Scotland England Green Link 1 / Eastern Link 1 - Marine Scheme

Environmental Appraisal Report
Volume 2

Chapter 7 - Physical Environment

nationalgrid SP TRANSMISSION

National Grid Electricity Transmission and Scottish Power Transmission

May 2022

Prepared for:

National Grid Electricity Transmission and
Scottish Power Transmission

Prepared by:

AECOM Limited
Aldgate Tower, 2 Leman Street
London, E1 8FA
United Kingdom

T: +44 20 7061 7000
aecom.com

In association with:

Xodus Group (Shipping and Navigation);

Wessex Archaeology (Marine Archaeology); and

Brown and May Marine Ltd (Commercial Fisheries)

Table of Contents

Figures

Tables

Executive Summary

This chapter of the Environmental Appraisal Report (EAR) contains an appraisal of the potential interaction of the Marine Scheme and the physical environment, focusing on the marine area between Mean High Water Spring (MHWS) at the Scottish landfall area at Thorntonloch Beach in East Lothian, and MHWS at the English landfall area at Seaham, County Durham.

The physical environment baseline is presented in Section 7.5 and has been determined using a desk-based approach for the entire marine installation corridor. It included a study of metocean conditions, water quality, geomorphology and sediment characteristics, coastal processes and future baseline conditions which consider the impact of climate change.

The appraisal follows the methodology as set out within Chapter 4: Approach to Environmental Appraisal and the best practice and standards in Section 7.2.2. It appraises the potential changes to seabed bathymetry and morphology such as bedforms, the metocean regime, water quality and turbidity. It also appraises the potential for the development of scour around the cable and cable protection which may risk the integrity of the cable.

The potential effects of the Marine Scheme on the physical environment have been appraised in Section 7.6. This appraisal concludes that the significance of the effect of installation, operation (including maintenance and repair), and decommissioning activities on the physical environment are **minor** to **negligible**, which is **not significant**.

The potential for interaction between the Marine Scheme and other plans/projects to result in significant cumulative effects, is considered in Chapter 16: Cumulative and In-Combination Effects. No interaction between the Marine Scheme and the English and Scottish Onshore Schemes is anticipated. There are no onshore scheme project activities associated with the marine environment, due to the use of Horizontal Directional Drill (HDD) at the landfalls.

7. Physical Environment

7.1 Introduction

This chapter of the Environmental Appraisal Report (EAR) contains an appraisal of the potential interaction of the Marine Scheme with the physical environment including marine geology, oceanography, physical processes (i.e. sediment transport) and water quality.

The Marine Scheme comprises the marine component of the Scotland England Green Link 1 (SEGL1)/ Eastern Link 1 (EL1) and extends from Mean High Water Springs (MHWS) at the Scottish landfall on Thorntonloch beach, to MHWS at the English landfall near Seaham. It is located within both English and Scottish territorial waters, within the 12 nautical mile (NM) limit from the coast. The Marine Scheme comprises an installation corridor of approximately 176 km length and 500 m maximum width within which cables will be installed (hereinafter referred to as the 'marine installation corridor'). The marine installation corridor extends from kilometre point (KP) 0, at its landfall in Scotland, to KP 176, at its landfall in England (See Figure 1-3). The Marine Scheme activities cover the following phases: installation, operation (including maintenance and repair), and decommissioning. Detailed descriptions of each of the Marine Scheme phases can be found in Chapter 2: Project Description.

The physical environment baseline, as understood through desk-based review, is presented in Section 7.5 of this EAR chapter. Potential impacts of the Marine Scheme on these receptors are appraised in Section 7.6 for the installation, operation (including maintenance and repair), and decommissioning phases of the Marine Scheme. Where appropriate, proportionate measures to avoid, mitigate or compensate for any identified adverse effects are proposed.

The potential for interaction between the Marine Scheme and other plans/projects, which may result in significant cumulative effects, is considered in Chapter 16: Cumulative and In-Combination Effects.

Also, of relevance to this chapter is the WFD Assessment for the Marine Scheme which is provided in Volume 3 Appendix 7.1. A Marine Protected Area (MPA) / Marine Conservation Zone (MCZ) Assessment has also been undertaken and is provided in Volume 3 Appendix 8.1.

7.2 Legislative Context

This section outlines legislation, policy and guidance relevant to the appraisal of the potential effects on the physical environment associated with the installation, operation (including maintenance and repair) and decommissioning of the Marine Scheme. For further information regarding the legislative context refer to Chapter 3: Legislative and Policy Framework.

A number of policies and regulations aim to assure that the physical environment is taken into account during the planning and execution of projects within UK waters. For the Marine Scheme these include the UK Marine Policy Statement (MPS) and the UK Marine Plans, specifically the Scottish National Marine Plan (Scottish Government, 2015), and the North East Inshore and North East Offshore Marine Plan[1] (HM Govenment, 2021) have a number of relevant policies specific to physical environment which are presented in EAR Volume 3 Appendix 3.1: Marine Plan Compliance Checklist**.**

A number of policies and laws require decision makers to consider the environmental impacts of a project. Legislation and policy relevant to the appraisal of Marine Scheme's effects on the physical environment is presented in EAR Volume 3 Appendix 3.2: Topic Specific Legislation.

7.2.1 Guidance

Guidance relevant to the appraisal of the physical environment has been taken from a range of current best practice and standards as no specific guidance exists for offshore cable developments. In undertaking the environmental appraisal, the following guidance has been considered:

[1] TheMarine Scheme falls entirely within the UK territorial waters (i.e. 12 NM), therefore within the Inshore portion of the North East marine area. The marine plan for the North East area has combined both inshore and offshore portions.

- A handbook on environmental impact assessment Guidance for Competent Authorities (Scottish National Heritage, 2018);
- Coastal Process Modelling for Offshore Wind farm Environmental Impact Assessment: Best Practice Guide. (ABPmer and HR Wallingford, 2009);
- Cumulative Impact Assessment Guidelines - Guiding Principles for Cumulative Impact Assessment in Offshore Wind Farms (RenewableUK, 2013);
- Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects (Cefas, 2012);
- Flood Risk Assessments: Climate Change Allowances (https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances) (Environment Agency, 2016);
- Environment Agency Bathing Water Quality (https://environment.data.gov.uk/bwq/profiles/) (Environment Agency);
- Environmental impact assessment for offshore renewable energy projects. (British Standards Institute (BSI), 2015);
- Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects (Cefas, 2011);
- Guidance on Environmental Impact Assessment in Relation to Dredging Applications (Office of the Deputy Prime Minister, 2001);
- Natural England Offshore wind cabling: ten years experience and recommendations (Natural England, 2018);
- Offshore wind farms: guidance note for Environmental Impact Assessment in respect of Food and Environmental Protection Act (FEPA) and Coast Protection Act (CPA) requirements: Version 2. (Cefas, 2004);
- Offshore wind, wave and tidal energy applications: consenting and licensing manual (Scottish Government, 2018);
- Review of environmental data associated with post-consent monitoring of licence conditions of offshore wind farms. MMO Project No: 1031 (Fugro EMU, 2014);
- Review of Cabling Techniques and Environmental Effects applicable to the Offshore Wind farm Industry (BERR, 2008);
- Nature Conservation Guidance on Offshore Wind Farm Development (Defra, 2005);
- Marine Renewable Energy and the Natural Heritage: An Overview and Policy Statement' (SNH, 2003); and
- Marine Scotland Licensing and Consents Manual covering marine renewables and offshore wind energy development. Report commissioned for Marine Scotland (ABPmer, 2012).

7.3 The Study Area

The Marine Scheme includes a marine installation corridor of approximately 176 km length and 500 m maximum width within which cables will be installed. This corridor extends from the Scottish landfall in Thorntonloch Beach (KP 0), to MHWS at the English landfall site near Seaham (KP 176) (Figure 7-1). Water depths vary along the marine installation corridor being in excess of 15 m along the majority of the offshore (defined for this appraisal as seaward of the 10m CD depth contour) area until reaching the shallower inshore areas close to the landfall sites.

The physical environment study area covers the length of the marine installation corridor as shown in Figure 7-1, including both landfall sites, to MHWS. In terms of physical marine and coastal processes, environmental baseline conditions have therefore been characterised at a wider regional scale.

7.4 Approach to Appraisal and Data Sources

7.4.1 Appraisal Methodology

This chapter applies the environmental appraisal methodology detailed in Chapter 4: Approach to Environmental Appraisal. The identification and appraisal of effects and mitigation are based on expert judgement and the guidelines listed in Section 7.2.1. The potential magnitude of environmental feature sensitivity and potential effects have been appraised using the terminology outlined in Chapter 4.

A non-statutory Scoping Report, submitted to and consulted on by the Marine Management Organisation (MMO) and Marine Scotland Licensing Operations Team (MS-LOT) between April and July 2021[2], identified aspects of the Marine Scheme that have the potential to impact the physical environment during installation, operation (including maintenance and repair), and decommissioning (NGET & SPT, 2021).

The appraisal of impacts was undertaken on geomorphology, sediments, bathymetry, seabed features, metocean conditions, climate change, coastal processes, sediment and water quality following an evidence-based approach, as presented during the scoping stage. This approach involves making use of previous experience from similar projects subject to similar environmental conditions to inform work and has become accepted best-practice for conducting coastal process studies and appraisals.

The approach applied to the appraisal of the effects resulting from the Marine Scheme on the physical environment comprises three parts:

- Identification of the study area for the specific subject;
- Description of the environmental baseline conditions; and
- Presentation of impact appraisal.

For the impact appraisal, the following approach was adopted:

- Consideration of impacts from individual phases, i.e. installation, operation (including maintenance and repair) and decommissioning; identification of the worst-case scenario for each impact;
- Investigation of likely impacts and appraisal of their significance;
- Describing any further mitigation measures in respect of the appraisal of likely effects; and
- Appraisal of any cumulative and residual effects.

7.4.2 Data Sources and Consultations

7.4.2.1 Data Sources

Information and data from a wide range of sources has been collated and used to inform the environmental baseline appraisal. The physical processes considered in this chapter relate to the distribution of sediments and seabed features, sediment transport, and metocean conditions in the study area, including consideration of climate change effects.

A bespoke survey covering the entire marine installation corridor has been undertaken (Fugro, 2021a). The survey provides detailed information on the seabed geology, surficial sediments, bathymetry, bedforms (i.e. sandwaves) and other seabed features. The presence of boulders, wrecks and seabed protection, associated with existing cables or pipelines, have also been mapped, as required to determine the precise alignment of the cable route.

A desk-based review of literature and data sources establishing baseline conditions within the North Sea was used to support this EAR. The following key technical reports and metocean data sources were identified:

[2] The non-statutory Scoping Report is publicly available on https://marine.gov.scot/sites/default/files/segl_el1_marine_scoping_report_-_base_report_rev_2.0.pdf

- Atlas of UK marine renewables resources (https://www.abpmer.co.uk/experience/atlas-of-uk-marine-renewable-energy-resources/): modelled wave, wind and tidal current (ABPmer);
- Admiralty TotalTide (ATT) (https://www.admiralty.co.uk/digital-services/admiralty-digital-publications/admiralty-totaltide) (Admiralty TotalTide);
- Cefas Climatology Report (2016). Waters Suspended sediment concentrations (SSC) (Cefas, 2016);
- Coastal Flood Boundary Dataset (CFB) (https://data.gov.uk/dataset/73834283-7dc4-488a-9583-a920072d9a9d/coastal-design-sea-levels-coastal-flood-boundary-extreme-sea-levels-2018). extreme water levels (Environment Agency, 2018);
- Dynamic Coast interactive GIS maps (http://www.dynamiccoast.com/webmap.html) (Dynamic Coast);
- Eastern Link Marine Survey (Fugro, 2021a; Fugro, 2021b; Fugro, 2021c);
- European Centre for Medium-range Weather Forecast (ECMWF) (https://www.ecmwf.int/). historic wind speed and wave datasets (ECMWF);
- EA 'Flood Risk Assessments: Climate Change Allowances (https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances): increase in wave height and wind (Environment Agency, 2016);
- Environment Agency Water Quality (https://environment.data.gov.uk/bwq/profiles/) (Environment Agency);
- East Lothian Shoreline Management Plan: Final Report (Babtie Group, 2004);
- Marine Survey Corridor Development and Selection - (RSK, 2020; RPS, 2020a);
- North Sea Atlas- Making the European Fisheries Ecosystem Plan Operational (MEFEPO, 2019);
- National Oceanography Centre BODC (https://www.bodc.ac.uk/): Tidal levels and current measurements (National Oceanography Centre BODC);
- North East Coastal Observatory (http://www.northeastcoastalobservatory.org.uk/) (North East Coastal Observatory);
- National Coastal Erosion Risk Mapping (NCERM) - (Environment Agency, 2022)(https://data.gov.uk/dataset/7564fcf7-2dd2-4878-bfb9-11c5cf971cf9/national-coastal-erosion-risk-mapping-ncerm-national-2018-2021);
- United Kingdom Hydrographic Office (UKHO) - Published Charts and Tide tables: tidal diamonds with current stream data; and
- UK Climate Projections (UKCP): sea level rise (https://www.metofficegov.uk/research/approach/collaboration/ukcp/index) (Met Office).

7.4.2.2 Summary of Consultation

Following submission of the non-statutory Scoping Report in April 2021, the MMO, MS-LOT and respective consultees and advisers had the opportunity to express their opinions and provide feedback on the proposal and EAR scope, with those specific to the physical environment considered in this chapter.

Details of the consultation process and associated responses are presented in Chapter 6: Consultation and Stakeholder Engagement.

Table 7-1 summarises consultation responses received from relevant statutory and non-statutory consultees in relation to the physical environment for the Marine Scheme and outlines how and where this has been addressed in this chapter.

Table 7-1: Scoping report consultation

Consultee	Consultee response/ comment	How and where addressed
East Lothian Council	Land and Soil Most of the proposed landfall site is within Thortonloch Local Geodiversity site and any impacts on this site should be considered. As this part of the project is in the intertidal zone agricultural land will not be affected. If it is likely that there will be compaction or contamination from machinery transported to the site should be considered. There is an area within the general landfall area (not below the high water mark) identified by the Coal Authority as a Development High Risk Area, while the surroundings are Low Risk Area. The Report should consider any effects that could arise from former mineral workings.	No intertidal effects are anticipated from the Marine Scheme due to the use of HDD at the landfalls, and so Thorntonloch Local Geodiversity site has not been considered further in this chapter.
East Lothian Council	Coastal Processes The Scoping Report discusses coastal process under part 6, Physical processes. Any impact of the proposal on coastal processes and vice versa should be considered. In addition to the UKCP18 information to which it refers, the Report should also consider East Lothian's Shoreline Management Plan published in 2003 which is still relevant. An electronic copy is available on request. The Report should refer to this and to the Dynamic Coast GIS mapping noted in the Report.	East Lothian's Shoreline Management Plan, including relevant information and guidance, has been considered in Section 7.5.5.1 and 7.6.
East Lothian Council	The Report should include proposals for how the proposal will be managed taking into account coastal processes including monitoring and mitigation. The Report should consider the possibility of a tidal surge washing away the beach and exposing the cable conduits. It should show what mitigation would be in place should this occur. If there is potential loss of the sand on the beach this is considered a significant effect. (For information: Why beaches lose their sand – and then suddenly reappear | The Independent | The Independent)	This has been considered in Section 7.6 of this chapter.
East Lothian Council	Water Thorntonloch is a designated Bathing Beach, and the report should consider any effects on bathing water quality. The Report notes that accidental spillage of pollutants will be considered and this is welcomed.	The impact of sediment disturbance has been appraised which includes consideration of effects on coastal bathing waters as covered in Section 7.6 of this chapter.
East Lothian Council	Emission of pollutants The Report should include information to show that consideration has been given to accidental release of pollutants during construction or operation. The Scoping Report includes this in Appendix A, which covers impacts that are unlikely to occur and will not be covered. However it is also included in Table 15~1 as an effect which appears to be included, so it's not	Mitigation measures for accidental spillages from vessels are included as embedded mitigation measures in **Section 7.6.1** of this chapter. This is also appraised in Volume 3 Appendix 7.1 WFD Assessment.

Consultee	Consultee response/ comment	How and where addressed
	clear whether or not this is intended to be included. Although this is unlikely to happen the effects could be significant were they to occur. This should therefore be included. A note of the mitigation shown in Appendix A for spillage from vessels should also be included.	
MMO	Consideration of the impacts of cable exposures even if they are unlikely to occur should be provided.	This chapter considers the potential cable exposure due to installation activities and beach erosion processes in Section 7.6. Consideration of the impacts of cable exposure is also considered in Chapter 8: Benthic Ecology.
MMO	The rationale for scoping out changes to hydrodynamics and impacts to offshore and coastal morphology should be included in Environmental Appraisal Report.	Section 7.6 of this chapter explains the rationale behind scoping out changes to coastal morphology. However, impacts on hydrodynamics and the associated impacts on offshore seabed geomorphology have not been scoped out and are discussed in Section 7.6.
MMO	An explanation of whether there will be any post-construction monitoring for coastal erosion should be provided, especially with regard to coastal erosion around connection with the landfall, to show that the scheme will not adversely affect this.	Section 7.7 explains the requirement for post-installation monitoring.
The Wildlife Trust	Re Table 6-1 from Scoping Report. Disturbance of coastal morphology at the landfall sites on the basis of the proposed landfall methods Will this appraisal capture the impact of cable installation on offshore morphology e.g. impact of seabed preparation and installation on sandwave morphology?	Offshore morphology is considered in Section 7.6.

7.4.3 Data Gaps and Limitations

A considerable amount of data relevant to the marine physical processes has been collected from publicly available data sources, supplemented with information from the baseline surveys for the Marine Scheme, including detailed bathymetric, geotechnical and geophysical surveys (Fugro, 2021a). Both modelled and empirical data from various sources have been used to inform the EAR. Whilst the available data cover a range of time periods, the spatial coverage is considered acceptable and given that statistical values relating to tidal processes, for example, do not vary significantly over time, this is not seen as a major limitation.

7.5 Baseline Conditions

7.5.1 Geomorphology and Sediments

7.5.1.1 Marine Surveys

Previous studies (RPS, 2020a; RPS, 2020b) consolidated information on geomorphology and seabed sediments based on high-resolution bathymetry, published geology and previous survey data (MMT, 2013).

Fugro has recently completed new surveys (Figure 7-1) which included the marine installation corridor (Fugro, 2021a); (Fugro, 2021b). The data collected have informed this appraisal and the wider EAR. The survey split the marine installation corridor into ten sections and the results provide detail of the seabed morphology, shallow sediment structure, benthic characterisation and habitat mapping (Figure 7-1).

7.5.1.2 Bathymetry and Seabed Features

This section provides a summary of the analysis of bathymetry and seabed features with further detail provided in Fugro (Fugro, 2021a); (Fugro, 2021b).

As shown in Figure 7-1, water depths within the survey area ranged from 1.8 m below LAT (Lowest Astronomical Tide) within the nearshore region at Seaham (KP 167.5 to KP 172.5) to 88.6 m below LAT, within a trough between sand waves between KP 45.0 to KP 65.0. The seabed deepens gently from west to the north east, with an average gradient of < 1°. The survey data exhibited rippled sediments, sandwaves and boulders on the seabed.

Areas of outcropping bedrock have been identified primarily close to the landfalls with patches recorded in areas between KP 2.5 and KP 5.0 (near the Scottish landfall), between KP 45.0 and KP 127.5, and then between KP 147.5 and KP 167.5 (near the English landfall). More than 1,300 boulders, up to 2 m in height, were also identified within 10 m of the marine installation corridor.

The offshore seabed sediments (i.e. seaward of the 10 m CD contour) consist predominantly of a Holocene veneer of silty fine to medium sand with shell fragments. Patches of sandy clay were also identified, predominantly between KP 14.5 to KP 41.0.

Ripples and megaripples were found throughout the survey area (Figure 7-2 and Figure 7-3) and were predominantly oriented in a north-east to south-west direction, changing to a south-east to north-west direction in the shallowest sections of the survey area within KP 2.5 to KP 5.0 and KP 167.5 to KP 172.5

Sandwaves were present in the deepest part of the survey area and were predominantly orientated in a north to south direction between KP 45.0 and KP 65.0 (Figure 7-3). The sandwaves were slightly asymmetrical in profile, reaching heights of 2.5 m and wavelengths up to approximately 130 m.

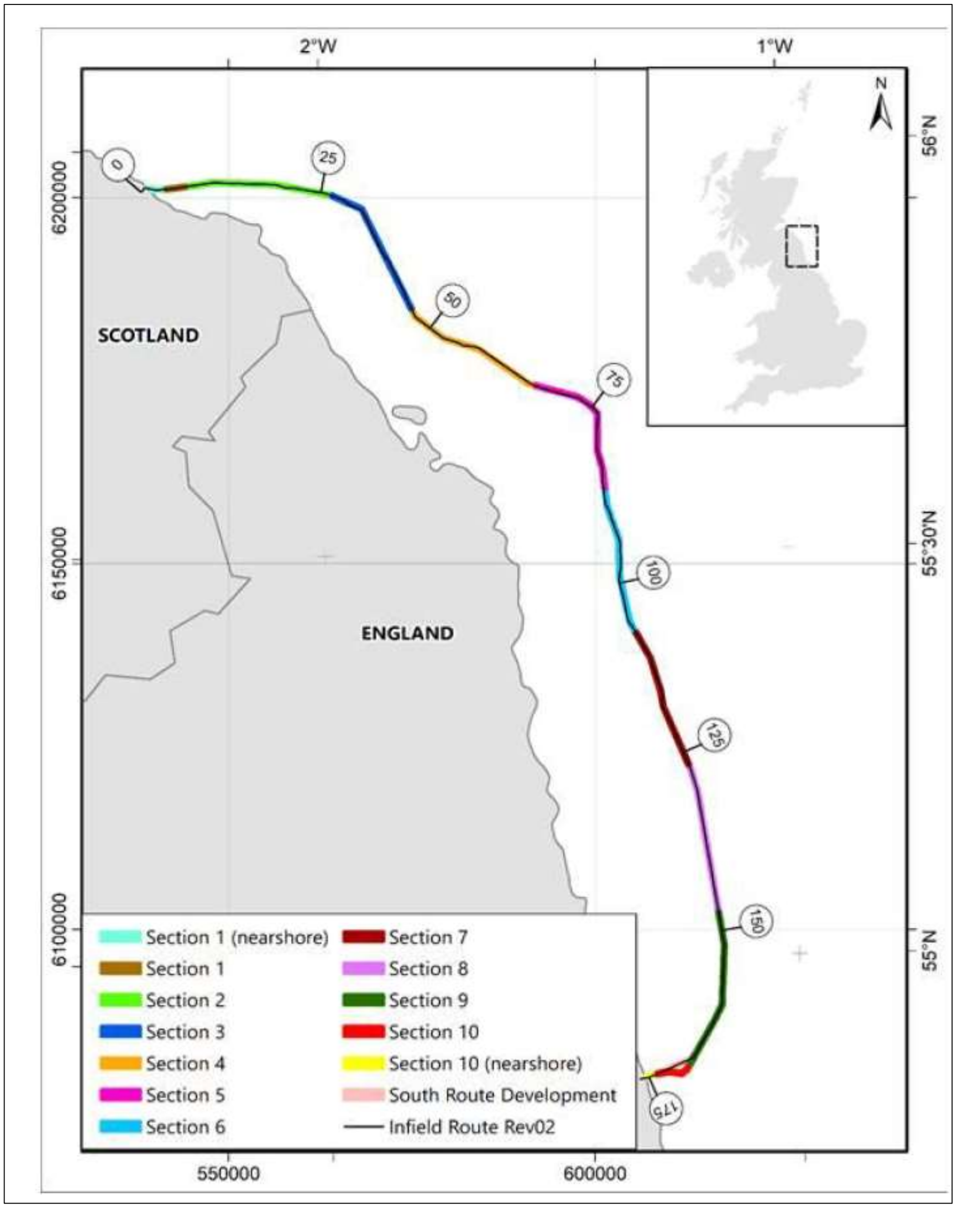


Figure 7-1: Definition of sections along the survey corridor with KP values shown in circles (source: Fugro (Eastern Link Marine Survey - Volume 1 of 6: Geophysical Survey Results, 2021a))

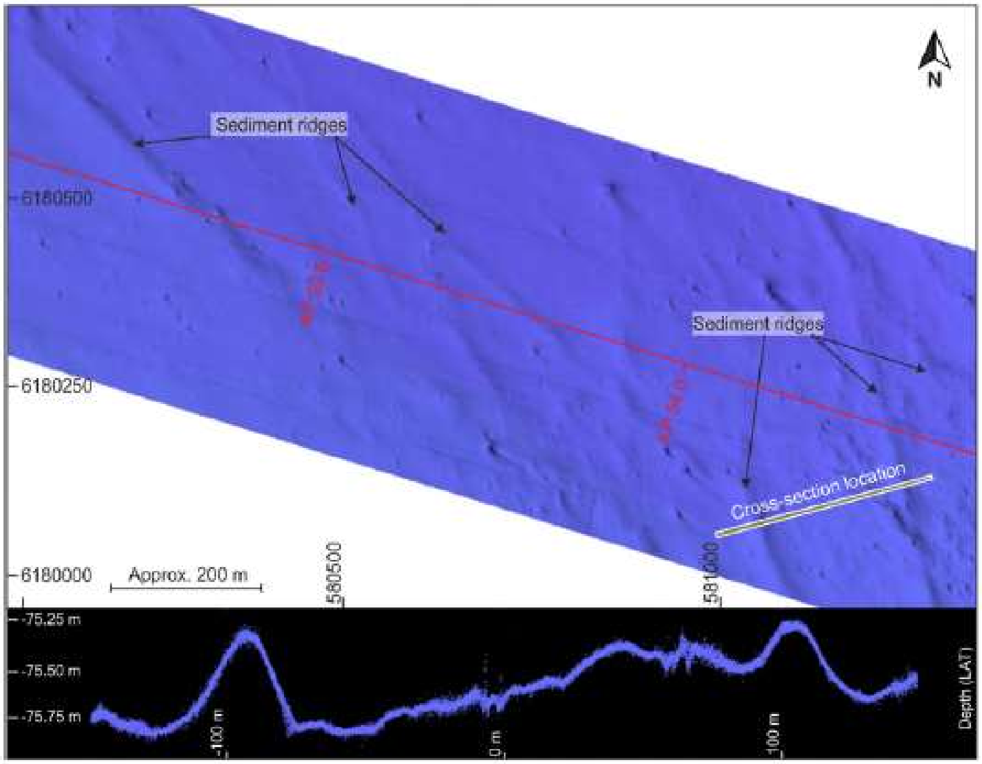


Figure 7-2: Sediment ridges between KP 53.0 and KP 54.5 (source: Fugro (Eastern Link Marine Survey - Volume 4 of 6 : Integrated Geotechnical and Geophysical Report, 2021c))

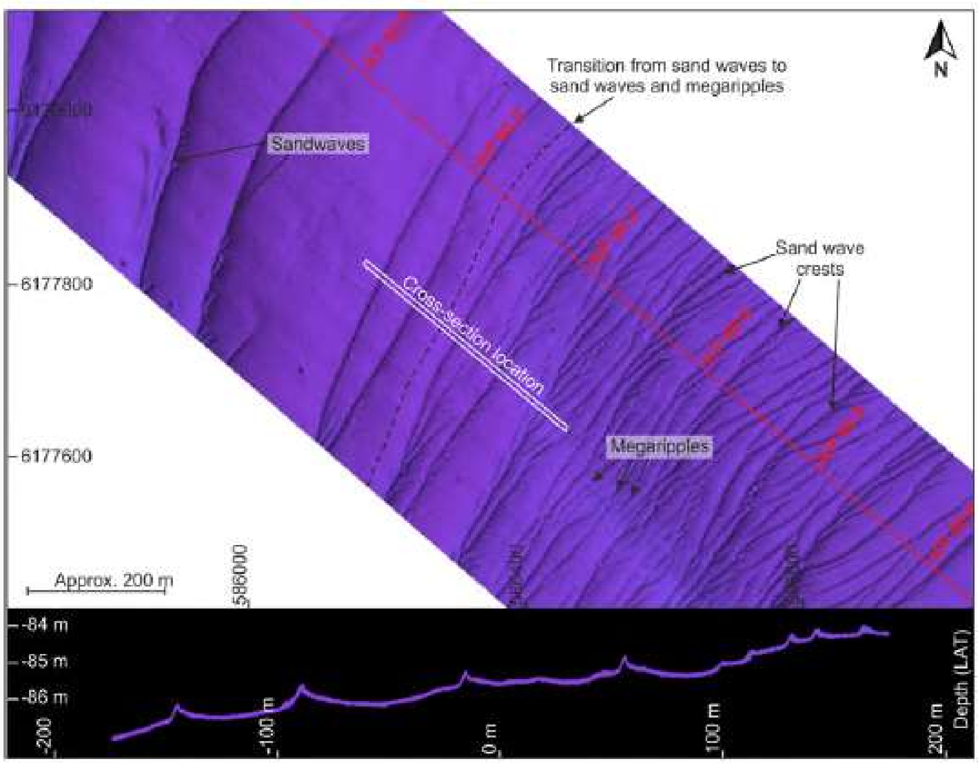


Figure 7-3: Sand waves and megaripples between KP 59.4 and KP 60.8 (source: Fugro (Eastern Link Marine Survey - Volume 4 of 6 : Integrated Geotechnical and Geophysical Report, 2021c)

7.5.1.3 Sediment Characteristics

Scottish Landfall (Intertidal)

The intertidal survey area at the Scottish landfall was characterised by moderately well sorted medium sand, with percentage of gravel < 1% and sand = 99.8%. Table 7-2 presents the sediment fractional composition and mean particle size for intertidal and subtidal sections. The sediment particle size distribution (PSD) was classified as unimodal and symmetrical at all stations with fines being absent. All test stations were classified as 'sand' under the British Geological Survey (BGS) modified Folk classification (Long, 2006) and had unimodal distributions with peaks at 426.8 µm and 301.8 µm (medium sand). The median sediment particle size was between 316 µm and 492 µm, with a mean of 433 µm, all falling within the medium sand range.

Marine Installation Corridor (Subtidal)

The sediment along the marine installation corridor was generally found to be heterogeneous, comprising varying proportions of gravel, sand and fines, with variations in gravel and fines being responsible for the pattern of sediment distribution recorded across the subtidal section of the survey area. Muddy sand was the most frequently occurring sediment type.

The sediment heterogeneity resulted in seven sediment classes being identified under the Folk (BGS modified) classification, i.e. muddy sand, sand, gravelly muddy sand, sandy mud, gravelly sand, muddy sandy gravel and sandy gravel. Sediment along the survey area was predominantly sandy with a mean sand content of 73.51%. Fines were recorded at all stations, with a mean content of 20.48%. Of the fines, the silt content was consistently higher than the clay content, as shown in Table 7-2.

An overall pattern of increased sediment coarseness and heterogeneity was recorded between the Scottish landfall and central sections (Figure 7-1), with section 5 having the highest gravel content. The sediment coarseness subsequently decreased southwards with the finest sediment recorded in Section 8. Localised areas of very coarse sediment occurred within the section from KP 65 to KP 87.5 and KP 167.5 to KP 172.5 and to lesser degree between KP 2.5 and KP 5.0.

A southward pattern of increased heterogeneity was identified, with the Scottish landfall area (KP 0.0 to KP 2.5) being predominantly sandy, the central sections of the survey area (KP 5.0 to KP 167.5) comprising varying proportions of gravel and mud, with the proportion of mud increasing in the southern sections of the survey area between KP 127.5 and KP 167.5) (Figure 7-1) having on average the highest mud content.

There was no sediment distributional pattern associated with depth, with sections grouped on the basis of the sediment characteristics rather than depth. In general, sections in shallow water (depth range 10 m to 20 m) were characterised by sand and muddy sand; those in deeper water were heterogeneous comprising varying proportions of sand, gravel and mud.

English Landfall (Intertidal)

The intertidal survey area at the English landfall was relatively heterogeneous by comparison to the Scottish landfall including moderately well sorted to moderately sorted medium sand, and poorly sorted to very poorly sorted sandy gravel, the coarseness of which ranged from very coarse sand to granule. The sediment distribution ranged from unimodal to polymodal, and from very fine skewed to very coarse skewed. The sediment fractional composition indicated a coarse sediment comprising gravel and sand, whereas fines were absent throughout the English landfall intertidal. The gravel and sand contents are 32.85% and 67.15%, respectively, across the English landfall intertidal (Table 7-2). Two sediment classes were identified under the Folk (BGS) modified classification, of which 'sandy gravel' typified three stations and 'sand' typified two stations. The mean particle size is 1405 µm.

Table 7-2: Sediment fractional composition and particle size

Tidal area and site	Fractional composition (%)			Fines (%)		Mean particle size
	Gravel	Sand	Fines	Silt	Clay	(µm)
Scottish Landfall (intertidal)	0.20	99.80	0.00	0.00	0.00	433
Marine installation corridor (subtidal)	6.02	73.51	20.48	16.82	3.66	383
English Landfall (intertidal)	32.85	67.15	0.00	0.00	0.00	1405

7.5.1.4 Suspended Sediment

To appraise the scale of potential sediment disturbance processes resulting from installation activities, the background spatial and temporal variations in suspended sediment concentrations are required for the water column along the marine installation corridor. The Centre for Fisheries, Environment and Aquaculture Science (Cefas) (Suspended sediment climatologies around the UK, 2016) provides the spatial distribution of average non-algal Suspended Particulate Matter (SPM) between 1998 and 2015 for the majority of the UK continental shelf. The daily images of non-algal SPM from 1/1/1998 to 31/12/2015 were averaged monthly means for the 18 years, which were used to calculate a climatological average (Figure 7-4) as well as climatological monthly averages.

The largest plume concentrations are associated with large rivers such as Humber Estuary, Thames Estuary, Severn Estuary and Liverpool Bay, where the mean values of SPM are above 10 mg/l. Values of suspended sediment in the summer are generally low in offshore areas – typically 0 to 2 mg/l. The winter suspended sediment distribution shows a similar pattern in the coastal areas, but the concentrations are higher (Figure 7-5). Based on the data presented in Cefas (Suspended sediment climatologies around the UK, 2016), the annual averaged SPM associated within the Marine Scheme has been estimated as approximately 1 mg/l to 3 mg/l. Higher levels of SPM up to 5 mg/l may be found within the nearshore landfall areas. The main feature of the sediment concentration distribution for the winter data is the plume-like feature in the suspended sediment field extending from north-east Norfolk extending in a north-easterly direction across the North Sea towards the Dutch coast. However, this plume-like feature is confined within the Southern North Sea region and therefore has no direct impact on the marine installation corridor.

Analysis of averaged time-series data identified an increasing trend in the annual average SPM for the Northern North Sea regions. This long-term change may be caused by increased wind and wave, changes to land use and river management, draining of wetlands, and marine activities such as trawling.

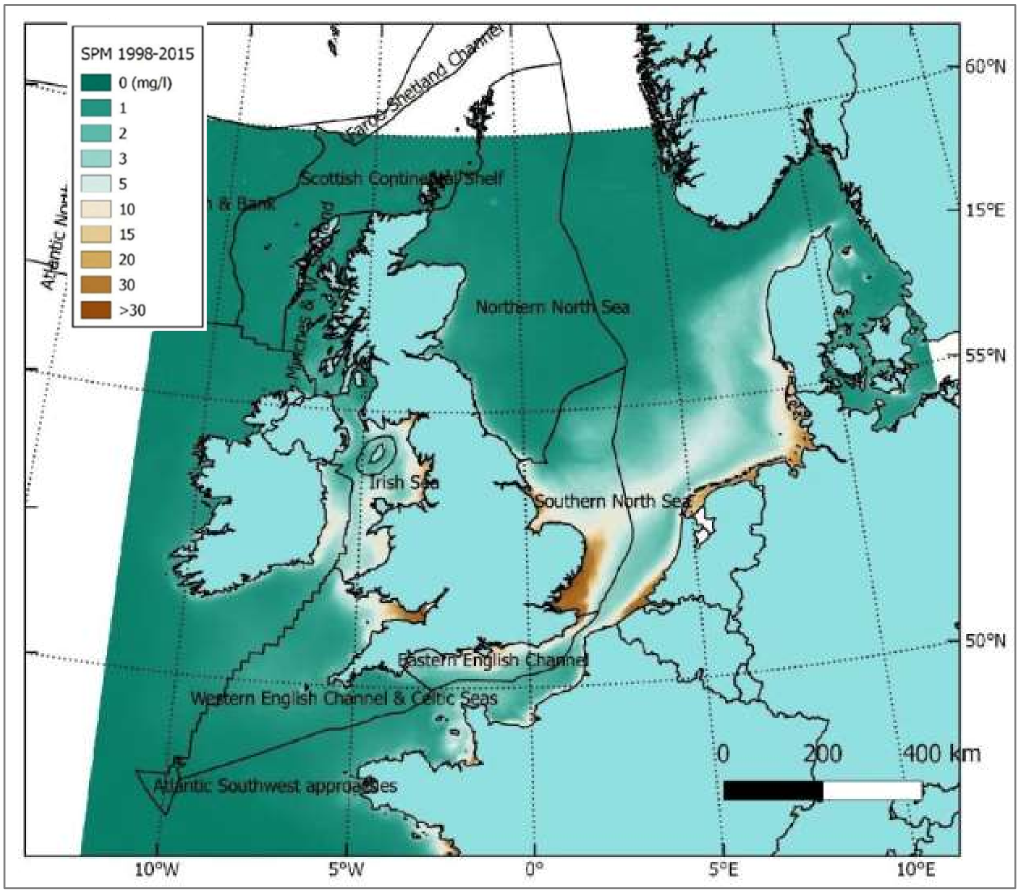
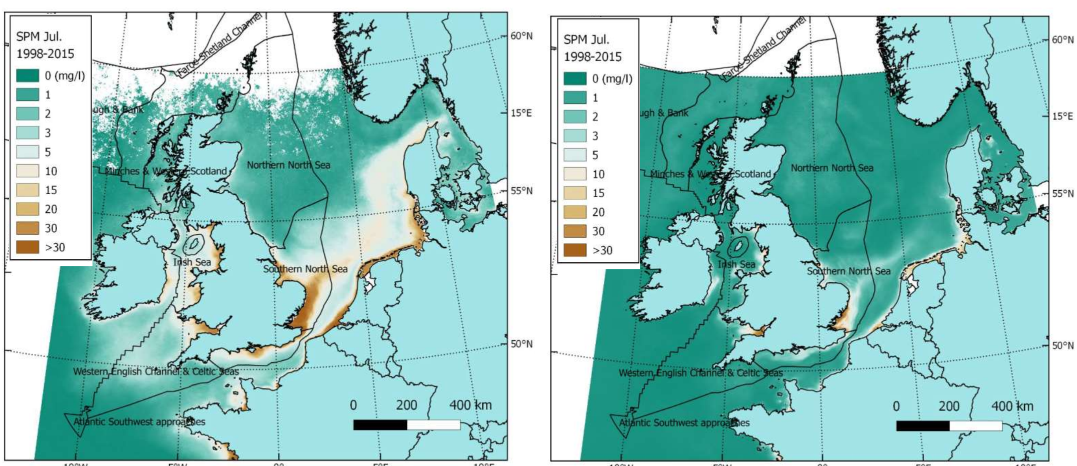


Figure 7-4: Average suspended sediment around the UK (source: Cefas (Suspended sediment climatologies around the UK, 2016))



(a) January **(b) July**

Figure 7-5: Monthly averaged SPM (a) January, (b) July (source: Cefas (Suspended sediment climatologies around the UK, 2016))

7.5.1.5 Sediment quality

Any sediment-bound contaminants, such as heavy metals of hydrocarbons, may be suspended if disturbed by the Marine Scheme which would then have the potential to affect other receptors such as benthic ecology.

In the absence of Environmental Quality Standards for in situ sediments in the UK, the Centre for Environment, Fisheries and Aquaculture Science (Cefas) Chemical Action Levels (Marine Management Organisation, 2014) (Reviewed 2020) values have been used to help inform a ‘Weight of Evidence’ (WoE) approach. These values are used in conjunction with a range of other assessment methods to make management decisions regarding the fate of dredged material. The action levels are not ‘pass/fail’ criteria but triggers for further assessment. In general, contaminant levels in dredged material below action level 1 are of no concern and are unlikely to influence the licensing decision. However, dredged material with contaminant levels above action level 2 is generally considered unsuitable for sea disposal. Dredged material with contaminant levels between action levels 1 and 2 requires further consideration and testing before a decision can be made. Action levels are therefore, used as a guide in assessments of sediment contamination in non-dredging activities.

Project specific sediment chemistry analysis found all heavy metals and hydrocarbons to be present in low concentrations, with the exception of a small number of stations where some thresholds for one or more of the following metals – arsenic, nickel, chromium and lead – exceeded the Cefas Action Level 1 threshold (Fugro, 2021b). No heavy metal concentrations exceeded Cefas Action Level 2. Metal concentrations were within background levels reported from a Marine Scotland monitoring station in the Firth of Forth and a Clean Safe Seas Environmental Monitoring Programme (CSEMP) station at Tyne/Tees (Fugro, 2021b) indicating that these levels of contamination are typical for North Sea sediments.

There were no stations with levels of hydrocarbons above quality standards but there were a number of Canadian PEL thresholds (Canadian sediment quality guidelines (Canadian Council of Ministers of the Environment, 2001)) exceeded for PAHs, though this was limited to a single station (ST37) at KP 162. The concentration of the heavy metals’ arsenic, chromium, nickel and lead were also elevated at this station but were below Cefas Action Level 1.

Contaminants are generally associated with finer material such as silts and clays, which are limited within the mostly coarse sediments found within the marine installation corridor. Where finer sediments do occur, the potential for mobilisation of contaminants is limited, in the same way as the mobilisation of the sediments themselves will be limited.

7.5.2 Metocean Conditions

7.5.2.1 Data Sources

Details of metocean conditions along the marine installation corridor are required to support environmental appraisal. The physical environment varies as a continuum along the entire marine installation corridor. To cover the range of conditions, metocean data sources within the North Sea have been identified and listed in Table 7-3 and Figure 7-6. The Atlas of UK Marine Renewables Resources (‘The Atlas’) (ABPmer) provides a good indication of the hydrodynamic regimes in the nearshore (< 10 m CD) and offshore regions of the marine installation corridor. These data were validated by comparison with data from independent sources such as predictions made using the Admiralty TotalTide software, Admiralty Charts and measured datasets from the BODC (British Oceanographic Data Centre) for locations adjacent to the Marine Scheme.

Modelled wave and wind conditions at three locations were extracted from European Centre for Medium-range Weather Forecast model (ECMWF). Time-series data for wave measurements were obtained for 5-10 years with the Torness wave buoy close to the Scottish landfall and the Newbiggin and Whitby buoys to the north and south of the English landfall (Figure 7-6). Extreme sea level data were extracted at locations near the Scottish and English landfalls from the Environment Agency’s Coastal Flood Boundary (CFB) dataset.

Table 7-3: Metocean data sources

Parameter	Source	Location (see Figure 7-6)
Tide levels	Admiralty Chart /TotalTide	Dunbar, Seaham
Extreme sea levels	CFB	Thorntonloch, Seaham
Tidal currents	Admiralty Chart /TotalTide	SN002D, SN021H, SN021G, SN021A, SN019H, SN019J
	Atlas of UK marine renewables resources	EL1-A, EL1-B, EL1-C
	BODC	BODC01, BODC02, BODC03, BODC04
Wind	ECMWF	EL1-A, EL1-B, EL1-C
Waves	Wave buoy	Torness, Newbiggin, Whitby
	ECMWF	EL1-A, EL1-B, EL1-C

Figure 7-6: Metocean data sites (background image source: Google Earth)

7.5.2.2 Tides

Tide level statistics (Table 7-4) at Dunbar and Seaham have been obtained using the Admiralty's TotalTide software. Dunbar is approximately 7 km from the Scottish landfall at Thorntonloch, while the English landfall is north of Seaham harbour. The tides are semi-diurnal with a macro-tidal range of 4.4 m - 4.5 m for spring tidal range and 2.1 m for neap tidal range. The vertical datum, Ordnance Datum Newlyn (ODN), is +2.80 m at Dunbar and +2.70 m at Seaham relative to local Chart Datum (CD).

For the offshore sections (i.e. seaward of the 10 m CD depth contour) of the marine installation corridor, the mean spring tidal range decreases steadily along the coast towards the mid-point at KP 87.5, reducing from over 4.5 m near the English landfall to approximately 3.87 m (Table 7-5).

Table 7-4: Tidal level statistics (mODN)

Tidal Plane	Dunbar	Seaham
HAT	3.1	3.0
MHWS	2.5	2.5
MHWN	1.3	1.4
MLWN	-0.8	-0.7
MLWS	-1.9	-2.0
LAT	-2.7	-3.1

Table 7-5: Tidal ranges (m)

Tidal Plane	Mean Spring Range	Mean Neap Range
Thorntonloch	4.40	2.10
El1-A*	3.97	2.01
El1-B*	3.87	1.96
El1-C*	4.08	2.10
Seaham	4.50	2.10

*locations shown in Figure 7-6

7.5.2.3 Extreme Sea Levels

Extreme sea levels include contributions from tides, storm surge and sea level rise. Storm surges combined with strong winds and storm waves may have significant implications for coastal erosion and the stability of beaches and dunes. The extreme values at the Scottish and English landfalls are available from the Environment Agency's Coastal Flooding Boundary (CFB) dataset. The CFB data has been developed to inform work around the coast ranging from coastal flood modelling, scheme design, strategic planning and flood risk assessments. Extreme sea levels for 1 in 1, 1 in 20 and 1 in 50 year return periods are summarised in Table 7-6. Sea level rise from the baseline year 2017 has been included in the extreme sea levels provided for 2021 and 2061, assuming a 40-year design-life.

Table 7-6: Extreme sea levels at Scottish and English landfalls (mODN)

Return Period (yr)	English Landfall		Scottish Landfall	
	2021	2061	2021	2061
1	3.36	3.69	3.26	3.56
20	3.73	4.06	3.59	3.89
50	3.85	4.18	3.69	3.99

7.5.2.4 Tidal Currents

In The Atlas (ABPmer), tidal streams were modelled for different layers within the water column. The tidal current data presented is based on information from a layer representative of conditions at mid-depth. Table 7-7 provides the spring and neap peak flow speeds for three sites EL1-A, EL1-B and EL1-C located at the north, central and south of marine installation corridor (see Figure 7-6). The peak flow speeds are 0.26 m/s for a mean neap tide and 0.61 m/s for a mean spring tide.

The Atlas presents the tidal excursion ellipses as shown in Figure 7-7. The tidal excursion length is the net horizontal distance travelled by a water particle from low tide to height tide or vice versa. It can be used to describe the movement of fluid particles in the sea during a tidal cycle. The tidal excursion lengths are estimated by scaling from figures provided in The Atlas (ABPmer) to be 3.5 km to 4 km at the Scottish and 5 km to 6 km at the English landfalls, respectively. The extent of tidal excursion along the marine installation corridor vary from 6 km to 10 km. The Atlas (ABPmer, 2008) suggests that the predominant direction for tidal currents is aligned with a south-east to north-west axis along the marine installation corridor in Scottish and English areas.

The Admiralty TotalTide software has been used to predict the average current speed and direction over a complete tidal cycle from six hours before the time of high water to six hours after. Two sets of values are given covering both spring and neap tides. Six locations in the vicinity of the cable corridor were identified (i.e. SN019J-SN022D) as given in Table 7-7 and Figure 7-7. Peak current speeds of 0.36 m/s and 0.72 m/s were predicted for neap and spring tides, respectively.

Tidal current measurements were collected at four locations (BODC01, 02, 03 04, illustrated in Figure 7-6) from the BODC database due to their close proximity to the marine installation corridor. The time-series data were analysed to appraise peak currents during the survey period which gave a maximum value of 0.78 m/s recorded during a period of spring tides.

The above datasets provided an overview of the tidal current flow conditions along the entire marine installation corridor. Current speeds in the central section (KP 80 to KP 90) are generally strong, with peak currents of 0.62 m/s on a mean spring tide. The peak current on a mean spring tide increases with distance from the coast, with depth-averaged speeds increasing from about 0.31 m/s near the shore to more than 0.62 m/s near the mid-point of the marine installation corridor.

Observed and modelled currents indicate that flood (southwards) flowing currents are always stronger than ebb (northwards) currents (Figure 7-8). This asymmetry in the tidal currents is likely to result in net sediment transport in the direction of the flood currents for both bed load and suspended sediments, although this process has been observed to reverse under southerly wave conditions. The residual currents are responsible for the net southerly drift which will be important for the transport of any fine sediment fractions (i.e. clay/silt) carried in suspension.

Table 7-7: Tidal current speed (m/s)

Location*	Spring Peak Flow (m/s)	Neap Peak Flow (m/s)
EL1-A	0.59	0.30
EL1-B	0.62	0.30
EL1-C	0.53	0.26
SN019J	0.46	0.21
SN019H	0.51	0.26
SN021A	0.51	0.21
SN021G	0.72	0.36
SN021H	0.57	0.26
SN022D	0.36	0.15
BODC01	0.53	0.35
BODC02	0.78	0.36
BODC03	0.55	0.31
BODC04	0.31	0.13

*See location in illustrated in Figure 7-6

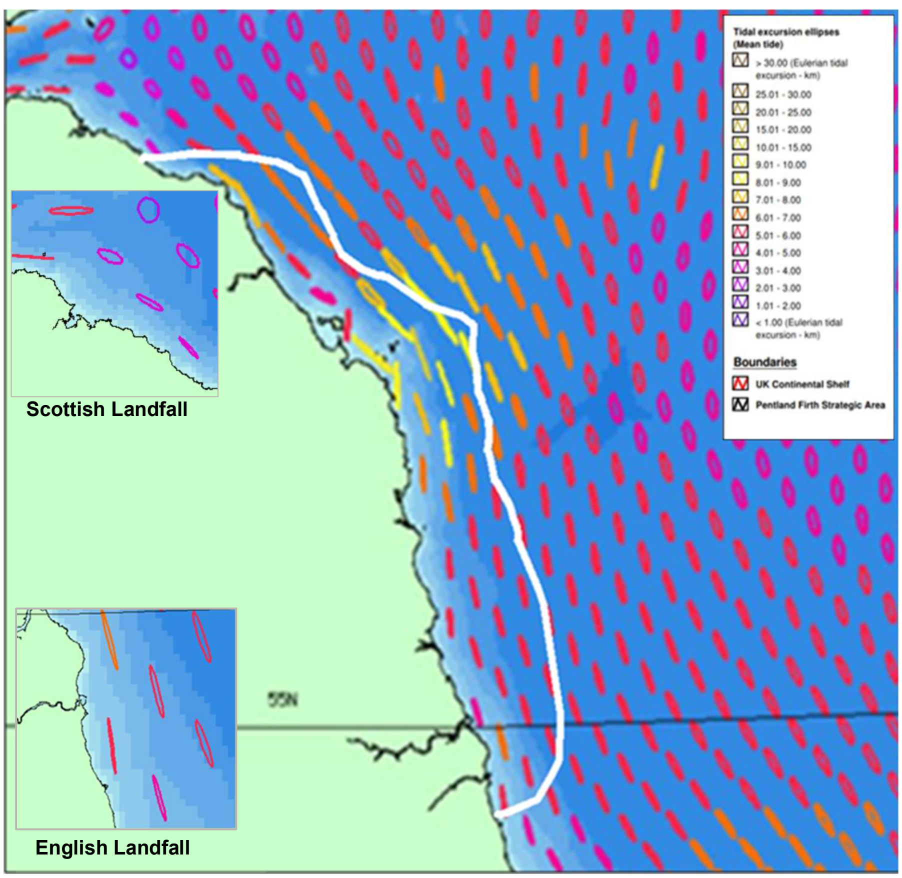


Figure 7-7: Tidal excursion ellipses (source: (ABPmer, 2008))

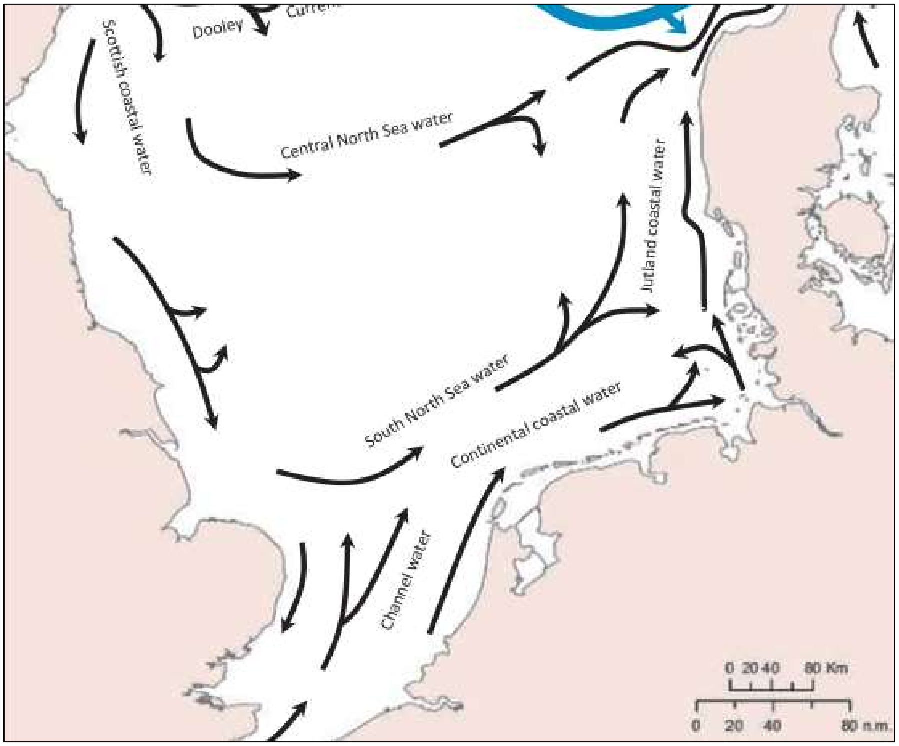


Figure 7-8: Schematic diagram of circulation in North Sea (source: MEFEPO (North Sea Atlas-Making the European Fisheries Ecosystem Plan Operational., 2019))

7.5.2.5 Waves and Winds

Wave regime along the marine installation corridor includes both swell waves generated elsewhere in the North Sea and locally generated wind waves. Strong winds in the North Sea can occur with wave heights varying greatly due to fetch limitations and water depth effects nearshore. 10 year wave (wave height, period and direction) and wind data (speed and direction) at three locations along the marine installation corridor were extracted from a global model operated by the European Centre for Medium-range Weather Forecasts (ECMWF available at: https://www.ecmwf.int/en/forecasts/datasets/open-data) at KP 25.0, KP 100.0 and KP 160.0. The wave and wind data in Table 7-8 show significant wave heights along the marine installation corridor are in the range of 1.35 m and 0.88 m, with wave heights decreasing towards the south, approaching the English landfall. Annual wind speeds are between 6.8 m/s and 7.35 m/s along the marine installation corridor.

The extracted data show the strong seasonal variability of wave height and wind speed, in which higher waves and stronger wind present in the winter. Figure 7-9 shows wave and wind roses along the marine installation corridor. The directional resolution in each wave and wind rose plot is 30º. The wave rose shows that the prevailing waves come from the north and north-east sector. The wind rose shows a wider distribution of conditions with the strongest winds from the south-east to west sector.

Wave conditions at Torness Power Station were obtained from the wave buoy operated by EDF Energy, close to the Scottish landfall. The time series data covers the period from December 2014 to September 2019 at 30min intervals. The wave parameters provided include significant wave height, peak period and direction. The wave buoy is approximately 2 km north of the Scottish landfall in a water depth of 17 m. The predominant waves approaching the Scottish landfall are from the north-east. The mean wave height is 0.77 m. The recorded maximum wave height is 6.1 m with Tp=10.0s.

The National Network of Regional Coastal Monitoring Programmes of England operates a coastal wave network which concentrates on measurements in shallow water. The North East Coastal Observatory provides measured wave data at Newbiggin and Whitby (Figure 7-10), which are 38 km and 62 km from the English landfall, respectively. Wave parameters were recorded over a five year period using a Datawell Directional Waverider Mk III buoy deployed in a water depth of approximately 17-18 m. Average annual wave heights are 0.93 m at Newbiggin and 0.98 m at Whitby. The highest monthly average significant wave heights occur in winter. The one year extreme significant wave height is 4.31 m at Newbiggin rising to 5.65 m at Whitby. The wave rose (Figure 7-10) shows that the prevailing waves come from the north-east sector.

Table 7-8: Wave climates Hs(m) and wind speed (m/s)

Location*		Annual	Summer	Winter
Torness	Hs	0.77	0.55	0.88
EL1-A	Hs	1.35	0.96	1.76
	Wind Speed	7.35	5.83	9.02
EL1-B	Hs	1.23	0.85	1.60
	Wind Speed	7.06	5.59	8.71
Newbiggin	Hs	0.93	0.64	1.13
EL1-C	Hs	0.88	0.67	1.08
	Wind Speed	6.80	5.51	8.28
Whitby	Hs	0.98	0.66	1.13

*locations ordered north to south as illustrated in Figure 7-6

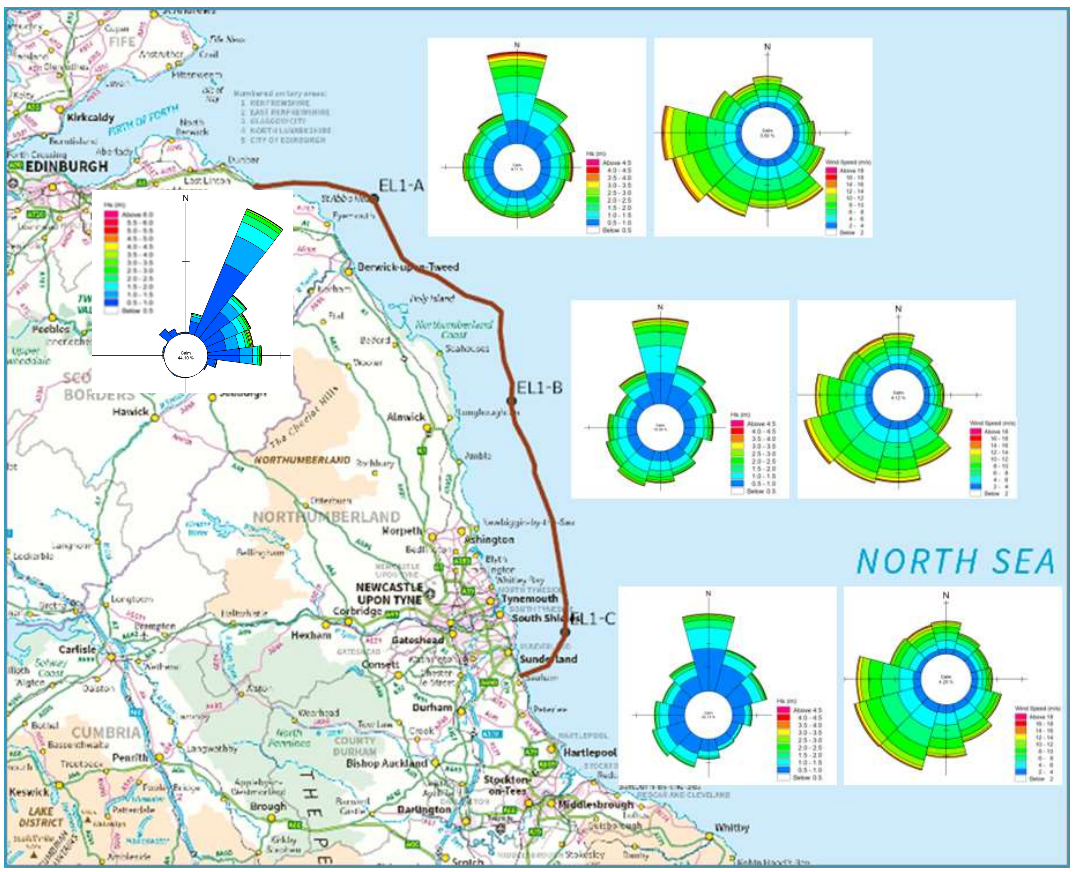


Figure 7-9: Wave and wind roses

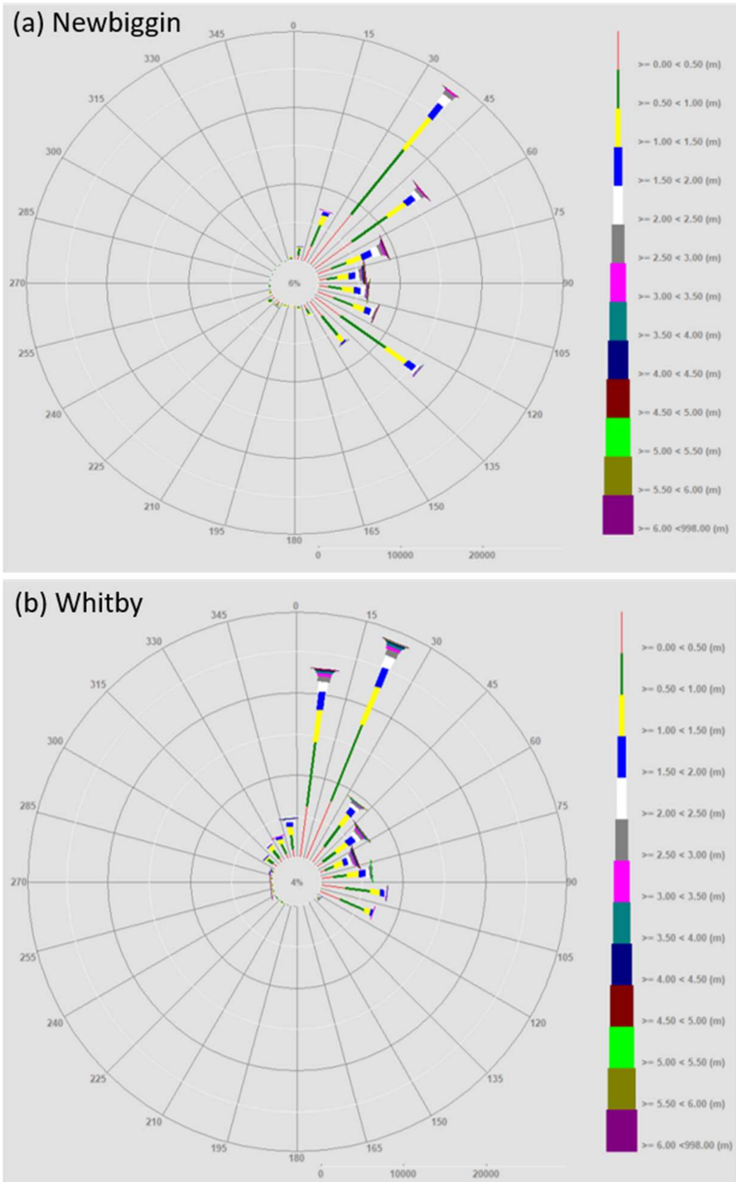


Figure 7-10: Wave roses at (a) Newbiggin and (b) Whitby (source: NNRCMP (Coastal Wave Network Annual Report, 2019))

7.5.3 Water Quality

7.5.3.1 Scottish Landfall

The Water Environment and Water Services (Scotland) Scottish Landfall Act 2003 (WEWSSA) is designed to protect the water environment by preventing deterioration, protecting and enhancing aquatic ecosystems, promoting sustainable water use and reducing pollution. The main regulatory bodies are the Scottish Ministers and SEPA.

The East Lothian coast is considered to be nationally important in terms of recreation and is a significant tourism asset. There are nine designated bathing waters in the area at Seton Sands, Gullane, Yellowcraig, North Berwick Bay, North Berwick, Milsey Bay, Belhaven Bay, Dunbar, Whitesands and Thorntonloch. A programme of monitoring and water classification is undertaken by SEPA (SEPA, 2017) as part of the WFD and WEWSSA requirements. The most recent classification data available from SEPA https://www2.sepa.org.uk/bathingwaters/locations.aspx (Water Framework Directive (WFD) classification data, 2017) shows that the nearshore and landfall site at Thorntonloch Beach falls into the 'Good' category for classification of the waterbody.

7.5.3.2 English Landfall

Water quality at designated bathing water sites in England is assessed by the Environment Agency (https://environment.data.gov.uk/bwq/profiles/) (Environment Agency, 2020). The classification data indicates that the 'Bathing Water' near the landfall at Seaham Beach falls into the 'Good' waterbody category based on measurements.

7.5.4 Future Baseline Condition

7.5.4.1 Climate Change

Due to natural cycles and global warming, the baseline environment is expected to exhibit some degree of change over time, with or without the Marine Scheme in place.

7.5.4.2 Sea Level Rise

The UK Climate Change Projections 2018 (UKCP18) provides the most up-to-date assessment of how the climate may change up to 2100 and post-2100. Sea level rise data along the UK coastline can be downloaded from the UKCP18 website (UK MetOffice, 2018) (https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/download-data), for individual grid squares. The RCP8.5 scenario is a future scenario where greenhouse gas emissions continue to grow unmitigated. These best estimates suggest a global average temperature rise of 4.3 °C by 2100 compared to the pre-industrial period. For the RCP8.5 scenario 95th percentile case, sea level rise from 2021 is 0.35 m (English landfall) and 0.32 m (Scottish landfall) in 2061, allowing for the 40 year design life of the Marine Scheme.

7.5.4.3 Tides and Water Levels

Extreme water levels are expected to increase in terms of storm surge and mean water level due to sea level rise over the lifetime of the Marine Scheme. Extreme sea levels in 2061 (allowing for a 40-year design life) for 1 in 1, 1 in 20 and 1 in 50 return periods are summarised in Table 7-6. The astronomical tidal range about the new mean level and tidal currents are unlikely to be measurably affected by the relatively small increases in water level.

7.5.4.4 Wind and Wave

Changes in future wind and wave conditions are provided in, 'Flood Risk Assessments: Climate Change Allowances' (Environment Agency, 2016). The guidance states that wind speeds and wave height should be increased by 5% between 1990 and 2055 and by 10% for the period 2056 to 2115.

A rise in sea level and increased storminess may allow larger waves, and therefore more wave energy, to reach the coast in certain conditions and consequently will result in an increase in local erosion rates, depth, patterns and affect the equilibrium position of coastal features.

7.5.4.5 Sediment Characteristics

Climate change is not expected to have any effect on composition of sediment fractions, nor any measurable influence on the distribution of seabed sediments.

7.5.4.6 Water Quality

The nearshore areas close to the Scottish and English landfalls fall into the 'Good' water body category. It is considered that this will remain as the future baseline.

7.5.5 Coastal Processes

7.5.5.1 Scottish Landfall

The Scottish landfall is characterised as having a smooth sandy seabed along this section of the East Lothian coastline. The intertidal area between MHWS and MLWS extends for approximately 100 m. The

Shoreline Management Plan (SMP) (Babtie Group and ABP, 2002) for the East Lothian coastline sets out a strategy for coastal management taking account of natural processes and environmental influences. The SMP provides the preferred option for coastal defence for specific stretches of coastline. The East Lothian shore was divided into 13 coastal Process Units (PU). The landfall is located in the Thorntonloch PU and more specifically within the MU22 Management Unit (MU) within this PU.

The coastline is predominantly rocky, with a sandy foreshore backed by sand dunes. The dominant wave directions for this stretch of the coast are from a sector between north and east with sediment transport from east and west. The ‘Dynamic Coast’ interactive GIS maps used by SEPA (Dynamic Coast, n.d.) provide details of historical shoreline change at Thorntonloch Beach and indicates that the coastline is currently stable.

No significant erosion / accretion has been observed at the proposed landfall. The preferred management option for the coastline at the Scottish landfall, as defined in the SMP, is for ‘Limited Intervention’, likely to involve monitoring and reactive maintenance/repair work as necessary. In the long-term a slow rate of coastal erosion may result in some further loss of frontage to the south of the Scottish landfall site and the evidence suggests that the rate of loss is likely to be low and there will therefore be limited future change to the shoreline position. The SMP (Babtie Group and ABP, 2002) assumed a worst-case erosion rate of 0.25 m/year along this part of the coast, resulting in 12.5 m of erosion over a 50-year period.

7.5.5.2 English Landfall

The English landfall is characterised by sandy beaches and cliffs which are actively eroded by the sea, which reaches the base of the cliffs at high tide. Erosion by the action of waves causes deepening of the seabed in the area fronting the cliff having a de-stabilising effect.

As offshore waves transfer from the deep water to shallower coastal areas (i.e. from offshore sections of the marine installation corridor to the landfall), several important modifications to the waves may result due to the interactions between the deep water waves and the seabed, with the resultant modifications producing shallow water waves. These physical ‘wave transformation’ processes include shoaling, refraction, breaking and energy loss due to bottom friction. As a result of increased depths in the nearshore region, the shoreline will be subject to the full force of waves from the North Sea with limited attenuation before they reach the cliff line.

At the English landfall site, the short, medium, long-term SMP policy between Tyne to Flamborough Head is for No Active Intervention (NAI) for the unprotected cliff. In the medium term (up to 2055), the extent of shoreline retreat is predicted to be approximately 52 m, 75 m and 98 m for the 95%, 50% and 5% percentile confidence limit under a NAI scenario (Environment Agency, 2022).

7.6 Appraisal of Potential Impacts

This section discusses the potential impacts on the identified physical environment receptors during installation, operation (including maintenance and repair), and decommissioning phases of the Marine Scheme as presented in Chapter 2:Project Description. The appraisal has been undertaken in accordance with the methodology presented in Chapter 4: Approach to Environmental Appraisal.

An overview of the potential impacts considered as part of this appraisal is provided in Table 7-9.

Table 7-9: Potential impacts

Phase	Activities	Sub Activities	Potential Impacts
Installation	Pre-Installation	Sea trials	Temporary seabed disturbance and increases in suspended sediment concentrations as a result of trialing of cable burial tools.
		Route clearance	Temporary seabed disturbance due to:

Phase	Activities	Sub Activities	Potential Impacts
	Cable Installation	(various methods depending on seabed)	• The movement and/or partial disturbance of sandwaves and sandwave fields by plough or Mass Flow Excavator; • Displacement and removal of debris and boulders by grapple lay runs and boulder clearance; and • Removal of out of service (OOS) cables using a de-trenching grapnel will temporarily leave an open trench. Possible localised permanent seabed disturbance due to the displacement and removal of boulders. Water contamination due to release of contaminants (e.g. heavy metals, hydrocarbons) held in pore water within the seabed sediments into the water column.
		Cable laying	Cable laying will have no significant impact on the seabed or any associated physical processes.
		Cable burial	Sediment suspension: Cable burial techniques may cause the sediment to become suspended, increasing turbidity and potentially smothering sensitive habitats and altering the seabed bathymetry once the sediment is re-deposited having been transported in suspension.
		Cable protection (various methods depending on seabed including rock placement)	Seabed morphology alteration: The seabed profile may be raised in certain locations due to the placement of protective material (e.g. rock placement or concrete mattressing) which will remain in place for at least the lifetime of the cables. Localised scour may develop about these protective materials
		Cable crossings	Seabed morphology alteration: The seabed profile will be raised due to the placement of material which will remain in place for at least the lifetime of the project. Scour likely to develop around the edge of placed rock or concrete mattresses where embedded mitigation options cannot be used.
		HDD Installation	Seabed disturbance: HDD will be used for cable installation at landfall and therefore there will be no disturbance in the intertidal zone. However, the excavation of the exit pit at the subtidal breakout point will cause localised seabed disturbance resulting in sediment suspension. Water contamination: Fluid discharges will be released to the sea during HDD activities. However, biodegradable drilling fluids (classified as PLONOR (Posing Little Or NO Risk to the environment) substances) will be used, drilling fluids will be tested for contamination to determine possible reuse or disposal; and if disposal is required, drilling fluids would be transported by a licensed courier to a licensed waste disposal site.
		Anchor deployment	Seabed disturbance: During cable installation in waters < 10 m deep, anchors will be used which will impact various points of the seabed up to 1.5 km from the vessel.
Operation (including maintenance and repair)		Physical presence of cable and cable protection	For at least the lifespan of the project the seabed morphology will be raised where cable protection is emplaced.

Phase	Activities	Sub Activities	Potential Impacts
			Changes to the metocean regime.
		Repairs and monitoring surveys	Potential impacts (on seabed bathymetry, bedforms and suspended sediment concentration), are the same as those described for the main installation activities. Cable exposure due to storm events requiring monitoring and potentially localised cable protection. Water contamination: Caused by the disturbance of the seabed may lead to the re-dissolution of contaminants (e.g. heavy metals, hydrocarbons) held in pore water within the seabed into the water. No samples collected during the benthic survey of the marine installation corridor exceeded Cefas Action Level 2, with the concentrations reported within background levels reported from a Marine Scotland monitoring station in the Firth of Forth and a Clean Safe Seas Environmental Monitoring Programme (CSEMP) station at Tyne/Tees ((Fugro, 2021b)).
Decommissioning		Cable/ cable protection removal	The impacts described for cable installation are applicable to the decommissioning phase of the Marine Scheme.
Cable installation, operation and maintenance, and decommissioning activities			Coastal processes and geomorphology: Seabed disturbance and associated increase in suspended sediment concentrations and deposition; scour around cable protection. Changes to these physical processes could lead to changes to coastal geomorphology. However, the EAR below finds that the magnitude of these impacts are minor to negligible as they are highly localised and therefore have a **negligible** effect, which is **not significant**, on coastal geomorphology.

7.6.1 Embedded Mitigation

A range of embedded mitigation measures have been proposed to minimise potential interactions of the Marine Scheme with the physical environment. These include the following in Table 7-10, which are also outlined in Chapter 2: Project Description.

Table 7-10: Physical Environment Embedded Mitigation

Measure	Description
Pre-Installation	
Micro-routeing	Detailed route development and micro-routeing to be undertaken within the marine installation corridor to avoid or minimise localised engineering and environmental constraints. Changes to the sedimentary and metocean environments will be minimised through micro-routing within the marine installation corridor (i.e. to avoid obstacles such as major aggregations of boulders on the seabed)the use of appropriate burial techniques and cable protection methods such as fall pipes for rock placement
Profile of rock berms	The profile of rock berms will be designed to minimise the potential for scour to occur as much as possible. Adopting such a best practice approach will reduce the impact associated with elevated suspended sediment concentrations due to localised scouring at the edge of berms from minor to negligible and is to be implemented where practicable.

Measure	Description
Safety legislation	Vessels associated with all phases of the Marine Scheme will: ▪ Follow the International Convention for the Prevention of Pollution from Ships (MARPOL) regulations; ▪ All vessel wastes will be managed in accordance with the requirements set out within the International Convention for the Prevention of Pollution from Ships (MARPOL) (the discharging of contaminants is not permitted within 12 nm from the coast to preserve bathing waters); ▪ Vessel contingency plans for marine oil pollution in the form of Shipboard Oil Pollution Emergency Plan (SOPEP) and chemical handling procedures will be in place.
Installation	
Cable burial	Minimum cable burial depth of 0.6 m, with a target cable burial depth of 1.5 m. .
Landfall installation	Horizontal Directional Drilling (HDD) will be used at both landfalls to install the cables beneath the shallow subtidal and the intertidal (between MHWS and MLWS) zone to the landfall. This will keep sediment disturbance to a minimum, significantly reduce (if not avoid) the use of cable protection measures close to shore and avoid directs on sensitive coastal and intertidal habitats and features.
Operation (including maintenance and repair)	
Existing monitoring programmes	The Marine Scheme will be monitored via existing monitoring programmes, such as the Coastal Explorer programme designed by the East Riding Yorkshire Council (ERYC) and data from the Scottish Coastal Observatory.

7.6.2 Installation Phase

Various cable installation and cable protection measures are currently being considered; as detailed in Chapter 2: Project Description, these include surface lay of the subsea cables followed by post-lay burial in two trenches. For the purpose of this appraisal of potential impacts on the physical environment, laying in two trenches is the worst-case scenario considered, resulting in the greatest overall seabed disturbance. A number of seabed installation methods may be used, depending upon seabed conditions and wider engineering constraints. The method with the widest swathe of direct footprint is the displacement plough, however, its use will be limited to small sections of the cable route, where hardness of seabed does not allow use of other trenching methods.

7.6.2.1 Changes to Seabed Bathymetry in water depths > 10 m

This section considers the potential impacts of the Marine Scheme on the wider seabed bathymetry, any sensitive features (such as sandbanks, sandwaves and protected features) within the marine installation corridor. Beyond the 10 m CD contour, hydrodynamic processes will be dominated by tidal currents. Whereas, in the shallower water (<10 m), wave processes will also be important. The 10 m contour has therefore been used to differentiate between shallow water and deeper water settings.

During pre-installation activities, there is potential for temporary seabed disturbance as a result of surveys and sea trials of equipment.

Vibrocore and cone penetration test samples taken pre-construction will locally disturb the bed. The seabed is considered to have low sensitivity as natural wave and tidal action will cause sediment to evenly disperse and return the bed to equilibrium conditions. Due to the relatively small scale of the area disturbed (i.e. 1-2 m diameter) compared to the 500m width of the marine installation corridor and given that the separation between supplementary samples along the route is likely to be much greater than this, the magnitude of this disturbance is considered low and the effect is **negligible** and therefore **not significant**.

Cable installation will result in temporary disturbance to the seabed. Cable route clearance will include the removal of sandwaves by ploughs and Mass Flow Excavator (MFE), with impact swathes between 15 - 25 m. Smaller-scale sandwaves (and smaller bedforms i.e., ripples and megaripples) may be removed during route clearing activities. Larger sandwaves and sandwave fields are likely to only be partially disturbed.

The sensitivity of sandwaves and sandwave fields is considered low as the temporary nature of the proposed works within the project footprint are not likely to influence the overall form and function of the bedform system which can be expected to recover through natural sediment transport processes in the short to medium term. Therefore, the magnitude of the impact is considered low, and the effect is **negligible** and therefore **not significant**.

Displacement of seabed debris and boulder removal during grapnel runs (with a swathe of impact 5-10 m) and boulder clearance activities will cause potentially permeant disturbance to the seabed bathymetry. Seabed disturbance of this kind will be localised and despite the potential permanent nature of the change, the magnitude of the impact is considered low and the effect is **negligible** and therefore **not significant.**

Changes to seabed bathymetry (water depths >10 m) caused by cable crossing and cable protection emplacement

There are a number of locations along the marine installation corridor where cable burial is not possible due to the (up to) seven cable crossing points or hard substrates where there is insufficient sediment cover. Therefore, cable protection such as rock placement and concrete mattresses will be used to protect the cable. Rock placement will be minimised. Analysis of potential to modify target burial depth, exact installation methodology and/or repeat burial as mitigation options will be considered first, with rock placement a 'last resort'.

Where rock placement is required to protect an exposed or shallow buried cable, the height and width of these berms will be kept to a safe minimum, typically a height of 0.5 m to 0.8 m (but potentially up to 1 m), with a width of 6 to 8 m. Up to 63 km of berm will be required for the protection of the cables, including contingency, with a further 7 km estimated for all cable and pipeline crossings. Table 7-11 and Table 7-12 detail rock placement locations. The total volume of rock to be used is 200,545 m^3 (267,393 tonnes).

Mattresses comprise prefabricated articulated concrete structures made of individual blocks connected by ropes or straps. These can be placed directly on top of a cable to stabilise and provide protection. Up to 300 mattresses may be required to protect the subsea cable at cable and pipeline crossings.

Standard mattress dimensions are 6 m by 3 m and footprint parameters are shown in Table 7-13.

At each location where cable protection is used, the seabed profile will be raised due to the placement of material which will remain in place for at least the lifetime of the Marine Scheme (40 years).

Table 7-11: Rock placement locations associated with rock outcrops and boulders

Territorial Waters	Start KP	End KP	Distance
Scotland	0.739	0.749	0.010
Scotland	2.300	4.920	2.620
Scotland	5.171	5.188	0.017
Scotland	5.200	5.213	0.013
Scotland	5.254	5.268	0.014
Scotland	5.290	5.307	0.017
Scotland	5.842	5.856	0.014
Scotland	6.026	6.046	0.019
Scotland	6.064	6.071	0.006
Scotland	6.274	7.797	1.523
Scotland	15.700	18.400	2.700

Territorial Waters	Start KP	End KP	Distance
Scotland/ UK	30.500	39.500	9.000
UK	47.980	48.365	0.385
UK	48.900	51.900	3.000
UK	65.100	74.100	9.000
UK	74.600	77.500	2.900
UK	78.400	80.900	2.500
UK	81.720	82.320	0.600
UK	84.800	85.000	0.200
UK	85.000	88.510	3.510
UK	85.550	86.400	0.850
UK	90.400	91.344	0.944
UK	90.600	94.400	3.800
UK	91.900	92.500	0.600
UK	93.000	94.270	1.270
UK	95.900	96.300	0.400
UK	97.000	97.700	0.700
UK	97.700	99.000	1.300
UK	98.500	99.400	0.900
UK	99.500	102.000	2.500
UK	116.100	117.400	1.300
UK	167.814	167.897	0.083
UK	168.175	168.205	0.030
UK	168.178	168.657	0.417
UK	168.705	169.311	0.606
UK	169.969	170.077	0.108
UK	170.213	171.848	1.635
UK	171.929	171.949	0.019
UK	172.418	173.000	0.582

Table 7-12: Rock placement locations associated with crossing points

ID	KP	Asset	Owner	Type	Status	Assumed length (km)	Volume (m3), using 7.5m3/m	Weight (Tonnes), using 10T/m
1&2	Landfall approximately 3 km north of KP 1	Berwick Bank Offshore Wind Farm	SSE	Power	Planned	0.50	3750	5000
3	128.8	NSL North Interconnector	NGV	Power	Installed	0.50	3750	5000
4	128.9	NSL South Interconnector	NGV	Power	Installed	0.50	3750	5000
5	137.4	Havingsten 2.1 North	Alcatel Submarine Networks (ASN)	FO	Installed	0.50	3750	5000
6	141.4	Havingsten 2.1 South	Alcatel Submarine Networks (ASN)	FO	Planned	0.50	3750	5000
7	135.4	NO-UK Fibre Optic Cable System	Altibox Carrier	FO	Installed	0.50	3750	5000

Table 7-13: Concrete mattress footprint parameters

Aspect	Parameter	Value	Notes
Mattresses (cable and pipeline crossings)	Number	Up to 300	
	Footprint	Up to 5,400 m^2	Assumes mattress of 6 m by 3 m x 300
Mattresses (HDD breakouts)	Number	Up to 20	
	Footprint	Up to 360 m^2	Assumes mattress of 6 m by 3 m x 20

Scour can develop around the edge of cable protection, (Larsen *et al*., 2018), or where the rock or concrete mattress placement causes an increase in local current velocity around the structure to above the critical velocity for sediment transport. Where possible, best practice can be used in the layout design of the rock protection to minimise scour, for example Larsen *et al.* (2018) found that scour was reduced around berms built parallel or near parallel to the current direction. Profiling may also be used to similar effect where alignment is not appropriate.

Assuming it is not possible or practical to implement best practice, the magnitude of the impact due to elevated suspended sediment concentrations as a result of localised scour would be low and the effect is appraised as **negligible** and therefore **not significant**.

7.6.2.2 Changes to seabed bathymetry in water depths < 10 m

Changes to seabed bathymetry (water depths <10 m) caused by anchor deployment

It is anticipated that installation vessels will primarily use dynamic positioning to maintain vessel position during installation operations in water depths greater than 20m. The use of anchor spreads will therefore not be required in these deeper areas. Dynamically positioned vessels will not disturb the seabed in water > 20 m deep (National Grid NSN Link, 2014).

Anchors are however likely to be used to maintain the position of vessels in shallow waters (i.e. landward of the 20 m CD depth contour) impacting various points of the seabed up to 1 km from the vessel.

Between KP 2 – KP 5 off the Scottish landfall, in water depths less than 20 m CD, there is an area of sandwaves / megaripples which may be impacted by anchor deployment. There are no sandwaves or megaripples within water depths < 20 m CD at Seaham. The areas of seabed disturbed by anchor deployment are small and highly localised in relation to the scale of the sandwaves, therefore the magnitude of the impact is considered low. The sensitivity of these bed features is considered to be low as sediment transport, at these depths will be driven primarily by tidal action. The timescale for impact recovery of the seabed will be less than the 7-day interval between spring and neap tides which can be considered as short-term and low magnitude. The significance of the effect is appraised as **negligible** and therefore **not significant**.

Changes to seabed bathymetry (water depths <10 m) caused by HDD

At both landfalls, HDD techniques will be used to minimise the impact of sediment disturbance in the intertidal zone during cable installation. However, the excavation of the exit pit at the breakout is estimated to cause a 5000 m^2 (40 m radius) area of seabed disturbance due to the excavated sediment being side casted. A similar area may be disturbed by a section of backhoe trenching at this location over distance of up to 200m with a 30m wide swathe. Chapter 2: Project Description, Figure 2-14 and Figure 2-15 show the potential breakout areas at the Scottish and English landfall sites. The magnitude of the impact at both locations is considered to be medium, as the volume of material spread over the area affected will be relatively small. There are no sandwaves or sandbanks in the vicinity that might be impacted, and therefore the sensitivity of the potentially impacted area is considered low. Sensitivity is also considered low due to the dynamic nature of the seabed where sediment driven by natural wave and tidal action will evenly disperse and return the bed to equilibrium conditions following exposure to the strongest tidal currents within a 15-day spring-neap tidal cycle. The effect is appraised to be **minor** and therefore **not significant.**

7.6.2.3 Suspended sediment

As previously described, cable burial in water depths deeper than the 10 m CD contour will result in disturbance of the seabed and a proportion of the sediment from the seabed will be suspended into the water column, including nearshore bathing waters. For shallower areas where the seabed is disturbed (i.e. up to the 4m CD depth contour), the extent of any impact due to suspended sediment is expected to be consistent with that calculated for deeper water. However, the magnitude of tidal currents will be reduced in shallower water due to the influence of bed friction, although, there will also be the additional effect of wave-induced currents. The tidal component of the local current has not therefore been reduced for shallow water conditions to allow for such wave effects. Any seabed disturbance will result in temporary increases in near-bed suspended sediment concentration (SSC) which could provide an adverse impact on water quality. Once sediment is redeposited onto the bed it may impact nearby sensitive habitats due to smothering. Sediment deposition may also alter seabed morphology. Preliminary calculations have been carried out to estimate the extent of sediment dispersion before deposition and establish the magnitude of these potential impacts. These are described below.

The quantity of sediment ejected from trenching activities associated with the equipment used can be estimated using the parameters listed in Table 7-14. The installation speed is likely to be variable depending on the soils encountered and the type of trencher used. Therefore, a range between 300 m/h (National Grid NSN Link, 2014) to 500 m/h (which accounts for cable laying without simultaneous cable burial) is considered. Based on these values the rate of sediment ejected from one trench has been calculated (Table 7-15). As the worst case scenario may be burial in two trenches, the expected amount of ejected sediment may be twice the amount calculated.

Table 7-14: Trench parameters and proportion of sediment re-depositing into the trench after trenching

Trench Parameters	Proportion
Proportion of sediment falling directly back into trench (plough)	95 %
Proportion of sediment falling directly back into trench (trenching – jetting or mechanical)	80 %
Installation speed	300 - 500 m/h
Trench width	1 - 6 m
Trench depth	0.6 - 1.5 m

Source: < National Grid NSN Link (2014)>

Table 7-15: Rate of sediment ejected from the trench

Trenching method	300 m/h installation speed	500 m/h installation speed
Ploughing	0.2 - 2.3 m^3/minute	0.2 - 3.7 m^3/minute
Trenching – jetting or mechanical	0.6 - 9 m^3/minute	0.99 - 14.94 m^3/minute

Source: < AECOM (2021)>

The settling velocity (w_s) of coarse and fine sand was estimated using Soulsby's (1997) equation:

$$w_s = \frac{v}{d}[\left(10.36^2 + 1.049{D_*}^3\right)^{\frac{1}{2}} - 10.36$$

where v is the kinematic viscosity of water, d is the median grain size and D_* is the dimensionless particle diameter. Based on the settling velocity, the time required for the different grain sizes to fall 5 m was also estimated. Next, the velocity for the bottom 2 m of the water column (0.34 m/s) was estimated based on the depth average velocity (0.45 m/s), so that the distance travelled before deposition (based on flow velocity estimated for the bottom 2 m of the water column) could be estimated. The results are displayed in Table 7-16.

Table 7-16: Estimates of sediment settling velocity and upper limit of distance travelled before deposition

Grain size	Dimensionless particle diameter	Settling velocity (m/s) (Soulsby, 1997)	Time required to fall 5 m (secs)	Distance travelled before reaching seabed (based on flow velocity estimated at 2 m above the bed)
Coarse sand (0.000125 m)	2.54	0.0087	580	200
Fine sand (0.00005 m)	1.02	0.0014	3,470	1,400
Silt (0.000005 m)	-	0.0005[1]	10,000	3,400

Note 1. Soulsby formula applicable for non-cohesive sediments only. A typical settling velocity equivalent to 0.5 mm/s is assumed for silt particles.

The distance travelled by suspended coarse sand before deposition, will remain within the marine installation corridor (which is 500 m wide) based on the 200 m travel distance referred to in Table 7-16. Fine sands and silts will however be transported beyond the marine installation corridor, with any fine sand settling on the seabed up to 1.4 km from the point where it is mobilised. Based on the calculated settling velocities any silt-sized material will remain in suspension for several days and may therefore travel significant distances, similar to the tidal excursion distances referred to in Section 7.5.2.4. However, given that dispersion processes will also act to dilute the concentration of silt carried in suspension, elevated concentration levels at a distance of 1.4 km from the source will be negligible.

There will be no significant elevated concentration levels beyond the travel distance calculated for fine sand, 1.4 km from the point of sediment mobilisation within the marine installation corridor.

Based on these calculations, the magnitude of the impact is considered low as any measurable change in suspended sediment concentrations will be temporary and localised, i.e. mostly within the bottom 5 m of the water column and also within the extent of the marine installation corridor. The finer fractions that are transported further will be diluted so that the suspended sediment concentration will be low and the deposition thickness on the seabed, where the sediment is able to settle, will be negligible. Therefore, the effect inside and outside of the cable corridor is appraised as **negligible** which is **not significant**.

As previously described, the excavation of the HDD exit pit will disturb the seabed sediment, which may cause sediment suspension and associated increase in turbidity in water depths < 10 m.

The sediment at the Scottish landfall consists of gravel, sand, rock platform and a man-made surface, while sediment at the English landfall is sand. Any sediment suspended will be coarse enough that it will be transported up to 40 m before being redeposited. Due to the temporary nature of the works, and the limited extent of sediment dispersion caused by HDD activities, the magnitude of the impact is considered to be minor. There are no sandwaves or sandbanks in the vicinity that might be impacted, and the sensitivity of the potentially impacted area is considered low. The effect is appraised as **negligible** and therefore **not significant**.

7.6.2.4 Impact on water quality

Cefas (2005) explain that seabed disturbance can cause the re-dissolution of contaminants (e.g. heavy metals, hydrocarbons) held in pore water within the seabed back into the ocean.

The sensitivity of the deeper water (>10 m water depth) environment to the re-dissolution of low quantities of contaminant concentrations that are generally found in offshore sediments (Intertek, 2012) is considered low. Contaminant levels in the samples from the marine installation corridor were generally below Cefas Action Level 1, with the exception of a small number of samples, which were within locally reported background levels. Based on this, the magnitude of the impact is also considered low. The effect is appraised to be **negligible** and therefore **not significant**.

In the shallow water setting (<10 m water depth), the water quality assessment for 2021 has been classified as ‘excellent’ at both Scottish and English landfalls (EA, 2021; SEPA, 2021). It has therefore been assumed that the natural suspension of sediment regularly experienced in the nearshore environment due to current and wave action, is not associated with the re-dissolution of contaminants. As such, it is expected that the magnitude of the impact of re-suspension of sediment caused by cable installation activities in the nearshore environment, resulting re-dissolution of contaminants is **low**. The effect of the impact is appraised to be **negligible** and therefore **not significant**.

7.6.2.5 Changes to Metocean Regime

Installation activities and the presence of vessels and other equipment will be relatively small-scale and transient; thus, the impact magnitude is considered low. These activities will have no substantive effect on the metocean regime including water levels (tidal and surge levels), currents and waves, considered to have a low sensitivity. The effect of any impact is appraised to be **negligible** and therefore **not significant**.

7.6.3 Operation Phase

7.6.3.1 Changes to seabed bathymetry, bedforms and suspended sediment concentration

Potential impacts (on seabed bathymetry, bedforms and suspended sediment concentration) caused by operation and maintenance activities, are the same as those described for the main installation activities, but on a much smaller scale. Therefore, the magnitude of the impacts associated with repair works and surveys carried out during the operation phase are considered low. The sensitivity of both the nearshore and offshore environments to these impacts is also considered low and the effects of the impact are appraised to be **negligible** and therefore **not significant**.

7.6.3.2 Impact of cable exposure

Throughout the operational lifespan of the cable, rock or mattress protection may partially fail under extreme storm conditions, exposing the cable. As a result, cable movement might occur along the exposed section which may cause seabed agitation and sediment suspension. Cable exposure and any associated impacts will be limited by the extent of the protection that is damaged since beyond these limits the cable will be buried. The lateral extent of cable movement leading to disturbance of the seabed will also be limited since it can be considered as fixed when buried. This effect will also be transient as remedial works will be carried out to reinstate the cable protection where this is identified by planned monitoring activities. Therefore, the magnitude of this impact is considered low. The sensitivity of both the nearshore and offshore environments to this impact is considered low and the significance of the effect is appraised to be **negligible** and therefore **not significant**.

7.6.3.3 Water contamination

The effect of water contamination is the same as described for the main installation activities but on a much smaller scale. Quantities of any operational discharges and dissolved contaminants will be small relative to the other direct inputs to the water column making the magnitude of the impact low, therefore, the effect of associated impacts is considered to be **negligible** and therefore **not significant**.

7.6.3.4 Changes to metocean regime

Those parts of the cable which are buried will cause no changes to the metocean regime, such as water levels, waves and currents, throughout the lifespan of the cables. Where rock placement or mattresses are used, there may be very localised changes to tidal or wave-induced currents, for example associated with localised scour around the protection. Any such local changes will be immeasurable in the wider environment, and the presence of the cable protection will cause no changes to the wider metocean regime which is appraised to have low sensitivity. The associated effects are considered to be **negligible** and therefore **not significant**.

7.6.4 Decommissioning Phase

Cables in the UK territorial waters are installed on The Crown Estate and Crown Estate Scotland land and therefore a lease or licence is generally entered into for a set term, in this case, 40 years.

At the end of the cable's life the options for decommissioning will be evaluated. There is the option for the cable to be left in place if the environment is best served by doing so, recognising that recovering cables may lead to more damage to the physical environment or other seabed interests compared to leaving them in place. The worst-case scenario in terms of potential impacts would be the full removal of the cables, with similar impacts to construction.

7.6.5 Environmental Risks (Unplanned Events)

Due to natural cycles and global warming, the baseline environment is expected to exhibit some degree of change over time, with or without the Marine Scheme in place. Therefore, it is important to consider any potential impacts on the marine environment as a result of the climate change that might occur over the timescale of the development during the design stage. For the RCP8.5 scenario 95th percentile case, sea level rise from 2027 is 0.42 m (English landfall) and 0.38 m (Scottish landfall) in 2067, allowing for the 40 years design life for the development. The resulting increase in water depth will allow larger waves to reach nearshore areas. Cable protection in these areas will therefore need to consider these larger waves in the future within the design which may involve using larger rock than would be required for a design based on present-day conditions.

Climate change and associated increase in storm events and storm severity has the potential to cause greater coastal erosion which in turn could increase the risk of cable exposure. Where the cable makes landfall, changes to the coastline’s infrastructure, such as flood defence installation or modification, may alter the baseline conditions that the appraisal presented here is based on. As above, these are issues that will need to be considered during the design stage, for example, by providing a suitable buffer distance allowing for higher rates of coastal erosion than predicted for present-day conditions before confirming the most suitable location for the onshore cable jointing bay.

7.7 Mitigation and Monitoring

No significant effects are predicted on physical environment receptors as a result of the Marine Scheme installation, operation (including maintenance and repair) and decommissioning; therefore, no additional specific mitigation measures are required.

7.8 Residual Impacts

No residual impacts are anticipated from either the installation, operation or decommissioning stages of the Marine Scheme.

7.9 Cumulative and In-Combination effects

The full cumulative and in-combination effects appraisal is presented in Chapter 16: Cumulative and In-Combination Effects.

This includes a matrix (Table 16-6) to identify potential physical environment impact pathway interactions between the Marine Scheme and the English and Scottish Onshore Schemes. No interaction is anticipated between the Marine Scheme and the English and Scottish Onshore Schemes. There are no project activities associated with the English and Scottish Onshore Schemes within the marine environment due to the use of HDD at the landfalls.

In-combination effects are where receptors could be affected by more than one environmental impact. Where a receptor has been identified as only experiencing one effect or where only one topic has identified effects on that receptor, there is no potential for in-combination effects. The receptor groups within this chapter do not interact between chapters, therefore receptors have been wholly appraised within this respective topic chapter.

7.10 Summary of Appraisal

A summary of the findings of the appraisal is provided in Table 7-17 below.

Table 7-17: Summary of environmental appraisal

Project Phase	Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Project Specific Mitigation	Significance of Residual Effect
Pre-Installation: Sea trials	Temporary seabed disturbance	Seabed and bedforms	Low	Low	**Negligible**	None required	**Negligible** which is **not significant**
	Increase in suspended sediment concentrations	Water column	Low	Low	**Negligible**	None required	**Negligible** which is **not significant**
Pre-Installation: Surveys	Temporary seabed disturbance	Seabed and bedforms	Low	Low	**Negligible**	None required	**Negligible** which is **not significant**
Cable Installation: Route clearance	Temporary seabed disturbance: Destruction – partial disturbance of sandwaves and sandwave fields.	Seabed and bedforms	Low	Low	**Negligible**	None required	**Negligible** which is **not significant**
	Localised permanent seabed disturbance due to Displacement and removal of debris and boulders.	Seabed morphology	Low	Low	**Negligible**	None required	**Negligible** which is **not significant**
	Water contamination	Sea water	Low	Low	**Negligible**	None required	**Negligible** which is **not significant**
Cable Installation: Cable burial	Increase in suspended sediment concentrations and redeposition onto seabed changing seabed morphology *inside* installation corridor	Seabed morphology	Low	Low	**Negligible**	None required	**Negligible** which is **not significant**
	Increase in suspended sediment concentrations and	Seabed morphology	Low	Low	**Negligible**	None required	**Negligible** which is **not significant**

Project Phase	Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Project Specific Mitigation	Significance of Residual Effect
	redeposition onto seabed changing seabed morphology *outside* installation corridor						
Cable Installation: Cable protection	Scour about the rock placement and concrete mattressing built parallel or near parallel to the current direction	Seabed morphology and possible reduction in integrity of cable protection	Low	Low	**Negligible**	None required	**Negligible** which is **not significant**
Cable Installation: HDD installation/ pit excavation	Nearshore seabed disturbance	Nearshore Seabed morphology	Low	Medium	**Minor**	None required	**Minor** which is **not significant**
	Increase in suspended sediment concentrations and redeposition onto seabed changing seabed morphology	Seawater and seabed morphology	Low	Low	**Negligible**	None required	**Negligible** which is **not significant**
	Water contamination	Seawater	Low	Low	**Negligible**	None required	**Negligible** which is **not significant**
Cable Installation: Anchor deployment	Seabed disturbance	Seabed	Low	Low	**Negligible**	None required	**Negligible** which is **not significant**
Operation (including maintenance and repair): Physical presence of cable and cable protection	Seabed morphology raised causing impact on wider metocean regime	Metocean regime	Low	Low	**Negligible**	None required	**Negligible** which is **not significant**

Project Phase	Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Project Specific Mitigation	Significance of Residual Effect
Operation (including maintenance and repair): Repairs and monitoring surveys	Changes to seabed bathymetry	Seabed and bedforms	Low	Low	**Negligible**	Post-construction monitoring will be undertaken along the length of the marine installation corridor with a particular focus on areas where cable protection is used.	**Negligible** which is **not significant**
	Cable exposure – increased SSC due to cable movement	Seawater	Low	Low	**Negligible**		**Negligible** which is **not significant**
	Water contamination caused by the disturbance of the seabed can lead to the re-dissolution of contaminants	Seawater quality	Low	Low	**Negligible**		**Negligible** which is **not significant**
Decommissioning Phase				Potential effects of decommissioning the same as route preparation and cable installation			

7.11 References

ABPmer. (2008). *Atlas of UK marine renewables resources*. Retrieved from https://www.abpmer.co.uk/experience/atlas-of-uk-marine-renewable-energy-resources/

ABPmer. (2012). *Marine Scotland Licensing and Consents Manual covering marine renewables and offshore wind energy development. Report commissioned for Marine Scotland.*

ABPmer and HR Wallingford. (2009). *Coastal Process Modelling for Offshore Wind farm Environmental Impact Assessment: Best Practice Guide. Produced for COWRIE.*

Admiralty TotalTide . (n.d.). Retrieved from https://www.admiralty.co.uk/digital-services/admiralty-digital-publications/admiralty-totaltide

Babtie Group. (2004). *East Lothian Council - Shoreline Management Plan.*

Babtie Group and ABP. (2002). *East Lothian Council - Shoreline Management Plan: Final Report .*

BERR. (2008). *Review of Cabling Techniques and Environmental Effects applicable to the Offshore Wind farm Industry .*

British Standards Institute (BSI). (2015). *Environmental Impact Assessment for Offshore Renewable Energy Projects – Guide.* Retrieved February 2021, from http://shop.bsigroup.com/upload/271276/PD%206900.pdf

Canadian Council of Ministers of the Environment. (2001). *Canadian Sediment Quality Guidelines for the Protection of Aquatic Life*. Retrieved from https://www.pla.co.uk/Environment/Canadian-Sediment-Quality-Guidelines-for-the-Protection-of-Aquatic-Life

Cefas. (2004). • *Offshore wind farms: guidance note for Environmental Impact Assessment in respect of Food and Environmental Protection Act (FEPA) and Coast Protection Act (CPA) requirements: Version 2 .*

Cefas. (2011). *Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects.*

Cefas. (2012). *Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects.*

Cefas. (2016). *Suspended sediment climatologies around the UK.*

Defra. (2005). *Nature Conservation Guidance on Offshore Wind Farm Development.*

Department for Environment Food & Rural Affairs. (2022). *Swimfo: Find a bathing water*. Retrieved from Department for Environment Food & Rural Affairs: https://environment.data.gov.uk/bwq/profiles/

Dynamic Coast. (n.d.). *Dynamic Coast interactive GIS maps*. Retrieved from http://www.dynamiccoast.com/webmap.html

Dynamic Coast interactive GIS maps. (n.d.). Retrieved from http://www.dynamiccoast.com/webmap.html

ECMWF. (n.d.). *European Centre for Medium-range Weather Forecast: historic wind speed and wave data sets*. Retrieved from https://www.ecmwf.int/

Environment Agency. (2016). *Flood Risk Assessments: Climate Change Allowances.*

Environment Agency. (2018). *Coastal Flood Boundary Dataset (CFBD)*. Retrieved from https://data.gov.uk/dataset/73834283-7dc4-488a-9583-a920072d9a9d/coastal-design-sea-levels-coastal-flood-boundary-extreme-sea-levels-2018

Environment Agency. (2020). *Swimfo*. Retrieved from https://environment.data.gov.uk/bwq/profiles/

Environment Agency. (2022). *National Coastal Erosion Risk Mapping (NCERM)*. Retrieved from https://data.gov.uk/dataset/7564fcf7-2dd2-4878-bfb9-11c5cf971cf9/national-coastal-erosion-risk-mapping-ncerm-national-2018-2021

Environment Agency. (n.d.). *Flood Risk Assessments: Climate Change Allowances*. Retrieved from https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Environment Agency. (n.d.). *Water Quality*. Retrieved from https://environment.data.gov.uk/bwq/profiles/

Fugro. (2021a). *Eastern Link Marine Survey - Volume 1 of 6: Geophysical Survey Results.*

Fugro. (2021b). *Eastern Link Marine Survey - Volume 5 of 6 : Benthic Characterisation Survey.*

Fugro. (2021c). *Eastern Link Marine Survey - Volume 4 of 6 : Integrated Geotechnical and Geophysical Report.*

Fugro EMU. (2014). *Review of environmental data associated with post-consent monitoring of licence conditions of offshore wind farms.* Retrieved from https://www.gov.uk/government/publications/review-of-environmental-data-mmo-1031

HM Govenment. (2021). *North East Inshore and North East Offshore Marine Plan.* https://www.gov.uk/government/publications/the-north-east-marine-plans-documents. Retrieved from https://www.gov.uk/government/publications/the-north-east-marine-plans-documents

HMSO. (2003). *Water Environment and Water Services (Scotland) Act 2003.*

HMSO. (2011). *The Water Environment (Controlled Activities) (Scotland) Regulations 2011. Scottish Statutory Instrument 2011 No. 209.*

HMSO. (2011). *UK Mareine Policy Statement.*

Long, D. (2006). *BGS detailed explanation of seabed sediment modified Folk classification.*

Marine Management Organisation. (2014). *Cefas Chemical Action Levels*. Retrieved from https://www.gov.uk/guidance/marine-licensing-sediment-analysis-and-sample-plans###Suitability%20of%20material

MEFEPO. (2019). *North Sea Atlas- Making the European Fisheries Ecosystem Plan Operational.*

Met Office. (n.d.). *UK Climate Projections (UKCP): sea level rise* . Retrieved from https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index

MMT. (2013). *Anglo-Scottish Eastern HVDC Link - Integrated Geophysical & Geotechnical Report.*

National Oceanography Centre BODC . (n.d.). *Tidal levels and current measurements*. Retrieved from https://www.bodc.ac.uk/

Natural England. (2018). *Natural England Offshore wind cabling: ten years experience and recommendations.*

Natural England. (2018). *Natural England Offshore wind energy cabling: ten years experience and recommendations.*

NGET & SPT. (2021). *Scotland to England Green Link (SEGL) ~ Eastern Link 1 Marine Scheme - Scoping Report.* https://marine.gov.scot/sites/default/files/segl_el1_marine_scoping_report_-_base_report_rev_2.0.pdf.

NNRCMP. (2019). *Coastal Wave Network Annual Report.*

North East Coastal Observatory . (n.d.). Retrieved from http://www.northeastcoastalobservatory.org.uk/

Office of the Deputy Prime Minister. (2001). *Guidance on Environmental Impact Assessment in Relation to Dredging Applications.*

RenewableUK. (2013). • *Cumulative Impact Assessment Guidelines - Guiding Principles for Cumulative Impact Assessment in Offshore Wind Farms.*

Royal Haskoning. (2007). *River Tyne to Flamborough Head Shoreline Management Plan 2 .*

RPS. (2020a). *Eastern Link Phase 2 Marine Route Refinement & Selection, Rev07, Project No: EOR0752. March 2020.*

RPS. (2020b). *Berwick Bank Wind Farm Offshore Scoping Report. August 2020.*

RSK. (2020). *Eastern Link – Phase 3: Marine Survey Corridor Development and Selection 661767. May 2020.*

Scottish Environment Protection Agency. (2022). *Bathing Waters results for Scotland* . Retrieved from SEPA: https://www2.sepa.org.uk/bathingwaters/locations.aspx

Scottish Government. (2015). *Scotland's National Marine Plan*. Retrieved from https://www.gov.scot/publications/scotlands-national-marine-plan-9781784128555/

Scottish Government. (2018). *Offshore wind, wave and tidal energy applications: consenting and licensing manual*. Retrieved from https://www.gov.scot/publications/marine-scotland-consenting-licensing-manual-offshore-wind-wave-tidal-energy-applications/

Scottish National Heritage. (2018).

SEPA. (2017). *Water Framework Directive (WFD) classification data*. Retrieved from https://www.sepa.org.uk/data-visualisation/water-classification-hub/

SNH. (2003). *Marine Renewable Energy and the Natural Heritage: An Overview and Policy Statement.*

UK Climate Projections (UKCP). (n.d.). *Sea level rise*. Retrieved from https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index

UK Government. (2020, October). *New Plans to Make UK World Leader in Green Energy*. Retrieved from Prime Minister's Office Press Release: https://www.gov.uk/government/news/new-plans-to-make-uk-world-leader-in-green-energy

UK MetOffice. (2018). *https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/download-data.*

UM Met Office. (2018). *https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/download-data.*