECC boundary (see **Figure 8-9)**
Non-designated sites and features	Holderness Cliffs	Soft, rapidly eroding coastal cliffs and beach platform	HDD exit points at possible landfall locations
	Smithic Sands	Offshore sand bank	Offshore ECC buffer partially crosses southern part of Smithic Sands
	Flamborough Front	Seasonal tidal mixing front	Potentially present within array areas

8.7.2 Effects

117. In addition to identifiable receptors, an assessment of changes to the marine physical environment which in themselves are not necessarily effects to which significance can be ascribed (such as changes in suspended sediment and chemical concentrations) is outlined in section 8.7.4 to section 8.7.5. These changes however, may directly impact other receptors such as benthic habitats for example. In this case, the magnitude of impact is determined in a similar manner to that of marine physical environment receptors but the significance of effects on other receptors is made within **Chapter 9 Benthic Habitats**, **Chapter 10 Fish and Shellfish Ecology**, and **Chapter 17 Offshore Archaeology and Cultural Heritage**.

8.7.3 Justification for Use of a Conceptual Approach for Changes to Suspended Sediment Concentration, Seabed Level and Wave and Tide Regime

118. Previous numerical modelling undertaken for the Dogger Bank A, B and C and Sofia offshore wind farms provides a suitable analogue to assess the potential effects of the Projects on the identified marine physical environment receptors. At PEIR, the results of the modelling and theoretical approaches from existing offshore wind farms are used as part of the conceptual evidence-based assessment of potential construction and operation impact and effect from the Projects. Justification for the using the modelling results from these projects is provided in **Appendix 8.1**. Bespoke numerical modelling of the effects of the Projects on the marine physical environment will be undertaken as part of the ES.

8.7.4 Potential Effects During Construction

119. During construction, seabed and shallow sub-seabed sediments will be disturbed during the following activities:

- Seabed preparation (including seabed levelling and clearance);
- Installation of foundations for wind turbines and offshore platforms;
- Drill arisings from foundations for wind turbines;
- Installation of offshore export, array and inter platform cables;
- Installation of cofferdams at HDD exit pits; and
- Dredging of flotations pits during offshore export cable installation at the landfall.

8.7.4.1 Impact C1a: Changes in Suspended Sediment Concentration and Transport due to Seabed Preparation for Foundation Installation

8.7.4.1.1 Description of Change

120. Seabed sediments and shallow near-bed sediments within the DBS array areas and the offshore export cable corridor would be disturbed during seabed preparation 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 localised and short-term increases in suspended sediment concentrations both at the point of dredging at the seabed and at the point of its discharge back into the water column.

121. 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. Numerical modelling of sediment plumes undertaken for the Dogger Bank A and B offshore wind farms show that predicted suspended sediment concentration in the bottom layer from a sediment plume created during installation of 24 gravity based foundations over a 30-day simulation period are greater than 200mg/l in close proximity to the area of disturbance and reduce to background levels within 65km of the disturbance. Far-field changes as a result of the same disturbance would be much lower.

122. Seabed sediments within the array areas are dominated by sandy sediments and mixed sediment (gravelly sand and sandy gravel) that are expected to have a relatively low mud content. As outlined in section 8.5.8, average suspended sediment concentration in the array areas is less than 3mg/l.

123. The worst case scenario for total volume of seabed sediments released during the construction phase is associated with seabed preparation for gravity based foundations for the offshore platforms and suction bucket jacket foundations for wind turbines. The volume of sediment disturbed will depend on the depth of dredging/clearance for seabed preparation. The disturbance effects at each foundation location are only likely to last for a few days of construction activity within the overall construction programme lasting up to 60 months in total if DBS East and DBS West are constructed together, and 84 months if they are constructed separately.

124. It is expected that any medium to coarse sand and coarse-grained mixed sediment across the array areas, and at the location of the offshore platforms in the offshore export cable corridor (located at least 40km offshore), disturbed by the drag head of the dredger at the seabed would remain close to the seabed and settle back rapidly. Most of the coarse sediment released at the water surface from the dredge vessel would fall rapidly (minutes or tens of minutes) to the seabed within a few tens of metres along the axis of tidal flow.

125. Any released fine sand, silt or clay will likely stay in suspension for longer and form a plume which would become advected by tidal currents. 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). Smaller amounts of suspended sediment would extend further from the dredged area, along the axis of predominant tidal flows, but the concentrations would be indistinguishable from background levels within 65km of the area of disturbance.

126. 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).

127. If both DBS East and DBS West are constructed together, a larger volume of sediment would be disturbed over the entire construction phase which may result in higher concentrations of suspended sediment overall. However, suspended sediment concentrations arising from one foundation installation are unlikely to persist for a sufficiently long period of time for them to interact with subsequent operations, and therefore no cumulative effect is anticipated from multiple installations should DBS East and DBS West be developed concurrently.

8.7.4.1.2 Magnitude of Impact – DBS East or DBS West in Isolation

128. Seabed preparation for foundation installation will disturb the seabed with a worst-case scenario for 48 large wind turbines being suction bucket jacket foundations and gravity base foundations for six offshore platforms. The likely magnitude of impact is shown in **Table 8-22**.

Table 8-22 Magnitude of Impact on Suspended Sediment Concentrations Under the Worst Case Scenario for Foundation Installation

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

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

8.7.4.1.3 Magnitude of Impact – DBS East and DBS West Together

129. The worst-case scenario for changes in suspended sediment concentrations due to the installation of 95 large wind turbines and eleven offshore platforms will have the same magnitude of impact as outlined in section 8.7.4.1.2.

8.7.4.1.4 Sensitivity of Receptor

130. The array areas and offshore export cable corridor are located within offshore marine waters and specifically the Southern North Sea SAC and almost all of the array areas are within the Dogger Bank SAC. The sensitivity and value of these receptors is presented in **Table 8-23**.

Table 8-23 Sensitivity and Value Assessment for Receptors Impacted by Changes to Suspended Sediment Concentration

Receptor	Tolerance	Recoverability	Value	Sensitivity
Dogger Bank SAC	High	High	High	Negligible
Southern North Sea SAC	High	High	High	Negligible
Marine waters (offshore)	High	High	Low	Negligible

8.7.4.1.5 Significance of Effect – DBS East or DBS West in Isolation

131. The effect on suspended sediment concentrations due to foundation installation is considered to have medium magnitude of impact and negligible sensitivity, resulting in a **negligible** significance of effect. No additional mitigation is proposed. Any changes in suspended sediment will be short-lived and considering the coarse-grained nature of the seabed, any disturbed sediment would settle back to the seabed in close proximity to the area of disturbance.

8.7.4.1.6 Significance of Effect – DBS East and DBS West Together

132. If both Projects are constructed together a larger volume of sediment will be disturbed over the construction phase which may result in higher concentrations of suspended sediment overall. However, as outlined in section 8.7.4.1.1, suspended sediment concentrations arising from one foundation installation are unlikely to persist for a sufficiently long period of time for them to interact with subsequent operations, and therefore no cumulative effect is anticipated from multiple installations. Therefore, the construction of DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation, and the significance of effect is considered to be **negligible** due to a medium magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.4.2 Impact C1b: Changes in Suspended Sediment Concentration and Transport due to Drill Arisings from Foundations

8.7.4.2.1 Description of Change

133. Sediments below the seabed within the array areas would become disturbed during any drilling activities that may be needed at the location of piled foundations. Ambient suspended sediment concentrations across the array areas are typically less than 3 mg/l in DBS East reducing to below 2mg/l in DBS West (section 8.5.8) meaning that the transient impact of sediment plumes arising from installation of the windfarm foundations may be significant (although temporally limited) under specific circumstances. The disposal of any sediment that would be disturbed or removed during drilling would occur within the windfarm site in close proximity to each foundation.

134. The worst case scenario for a release from an individual wind turbine assumes a monopile foundation for a large wind turbine. In this case, an 18m drill diameter would be used from the seabed to a depth of 70m, releasing a maximum of 17,813m^3 of sediment per foundation into the water column. The maximum volume of arisings outlined in **Table 8-3** assumes 5% of monopile foundation locations are drilled as a worst case scenario which would amount to a maximum of five individual foundations across both Projects. The worst case for offshore platform foundations assumes the same pile diameter as for wind turbines and the maximum drill arisings shown in **Table 8-3** assumes each foundation requires drilling to a depth of 70m.

135. The drilling process would cause localised and short-term increases in suspended sediment at the point of discharge of the drill arisings only. Released sediment may then be transported by tidal currents in suspension in the water column. Any fine sediment released is likely to be widely and rapidly dispersed. Given the seabed sediment are dominated by sand and mixed sediment, this would result in low suspended sediment concentrations. 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 60 months in total if DBS East and DBS West are constructed together, and 84 months if they are constructed separately.

136. The conceptual evidence-based assessment suggests that away from the immediate release locations, elevations in suspended sediment above background levels would be very low (less than 10mg/l) and within the range of natural variability. Net movement of fine-grained sediment retained within a plume would be to the north-west or south-west, 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. Furthermore, only 5% of foundations are expected to be drilled.

137. The conceptual assessment is supported by modelling undertaken for the adjacent Dogger Bank A & B and Dogger Bank C and Sofia offshore wind farms which has a similar seabed and shallow sub-surface geological composition. A maximum suspended sediment concentration of greater than 200mg/l was predicted to occur within the confines of the foundation installation area gradually reducing with distance until they reach background levels within 50km of the location of disturbance.

138. Considering only 5% (up to five in total) of wind turbine foundations are expected to be drilled across the Projects producing a maximum volume of 84,611m^3 of disturbed sediment, any changes to suspended sediment concentration and transport resulting from drill arisings from monopile foundations are expected to be less than predicted for the Dogger Bank A, B & C and Sofia offshore wind farms which simulated a total volume of sediment released of 149,280m^3 over a period of 30 days.

8.7.4.2.2 Magnitude of Impact – DBS East or DBS West in Isolation

139. The scale of this impact will be relatively localised (near-field) for coarser sediments due to rapid settling out. While fine sediments have greater potential to become mobilised, their volumes are expected to be low and any suspended sediments in the water column are predicted to return to baseline conditions within days due to dispersion and dilution.

140. The magnitude of impact for the worst case scenario due to the installation of 48 large wind turbines and six offshore platforms is given in **Table 8-24**.

Table 8-24 Magnitude of Impact on Suspended Sediment Concentration and Transport due to Drill Arisings from Foundations

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Medium	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.

8.7.4.2.3 Magnitude of Impact – DBS East and DBS West Together

141. The worst-case scenario for changes in suspended sediment concentrations due to drill arisings from the installation of 95 large wind turbines and 11 offshore platform foundations will have the same magnitude of impact as outlined in section 8.7.4.2.2.

8.7.4.2.4 Sensitivity of Receptor

142. The array areas and offshore export cable corridor is located within the Southern North Sea SAC and parts of the array areas are within the Dogger Bank SAC. The sensitivity and value of these receptors is presented in **Table 8-25**.

Table 8-25 Sensitivity and Value Assessment for Receptors Impacted by Changes to Suspended Sediment Concentration

Receptor	Tolerance	Recoverability	Value	Sensitivity
Dogger Bank SAC	High	High	High	Negligible
Southern North Sea SAC	High	High	High	Negligible
Marine waters (offshore)	High	High	Low	Negligible

8.7.4.2.5 Significance of Effect – DBS East or DBS West in Isolation

143. The effect on suspended sediment concentrations due to drill arisings from foundation installation is considered to have negligible magnitude of impact and negligible sensitivity, resulting in a likely **negligible** significance of effect. No additional mitigation is proposed.

8.7.4.2.6 Significance of Effect – DBS East and DBS West Together

144. Construction of DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.4.2.5 and considered to have a likely **negligible** significance of effect due to a negligible magnitude of effect and negligible sensitivity. No additional mitigation is proposed.

8.7.4.3 Impact C1c: Changes in Suspended Sediment Concentration and Transport due to Cable Installation (Array, Inter Platform and Export)

8.7.4.3.1 Description of Change

145. The installation parameters of the array, inter platform and offshore export cables are dependent upon the final project design. The worst-case cable laying technique is considered to be jetting, and so the assessment below considers 100% of the cables are installed by jetting.

146. As a worst case scenario, it is assumed seabed clearance and levelling (pre-sweeping) may be required prior to cable 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 dredge vessel. This process would cause localised and short-term increases in suspended sediment both at the point of dredging at the seabed and, more importantly, at the point of its discharge back into the water column.

147. 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 seabed levelling would be disposed of within close proximity to the point of excavation, meaning there will be no net loss of sediment.

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

149. Conceptual evidence-based assessment indicates that the changes in suspended sediments due to cable installation would be similar to those that have been assessed in relation to the disturbance of near-surface sediments during foundation installation activities (see Impact C1a, section 8.7.4.1).

150. Based on the modelling undertaken along the export cable corridor for the Dogger Bank A and B offshore wind farms, the maximum suspended sediment concentration was 100-200mg/l at two specific locations, one near the coast and one approximately 50km offshore. Elsewhere along the export cable corridor suspended sediment concentrations were typically less than 100mg/l and reduce to background levels of 2mg/l within 50km of the export cable corridor.

151. Jetting in advance of cable installation would disturb seabed sediments. In the nearshore where coarse-grained sands and gravels dominate the seabed sediment (see section 8.7.3), these grain-size fractions would remain close to the bed and settle back to the bed rapidly. The sediment plume created by the jetting process would raise elevations of suspended sediment concentrations. Elevation may be further raised if dredging of flotation pits is required to accommodate installation vessels in shallow water during cable installation. However, considering background suspended sediment concentrations are higher in the nearshore due to coastal erosion, any changes due to cable installation activities are likely to be within the range of changes caused during large storm events.

152. Further offshore along the export cable corridor and within the array areas, seabed sediments become sand dominated and potentially include higher proportions of fine sand and silt. Also, the background suspended sediment concentrations further offshore are lower meaning any changes may have a greater impact. However, as with Impact C1b (see section 8.7.4.1), any fine sand, silt or clay fraction mobilised during jetting will form a passive plume which would become advected by tidal currents. 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 amounts of suspended sediment would extend further from the jetting area, along the axis of predominant tidal flows, the magnitudes would be indistinguishable from background levels.

8.7.4.3.2 Magnitude of Impact – DBS East or DBS West in Isolation

153. The scale of this impact will be relatively localised for coarser sediments (due to immediate settling out) and larger-scale for finer sediments. However, suspended sediments in the water column are predicted to return to baseline conditions within days after completion of installation due to dispersion and dilution. The magnitude of impact for the worst case scenario due to cable installation is given in **Table 8-26**.

Table 8-26 Magnitude of Impact on Suspended Sediment Concentrations for Cable Installation for a Project in Isolation

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
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 the cable installation activity.

8.7.4.3.3 Magnitude of Impact – DBS East and DBS West Together

154. The worst-case scenario for changes in suspended sediment concentrations due to cable installation will have the same magnitude of impact as outlined in section 8.7.4.3.2.

8.7.4.3.4 Sensitivity of Receptor

155. The offshore export cable corridor is located within the Holderness Inshore MCZ and crosses the southern part of Smithic Sands. Inshore, it crosses a WFD water body in within close proximity to several bathing waters. Further offshore, the export cable corridor is located within the Southern North Sea SAC and the array and inter platform cables are within the Dogger Bank SAC. The sensitivity and value of these receptors is presented in **Table 8-27**.

Table 8-27 Sensitivity and Value Assessment for Receptors Impacted by Changes to Suspended Sediment Concentration During Cable Installation

Receptor	Tolerance	Recoverability	Value	Sensitivity
Holderness Inshore MCZ	High	High	High	Negligible
Smithic Sands	High	High	Medium	Negligible
Dogger Bank SAC	High	High	High	Negligible
Southern North Sea SAC	High	High	High	Negligible
Marine waters (offshore)	High	High	Low	Negligible
Marine waters (inshore)	High	High	High	Negligible

8.7.4.3.5 Significance of Effect – DBS East or DBS West in Isolation

156. The effects on suspended sediment concentrations due to cable installation is considered to have a negligible magnitude of impact and negligible sensitivity, resulting in a likely **negligible** significance of effect. No additional mitigation is proposed. Any changes in suspended sediment will be short-lived and considering the coarse-grained nature of the seabed, any disturbed sediment would settle back to the seabed in close proximity to the area of disturbance.

8.7.4.3.6 Significance of Effect – DBS East and DBS West Together

157. Construction of DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.4.2.5 and is considered to be of **negligible** significance of effect due to a negligible magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.4.4 Impact C1d: Changes in Suspended Sediment Concentration and Transport Due to HDD Exit Cable Installation

8.7.4.4.1 Description of Change

158. The details and location of the HDD exit pits is dependent upon the final project design. The indicative length of the HDD could be up to 1,400m but it is possible the HDD exit pit will be located within the intertidal zone. The HDD exit points will require excavation of a trench to bury the nearshore portion of the offshore export cable on the seaward side of the landfall location. This excavation may increase suspended sediment concentrations close to the shore.

159. A worst case scenario assumes the HDD will be located in the intertidal zone and that the excavation will include temporary installation of cofferdams. The excavated material will be disposed of directly adjacent to the location of the excavation and will comprise gravelly sandy beach sediments and glacial till from the underlying shore platform. Excavation will be undertaken at low tide but the excavated sediment will become submerged at high tide, where seabed currents (predominantly wave-driven) will mobilise and redistribute it.

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

8.7.4.4.2 Magnitude of Impact – DBS East or DBS West in Isolation

161. The magnitude of impact for the worst case scenario due to landfall HDD assumes the HDD exit points are located in the intertidal zone (**Table 8-28**).

Table 8-28 Magnitude of Impact on Suspended Sediment Concentrations Under the Worst Case Scenario Due to Landfall HDD

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
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 the cable installation activity.

8.7.4.4.3 Magnitude of Impact – DBS East and DBS West Together

162. The worst-case scenario for changes in suspended sediment concentrations due to installation of the landfall HDD for both projects will have the same magnitude of impact as outlined in section 8.7.4.4.2.

8.7.4.4.4 Sensitivity of Receptor

163. Changes in suspended sediment concentrations due to landfall HDD installation may impact the Holderness Inshore MCZ, WFD water bodies and bathing waters. The sensitivity and value of these receptors to changes in suspended sediment concentration is given in **Table 8-29**.

Table 8-29 Sensitivity and Value Assessment for Morphological Receptor

Receptor	Tolerance	Recoverability	Value	Sensitivity
Holderness Inshore MCZ	High	High	High	Negligible
Marine waters (inshore)	High	High	High	Negligible

8.7.4.4.5 *Significance of Effect – DBS East or DBS West in Isolation*

164. The effects on suspended sediment concentrations due to landfall HDD installation within the offshore export cable corridor are considered to have a negligible magnitude of impact and negligible sensitivity, resulting in likely **negligible** significance of effect. No additional mitigation is proposed. Trenching within the intertidal zone during installation of the HDD exit pits and cable installation will temporarily disturb sediment that may become mobilised in suspension during high tides. However, considering the relatively thin cover of beach sediment, the excavation will likely occur within the underlying till creating aggregated clasts/blocks of cohesive material that will not form suspended sediment load.

8.7.4.4.6 *Significance of Effect – DBS East and DBS West Together*

165. Construction of DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.5.9.6 and considered to have a likely **negligible** significance of effect, due to a negligible magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.4.5 Impact C1e: Deterioration in Water Quality Associated With Release of Sediment Bound Contamination

8.7.4.5.1 *Description of Change*

166. The receptor for this impact is marine waters (both offshore and inshore). All activities assessed in impacts C1a to C1d could cause localised and short-term increases in suspended sediment at the point of disturbance. Released sediment may then be transported by tidal currents in suspension in the water column releasing any bound contamination.

167. Sediment data available indicates that for all parameters, sediment contaminant concentrations are likely to be low (sections 8.5 and 8.6). Where exceedance of sediment guidelines occur, these are marginal (i.e. only just above lower guideline values) and no samples exceeded the Cefas Action Level 2 (where available) which indicates that there is minimal risk to the water column if suspended. Additionally, as assessed in Impacts C1a to C1d, sediments are not predicted to remain in suspension for long periods of time (days) given that the seabed material is predominantly coarse gravel and sand with low levels of fines.

168. As discussed in section 8.7.4.1, if both DBS East and DBS West are constructed together, a larger volume of material would be suspended at the same time. However, predicted suspended sediment concentrations arising from impacts C1a to C1d are unlikely to persist for a sufficiently long period of time for them to interact with subsequent operations, and given that sediment contaminant levels are predicted to be low across the sites, no cumulative effect is anticipated from multiple installations should DBS East and DBS West be developed concurrently.

8.7.4.5.2 Magnitude of Impact – DBS East or DBS West in Isolation

169. The scale of this impact will be relatively localised (near-field) for coarser sediments (due to rapid settling out). While fine sediments have greater potential to become mobilised, their volumes are expected to be low and any suspended sediments in the water column are predicted to return to baseline conditions within days due to dispersion and dilution. Sediment contaminant levels are also predicted to be low. The magnitude of impact for the worst case scenario is given in **Table 8-30**.

Table 8-30 Magnitude of Impact on Water Quality

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Negligible	Negligible	Negligible	Negligible	Negligible
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible

8.7.4.5.3 Magnitude of Impact – DBS East and DBS West Together

170. The worst-case scenario for effects on water quality will have the same magnitude of impact as outlined in **Table 8-30** given the low levels of contaminants predicted.

8.7.4.5.4 Sensitivity of Receptor

171. Increases in chemical concentrations may impact on marine waters both offshore and inshore (including WFD water bodies and bathing waters). The sensitivity and value of these receptors to changes in chemical contaminant concentration is given in **Table 8-31**.

Table 8-31 Sensitivity and Value Assessment for Morphological Receptor

Receptor	Tolerance	Recoverability	Value	Sensitivity
Marine waters (offshore)	Negligible	Negligible	Low	Negligible
Marine waters (inshore)	Negligible	Negligible	High	Negligible

8.7.4.5.5 Significance of Effect – DBS East or DBS West in Isolation

172. The effects on water quality due to the release of sediment bound contaminants are considered likely to have a **negligible** significance of effect, due to a negligible magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.4.5.6 Significance of Effect – DBS East and DBS West Together

173. Construction of DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation. As a result, the significance of effect is likely **negligible**, due to a negligible magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.4.6 Impact C2a: Changes in Seabed Level Due to Seabed Preparation for Foundation Installation

8.7.4.6.1 Description of Change

174. The increase in suspended sediment concentration associated with Impact C1a (section 8.7.4.1) has the potential to deposit sediment from the plume and change the elevation of the seabed.

175. 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. The resulting change would be a measurable protrusion above the existing seabed, but one which would remain local to the release point. The geometry of the change would vary across the array areas, depending on the prevailing physical conditions, but in all cases the deposited sediment would be similar (but not exactly the same as) both the seabed that it has replaced and the surrounding seabed.

176. The overall change in elevation of the seabed would be small when compared to the water depths across the array areas (12 to 40m below LAT). Any changes in seabed elevation would be within the natural change to the seabed caused by bedload sediment transport and hence the effect on marine physical processes would be negligible. Over time, the sediment within the mound would be gradually re-dispersed by prevailing hydrodynamic currents as bedload sediment.

177. This conceptual evidence-based assessment is supported by the findings of numerical modelling for the adjacent Dogger Bank A & B and Dogger Bank C and Sofia offshore wind farms which show the maximum predicted deposition resulting from a sediment plume was 10-50mm in localised areas adjacent to the foundation installation area. Outside the area of foundation installation, deposition reduces to an average of 1-5mm within 10km of the disturbance and is less than 0.5mm within 35km. Over an installation period of 30 days, changes in seabed level induced by deposition of suspended sediment are persistent for a maximum period of seven days within the foundation installation area and reduce to hours to days with distance from the location of disturbance.

8.7.4.6.2 Magnitude of Impact – DBS East or DBS West in Isolation

178. The magnitude of impact for the worst case scenario due to the installation of 48 large wind turbines and six offshore platforms is the same as for Impact C1a (section 8.7.4.1), as outlined in **Table 8-32**.

Table 8-32 Magnitude of Impact on Seabed Level Under the Worst Case Scenario for Seabed Preparation for Foundation Installation

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

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

8.7.4.6.3 Magnitude of Impact – DBS East and DBS West Together

179. The worst-case scenario for changes in seabed level due to the installation of 95 large wind turbines and eleven offshore platforms will have the same magnitude of impact as outlined in section 8.7.4.6.2.

8.7.4.6.4 Sensitivity of Receptor

180. The array areas and offshore export cable corridor is located within the Southern North Sea SAC and parts of the array areas are within the Dogger Bank SAC. The sensitivity and value of these morphological receptors is presented in **Table 8-33**.

Table 8-33 Sensitivity and Value Assessment for Receptors Impacted by Changes to Suspended Sediment Concentration

Receptor	Tolerance	Recoverability	Value	Sensitivity
Dogger Bank SAC	High	High	High	Negligible
Southern North Sea SAC	High	High	High	Negligible

8.7.4.6.5 Significance of Effect – DBS East or DBS West in Isolation

181. The impacts on seabed level due to seabed preparation for foundation installation are considered to have a low magnitude of impact and negligible sensitivity, resulting in a likely **negligible** significance of effect. No additional mitigation is proposed.

8.7.4.6.6 Significance of Effect – DBS East and DBS West Together

182. Construction of DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.4.6.5 and considered likely to have a **negligible** significance of effect, due to a low magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.4.7 Impact C2b: Changes to Seabed Level Due to Drill Arisings from Foundations

8.7.4.7.1 Description of Change

183. A combination of increased suspended sediment concentration combined with the disposal of any sediment that would be disturbed or removed whilst drilling monopile foundations has the potential to deposit sediment and change the seabed elevation.

184. Drilling of piles could potentially occur through up to 13 geological units (**Table 8-14**) comprising sand, silt, organic deposits and high strength clay (till). If the drilling penetrates the till, 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 individual fine-grained sediment components immediately upon release. The coarser sediment fractions (medium and coarse sands and gravels) would also settle out of suspension in close proximity to each foundation location. Under this scenario, the worst-case scenario assumes that a 'mound' would reside on the seabed near the site of its release.

185. If drilling penetrates fine-sand and silt deposits associated with Holocene age geological units, the process will cause localised and short-term increases in suspended sediment at the point of discharge of the drill arisings only. Released sediment may then be transported by tidal currents in suspension in the water column (see Impact C1b, section 8.7.4.2). Any fine sediment released is likely to be widely and rapidly dispersed.

186. The worst case for drill arisings is for the maximum number of the largest wind turbines (diameter) and the maximum number of offshore platforms and assumes only 5% of locations will be drilled (maximum five locations). The distribution of fine-grained deposits across the array areas is likely discontinuous due to geological understanding of the Dogger Bank region (section 8.5.2). Therefore, the probability of drilling through fine-grained deposits is considered low.

8.7.4.7.2 Magnitude of Impact – DBS East or DBS West in Isolation

187. The scale of this impact will be relatively localised (near-field) for coarser sediments or aggregated clasts of till (due to rapid settling out). While fine sediments have greater potential to become mobilised, the potential for encountering them during drilling is low and any suspended sediments in the water column are predicted to return to baseline conditions within days due to dispersion and dilution.

188. The magnitude of impact for the worst case scenario due to the installation of 48 large wind turbines and six offshore platforms is given in **Table 8-34**.

Table 8-34 Magnitude of Impact Seabed Level Under the Worst Case Scenario Due to Drill Arisings from Foundations

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Medium	Negligible	Negligible	Negligible	Low
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.

8.7.4.7.3 Magnitude of Impact – DBS East and DBS West Together

189. The worst-case scenario for changes in seabed level due to drill arisings from the installation of 95 large wind turbines and eleven offshore platforms will have the same magnitude of impact as outlined in section 8.7.4.6.2.

8.7.4.7.4 Sensitivity of Receptor

190. The array areas and offshore export cable corridor is located within the Southern North Sea SAC and parts of the array areas are within the Dogger Bank SAC. The sensitivity and value of these morphological receptors is presented in **Table 8-35**.

Table 8-35 Sensitivity and Value Assessment for Receptors Impacted by Changes in Seabed Level

Receptor	Tolerance	Recoverability	Value	Sensitivity
Dogger Bank SAC	High	High	High	Negligible
Southern North Sea SAC	High	High	High	Negligible

8.7.4.7.5 Significance of Effect – DBS East or DBS West in Isolation

191. The effect on seabed level due to drill arisings from foundation installation is considered to have a low magnitude of impact and negligible sensitivity, resulting in likely to have a **negligible** significance of effect. No additional mitigation is proposed.

8.7.4.7.6 Significance of Effect – DBS East and DBS West Together

192. Construction of DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.4.7.5 and considered likely to have a **negligible** significance of effect, due to a low magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.4.8 Impact C2c: Changes in Seabed Level Due to Cable Installation (Array, Inter-array and Export)

8.7.4.8.1 Description of Change

193. The increases in suspended sediment concentrations associated with offshore export cable installation (including potential dredging of flotation pits to accommodate installation vessels in shallow water) have the potential to result in changes in seabed level as the suspended sediment is deposited on the seabed.

194. 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 elevated area (likely to be tens of centimetres high) parallel to the cable as the point of release moves along the excavation.

195. The finer sediment would also be released to form a passive plume and become more widely dispersed across the tidal excursion 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 (in the order of millimetres).

196. This assessment is supported by modelling undertaken for the Dogger Bank A & B and Dogger Bank C and Sofia offshore wind farms which showed that after a simulation period of 30 days, changes in seabed level were less than 0.5mm, and in some places zero, along the length of the export cable corridor.

197. The worst case assumes 100% of the cables will be buried to a depth of 1m. Where the offshore export cable corridor crosses areas of mobile bedforms, the cable will be installed in mobile sands, with no disturbance of the underlying geological units (see section 8.7.2). However, intrusive surveys along the Creyke Beck export cable corridor show high strength clays (till) may be present at seabed and there is potential for these to be disturbed during cable installation. If cable installation disturbs the till, then a worst-case scenario is considered whereby the sediment released from the jetting is assumed to be 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 individual fine-grained sediment components immediately upon release. The clasts would later be disaggregated through sediment transport processes within the limits of background physical processes.

8.7.4.8.2 Magnitude of Impact – DBS East or DBS West in Isolation

198. The scale of this impact will be relatively localised (near-field) for coarser sediments or aggregated clasts of till (due to rapid settling out). Numerical modelling and conceptual evidence-based assessments of deposition from sediment plumes during cable installation indicate that any changes in seabed level are of the order of millimetres and are therefore immeasurable within the limits of bathymetric survey data. Any changes in seabed level will be minimal and sediment will be redistributed by background bedload transport processes. Therefore, the magnitude of impact for the worst case scenario due to cable installation is given in **Table 8-36**.

Table 8-36 Magnitude of Impact on Seabed Level Under the Worst Case Scenario Due to Cable Installation

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
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 the cable installation activity.

8.7.4.8.3 Magnitude of Impact – DBS East and DBS West Together

199. The worst-case scenario for changes in seabed level due to cable will have the same magnitude of impact as outlined in section 8.7.4.8.2.

8.7.4.8.4 Sensitivity of Receptor

200. The offshore export cable corridor is located within the Holderness Inshore MCZ and crosses the southern part of Smithic Sands. Further offshore, the export cable corridor is located within the Southern North Sea SAC and the array and inter platform cables are within the Dogger Bank SAC. The sensitivity and value of these receptors is presented in **Table 8-37**.

Table 8-37 Sensitivity and Value Assessment for Receptors Impacted by Changes to Suspended Sediment Concentration During Cable Installation

Receptor	Tolerance	Recoverability	Value	Sensitivity
Holderness Inshore MCZ	High	High	High	Negligible
Smithic Sands	High	High	Medium	Negligible
Dogger Bank SAC	High	High	High	Negligible
Southern North Sea SAC	High	High	High	Negligible

8.7.4.8.5 Significance of Effect – DBS East or DBS West in Isolation

201. The effect on changes in seabed level due to deposition of suspended sediment during cable installation is considered to have negligible magnitude of impact and negligible sensitivity, resulting in a likely **negligible** significance of effect. No additional mitigation is proposed.

8.7.4.8.6 Significance of Effect – DBS East and DBS West Together

202. Construction of DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.4.8.5 and considered likely to have a **negligible** significance of effect, due to a negligible magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.4.9 Impact C3: Changes to Bedload Sediment Transport Due to Landfall HDD Works

8.7.4.9.1 Description of Change

203. The details and location of the HDD exit pits are dependent upon the final project design. The indicative length of the HDD will be 1,400m but it is possible the HDD exit pits will be located within the intertidal zone. The HDD exit point will require excavation of the exit pits to install the HDD ducts on the seaward side of the landfall. This excavation may use temporary cofferdams in the intertidal zone which could interrupt sediment transport pathways along the coast.

204. Net sediment transport at the possible landfall locations is to the south, driven by waves approaching from the north and north-east. A cofferdam oriented broadly perpendicular to the coast would interrupt sediment transport and if in place for a period of several months, there is potential for a build-up of sediment on the northern side of the cofferdam and depletion (due to sediment starving) on the southern side.

205. Considering beach sediments are relatively thin along the Holderness coast, significant accumulations of sediment are not expected. Also, upon completion of HDD duct installation and following export cable installation, the cofferdams will be removed, and the trenches backfilled to reinstate the intertidal zone close to its original morphology. This activity would result in some localised and short-term disturbance to the beach and nearshore zone, but there would be no long-term effect on sediment transport processes.

8.7.4.9.2 Magnitude of Impact – DBS East or DBS West in Isolation

206. The magnitude of impact for the worst case scenario due to HDD landfall works within the intertidal zone is given in **Table 8-38**.

Table 8-38 Magnitude of Impact on Bedload Sediment Transport Under the Worst Case Scenario for HDD Exit Cable Installation

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
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 the cable installation activity.

8.7.4.9.3 Magnitude of Impact – DBS East and DBS West Together

207. The worst-case scenario for changes in bedload sediment transport due to installation of the export cable at the HDD exit will have the same magnitude of impact as outlined in section 8.7.4.9.2.

8.7.4.9.4 Sensitivity of Receptor

208. Temporary (several months) interruption to bedload sediment transport within the intertidal zone has the potential to impact coastal receptors. The value and sensitivity of these receptors is presented in **Table 8-39**.

Table 8-39 Sensitivity and Value of Morphological Receptors

Receptor	Tolerance	Recoverability	Value	Sensitivity
Holderness Cliffs	High	High	Low	Negligible

8.7.4.9.5 Significance of Effect – DBS East or DBS West in Isolation

209. Net sediment transport rates along the Holderness coast are maintained by cliff erosion (Pye and Blott 2015). Therefore, any temporary (of the order of months) interruption to sediment transport due to the presence of cofferdams in the nearshore zone will have no effect on baseline coastal erosion rates. Furthermore, changes in bedload transport will be minimal due to the thin cover of beach sediments and coastal erosion of the cliffs is expected to continue to supply sediment to and along the coastline. Upon completion of cable installation, the trench will be backfilled and the beach profile returned to its original form following cable installation. Therefore, any effect on the Holderness Cliffs will be short-lived and the beach morphology will recover quickly (less than a year). As a result, there will likely be a **negligible** significance of effect locally to the Holderness Cliffs due to a negligible magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.4.9.6 Significance of Effect – DBS East and DBS West Together

210. Construction of DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.4.9.5 and the effect on the Holderness Cliffs is considered likely to have a **negligible** significance of effect, due to a negligible magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.4.10 Impact C4: Indentations on the Seabed Due to Installation Vessels

8.7.4.10.1 Description of Change

211. There is potential for certain vessels used during installation of the foundations and cable infrastructure to directly impact the seabed. 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 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 is considered to correspond to the use of jack-up vessels, since the depressions would be greater than the anchor scars.

212. 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.

213. A four-legged jack-up barge used for the installation of wind turbine and offshore platforms would have a footprint of 1,100m^2. Each leg could penetrate 5 to 15m into the seabed and may be cylindrical, triangular, truss leg or lattice. The worst-case scenario assumes six jack-up deployments will be required at each wind turbine and five at each offshore platform location (**Table 8-3**).

8.7.4.10.2 Magnitude of Impact – DBS East or DBS West in Isolation

214. The worst-case changes in terms of indentations on the seabed due to installation vessels are likely to have the magnitudes of effect described in **Table 8-40**.

Table 8-40 Magnitude of Impact on Seabed Level Changes due to Indentions Under the Worst Case Scenario for Installation Vessels

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

*The near-field impacts are confined to the immediate vicinity of a jack-up leg, far-field effects are beyond the immediate vicinity of the jack-up leg

8.7.4.10.3 Magnitude of Impact – DBS East and DBS West Together

215. The worst-case scenario for changes in seabed level due to installation vessels will have the same magnitude of impact as outlined in section 8.7.4.10.2.

8.7.4.10.4 Sensitivity of Receptor

216. Installation of foundations within the DBS array areas will result in jack-up and anchor indentations on the seabed within the Dogger Bank SAC and Southern North Sea SAC. Installation of the export cable and cable protection measures in the nearshore will create indentations on the seabed within the Holderness Inshore MCZ. Given this, the sensitivity and value of these receptors is presented in **Table 8-41**.

Table 8-41 Sensitivity and Value Assessment for Morphological Receptors

Receptor	Tolerance	Recoverability	Value	Sensitivity
Dogger Bank SAC	High	High	High	Negligible
Southern North Sea SAC	High	High	High	Negligible
Holderness Inshore MCZ	High	High	High	Negligible

8.7.4.10.5 Significance of Effect – DBS East or DBS West in Isolation

217. The layout of wind turbines and offshore platforms, and array, inter platform and export cables will be decided post-consent and indentations on the seabed during their installation may occur. However, any disturbance footprint would be limited in scale and any impacts would be temporary in nature with indentations infilling through natural processes over the course of days to months. Therefore, the effect on seabed morphology is considered to have a medium magnitude of impact and negligible sensitivity, resulting in a likely **negligible** significance of effect. No additional mitigation is proposed.

8.7.4.10.6 Significance of Effect – DBS East and DBS West Together

218. Construction of DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.4.10.5 and considered likely to have a **negligible** significance of effect, due to a medium magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.5 Potential Effects During Operation

8.7.5.1 Impact O1 Changes to the Tidal Regime Due to the Presence of Infrastructure (Wind Turbines and Offshore Platforms)

8.7.5.1.1 Description of Change

219. During the operation of DBS East and DBS West there is potential for the presence of foundations to cause changes to the tidal regime, particularly tidal current, due to physical blockage effects. This has the potential to contribute to changes in seabed morphology due to alteration of sediment transport patterns.

220. 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.

221. The impact of foundations on tidal currents was modelled as part of the EIA for the entire developable area of the Dogger Bank A & B and Dogger Bank C and Sofia offshore wind farms and the results showed that there were no significant changes to tidal regime due to the installation of the maximum number of gravity based foundations spaced between 700 and 750m apart. The maximum change to depth-averaged current velocity was predicted to be ±0.03m/s which is approximately 7% of baseline conditions, reducing to 2% within a couple of kilometres of the array area.

222. 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 localised in spatial extent. This is confirmed by existing guidance documents (ETSU, 2000; ETSU, 2002; Lambkin *et al*. 2009) and numerous ESs for a range of existing and planned offshore windfarms. For example, post-construction monitoring of Dudgeon Offshore Windfarm demonstrated that changes to seabed sediment distribution due to the presence of wind turbines are minimal, implying that changes to tidal currents (and waves) are local and do not have a significant effect on sediment transport further afield.

8.7.5.1.2 Magnitude of Impact – DBS East or DBS West in Isolation

223. The worst case for changes to tidal currents due to the presence of wind turbine and offshore platform foundations will likely have the magnitude of impact as shown in **Table 8-42**.

Table 8-42 Magnitude of Impact on the Tidal Regime Under the Worst Case Scenario for Foundations

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

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

224. These effects on the tidal regime can be translated into a 'zone of potential influence' based on an understanding of the tidal ellipses which will be incorporated in the final ES. The zone of potential influence is based on the knowledge that effects arising from wind turbine and offshore platform foundations on the tidal regime are relatively small in magnitude, and local. It is expected that changes to the tidal regime would have returned to background levels immediately outside the excursion of one tidal ellipse, and this threshold will be used to produce the maximum 'zone of potential influence' on the tidal regime.

8.7.5.1.3 Magnitude of Impact – DBS East and DBS West Together

225. The worst-case scenario for changes in tidal currents due to the presence of foundations will have the same magnitude of impact as outlined in section 8.7.5.1.2.

8.7.5.1.4 Sensitivity of Receptor

226. The predicted zone of influence for the DBS array areas encompasses the Southern North Sea SAC and Dogger Bank SAC. Given this, the sensitivity and value of this receptor is presented in **Table 8-43.**

Table 8-43 Sensitivity and Value Assessment for Morphological Receptor

Receptor	Tolerance	Recoverability	Value	Sensitivity
Dogger Bank SAC	High	High	High	Negligible
Southern North Sea SAC	High	High	High	Negligible

8.7.5.1.5 Significance of Effect – DBS East or DBS West in Isolation

227. The predicted zone of influence encompasses the Southern North Sea SAC and Dogger Bank SAC. However, as outlined in section 8.7.5.1.1, changes to the tidal currents due to the presence of foundations on the seabed will be small. Considering the negligible to low magnitude of impact and the negligible sensitivity, the significance of the effect is considered likely to have a **negligible** significance of effect. No additional mitigation is proposed.

8.7.5.1.6 Significance of Effect – DBS East and DBS West Together

228. Construction of DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation. Therefore, the significance of the effect is the same as outlined in section 8.7.5.1.5 and considered likely to have a **negligible** significance of effect due to the negligible to low magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.5.2 Impact O2 Changes to the Wave Regime Due to the Presence of Infrastructure (Wind Turbines and Offshore Platforms)

8.7.5.2.1 Description of Change

229. The presence of the worst-case wind turbine and offshore platform foundation structures (as outlined in **Table 8-3**) 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 Impact O3, section 8.7.5.3)

230. The evidence-based assessment suggests 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. Generally, this causes a small wave shadow effect to be created by each foundation. 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 relatively large separation distances.

231. Modelling undertaken for the entire developable area of the Dogger Bank A & B and Dogger Bank C and Sofia offshore wind farms show that under the worst case scenario of gravity based foundations spaced between 700 and 750m apart, the maximum change in significant wave height was ±0.3m along the boundary of the array areas. The predicted pattern is a maximum increase in wave height of 6% along the northern boundary due to up-wave reflection and a maximum decrease in wave height of 7.5% along the southern boundary due to down-wave blocking.

232. In addition to the bespoke assessments at the existing Dogger Bank projects, there is a strong evidence base which demonstrates that the changes in the wave regime due to the presence of foundation structures, even under a worst-case scenario, are both relatively small in magnitude (typically less than 10% of baseline wave heights in close proximity to each structure, reducing with greater distance from each structure). Effects are relatively localised in spatial extent, extending as a shadow zone typically up to 10km from the site along the axis of wave approach, but with low magnitudes (only a few percent change across this wider area). This is confirmed by a review of modelling studies from around 30 wind farms in the UK and European waters (Seagreen, 2012), existing guidance documents (ETSU, 2000; ETSU, 2002; Lambkin *et al.* 2009), published research (Ohl *et al.* 2001) and post-installation monitoring (Cefas, 2005).

8.7.5.2.2 Magnitude of Impact – DBS East or DBS West in Isolation

233. The worst case for changes to wave regime due to the presence of foundations are likely to have the following magnitude of impact (**Table 8-44**).

Table 8-44 Magnitude of Impact on the Wave Regime Under the Worst Case Scenario for Foundations

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

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

8.7.5.2.3 Magnitude of Impact – DBS East and DBS West Together

234. The worst-case scenario for changes in wave regime due to the presence of foundations will have the same magnitude of impact as outlined in section 8.7.5.2.2.

8.7.5.2.4 Sensitivity of Receptor

235. The predicted zone of influence for the DBS array areas encompasses the Southern North Sea SAC and Dogger Bank SAC. Given this, the sensitivity and value of these receptors is presented in **Table 8-45.**

Table 8-45 Sensitivity and Value Assessment for Morphological Receptors

Receptor	Tolerance	Recoverability	Value	Sensitivity
Dogger Bank SAC	High	High	High	Negligible
Southern North Sea SAC	High	High	High	Negligible

8.7.5.2.5 Significance of Effect – DBS East or DBS West in Isolation

236. The predicted zone of influence encompasses the Southern North Sea SAC and Dogger Bank SAC. However, as outlined in section 8.7.5.2.1, changes to the wave regime due to the presence of foundations in the water column will be small. Considering the negligible to low magnitude of impact and the negligible sensitivity, the significance of the effect is considered to have a likely **negligible** significance of effect. No additional mitigation is proposed.

8.7.5.2.6 Significance of Effect – DBS East and DBS West Together

237. Construction of DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.5.2.5 and considered to have a likely **negligible** significance of effect due to the negligible to low magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.5.3 Impact O3 Changes to Water Circulation (Flamborough Front) Due to the Presence of Infrastructure (Wind Turbines and Offshore Platforms)

8.7.5.3.1 Description of Change

238. The main potential impact on the Flamborough Front is changes to near-field mixing due to foundation wake effects and the potential for destabilising local water column stratification (i.e. those restricted to the area inside and immediately outside the array areas) driven by interaction of the tidal (hydrodynamic) processes with the foundation units across the offshore array. There would be a (slight) difference between the potential disturbance of the front if it crossed into the array areas and the potential disturbance of areas of stratification north of the front.

239. The worst case for foundations would be gravity based foundations for offshore platforms and suction bucket jacket foundations for wind turbines. These foundations are considered to have the greatest blockage effect and hence could create the greatest amount of turbulence.

240. Carpenter *et al.* (2016) and Cazenave *et al.* (2016) investigated the potential large-scale impacts of wind farm turbine foundations on shelf sea stratification and these studies provide the evidence base for this assessment. Carpenter *et al.* (2016) use an idealised (conceptual) numerical model of structure induced turbulent mixing in conjunction with existing environmental hindcast data to consider the potential for large-scale change to stratification of the German Bight region of the North Sea in response to planned wind farm developments. The study showed that stratification is only gradually broken down by interaction with the wind farm. A range of 'timescale for (complete) mixing' estimates were provided (about 100 to 500 days) if the same body of initially stratified water is continually passed through the wind farm. In practice, due to non-zero residual rates of tidal advection, the same body of water will not be repeatedly passed through the same wind farm for 100 to 500 days. As a result, the mixing influence of the foundations will only lead to some partial reduction in the strength of stratification in water that passes through the wind farm.

241. Any increased turbulence resulting from the presence of the Projects foundation structures would be isolated to the local area of each foundation, dissipating downstream without leading to any larger array-scale effects. All foundations will lead to some level of local turbulence and depending on the final design configuration of the foundations, the gravity based foundation cross-section through the water column has the potential to lead to the highest level of turbulence compared to other foundation options. However, in that scenario the scale of turbulence is considered to remain localised in the form of a wake in the lee of each foundation without a larger array scale effect. The measurable distance of any wake is likely to be less than the minimum separation between foundations of 830m. These effects will remain small compared to the Flamborough feature in its entirety. The magnitude of any impact on the Flamborough Front is considered to be negligible because the influence from any turbulent flow wakes is likely to remain spatially distant.

242. Carpenter *et al.* (2016) conclude that no large-scale changes to stratification of the North Sea are expected at the current levels of offshore wind farm construction and that 'extensive' regions of the North Sea would need to be covered in offshore wind farms for a significant impact on stratification to occur. The study also found that the results are sensitive to the assumed type (shape and size) of foundation structure being assessed, and to the assumptions made about the evolution of the pycnocline thickness under enhanced mixing conditions.

243. Cazenave *et al.* (2016) used a regional scale 3D hydrodynamic model with a number of wind farm foundations represented as small islands in the mesh. The results showed that although wind farm foundations have some limited influence on the strength of stratification locally, it does not suggest that naturally present stratification would become completely mixed by this process.

244. Schultze *et al.* (2020) used observations and high-resolution large eddy simulations to quantify the loss of stratification within the wake of a single monopile structure within four different water body stratification strengths. Their observations showed that the turbulent wake of a monopile structure is narrow and highly energetic within the first 100m, with the dissipation of turbulence above background levels downstream of the structure. The effect of a single turbine on stratification is relatively low compared to other naturally occurring mixing mechanisms, but the effect depends on the strength of the stratification, with more impact on weakly stratified water column. Turbulent mixing is not sufficient to overcome stronger stratification, as the buoyancy of the surface layer retains a stronger influence than the increased turbulent mixing induced by the structure. Also,

although the wake can persist for a long distance downstream of the structure (several 100s of metres), the energy dissipation of the wake falls rapidly away from the structure until it becomes fully dissipated/undetectable.

8.7.5.3.2 Magnitude of Impact – DBS East or DBS West in Isolation

245. The worst case for changes to water circulation due to the presence of foundations are likely to have the following magnitude of impact (**Table 8-46**).

Table 8-46 Magnitude of Impact on Water Circulation Under the Worst Case Scenario for Foundations

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

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

8.7.5.3.3 Magnitude of Impact – DBS East and DBS West Together

246. The worst-case scenario for changes to water circulation due to the presence of foundations will have the same magnitude of impact as outlined in section 8.7.5.3.2.

8.7.5.3.4 Sensitivity of Receptor

247. The Flamborough Front may be present seasonally within the array areas and offshore export cable corridor. Given this, the sensitivity and value of this receptor is presented in **Table 8-47.**

Table 8-47 Sensitivity and Value Assessment for Morphological Receptor

Receptor	Tolerance	Recoverability	Value	Sensitivity
Flamborough Front	High	High	Medium	Negligible

8.7.5.3.5 Significance of Effect – DBS East or DBS West in Isolation

248. Given that the Flamborough Front is highly dynamic and ephemeral regional-scale feature, it would not be affected by localised, small-scale changes in water column turbulence induced by individual near-field wakes at foundation locations, especially if the strength of stratification (due to buoyancy forces) was sufficient to overcome any increased mixing. As a result, changes to water circulation due to the presence of foundations on the seabed will be small. Considering the negligible to low magnitude of impact and the negligible sensitivity, the likely significance of effect is considered to be **negligible**. No additional mitigation is proposed.

8.7.5.3.6 Significance of Effect – DBS East and DBS West Together

249. Construction of DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.5.3 and considered to have a likely **negligible** significance of effect due to a negligible to high magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.5.4 Impact O4a Changes to Bedload Sediment Transport and Seabed Morphology Due to the Presence of Infrastructure

8.7.5.4.1 Description of Change

250. Modifications to the tidal regime and/or the wave regime due to the presence of the foundation structures during the operational phase may affect the sediment regime. This section addresses the broader patterns of bedload sediment transport across, and beyond, the array areas. The worst-case scenario is outlined in **Table 8-3**.

251. The predicted reductions in tidal regime (Impact O1) and wave regime (Impact O2) associated with the presence of the worst-case gravity based foundations and suction bucket jacket foundations would result in a reduction in the sediment transport potential across the areas where such changes are observed. Conversely, the areas of increased turbulence around each structure would result in increased sediment transport potential.

252. These changes to the marine physical environment would be of a limited scale and largely confined to local wake or wave shadow effects attributable to individual wind turbine and offshore platform foundations (near-field) 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 (far-field) would be significantly lower (typically less than 1%) than the changes local to each wind turbine.

8.7.5.4.2 Magnitude of Impact – DBS East or DBS West in Isolation

253. The worst case for changes to bedload sediment transport regime and seabed morphology due to the presence of foundations are likely to have the following magnitude of impact (**Table 8-48**).

Table 8-48 Magnitude of Impact on Bedload Sediment Transport Regime and Seabed Morphology Under the Worst Case Scenario for Foundations

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

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

8.7.5.4.3 Magnitude of Impact – DBS East and DBS West Together

254. The worst-case scenario for changes in bedload sediment transport regime and seabed morphology due to the presence of foundations will have the same magnitude of impact as outlined in section 8.7.5.4.2.

8.7.5.4.4 Sensitivity of Receptor

255. The predicted zone of influence for the DBS array areas encompasses the Southern North Sea SAC and Dogger Bank SAC. Given this, the sensitivity and value of these receptors are presented in **Table 8-49.**

Table 8-49 Sensitivity and Value Assessment for Morphological Receptors

Receptor	Tolerance	Recoverability	Value	Sensitivity
Dogger Bank SAC	High	High	High	Negligible
Southern North Sea SAC	High	High	High	Negligible

8.7.5.4.5 Significance of Effect – DBS East or DBS West in Isolation

256. The predicted zone of influence encompasses the Southern North Sea SAC and Dogger Bank SAC. However, as outlined in section 8.7.5.2.1, changes to bedload sediment transport due to the presence of foundations on the seabed will be small. Considering the negligible to low magnitude of impact and negligible sensitivity, the significance of the effect is considered to be **negligible**. No additional mitigation is proposed.

8.7.5.4.6 Significance of Effect – DBS East and DBS West Together

257. Construction of DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.5.4.5 and considered to have a likely **negligible** significance of effect. No additional mitigation is proposed.

8.7.5.5 Impact O4b Changes to Bedload Sediment Transport and Seabed Morphology Due to the Presence of Cable Protection Measures

8.7.5.5.1 Description of Change

258. 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 (**Table 8-3**).

259. Cable protection measures may take the form of rock armour, concrete mattresses, steel bridging/ducting, CPS ducting/articulated pipe (cast iron or plastic), concrete bridging and/or rock bags.

260. The effects that export cable protection may have on the marine physical environment primarily relate to the potential for interruption of sediment transport processes and the footprint they present on the seabed.

261. 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 effect depending on whether the cable protection works are in 'nearshore' or 'offshore' areas within the offshore cable corridor. Any works in areas closest to the coast have the potential to affect alongshore sediment transport processes and circulatory pathways across any nearshore banks such as the Smithic Bank.

262. The seaward limit which marks the effective boundary of wave-driven sediment transport is called the 'closure depth' and can be calculated using the methods of Hallermeier (1978). For the seabed offshore from the landfall, this would typically be located in around 6m of water based on the average significant wave heights recorded by the Hornsea buoy (**Table 8-19**).

263. Any protrusions from the seabed associated with cable protection measures could potentially have an effect on 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.

264. The potential magnitude of the effect will depend on the local sediment transport rates; a lower rate would reduce the potential effect on sediment supply to wider areas. There would be a range of sediment transport potentials across the export cables. If chalk or 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.

265. Where the seabed is composed of mobile sand, it can be transported under existing tidal conditions. If the protection does present an obstruction to this bedload transport the sediment would first accumulate on one side or both sides of the obstacle (depending on the gross and net transport at that location) to the height of the protrusion (up to 1.4m). 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 affected significantly.

266. The presence of cable protection works on the seabed would represent the worst case in terms of a direct loss of seabed area, but this footprint would be lower than that of the wind turbine foundations (and associated scour protection works) within the DBS array areas (**Table 8-3**).

267. The most important marine geological and geomorphological features present in the nearshore and at the landfall are those associated with the Holderness Inshore MCZ. The beach and nearshore zone are covered by a relatively thin cover of potentially mobile sediment and Pleistocene till is typically exposed at seabed. This means bedload sediment transport rates are low.

268. A commitment has also been made to install the export cable at the landfall using HDD techniques, thus minimising disturbance. There is potential for the HDD exits at the landfall to be located within the intertidal zone which would be within a zone of bedload sediment transport. If the HDD exits are located seaward of the closure depth, there would be no interruption to sediment transport pathways close to the coast because the export cables would be buried.

8.7.5.5.2 Magnitude of Impact – DBS East or DBS West in Isolation

269. The worst case changes to bedload sediment transport and seabed morphology due to cable protection measures for cables are likely to have the following magnitudes of effect (**Table 8-50**).

Table 8-50 Magnitude of Impact on Bedload Transport and Seabed Morphology Under the Worst Case Scenario Due to Cable Protection Measures

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Inshore of closure depth	Low	High	High	Negligible	Low
Offshore of closure depth	Negligible	High	High	Negligible	Negligible

8.7.5.5.3 Magnitude of Impact – DBS East and DBS West Together

270. The worst-case scenario for changes in bedload sediment transport and seabed morphology due to the presence of cable protection measures will have the same magnitude of impact as outlined in section 8.7.5.5.2.

8.7.5.5.4 Sensitivity of Receptor

271. Temporary interruptions to bedload sediment transport within the intertidal zone have the potential to impact coastal receptors. The value and sensitivity of these receptors is presented in **Table 8-51**.

Table 8-51 Sensitivity and Value of Morphological Receptors

Receptor	Tolerance	Recoverability	Value	Sensitivity
Smithic Sands	Medium	High	Medium	Low

8.7.5.5.5 Significance of Effect – DBS East or DBS West in Isolation

272. Offshore of the closure depth, the effects on wave-driven bedload sediment transport and seabed morphology arising from the presence of export cable protection measures would not extend far beyond the direct footprint. Here, any changes in sediment transport will largely be driven by tidal currents. There is potential for the cable protection measures to effect net sediment transport direction in and around Smithic Sands. If cable protection does present an obstruction to bedload transport, then a continued build up would form a 'ramp' over which sediment transport would occur by bedload processes, thereby bypassing the protection. The gross patterns of bedload transport across the export cable would therefore not be affected significantly. Considering the negligible to low magnitude of impact and the negligible to low sensitivity, the effect on Smithic Sands is likely to be of **negligible** significance of effect. No additional mitigation is proposed.

8.7.5.5.6 Significance of Effect – DBS East and DBS West Together

273. Construction of DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.5.6.5 and considered to have a likely **negligible** significance of effect due to the negligible to low magnitude of impact and the negligible to low sensitivity. No additional mitigation is proposed.

8.7.5.6 Impact O5 Cable Repairs and Reburial

8.7.5.6.1 Description of Change

274. Cable repairs and reburial could be needed over the operational lifetime of the Projects. The disturbance areas for reburial and repairs of cables are extremely small in comparison to construction.

275. There is potential for temporary physical disturbance to impact on marine waters (both inshore and offshore) and the Holderness Inshore MCZ and

Smithic Sands due to offshore export cable maintenance and repair operations. The worst case maximum disturbance area for cable repair assumes 25% amounting to a total area of 1,354,662m^2 if DBS East and DBS West are constructed together. It is highly unlikely all repair activities will occur in one location so the footprint of potential repairs in marine waters and across the Holderness Inshore MCZ and Smithic Sands will be considerably lower.

276. As with Impact C2c (section 8.7.4.8), the scale of this impact will be relatively localised (near-field) for coarser sediments or aggregated clasts of till (due to rapid settling out). While fine sediments have greater potential to become mobilised, the potential for encountering them during cable installation is low and any suspended sediments in the water column are predicted to return to baseline conditions within days due to dispersion and dilution.

8.7.5.6.2 Magnitude of Impact – DBS East or DBS West in Isolation

277. The magnitude of impact for the worst case scenario due to the repair and reburial of the cables is given in **Table 8-52**.

Table 8-52 Magnitude of Impact Under the Worst Case Scenario Due to Repair and Reburial of Cables

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
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 the cable installation activity.

8.7.5.6.3 Magnitude of Impact – DBS East and DBS West Together

278. The worst-case scenario for due to repair and reburial of cables will have the same magnitude of impact as outlined in section 8.7.5.6.2.

8.7.5.6.4 Sensitivity of Receptor

279. The offshore export cable corridor is located within marine waters (both offshore and inshore) and specifically within the Holderness Inshore MCZ and crosses the southern tip of Smithic Sands. The sensitivity and value of these receptors are presented in **Table 8-53**.

Table 8-53 Sensitivity and value assessment for morphological receptors

Receptor	Tolerance	Recoverability	Value	Sensitivity
Holderness Inshore MCZ	High	High	High	Negligible
Smithic Sands	Medium	High	Medium	Low
Marine waters (offshore)	High	High	Low	Negligible
Marine waters (inshore)	High	High	High	Negligible

8.7.5.6.5 Significance of Effect – DBS East or DBS West in Isolation

280. The effect on marine waters (inshore and offshore), the Holderness Inshore MCZ and Smithic Sands due to changes in suspended sediment is considered to have a likely **negligible** significance of effect due to the negligible magnitude of impact and negligible to low sensitivity. No additional mitigation is proposed.

8.7.5.6.6 Significance of Effect – DBS East and DBS West Together

281. Cable repairs across DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.5.6.5 and considered to have a likely **negligible** significance of effect, due to the negligible magnitude of impact and negligible to low sensitivity. No additional mitigation is proposed.

8.7.5.7 Impact O6 Deterioration in Water Quality Associated with Release of Sediment Bound Contamination Due to Cable Repairs and Reburial

8.7.5.7.1 Description of Change

282. As outlined in Impact O4c, cable repairs and reburial could be needed over the operational lifetime of the Projects but that the disturbance areas for reburial and repairs of cables are extremely small in comparison to construction.

283. As for impact C1f, sediment data available indicates that for all parameters, sediment contaminant concentrations are likely to be low (section 8.5). Where exceedance of sediment guidelines occur, these are marginal (i.e. only just above lower guideline values) and no samples exceeded the Cefas Action Level 1 which indicates that there is minimal risk to the water column if suspended. Additionally, the scale of increase in suspended sediment will be relatively localised (near-field) for coarser sediments or aggregated clasts of till (due to rapid settling out). While fine sediments have greater potential to become mobilised, the potential for encountering them during cable installation is low and any suspended sediments in the water column are predicted to return to baseline conditions within days due to dispersion and dilution.

8.7.5.7.2 Magnitude of Impact – DBS East or DBS West in Isolation

284. The magnitude of impact for the worst case scenario due to the repair and reburial of the cables is given in **Table 8-54**.

Table 8-54 Magnitude of Impact of Release of Sediment Bound Contamination Under the Worst Case Scenario Due to Repair and Reburial of Cables

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Negligible	Negligible	Negligible	Negligible	Negligible
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible

8.7.5.7.3 Magnitude of Impact – DBS East and DBS West Together

285. The worst-case scenario for effects on water quality associated with sediment bound contamination due to repair and reburial of cables will have the same magnitude of impact as outlined in section 8.7.5.7.2.

8.7.5.7.4 Sensitivity of Receptor

286. Increases in chemical concentrations may impact on marine waters both offshore and inshore (including WFD water bodies and bathing waters). The sensitivity and value of these receptors to changes in chemical contaminant concentration is given in **Table 8-31**.

Table 8-55 Sensitivity and Value Assessment for Receptors

Receptor	Tolerance	Recoverability	Value	Sensitivity
Marine waters (offshore)	High	High	Low	Negligible
Marine waters (inshore)	High	High	High	Negligible

8.7.5.7.5 Significance of Effect – DBS East or DBS West in Isolation

287. The receptor marine waters – inshore and offshore -are considered negligible in terms of sensitivity, due to dilution available and ability of the water column to recover, and are considered negligible in terms of magnitude of impact. As a result, the significance of effect is predicted to have a likely **negligible** significance of effect. No additional mitigation is proposed**.**

8.7.5.7.6 Significance of Effect – DBS East and DBS West Together

288. The receptor marine waters – inshore and offshore -are considered negligible in terms of sensitivity, due to dilution available and ability of the water column to recover, and are considered negligible in terms of magnitude of impact. As a result, the significance of effect is predicted to have a likely **negligible** significance of effect. No additional mitigation is proposed**.**

8.7.5.8 Impact O7 Loss of Seabed Area Due to the Footprint of Foundations

8.7.5.8.1 Description of Change

289. The seabed would be directly impacted by the footprint of each foundation structure within the DBS array areas. This would constitute a loss in natural seabed area during the operational life of the Projects.

290. This direct footprint due to the presence of foundation structures could occur in one of two ways; with and without scour protection. Scour protection will be installed at locations where required, as determined by pre-construction surveys. A worst-case scenario of all foundations having scour protection is considered to provide a conservative assessment.

291. Under the worst case scenario of scour protection being provided for all foundations, 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.

292. The worst case is associated with the maximum number of suction bucket jacket foundations for wind turbines and gravity based foundations for offshore platforms, both with scour protection (**Table 8-3**).

8.7.5.8.2 Magnitude of Impact – DBS East or DBS West in Isolation

293. The worst-case loss of seabed due to the presence of foundation structures with scour protection is likely to have the following magnitude of impact (**Table 8-56**). It is likely that any secondary scour effects associated with scour protection would be confined to within a few metres of the direct footprint of that scour protection material.

Table 8-56 Magnitude of Impact on Loss of Seabed Area Due to the Footprint of Foundation Structures

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

*The near-field impacts are confined to the immediate vicinity of the foundation structures

8.7.5.8.3 Magnitude of Impact – DBS East and DBS West Together

294. The worst-case loss of seabed due to the presence of foundation structures with scour protection will have the same magnitude of impact as outlined in section 8.7.5.8.2.

8.7.5.8.4 Sensitivity of Receptor

295. The array areas and offshore export cable corridor is located within the Southern North Sea SAC with the majority of the array areas within the Dogger Bank SAC. The sensitivity and value of these morphological receptors is presented in **Table 8-57**.

Table 8-57 Sensitivity and Value Assessment for Receptors Impacted by Changes to Suspended Sediment Concentration

Receptor	Tolerance	Recoverability	Value	Sensitivity
Dogger Bank SAC	High	High	High	Negligible
Southern North Sea SAC	High	High	High	Negligible

8.7.5.8.5 Significance of Effect – DBS East or DBS West in Isolation

296. The near-field impacts are confined to the footprint of each foundation structure and have a high magnitude of impact, and considering the negligible sensitivity of receptors a likely **minor** significance of effect is predicted. No additional mitigation is proposed.

8.7.5.8.6 Significance of Effect – DBS East and DBS West Together

297. Construction of DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.5.8.5 and considered to have a likely **minor** significance of effect due to a high magnitude of impact in the nearshore and a negligible sensitivity. No additional mitigation is proposed.

8.7.5.9 Impact O8 Indentations on the Seabed due to Maintenance and Repair Vessels

8.7.5.9.1 Description of Change

298. Repair of wind turbines and offshore platforms, and array, inter platform and export cables may be required during the operational lifetime of the Projects. If required, there is potential for vessels that use jack-up legs or anchors to be used which may create indentations on the seabed as outlined in Impact C4 (section 8.7.4.10). The number of repairs required is unknown, but a significantly lower number of vessels will be required when compared with the construction phase.

8.7.5.9.2 Magnitude of Impact – DBS East or DBS West in Isolation

299. The worst-case changes in terms of indentations on the seabed due to installation vessels are likely to have the magnitudes of effect described in in **Table 8-58**.

Table 8-58 Magnitude of Impact on Seabed Level Changes due to Indentions Under the Worst Case Scenario for Installation Vessels

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

*The near-field impacts are confined to the immediate vicinity of a jack-up leg, far-field effects are beyond the immediate vicinity of the jack-up leg

8.7.5.9.3 Magnitude of Impact – DBS East and DBS West Together

300. The worst-case scenario for changes in seabed level due to installation vessels will have the same magnitude of impact as outlined in section 8.7.5.9.2.

8.7.5.9.4 Sensitivity of Receptor

301. Maintenance and repair of foundations within the DBS array areas will result in jack-up and anchor indentations on the seabed within the Dogger Bank SAC and Southern North Sea SAC. Any repairs to the cable protection measures within the nearshore zone will create indentations on the seabed within the Holderness Inshore MCZ. Given this, the sensitivity and value of this receptor is presented in **Table 8-59**.

Table 8-59 Sensitivity and Value Assessment for Morphological Receptors

Receptor	Tolerance	Recoverability	Value	Sensitivity
Dogger Bank SAC	High	High	High	Negligible
Southern North Sea SAC	High	High	High	Negligible
Holderness Inshore MCZ	High	High	High	Negligible

8.7.5.9.5 Significance of Effect – DBS East or DBS West in Isolation

302. The layout of wind turbines and offshore platform, and array, inter platform and export cables will be decided post-consent and indentations on the seabed during their installation may occur. However, any disturbance footprint would be limited in scale and any impacts would be temporary in nature with indentations infilling through natural processes over the course of days to months. Therefore, the likely significance of effect on the Holderness MCZ is considered to be **negligible** due to a medium magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.5.9.6 Significance of Effect – DBS East and DBS West Together

303. Construction of DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.5.9.5 and considered to have a likely **negligible** significance of effect due to a medium magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.6 Potential Effects During Decommissioning

304. The scope of the decommissioning works would be determined by the relevant legislation and guidance at the time. It is anticipated that all structures above the seabed will be completely removed, including all of the wind turbine components and the parts of the foundations above seabed level. Removal of some or all of the infield, interlink and export cables may be undertaken, although scour and cable protection would likely be left in-situ other than where there is a specific condition for its removal.

305. The decommissioning sequence will generally be the reverse of construction and will involve similar types and numbers of vessels and equipment. As such, the effect of decommissioning on the marine physical environment will be comparable to those during the constructions phase:

- Impact D1a: Changes in suspended sediment concentration due to foundation removal;
- Impact D1b: Changes in suspended sediment concentrations due to removal of parts of the array, inter platform and offshore export cables;
- Impact D2: Deterioration in water quality associated with the release of sediment bound contamination;
- Impact D3: Changes in seabed level due to removal of parts of the array, inter platform and offshore export cables; and,
- Impact D4: Indentations on the seabed due to decommissioning vessels.

306. The magnitude of effects would be comparable to or less than those identified for the construction phase. Accordingly, given the construction phase assessments concluded **negligible** significance of effect on the marine physical environment, it is anticipated that the same would be valid for the decommissioning phase regardless of the final decommissioning methodologies. The significance of effects will be the same for DBS East or DBS West in isolation and for DBS East and DBS West together.

8.8 Preliminary Assessment of Cumulative Effects

307. As detailed in section 8.4.4 this section presents a preliminary assessment of cumulative effects in relation to the marine physical environment. The final CEA will be undertaken within the ES chapter.

8.8.1 Initial Screening for Cumulative Effects

308. **Table 8-60** Potential Cumulative Effects below details the potential cumulative effects that may occur between the Projects and other plans, projects and activities. Only potential impacts assessed in section 8.7 where the potential for cumulative effects has been identified (minor, moderate or major) will be taken forward to the final CEA (i.e. those assessed as 'no impact' are not taken forward as there is no potential for them to contribute to a cumulative impact.

Table 8-60 Potential Cumulative Effects

Impact	Potential for Cumulative Effects	Data Confidence	Rationale
Construction			
Impact C2a: Changes in Seabed Level Due to Seabed Preparation for Foundation Installation	Yes	High	Depending on the construction timetable for other offshore wind farms, there is potential for temporal overlap in construction periods which could have a cumulative effect in relation to changes in seabed level due to deposition of suspended sediment plumes.
Operation & Maintenance			
Impact O1: Changes in tidal regime due to the presence of infrastructure (wind turbines and offshore platforms)	Yes	High	Cumulative effects could occur due to the presence of the Project alongside other offshore wind farms.

Impact	Potential for Cumulative Effects	Data Confidence	Rationale
Impact O2: Changes in wave regime due to the presence of infrastructure (wind turbines and offshore platforms)	Yes	High	
Impact O3: Changes to water circulation (Flamborough Front) due to the presence of infrastructure (wind turbines and offshore platforms)	Yes	High	
Impact O4a: Changes to bedload sediment transport and seabed morphology due to the presence of infrastructure	Yes	High	Effects could potentially coalesce with those arising from other windfarm projects (e.g. Hornsea Project 4) and disturb sediment transport pathways.

8.8.2 Plans/Projects Considered for Cumulative Impacts

309. A high-level list of plans/projects that may result in cumulative effects with the Projects is detailed in **Table 8-61**. For the marine physical environment, a search distance of 13km (based on the predicted zone of influence which will be updated using tidal ellipse data at final ES) from the offshore development area has been used to determine the initial list of projects considered for the CEA.

310. Plans / projects have been assigned a tier level between 1 and 7, based on the most recent guidance (see **Chapter 6 EIA Methodology**). For the final CEA at ES, this high-level list will be reviewed and screened to ensure all relevant plans / projects are considered in the final assessment. All listed plans / projects will be re-examined at ES to ensure each assigned tier remains accurate at the time of writing.

311. In addition to other offshore wind farms, the classes of projects that could potentially be considered for the cumulative assessment of infrastructure and other users includes:

- Marine aggregate extraction;
- Oil and gas exploration and extraction;
- Carbon capture and storage exploration;
- Sub-sea cables and pipelines; and
- Disposal sites.

312. With respect to these activities, the cumulative assessment considers them to be part of the baseline conditions for the surrounding area. As such, it is not expected that the Projects will contribute to cumulative effects with the existing activities in the above list, and therefore these have been have not been the subject of further assessment.

Table 8-61 High-Level List of Plans/Projects Screened For Further Assessment in the Final CEA

Tier	Plan / Project	Distance to Offshore Development Area (km)
Strategic Plans		
7	East Inshore, North East Inshore, East Offshore and North East Offshore Marine Plans	Within offshore development area
Offshore Wind Farms		
2	Dogger Bank A	7
Carbon Capture and Storage		
3	Northern Endurance CCS	2
7	CCS North Sea Leasing Round – SNS Areas 1 & 3	Within array areas
7	CCS North Sea Leasing Round – SNS Area 7	7
Subsea Cables		
6	Eastern Link 2 (SEGL2)	2
7	Third Eastern Link HVDC cable (TGDC)*	Crosses offshore export cable corridor
7	Fourth Eastern Link HVDC cable (E4L5)*	Crosses offshore export cable corridor
7	National Grid HND Bootstrap*	Potentially within the array areas
Marine Disposal Sites		
1	HU015	7

** Cable route not yet finalised*

8.9 Potential Monitoring Requirements

313. Monitoring requirements will be described in the In-Principle Monitoring Plan (IPMP) submitted alongside the DCO application and further developed and agreed with stakeholders prior to construction based on the IPMP and taking account of the final detailed design of the Projects.

314. The following monitoring which has overlaps with general asset integrity monitoring that is specific to the marine physical environment is proposed:

- Pre- and post-construction monitoring of sand waves to assess recovery rates and re-exposure of buried cables.
- Recovery of the physical form of the seabed, including from export cable installation in the Holderness Inshore MCZ and across Smithic Sands.
- Monitoring of scour protection measures and secondary scour to identify the extent, volume and integrity of any scour protection used.

315. No other monitoring is currently proposed in relation to the marine physical environment. This is on account of the outcomes of this assessment, which has concluded that all of the potential impacts considered will result in either no effects or, at worse, negligible significance of effect. The conclusions can be made with a high degree of certainty on account of an accumulation of evidence from a range of studies and other existing wind farms. 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.

8.10 Interactions

316. The effects identified and assessed in this chapter have the potential to interact with each other. The areas of potential interaction between effects are presented in **Table 8-62**. This provides a screening tool for which effects have the potential to interact. **Table 8-64** provides an assessment for each receptor (or receptor group) as related to these impacts.

317. Within **Table 8-64** the effects are assessed relative to each development phase to see if multiple effects could increase the significance of the effect upon a receptor. Following this a lifetime assessment is undertaken which considers the potential for effect to affect receptors across all development phases.

Table 8-62 Interactions Between Impacts – Screening (Operation)

Potential Interactions between Impacts										
Construction										
	Impact C1a	**Impact C1b**	**Impact C1c**	**Impact C1d**	**Impact C1e**	**Impact C2a**	**Impact C2b**	**Impact C2c**	**Impact C3**	**Impact C4**
Impact C1a: Changes in SSC and transport due to seabed preparation for foundation installation		No	No	No	Yes	Yes	No	No	No	Yes
Impact C1b: Changes in SSC and transport due to drill arisings from foundations	No		No	No	Yes	No	Yes	No	No	Yes
Impact C1c: Changes in SSC and transport due to array, inter platform and offshore export cable installation	No	No		No	Yes	No	No	Yes	No	Yes

Potential Interactions between Impacts

Construction

	Impact C1a	Impact C1b	Impact C1c	Impact C1d	Impact C1e	Impact C2a	Impact C2b	Impact C2c	Impact C3	Impact C4
Impact C1d: Changes in SSC and transport due to HDD exit cable installation	No	No	No		Yes	No	No	No	Yes	Yes
Impact C1e: Deterioration in water quality associated with the release of sediment bound contamination	Yes	Yes	Yes	Yes		No	No	No	No	Yes
Impact C2a: Changes in seabed level due to seabed preparation for foundation installation	Yes	No	No	No	No		No	No	No	Yes
Impact C2b: Changes to seabed level due to drill arisings from foundations	No	Yes	No	No	No	No		No	No	Yes

Potential Interactions between Impacts										
Construction										
	Impact C1a	**Impact C1b**	**Impact C1c**	**Impact C1d**	**Impact C1e**	**Impact C2a**	**Impact C2b**	**Impact C2c**	**Impact C3**	**Impact C4**
Impact C2c: Changes to seabed level due to array, inter platform and offshore export cable installation	No	No	Yes	No	No	No	No		No	Yes
Impact C3: Changes to bedload sediment transport due to HDD exit cable installation	No	No	No	Yes	No	No	No	No		Yes
Impact C4: Indentations on the seabed due installation vessels	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	

Table 8-63 Interactions Between Impacts – Screening (Operation & Decommissioning)

Potential Interactions between Impacts									
Operation									
	Impact O1:	**Impact O2:**	**Impact O3:**	**Impact O4a:**	**Impact O4b:**	**Impact O5:**	**Impact O6:**	**Impact O7:**	**Impact O8:**
Impact O1: Changes to the tidal regime due to the presence of infrastructure (wind turbines and offshore platforms)		Yes	Yes	Yes	No	No	No	No	No
Impact O2: Changes to the wave regime due to the presence of infrastructure (wind turbines and offshore platforms)	Yes		Yes	No	No	No	No	No	No

Potential Interactions between Impacts

Operation

	Impact O1:	Impact O2:	Impact O3:	Impact O4a:	Impact O4b:	Impact O5:	Impact O6:	Impact O7:	Impact O8:
Impact O3: Changes to water circulation (Flamborough Front) due to the presence of infrastructure (wind turbines and offshore platforms)	Yes	Yes		No	No	No	No	No	No
Impact O4a: Changes to bedload sediment transport and seabed morphology due to the presence of infrastructure (wind turbines and offshore platforms)	Yes	No	No		No	No	No	Yes	Yes

Potential Interactions between Impacts									
Operation									
	Impact O1:	**Impact O2:**	**Impact O3:**	**Impact O4a:**	**Impact O4b:**	**Impact O5:**	**Impact O6:**	**Impact O7:**	**Impact O8:**
Impact O4b: Changes to bedload sediment transport and seabed morphology due to the presence of cable protection measures	Yes	No	No	No		No	No	Yes	Yes
Impact O5: Cable repairs and reburial	No	No	No	Yes	No		Yes	Yes	Yes
Impact O6: Deterioration in water quality associated with the release of sediment bound contamination	No	No	No	No	No	Yes		No	No

Potential Interactions between Impacts

Operation

	Impact O1:	Impact O2:	Impact O3:	Impact O4a:	Impact O4b:	Impact O5:	Impact O6:	Impact O7:	Impact O8:
Impact O7: Loss of seabed area due to the footprint of foundations	No	No	No	Yes	Yes	Yes	No		No
Impact O8: Indentations on the seabed due to maintenance and repair vessels	No	No	No	Yes	Yes	Yes	No	No	

Decommissioning

	Impact D1a: Changes in suspended sediment concentration due to foundation removal	Impact D1b: Changes in suspended sediment concentrations due to removal of parts of the array, inter platform and offshore export cables	Impact D2: Deterioration in water quality associated with the release of sediment bound contamination	Impact D3: Changes in seabed level due to removal of parts of the array, inter platform and offshore export cables	Impact D4: Indentations on the seabed due to decommissioning vessels

Table 8-64 Interaction Between Impacts - Phase and Lifetime Assessment

Receptor	Highest Significance Level				
	Construction	**Operation**	**Decommissioning**	**Phase Assessment**	**Lifetime Assessment**
Dogger Bank SAC	Negligible	Negligible	Negligible	No greater than individually assessed impact. It is considered that there would either be no interactions or that they not result in a greater impact than assessed individually.	No greater than individually assessed impact.

Receptor	Highest Significance Level				
	Construction	Operation	Decommissioning	Phase Assessment	Lifetime Assessment
Sothern North Sea SAC	Negligible	Negligible	Negligible	No greater than individually assessed impact. It is considered that there would either be no interactions or that they not result in a greater impact than assessed individually.	No greater than individually assessed impact.

Receptor	Highest Significance Level				
	Construction	Operation	Decommissioning	Phase Assessment	Lifetime Assessment
Flamborough Head SAC and SSSI	Negligible	Negligible	Negligible	No greater than individually assessed impact. It is considered that there would either be no interactions or that they not result in a greater impact than assessed individually.	No greater than individually assessed impact.

Receptor	Highest Significance Level				
	Construction	Operation	Decommissioning	Phase Assessment	Lifetime Assessment
Dimlington Cliff SSSI	Negligible	Negligible	Negligible	No greater than individually assessed impact. It is considered that there would either be no interactions or that they not result in a greater impact than assessed individually.	No greater than individually assessed impact.

Receptor	Highest Significance Level				
	Construction	Operation	Decommissioning	Phase Assessment	Lifetime Assessment
Holderness Offshore MCZ	Negligible	Negligible	Negligible	No greater than individually assessed impact. It is considered that there would either be no interactions or that they not result in a greater impact than assessed individually.	No greater than individually assessed impact.

Receptor	Highest Significance Level				
	Construction	Operation	Decommissioning	Phase Assessment	Lifetime Assessment
Holderness Inshore MCZ	Negligible	Negligible	Negligible	No greater than individually assessed impact. It is considered that there would either be no interactions or that they not result in a greater impact than assessed individually.	No greater than individually assessed impact.

Receptor	Highest Significance Level				
	Construction	Operation	Decommissioning	Phase Assessment	Lifetime Assessment
Flamborough and Filey Coast SPA	Negligible	Negligible	Negligible	No greater than individually assessed impact. It is considered that there would either be no interactions or that they not result in a greater impact than assessed individually.	No greater than individually assessed impact.

Receptor	Highest Significance Level				
	Construction	Operation	Decommissioning	Phase Assessment	Lifetime Assessment
Greater Wash SPA	Negligible	Negligible	Negligible	No greater than individually assessed impact. It is considered that there would either be no interactions or that they not result in a greater impact than assessed individually.	No greater than individually assessed impact.

Receptor	Highest Significance Level				
	Construction	Operation	Decommissioning	Phase Assessment	Lifetime Assessment
Humber Estuary SPA	Negligible	Negligible	Negligible	No greater than individually assessed impact. It is considered that there would either be no interactions or that they not result in a greater impact than assessed individually.	No greater than individually assessed impact.

Receptor	Highest Significance Level				
	Construction	Operation	Decommissioning	Phase Assessment	Lifetime Assessment
Smithic Sands	Negligible	Negligible	Negligible	No greater than individually assessed impact. It is considered that there would either be no interactions or that they not result in a greater impact than assessed individually.	No greater than individually assessed impact.

Receptor	Highest Significance Level				
	Construction	Operation	Decommissioning	Phase Assessment	Lifetime Assessment
Holderness Cliffs	Negligible	Negligible	Negligible	No greater than individually assessed impact. It is considered that there would either be no interactions or that they not result in a greater impact than assessed individually.	No greater than individually assessed impact.

Receptor	Highest Significance Level				
	Construction	Operation	Decommissioning	Phase Assessment	Lifetime Assessment
Flamborough Front	Negligible	Negligible	Negligible	No greater than individually assessed impact. It is considered that there would either be no interactions or that they not result in a greater impact than assessed individually.	No greater than individually assessed impact.

Receptor	Highest Significance Level				
	Construction	Operation	Decommissioning	Phase Assessment	Lifetime Assessment
Marine waters (offshore)	Negligible	Negligible	Negligible	No greater than individually assessed impact. It is considered that there would either be no interactions or that they not result in a greater impact than assessed individually.	No greater than individually assessed impact.

Receptor	Highest Significance Level				
	Construction	Operation	Decommissioning	Phase Assessment	Lifetime Assessment
Marine waters (inshore)	Negligible	Negligible	Negligible	No greater than individually assessed impact. It is considered that there would either be no interactions or that they not result in a greater impact than assessed individually.	No greater than individually assessed impact.

8.11 Inter-Relationships

318. For the marine physical environment potential inter-relationships between other topics assessed within this PEIR including benthic habitats and offshore archaeology and cultural heritage. A summary of the potential inter-relationships is provided in **Table 8-65**.

Table 8-65 Marine Physical Environment Inter-relationships

Topic and Description	Related Chapter	Where Addressed in this Chapter	Rationale
Construction			
Effects on water column (suspended sediment concentration)	**Chapter 10 Fish and Shellfish Ecology** **Chapter 13 Commercial Fisheries** **Chapter 9 Benthic Habitats**	Section 8.7.4.6, 8.7.4.4	Suspended sediment could cause disturbance to fish and benthic species through smothering.
Effects on seabed (morphology and sediment composition)	**Chapter 9 Benthic Ecology** **Chapter 10 Fish and Shellfish Ecology** **Chapter 13 Commercial Fisheries** **Chapter 14 Shipping and Navigation**	Section 8.7.4.6, 8.7.4.4, 8.7.4.1	Disruption to seabed (morphology and sediment composition) could affect receptors outlined in these chapters by altering the existing sedimentary environment, however this is unlikely to be to levels which are significant.

Topic and Description	Related Chapter	Where Addressed in this Chapter	Rationale
	Chapter 17 Offshore Archaeology and Cultural Heritage **Chapter 16 Infrastructure and Other Users**		
Operation			
Effects on shoreline (morphology, sediment transport and sediment composition)	**Chapter 9 Benthic Habitats** **Chapter 20 Flood Risk and Hydrology** **Chapter 23 Landscape and Visual Impact Assessment**	Section 8.7.5.5, 8.7.5.4	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 (morphology and sediment transport)	**Chapter 9 Benthic Habitats** **Chapter 10 Fish and Shellfish Ecology** **Chapter 13 Commercial Fisheries** **Chapter 14 Shipping and Navigation**	Section 8.7.5.5, 8.7.4.6, 8.7.4.8, 8.7.4.10, 8.7.4.7	Disruption to sediment transport processes or loss of seabed area could affect the receptors within these chapters by altering the existing sedimentary environment, however this is unlikely to be to levels which are significant.

Topic and Description	Related Chapter	Where Addressed in this Chapter	Rationale
	Chapter 17 Offshore Archaeology and Cultural Heritage		
Decommissioning			
Inter-relationships for impacts during the decommissioning phase will be the same as those outlined above for the construction phase.			

8.12 Summary

319. This chapter has provided a characterisation of the existing environment for the marine physical environment based on both existing and site-specific survey data which has established that the significance of effect on the identified receptors during construction, operation and decommissioning phases of the Projects (in isolation and if both projects are built together) are considered to be **negligible.**

320. The specific receptors that have been identified in relation to the marine physical environment are: the Dogger Bank and Southern North Sea SACs; the Flamborough Head SAC and SSSI; Dimlington Cliff SSSI; the Holderness Offshore MCZ and Holderness Inshore MCZ; the Flamborough and Filey Coast, Greater Wash and Humber Estuary SPAs; Smithic Sands; the Holderness Cliffs; the Flamborough Front; and inshore and offshore marine waters (separated to reflect designations within inshore waters such as bathing waters).

321. The effects of changes in suspended sediment concentration on these receptors during the construction phase have been considered and due to the short duration of any disturbance and the relatively coarse nature of seabed sediments, any disturbed sediment is expected to settle back to the seabed in close proximity to the area of disturbance and return to baseline conditions within days of the activity.

322. Changes in suspended sediment have the potential to impact water quality if contaminated sediments are disturbed. However, the sensitivity of the receptors to changes in water quality is low and sediment contamination levels are also predicted to be low.

323. There is potential for changes in seabed level due to deposition of the disturbed sediment plume. However, a conceptual evidence-based assessment supported by analogous numerical modelling show any changes in seabed level are at the mm scale and therefore indistinguishable against background sedimentary processes.

324. HDD methods below the Holderness Cliffs will be used to install the export cables at the landfall. However, there is potential for the HDD exit point to be located within the intertidal zone which may require temporary installation of cofferdams during construction, which may impact sediment transport pathways in the intertidal and nearshore zone. Receptors sensitive to changes in sediment transport include Smithic Bank which may be present within the offshore export cable corridor. Assessment of site-specific survey data will be included in the ES to support a conceptual evidence-based assessment of the effect of the HDD exit point.

325. Changes to wave and tide regimes during the operation phase of the Projects have been assessed using analogous modelling. The results show the blockage effect caused by the presence of structures on the seabed and within the water column are small in magnitude and localised. Although small in magnitude, changes to the tide and wave regime may influence sediment transport resulting in a reduction or increase in sediment transport which would manifest as a change in seabed morphology. The effect will be confined to the area immediately adjacent to seabed structures.

326. The presence of cable protection measures on the seabed will potentially interrupt sediment transport which will have a greater effect in the nearshore and intertidal zone where receptors are sensitive to changes in sediment transport pathways. In time, sediment is expected to create a ramp over the cable protection measure allowing sediment to bypass. The location of any cable protection measures relative to sediment transport pathways will be assessed at ES to support a conceptual evidence-based assessment of the effect on Smithic Bank and other coastal receptors.

Table 8-66 Summary of Potential Likely Significant Effects on the Marine Physical Environment

Potential Impact	Receptor	Sensitivity	Magnitude of Impact	Pre-mitigation Effect	Mitigation Measures Proposed	Residual Effect	Residual Cumulative Effect
Construction							
Impact C1a: Changes in suspended sediment concentration and transport due to seabed preparation for foundation installation	Dogger Bank SAC	Negligible	Medium (near-field) Low (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Southern North Sea SAC	Negligible	Medium (near-field) Low (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Marine waters (offshore)	Negligible	Low	Negligible adverse	N/A	Negligible adverse	N/A
Impact C1b: Changes in suspended sediment concentration and transport	Dogger Bank SAC	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A

Potential Impact	Receptor	Sensitivity	Magnitude of Impact	Pre-mitigation Effect	Mitigation Measures Proposed	Residual Effect	Residual Cumulative Effect
due to drill arisings from foundations	Southern North Sea SAC	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Marine waters (offshore)	Negligible	Negligible	Negligible adverse	N/A	Negligible adverse	N/A
Impact C1c: Changes in suspended sediment concentration and transport due to array, inter platform and offshore export cable installation	Holderness Inshore MCZ	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Smithic Sands	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A

Potential Impact	Receptor	Sensitivity	Magnitude of Impact	Pre-mitigation Effect	Mitigation Measures Proposed	Residual Effect	Residual Cumulative Effect
	Dogger Bank SAC	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Southern North Sea SAC	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Marine waters (offshore)	Negligible	Negligible	Negligible adverse	N/A	Negligible adverse	N/A
	Marine waters (inshore)	Negligible	Negligible	Negligible adverse	N/A	Negligible adverse	N/A
Impact C1d: Changes in suspended sediment concentration and transport due to HDD exit cable installation	Holderness Inshore MCZ	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A

Potential Impact	Receptor	Sensitivity	Magnitude of Impact	Pre-mitigation Effect	Mitigation Measures Proposed	Residual Effect	Residual Cumulative Effect
	Marine waters (inshore)	Negligible	Negligible	Negligible adverse	N/A	Negligible adverse	N/A
Impact C1e: Deterioration in water quality associated with release of sediment bound contamination	Marine waters (offshore)	Negligible	Negligible	Negligible adverse	N/A	Negligible adverse	N/A
	Marine waters (inshore)	Negligible	Negligible	Negligible adverse	N/A	Negligible adverse	N/A
Impact C2a: Changes in seabed level due to seabed preparation for foundation installation	Dogger Bank SAC	Negligible	Low (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Southern North Sea SAC	Negligible	Low (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A

Potential Impact	Receptor	Sensitivity	Magnitude of Impact	Pre-mitigation Effect	Mitigation Measures Proposed	Residual Effect	Residual Cumulative Effect
Impact C2b: Changes to seabed level due to drill arisings from foundations	Dogger Bank SAC	Negligible	Low (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Southern North Sea SAC	Negligible	Low (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
Impact C2c: Changes in seabed level due to array, inter platform and offshore export cable installation	Holderness Inshore MCZ	Negligible	Negligible (near-field) Negligible (near-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Smithic Sands	Negligible	Negligible (near-field) Negligible (near-field)	Negligible adverse	N/A	Negligible adverse	N/A

Potential Impact	Receptor	Sensitivity	Magnitude of Impact	Pre-mitigation Effect	Mitigation Measures Proposed	Residual Effect	Residual Cumulative Effect
	Dogger Bank SAC	Negligible	Negligible (near-field) Negligible (near-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Southern North Sea SAC	Negligible	Negligible (near-field) Negligible (near-field)	Negligible adverse	N/A	Negligible adverse	N/A
Impact C3: Changes to bedload sediment transport due to HDD exit cable installation	Holderness Cliffs	Negligible	Negligible (near-field) Negligible (near-field)	Negligible adverse	N/A	Negligible adverse	N/A

Potential Impact	Receptor	Sensitivity	Magnitude of Impact	Pre-mitigation Effect	Mitigation Measures Proposed	Residual Effect	Residual Cumulative Effect
Impact C4: Indentations on the seabed due installation vessels	Dogger Bank SAC	Negligible	Medium (near-field) No change (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Southern North Sea SAC	Negligible	Medium (near-field) No change (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Holderness Inshore MCZ	Negligible	Medium (near-field) No change (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
Operation							
Impact O1 Changes to the tidal regime due to the presence of infrastructure	Dogger Bank SAC	Negligible	Low (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A

Potential Impact	Receptor	Sensitivity	Magnitude of Impact	Pre-mitigation Effect	Mitigation Measures Proposed	Residual Effect	Residual Cumulative Effect
(wind turbines and offshore platforms)	Southern North Sea SAC	Negligible	Low (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
Impact O2 Changes to the wave regime due to the presence of infrastructure (wind turbines and offshore platforms)	Dogger Bank SAC	Negligible	Low (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Southern North Sea SAC	Negligible	Low (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
Impact O3 Changes to water circulation (Flamborough Front) due to the presence of infrastructure (wind turbines and offshore platforms)	Flamborough Front	Negligible	Low (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A

Potential Impact	Receptor	Sensitivity	Magnitude of Impact	Pre-mitigation Effect	Mitigation Measures Proposed	Residual Effect	Residual Cumulative Effect
Impact O4a Changes to bedload sediment transport and seabed morphology due to the presence of infrastructure (wind turbines and offshore platforms)	Dogger Bank SAC	Negligible	Negligible (near-field) Low (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Southern North Sea SAC	Negligible	Negligible (near-field) Low (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
Impact O4b Changes to bedload sediment transport and seabed morphology due to the presence of cable protection measures	Flamborough Head SAC and SSSI	Medium	Negligible (near-field) Low (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Smithic Sands	Medium	Negligible (near-field) Low (far-field)	Negligible adverse	N/A	Negligible adverse	N/A

Potential Impact	Receptor	Sensitivity	Magnitude of Impact	Pre-mitigation Effect	Mitigation Measures Proposed	Residual Effect	Residual Cumulative Effect
	Holderness Cliffs	Negligible	Negligible (near-field) Low (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
Impact O5 Cable repairs and reburial	Holderness Inshore MCZ	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Smithic Sands	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
Impact O6 Deterioration in water quality associated with release of sediment bound contamination due to cable repairs and reburial	Marine waters (offshore)	Negligible	Negligible	Negligible adverse	N/A	Negligible adverse	N/A
	Marine waters (inshore)	Negligible	Negligible	Negligible adverse	N/A	Negligible adverse	N/A

Potential Impact	Receptor	Sensitivity	Magnitude of Impact	Pre-mitigation Effect	Mitigation Measures Proposed	Residual Effect	Residual Cumulative Effect
Impact O7 Loss of seabed area due to the footprint of foundations	Dogger Bank SAC	Negligible	High (near-field) No change (far-field)	Minor adverse	N/A	Minor adverse	N/A
	Southern North Sea SAC	Negligible	High (near-field) No change (far-field)	Minor adverse	N/A	Minor adverse	N/A
Impact O8 Indentations on the seabed due to maintenance and repair vessels	Dogger Bank SAC	Negligible	Medium (near-field) No change (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Southern North Sea SAC	Negligible	Medium (near-field) No change (far-field)	Negligible adverse	N/A	Negligible adverse	N/A

Potential Impact	Receptor	Sensitivity	Magnitude of Impact	Pre-mitigation Effect	Mitigation Measures Proposed	Residual Effect	Residual Cumulative Effect
	Holderness Inshore MCZ	Negligible	Medium (near-field) No change (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
Decommissioning							
The impacts during the decommissioning phase would be comparable to those identified for the construction phase. Accordingly, given that no significant impact was assessed for the identified marine physical environment receptors during the construction phase, it is anticipated that the same would be valid for the decommissioning phase.							

References

BEIS (2023a) Draft Overarching National Policy Statement for Energy (EN-1). Available at: EN-1 Overarching National Policy Statement for Energy (publishing.service.gov.uk) Accessed 17/04/2023

BEIS (2023b) Draft National Policy Statement for Renewable Energy Infrastructure (EN 3) Available at: NPS EN-3 - Renewable energy infrastructure (publishing.service.gov.uk) Accessed 17/04/2023

BEIS (2023c) Draft National Policy Statement for Electricity Networks Infrastructure (EN-5). Available at: EN-5 Electricity Networks National Policy Statement (publishing.service.gov.uk) Accessed 17/04/2023

Bray, M.J. and Hooke, J.M. (1997). Prediction of soft-cliff retreat with accelerating sea-level rise. Journal of Coastal Research, 13, 453-467.

British Geological Survey Offshore Geoindex. Available at https://mapapps2.bgs.ac.uk/geoindex_offshore/home.html

Carpenter, J.R., Merckelbach, L., Callies, U., Clark, S., Gaslikova, L. and Baschek, B., (2016). Potential impacts of offshore wind farms on North Sea stratification. PloS one,11(8).

Castedo, R., de la Vega-Panizo, R., Fernández-Hernández, M. and Paredes, C. (2015). Measurement of historical cliff-top changes and estimation of future trends using GIS data between Bridlington and Hornsea – Holderness Coast (UK). Geomorphology, 230, 146-160.

Castedo, R., Paredes, C., de la Vega-Panizo, R. and Santos, A.P., (2017). The modelling of coastal cliffs and future trends. Hydro-Geomorphology–Models and Trends. IntechOpen, pp.53-78.

Cazenave, P.W., Torres, R. and Allen, J.I. (2016). Unstructured grid modelling of offshore wind farm impacts on seasonally stratified shelf seas. Progress in Oceanography, 145, 25-41.

Channel Coastal Observatory (2014). Seabed Mapping: Flamborough Head to Spurn Point. TR47. East Riding Coastal Monitoring Programme.

Cefas (2004). Offshore wind farms: guidance note for Environmental Impact Assessment in respect of FEPA and Coast Protection Act requirements.

Cefas (2005). Assessment of the significance of changes to the inshore wave regime as a consequence of an offshore wind array. Defra R&D report.

Cefas (2011). Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects.

Cefas (2016). Suspended Sediment Climatologies around the UK. Report for the UK Department for Business, Energy and Industrial Strategy offshore energy Strategic Environmental Assessment Programme.

Cooper, N and Brew, D (2013) Impacts on the Physical Environment. In: R. C. Newell and T. Woddcock (Eds) Aggregate Dredging and the Marine Environment: an overview of recent research and current industry practie. The Crown Estate.

Cotterill C J, Phillips E, James L, Fredrik Forsberg C, Tjelta T I, Carter G and Dove D (2017). The evolution of Dogger Bank, North Sea: A complex history of terrestrial, glacial and marine environmental change. Quat Sci Rev, 171 136-153.

Department of Energy and Climate Change (2008). Atlas of UK Marine Renewable Energy Resources Technical Report. For BERR. R.1432.

Department of Energy and Climate Change (2011a) Overarching National Policy Statement for Energy (EN-1). Presented to Parliament pursuant to Section 5(9) of the Planning Act 2008. The Stationary Office, London.

Department of Energy and Climate Change (2011b) National Policy Statement for Renewable Energy Infrastructure (EN-3). Presented to Parliament pursuant to Section 5(9) of the Planning Act 2008. The Stationary Office, London.

Department of Energy and Climate Change (2011c) National Policy Statement for Electricity Networks Infrastructure (EN-5). Presented to Parliament pursuant to Section 5(9) of the Planning Act 2008. The Stationary Office, London.

EMODnet Digital Bathymetry 2020. Available at https://www.emodnet-bathymetry.eu/ .

Environment Agency (2017) Clearing the Waters for All. Available online at: Water Framework Directive assessment: estuarine and coastal waters - GOV.UK (www.gov.uk) Accessed 05/01/2023

ETSU. (Energy Technology Support Unit). (2000). An assessment of the environmental effects of offshore wind farms. Report No. ETSU W/35/00543/REP.

ETSU (Energy Technology Support Unit) (2002). Potential effects of offshore wind farms on coastal processes. Report No. ETSU W/35/00596/REP.

Forewind (2013a) Dogger Bank Creyke Beck Environmental Statement Chapter 9 Marine Physical Processes. Application Reference 6.9.

Forewind (2013b). Dogger Bank – Creyke Beck. Continuation from Part 1: ES Chapter 12 Appendix C - Gardline Cable Corridor Inshore Survey Report. Application Reference: 6.12.3

Hiscock, D.R. and Bell, S. (2004). Physical impacts of aggregate dredging on sea bed resources in coastal deposits. Journal of Coastal Research, 20 (10), 101-114.

HR Wallingford. (1993). Coastal Management. Mapping of littoral cells. Report SR 328

JNCC (Joint Nature Conservancy Committee) and Natural England (2011). General advice on assessing potential impacts of and mitigation for human activities on Marine Conservation Zone (MCZ) features, using existing regulation and legislation.

JNCC. (2016). UK0013036. Available at https://sac.jncc.gov.uk: https://sac.jncc.gov.uk/site/UK0013036

JNCC. (2017). Method for creating version 2 of the UK Composite Map of Annex I Sandbanks slightly covered by seawater all of the time.

John, S.A., Challinor, S.L., Simpson, M., Burt, T.N. and Spearman, J. (2000). Scoping the assessment of sediment plumes from dredging. CIRIA Publication

Kenyon, N.H. and Cooper, W. (2005). Sandbanks, sand transport and offshore wind farms. Report for the Department of Trade and Industry. Kenyon MarineGeo and ABP Marine Environmental Research Ltd, UK.

Lambkin, D.O., Harris, J.M., Cooper, W.S. and Coates, T. (2009). Coastal Process Modelling for Offshore Wind Farm Environmental Impact Assessment: Best Practice Guide. Report to COWRIE, September 2009.

Leatherman, S.P. (1990). Modelling shore response to sea-level rise on sedimentary coasts. Progress in Physical Geography, 14, 447-464.

Lee, E.M. and Clark, A.R. (2002). Investigation and management of soft rock cliffs. DEFRA. London: Thomas Telford, 388pp.

Lee, M. (2012). Flamborough Head, Filey Brigg to South Bay: Prediction of 50-Year Cliff Recession Distances. Report to Natural England.

Lee, M. (2014). Muston Sands to Reighton Sands: Prediction of 50-Year Cliff Recession Distances. Report to Natural England.

Miller, P.I. & Christodoulou, S. (2014) Frequent locations of ocean fronts as an indicator of pelagic diversity: application to marine protected areas and renewables. Marine Policy. 45, 318–329

MMO (Marine Management Organisation) (2012). East Inshore and East Offshore Marine Plan Areas: Evidence and Issues.

MMO (2015) High Level Review of Current UK Action Level Guidance MMO Project No: 1053. Available online at: High_level_review_of_current_UK_action_level_guidance_report__1053_.pdf (publishing.service.gov.uk) Accessed 05/01/2023

MMO (2017) Marine Planning: Issues and Evidence Database; Available online at https://www.gov.uk/government/publications/marine-planning-issues-and-evidence-database Accessed 06/02/2023

Newell, R.C., Seiderer, L.J., Robinson, J.E., Simpson, N.M., Pearce, B and Reeds, K.A. (2004). Impacts of overboard screening on sea bed and associated benthic biology community structure in relation to marine aggregate extraction. Technical Report to the Office of the Deputy Prime Minister and Minerals Industry Research Organisation. Project No. SAMP 1.022, Marine Ecological Surveys Ltd, St. Ives, Cornwall.

Ohl, C.O.G., Taylor, P.H., Eatock Taylor, R. and Borthwick, A.G.L. (2001). Water wave diffraction by a cylinder array part II: irregular waves. Journal of Fluid Mechanics, 442, 33 – 66.

OSPAR (2010) Quality Status Report. Available online at The Quality Status Report 2010 Available online at: The Quality Status Report 2010 (ospar.org) Accessed 05/01/2023

OSPAR (2017) Intermediate Assessment Quality Status Report. Available online at: https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/ Accessed 05/01/2023

Pye, K., & Blott, S. J. (2015). Spatial and temporal variations in soft-cliff erosion along the Holderness coast, East Riding of Yorkshire, UK. Journal of Coastal Conservation, Planning and Management, 19(6), 785 - 808. doi:10.1007/s11852-015-0378-8

Schultze, L.K.P., Merckelbach, L.M., Horstmann, J., Raasch, S. and Carpenter, J.R. (2020). Increased Mixing and Turbulence in the Wake of Offshore Wind Farm Foundations. Journal of Geophysical Research: Oceans, 125.

Scott Wilson (2010) Humber Estuary Coastal Authorities Group Flamborough Head to Gibraltar Point Shoreline Management Plan Non Technical Summary.

Tillin, H.M., Houghton, A.J., Saunders, J.E. Drabble, R. and Hull, S.C. (2011). Direct and indirect impacts of aggregate dredging. Science Monograph Series No. 1. MEPF 10/P144

Vize, S., Adnitt, C., Staniland, R., Everard, J., Sleigh, A., Cappell, R., McNulty, S., Budd, M., Bonnon, I. and Carey, J., (2008). Review of cabling techniques and environmental effects applicable to the offshore wind farm industry. Department for Business Enterprise & Regulatory Reform, London, UK, pp.211-223.

Whiteside, P.G.D., Ooms, K. and Postma, G.M. (1995). Generation and decay of sediment plumes from sand dredging overflow. Proceedings of the 14th World Dredging Congress. Amsterdam, The Netherlands. World Dredging Association, 877 – 892.

Woodworth, P.L. (2017). Sea level change in Great Britain between 1859 and the present. Geophysical Journal International, 18, 15pp.

RWE Renewables UK Dogger Bank South (West) Limited

RWE Renewables UK Dogger Bank South (East) Limited

Windmill Hill Business Park
Whitehill Way
Swindon
Wiltshire, SN5 6PB