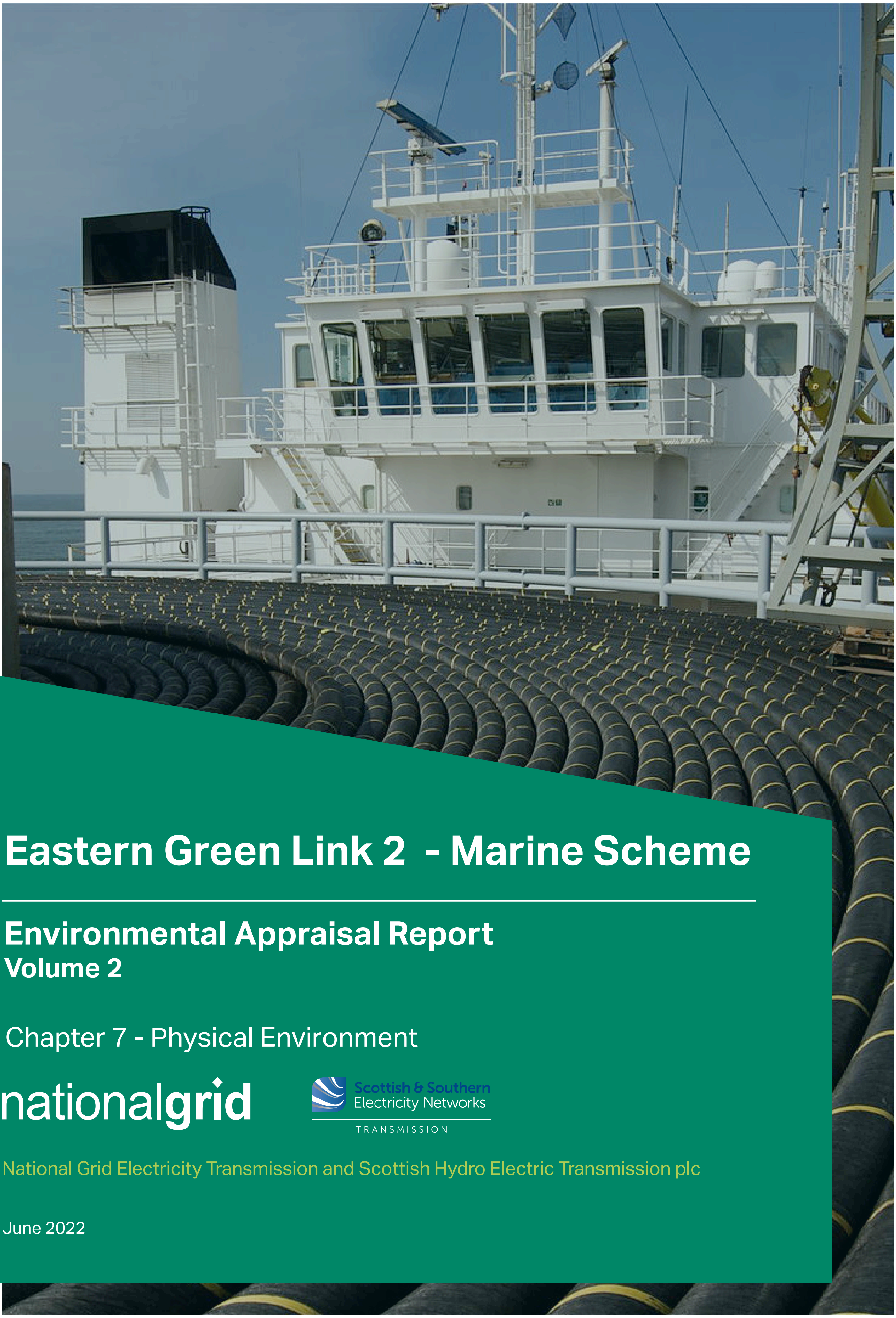

Eastern Green Link 2 - Marine Scheme

Environmental Appraisal Report
Volume 2

Chapter 7 - Physical Environment

nationalgrid

Scottish & Southern Electricity Networks TRANSMISSION

National Grid Electricity Transmission and Scottish Hydro Electric Transmission plc

June 2022

Prepared for:

National Grid Electricity Transmission and
Scottish Hydro Electric Transmission Plc

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Wessex Archaeology (Marine Archaeology); and

Brown and May Marine Ltd (Commercial Fisheries).

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7. Physical Environment

7.1 Introduction

This chapter of this Environmental Appraisal Report (EAR) presents the 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.

A description of the physical environment baseline, as established through desk-based review and geophysical and geotechnical survey data, is presented in Section 7.5. The potential impacts and effects of the Marine Scheme on these receptors are appraised in Section 0 for the Installation, Operation (including maintenance and repair), and Decommissioning Phases of the Marine Scheme, as described in Chapter 2: Project Description.

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.

Impacts on physical environment receptors may also be interrelated with potential impacts on ecological receptors and therefore should be read in conjunction with benthic ecology (Chapter 8), fish and shellfish ecology (Chapter 9), marine archaeology (Chapter 12), Marine Protected Area (MPA) and Marine Conservation Zone (MCZ) Assessment (Appendix 8.2) and Habitats Regulations Assessment (HRA) (Appendix 8.3). Additionally, this chapter is supported by the following documents:

- Appendix 7.1: Water Framework Directive (WFD) Compliance Assessment Report.

7.2 Legislative Context

This section outlines legislation, policy and guidance relevant to the physical environment. For further information regarding the legislative context, refer to Chapter 3: Legislative and Policy Framework and Appendix 3.2: Topic Specific Legislation.

7.2.1 International Legislation

The following international legislation and agreements, in which the UK is a signatory, are of relevance to the planning and execution of the Marine Scheme:

- European Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy – commonly referred to as the Water Framework Directive (European Commission, 2000); and
- European Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of environmental policy (MSFD).

7.2.2 National Legislation

The following national and devolved legislation is relevant to the planning and execution of projects in UK waters, including the Marine Scheme:

7.2.2.1 UK (England and Scotland)

- Marine and Coastal Access Act (MCAA) 2009 (HM Government, 2009).

7.2.2.2 Scotland

- Marine (Scotland) Act 2010 (Scottish Government, 2010);
- Water Environment and Water Services (Scotland) Act 2003 (HMSO, 2003);
- The Water Environment (Controlled Activities) (Scotland) Regulations 2011. Scottish Statutory Instrument 2011 No. 209 (HMSO, 2009), as amended;

- The Environment (EU Exit) (Scotland) (Amendment etc.) Regulations 2019.; and
- The Environment (EU Exit) (Miscellaneous Amendments) (Scotland) Regulations 2019.

7.2.2.3 England

- The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (as amended); and
- The Floods and Water (Amendment etc.) (EU Exit) Regulations 2019.

7.2.3 National Policy

The following national and devolved policies are relevant to the planning and execution of projects in UK waters, such as the Marine Scheme:

7.2.3.1 UK (Scotland and England)

- UK Marine Policy Statement (MPS) (HM Government, 2011).

7.2.3.2 Scotland

- Scottish National Marine Plan (2015) (Scottish Government, 2015).

7.2.3.3 England

- North East Inshore and North East Offshore Marine Plan (HM Government, 2021); and
- East Inshore and East Offshore Marine Plan (HM Government, 2014).

Detailed consideration of the Project Marine Scheme against relevant plan policies is provided within Appendix 3.1: Marine Plan Checklist.

7.2.4 Guidance

Best practice guidelines regarding offshore projects' impact on the physical environment. Although no specific guidance has been developed for offshore cables, the following existing has been used to inform this appraisal of potential effects on the physical environment, insofar as applicable to a cable installation project:

- Environmental Impact Assessment Handbook: Guidance for competent authorities, consultation bodies, and others involved in the Environmental Impact Assessment process in Scotland (SNH, 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);
- 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);
- Guidance on Best Practice for Marine and Coastal Physical Processes Baseline Survey and Monitoring Requirements to Inform EIA of Major Development Projects. (NRW, 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);
- Nature Conservation Guidance on Offshore Wind Farm Development (Defra, 2005);
- Marine Licensing: Sediment Analysis and Sample Plans. Marine Management Organisation. (2014);
- High Level Review of Current UK Action Level Guidance: MMO Project No. 1053 (MMO, 2015);
- ME5226 C7590: Review of Action Levels used for assessing Dredging and Disposal Marine Licences (Cefas, 2018);
- Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (Canadian Council of Ministers of the Environment, 1999);
- 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 Installation Corridor, as shown in Figure 7-1 extends approximately 436 km from Mean High Water Springs (MHWS) at the Scottish landfall, to MHWS at the English landfall.

The Study Area is focussed on the Marine Installation Corridor, although in terms of the physical metocean conditions, the potential Zone of Influence (ZoI) can extend beyond the defined Study Area and environmental baseline conditions have therefore been characterised on a wider regional scale, as appropriate.

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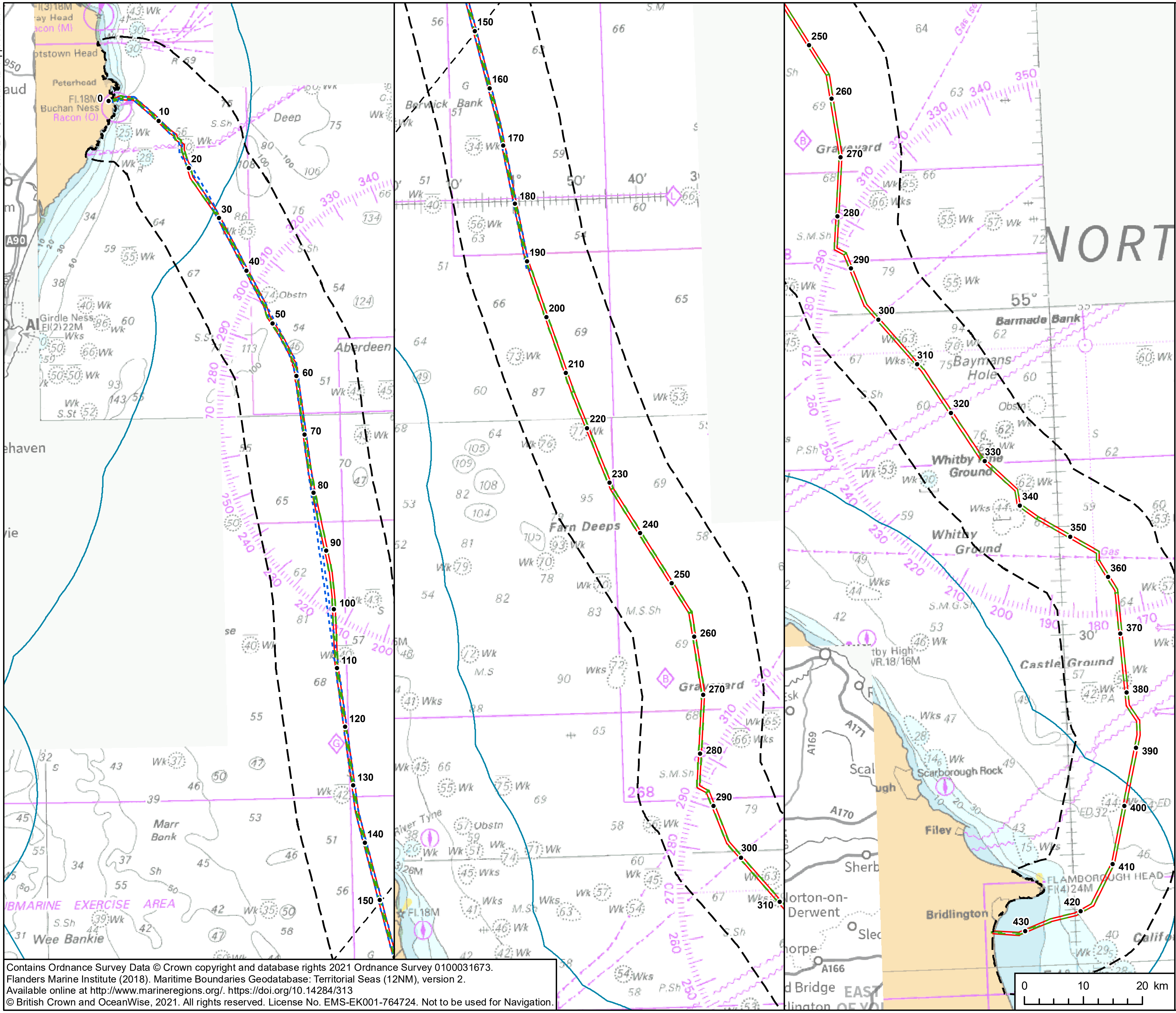

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Flanders Marine Institute (2018). Maritime Boundaries Geodatabase: Territorial Seas (12NM), version 2.
Available online at http://www.marineregions.org/. https://doi.org/10.14284/313
© British Crown and OceanWise, 2021. All rights reserved. License No. EMS-EK001-764724. Not to be used for Navigation.

Coordinate System: ETRS 1989 UTM Zone 30N

0 10 20 km

Scale @ A3 1:600,000

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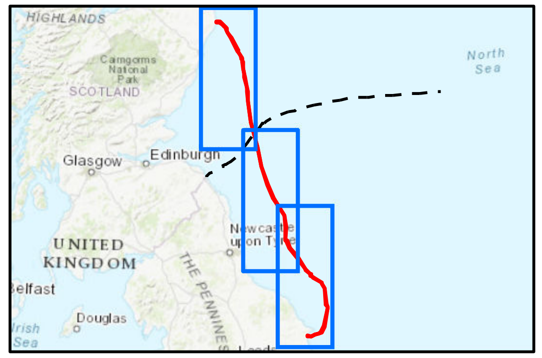
PROJECT

Eastern Green Link 2

KEY

- Marine Installation Corridor and Physical Environment Study Area
- Kilometre Point (KP)
- UK Territorial Sea Limit
- Scottish/English Water Border
- 10km Wider Study Area
- 2012 Survey Area
- 2021 Survey Area



TITLE

Figure 7-1
Physical Environment Study Area

REFERENCE

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SHEET NUMBER | DATE

1 of 1 | 24/06/2022

7.4 Approach to Appraisal and Data Sources

7.4.1 Appraisal Methodology

This appraisal applies the methodology detailed in Chapter 4: Approach to Environmental Appraisal. The identification and appraisal of effects and mitigation are based on expert judgment and advice drawn from the guidelines listed in Section 7.2.4

As detailed in Chapter 6, Section 6.2.3, a non-statutory scoping request was submitted to the Marine Scotland Licensing Operations Team (MS-LOT) and the Marine Management Organisation (MMO) in July 2021. Scoping responses are provided in Appendix 6.1, including those identifying aspects of the Marine Scheme that have the potential to affect the physical environment during its Installation, Operation and Maintenance, and Decommissioning Phases. Responses from stakeholders to the non-statutory scoping report concerning the physical environment have been considered and addressed as part of the preparation of this chapter.

This appraisal has been undertaken to identify potential impacts and effects on the following receptors associated with the physical environment:

- Marine geology;
- Oceanographic conditions;
- Physical processes; and
- Water quality.

As set out during non-statutory scoping report discussed above, the approach to the appraisal has been evidence based, involving qualitative techniques drawn from previous experience of similar projects, supported by calculations where appropriate.

7.4.2 Data Sources

Desk-based information and data have been obtained from a wide range of sources; collated and used to characterise the environmental baseline within the Study Area. The following key technical reports and data sources have been reviewed:

- Admiralty Tide Tables (UK Hydrographic Office, 2021);
- Admiralty TotalTide software (ATT) (Admiralty TotalTide, 2021);
- Atlas of UK marine renewables resources: modelled wave, wind and tidal current. (ABPmer, 2008);
- British Oceanographic Data Centre measured current data (BODC, 2021);
- Cefas Climatology Report (2016) Waters Suspended sediment concentrations (SSC) (Cefas, 2016);
- Coastal Flood Boundary Dataset (CFB) (Environment Agency, 2018);
- Dynamic Coast interactive GIS maps (Dynamic Coast, 2021);
- EA Coastal Flood Boundary dataset (Environment Agency, 2018);
- EA ‘Flood Risk Assessments: Climate Change Allowances (Environment Agency, 2016);
- ERYC Coastal Explorer Interactive Map (East Riding of Yorkshire Council, n.d.); Eastern Link Marine Survey (Fugro, 2021a; Fugro, 2021b; Fugro, 2021c);
- Environment Agency Water Quality (Environment Agency, 2021);
- European Centre for Medium-range Weather Forecast – Global hindcast model data (ECMWF) (ECMWF, 2021);
- Flamborough Head to Gibraltar Point Shoreline Management Plan (Humber Estuary Coastal Authorities Group, 2010);
- Hornsea Offshore Wind Farm - Project Two. Marine Survey Report (SMart Wind, 2015);

- Hornsea Project Four: Environmental Statement; PINS Doc. Ref. Annex A2.1 – Marine Geology, Oceanography and Physical Processes (Orsted, 2021);
- Southern North Sea Sediment Transport Study, Phase 2 (HR Wallingford, 2002);
- National Coastal Erosion Risk Mapping (NCERM) (NCERM, 2018);
- Ørsted Hornsea Four Wind Farm (HOW04). Pre-Construction Export Cable Route. Benthic Environmental Survey. Volume 4 - Combined Environmental Baseline Report and Habitat Assessment Survey (Bibby Hydromap and Benthic Solutions, 2019)
- National Network of Regional Coastal Monitoring Programmes (NNRCMP, 2021);
- National Oceanography Centre BODC (National Oceanography Centre BODC, 2021);
- North East Coastal Observatory (North East Coastal Observatory, 2021);
- North Sea Atlas- Making the European Fisheries Ecosystem Plan Operational (MEFEPO, 2019);
- Review of Cabling Techniques and Environmental Effects applicable to the Offshore Wind farm Industry (BERR, 2008);
- Review of environmental data associated with post-consent monitoring of licence conditions of offshore wind farms. MMO Project No: 1031 (Fugro EMU, 2014);
- UK Climate Projections (UKCP): sea level rise (Met Office, 2018); and
- United Kingdom Hydrographic Office (UKHO), Published Charts and Tide tables: tidal diamonds with current stream data.

7.4.2.1 Site Specific Survey Data

Geotechnical and geophysical surveys of the Marine Installation Corridor were undertaken in 2021 (Next Geosolutions, 2022a), the findings of which have been used to identify the physical features of the seabed and sediment characteristics of the Study Area.

The 2021 geophysical and geotechnical surveys included the following:

- April 2021: Topographical, and geophysical surveys undertaken at Scottish and English landfalls;
- May 2021: Nearshore waters geophysical surveys conducted at both landfalls;
- June 2021: Nearshore geotechnical surveys, comprising vibrocore (VC) sampling and cone penetration test (CPT) tests undertaken at both landfalls;
- May to July 2021: Geophysical surveys of the offshore section of the Marine Installation Corridor (between approximately KP5 to KP421);
- April to July 2021: Environmental surveys including Van Veen grab, mini Hamon grab, drop-down video camera with freshwater lens adaption; and
- August to September 2021: Geotechnical surveys of the offshore section of the Marine Installation Corridor (between approximately KP5 to KP421).

Between KP0 and KP213.4, the 2021 geophysical and geotechnical survey was descoped and the data collected supplemented with that collected by MMT in 2012 along the same survey corridor. The type of data integrated from the 2012 survey reported by Next Geosolutions in 2021, consists of bathymetric contours, seabed features, seabed geology, side scan sonar contacts, magnetic anomalies and geotechnical logs.

The results of the geophysical, geotechnical and environmental surveys conducted by Next Geosolutions are presented in the following reports:

- Integrated Geophysical And Geotechnical Survey Report (Volume 5) (EL-NGS-E403-ENG-REP-008) (Next Geosolutions, 2022a); and
- Environmental Baseline and Habitat Assessment Survey Report (Volume 5) (EL-NGS-E403-ENG-REP-009) (Next Geosolutions, 2022b).

7.4.3 Summary of Consultation

Advice from the MMO and MS-LOT and their respective consultees and advisers provided feedback on the Marine Scheme and EAR scope. Those consultees and advisors include NatureScot, Scottish Water, Marine Scotland Science, the MMO, Natural England and the Centre for Environment, Fisheries and Aquaculture Science (Cefas).

Responses to the most pertinent comments are provided below in Table 7-1, with full details of the consultation process and associated responses are presented in Appendix 6.1: Scoping Responses.

Table 7-1: Response to Pertinent Consultation Comments.

Consultee	Consultee Comment	Marine Scheme Response
MMO / Natural England	Chapter 6 is titled Physical Environment; however, it focuses mostly on physical process. The MMO requires that this chapter be updated to include marine geology and provide some discussion of regional geology, seabed sediment and composition and thickness, seabed mobility, and bedforms across the study area.	The scope of EAR Volume 2 Chapter 7: Physical Environment has been updated to include marine geology, seabed sediment and composition and thickness, seabed mobility, and bedforms across the study area.
MMO / Cefas	The MMO notes no project specific modelling is proposed, and instead several existing studies are referenced which the applicant intends to use for expert assessment. Results from existing studies must be robustly assessed for their appropriateness to provide evidence for this project (in terms of location, nature of proposed activities, and methods employed), to provide assurance that project specific modelling is not required. The MMO does not consider it appropriate to rely on the conclusions drawn regarding significance of effects in assessments for other projects - project specific expert assessment is required to determine significance. Note that the location of landfall is particularly sensitive from a geomorphological perspective, and therefore a precautionary approach should be employed when determining significance.	Noted. Data from other projects has been used to support the understanding of the baseline. The potential impacts of the Marine Scheme on the physical environment have been appraised in EAR Volume 2 Chapter 7: Physical Environment Section 7.6. The proposed approach to the appraisal of potential impacts on the physical environment has been discussed in Technical Workshops held with the MMO and Natural England in April and May 2022, as described in EAR Volume 2 Chapter 6: Consultation and Stakeholder Engagement. During these meetings, feedback was received that they were accepting of the adopted approach to the appraisal of potential impacts.
MMO / Cefas	Section 6.5 discusses potential physical process impacts, and a list of which impacts are scoped in or out from further assessment is summarised in Section 6.6. The impacts listed in section 6.6 do not directly correspond to the subsections in section 6.5, which makes the justification behind the conclusions which have been drawn somewhat unclear and the MMO consider there may be some errors/contradictions. This must be reviewed and confirmed which effect have and have not been scoped into assessment. Examples of what we consider unclear are as follows: Section 6.5 indicates that “Disturbance of coastal bathymetry and bedforms at the landfall sites” will be scoped into assessment, whilst section 6.6 states that it has been scoped out. We believe that section 6.6 is erroneous in this case and that this potential effect should be scoped in (as described in section 6.5.2). In this instance, the MMO considers that “disturbance of coastal bathymetry and bedforms at landfall sites” should be scoped in. Similarly, section 6.6 states that cable protection for the cable route at landfall sites will be scoped in, but this is not explicitly discussed in section 6.5.	A summary of the potential impacts which are screened in and out of the physical environment appraisal can be found in EAR Volume 2 Chapter 7: Physical Environment Section 7.6. Nearshore bathymetry and bedforms as well as cable protection and associated impacts throughout all project stages are appraised and scoped into EAR Volume 2 Chapter 7: Physical Environment Section 7.6.

Consultee	Consultee Comment	Marine Scheme Response
MMO / Cefas	Section 6.5.4.1 states that changes to bathymetry and bedforms as a result of installation and cable protection measures has been scoped out of assessment. Whilst the MMO can agree this in principle, for some offshore areas of the cable route, the evidence must be provided that there are no sensitive sandbanks, sandwave fields or protected features along the route to provide reassurance that the decision to scope this out is appropriate (i.e., a clearer discussion of potential for indirect impacts would be needed to justify scoping this out. This is necessary because changes to seabed morphology may affect coastal morphology as well as ecological receptors). Robust evidence that proposed sandwave levelling will not lead to any irreversible morphological change also needs to be presented to support this conclusion.	Bathymetry and seabed morphology was appraised both in the offshore and nearshore vicinity of the cable in EAR Volume 2 Chapter 7: Physical Environment Section 7.6.
MMO / Cefas	The potential effects to nearshore bathymetry and bedforms (where the cable approaches Flamborough Head and sections inshore of this) must be scoped in, due to the proximity of the project activities to sensitive geomorphological receptors (i.e., rapidly receding coastline) and protected areas (Flamborough Head SAC, including subtidal reefs). The assessment should consider changes due to anchoring activities associated with inshore cable installation in addition to other installation activities, including for the HDD installation, and inshore cable protection. Placement of external cable protection inshore should be minimised as far as reasonably practical given the sensitivity of the coastline geomorphological receptor (cliff recession).	The potential effects on nearshore bathymetry near Flamborough Head is assessed within EAR Volume 2 Chapter 7: Physical Environment Section 7.6.
MMO / Natural England	As highlighted in the Physical Environment comments above, Natural England consider that there is potential for the proposed works to disrupt sediment flow along the Holderness Coast, which in turn has the potential to impact on the features of Holderness Inshore MCZ (notably the geological feature). At this stage, the MMO disagree with Holderness Inshore MCZ being scoped out of further assessment at this stage.	Technical workshops have been held with the MMO, MS-LOT and Natural England in April and May 2022 to discuss the potential effects of the Marine Scheme on the Holderness Coast and the potential connection with the Holderness Inshore MCZ. This included detailed discussions on the approach adopted by the appraisal and the potential Zones of Influence of the Marine Scheme, as described in EAR Volume 2 Chapter 6: Consultation and Stakeholder Engagement. The potential effects on the Holderness Coast and potential features of the Holderness Inshore MCZ have been appraised in EAR Volume 2 Chapter 7: Physical Environment. A Marine Protected Area and Marine Conservation Zone Assessment has been undertaken to support the Marine Licence Applications as provided in EAR Volume 3 Appendix 8.3: MCZ / MPA assessment.
Natural England	Identification of Potential Effects. The Applicant will need to consider whether cable exposure and/or protection measures could result in scour (or secondary scour) and lead to the removal of seabed sediments.	The potential impacts of cable protection methods on seabed sediment and scouring is appraised in EAR Volume 2 Chapter 7: Physical Environment Section 7.6.

Consultee	Consultee Comment	Marine Scheme Response
Natural England	Natural England note that 'Disturbance of coastal bathymetry and bedforms at the landfall sites' is to be scoped out. Further to the comment above, until further investigations have been carried out to assess potential impacts of the proposed scheme on coastal morphology processes at landfall, then this should remain scoped in.	Potential changes to seabed morphology has been appraised in EAR Volume 2 Chapter 7: Physical Environment Section 7.6.
Natural England	Based on the comments above, and the importance of sediment flow along the Holderness coast in maintaining the habitats of the Humber Estuary, Natural England disagrees that impacts to the Humber Estuary SPA can be scoped out at this stage. We consider that the proposals have the potential to impact on the supporting habitat of the SPA (either alone or in combination). For the same reason, we consider that the Humber Estuary SAC should remain scoped in due to potential impacts to subtidal and intertidal habitat features, as well as migratory fish.	The potential impacts of the Marine Scheme on sediment dynamics along the Holderness Coast has been appraised in EAR Volume 2 Chapter 7: Physical Environment Section 7.6. The potential impacts of the Marine Scheme on the Humber Estuary SPA and SAC have been appraised in EAR Volume 3 Appendix 8.2: Habitat Regulations Assessment. The Humber Estuary SAC Annex II species present as qualifying features are sea lamprey and river lamprey, the impacts of the Marine Scheme on these features is appraised in EAR Volume 2 Chapter 9: Fish and Shellfish Ecology and in EAR Volume 3 Appendix 8.2: Habitat Regulations Assessment.
Cefas	The applicant should seek in situ observational data for suspended sediment for the Holderness Coast if available, to support assessment of changes to suspended sediments resulting from the project. Currently only satellite data is mentioned in the data sources list (Section 6.4.1). The assessments should consider the accuracy of the referenced modelled wave datasets in the coastal zone and acknowledge where uncertainty exists in modelled predictions in this area due to model resolution and complex coastal bathymetry/topography.	The nearshore bathmetry baseline is detailed in EAR Volume 2 Chapter 7: Physical Environment Section 7.5.1. Sources and datasets utilised in the preparation of the EAR Volume 2 Chapter 7: Physical Environment are listed in Section 7.4.2 and the accuracy and limitations of such datasets are noted in Section 7.4.3.

7.4.4 Data Gaps and Limitations

Data relevant to marine physical processes has been obtained from publicly available data sources, supplemented with information from the baseline surveys. Consistent with the approach set out during Scoping, no site-specific field measurements of waves, currents, or sediment concentrations have been collected along the Marine Installation Corridor. This is not uncommon for similar projects due to the availability of existing datasets from long-term coastal monitoring programmes, for example those carried out by East Yorkshire Riding Council (EYRC) and Cefas. Reference is made to previous studies and use made of modelled and empirical datasets from available sources to inform the appraisal and provide a robust, evidence-based approach consistent with other regional development.

The understanding of the long-term behaviour of Smithic Bank is limited by a lack of routine historical surveys. The sandbank is recognised as morphologically active feature dynamically linked to surrounding sediment sources and pathways (East Riding of Yorkshire Council, n.d.).

7.5 Baseline Conditions

This section covers the physical environment baseline for the Marine Scheme with regards to bathymetry, geology, seabed sediments (including contamination), currents and water quality. The description of the baseline conditions has been sub-divided based on the territorial and offshore waters through which the Marine Installation Corridor passes, for consistency with the remainder of the appraisal. Potential effects on metocean conditions, including tides and waves, were scoped out of further consideration and therefore no further detail has been provided on these aspects of the physical environment, except insofar as they are relevant to other processes.

All depths described in this chapter are relative to Lowest Astronomical Tide unless otherwise stated.

7.5.1 Bathymetry and Seabed Features

The bathymetry along the Marine Installation Corridor in UK waters is influenced by both geology and geological processes. The deposition of large volumes of sediment during glacial times and its subsequent reworking by the sea has created large features, such as sandbanks and sandwave fields, which have a direct impact on the subsequent bathymetric profiles.

Previous studies (RSK, 2020 and RPS, 2020) used high-resolution bathymetry, published geological information and survey data from National Grid and SHE Transmission (National Grid & SSE, 2013) to characterise the Study Area. These studies noted that the Marine Installation Corridor crossed large isolated sandwaves (up to 12 m in height) and sandwave fields. These were reported to be likely to be quasi-static, tending to be geologically constrained to relative deeps or edges of highs. It was anticipated that while the sandwaves within the field may be mobile, the location of the sandwave fields appeared to be geologically and hydrologically constrained.

Comparison between the 2012 and 2021 Multi Beam Echo Sounder (MBES) data (Figure 7-2) showed that there was a high level of consistency between the two surveys. For instance, differences in recorded seabed levels were typically less than ±0.3 m, over the 57 km section of the Scottish offshore section between KP109 and KP164 of the Marine Installation Corridor. This suggests that the seabed within this section can be considered to be relatively stable and the sandwaves within this region can be considered as static features.

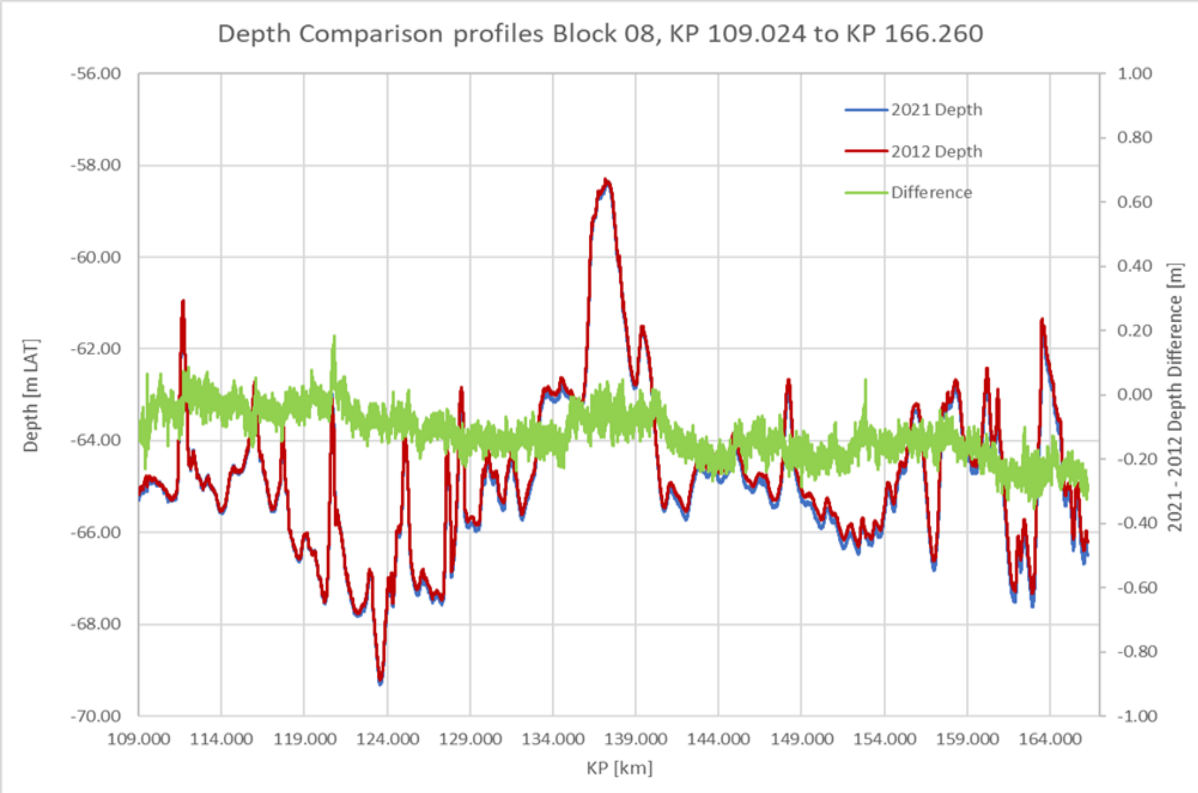

Figure 7-2: Comparison of measured depth between KP109 and KP164 between 2012 and 2021 surveys (Next Geosolutions, 2022a)

7.5.1.1 Scottish Territorial Waters

Between KP0 and KP1.3, water depths increased to 19 m at a slope of ~1.3° (Figure 7-3). From KP1.3 to KP2.4, water depths further increased to 31 m at a slope of ~1°, before deepening to 54 m at KP4.3 at a slope of ~1.2°. From KP4.3 to KP12, water depths continued to increase to 65.4 m. The seabed then undulates between KP12 and KP28.4 (Next Geosolutions, 2022a).

From KP0 to KP12, seabed morphology varied with areas of generally smooth seabed with patches of megaripples (with a wavelength of 1 m to 10 m) and sandwave fields (with a wavelength of 10 m to 500 m) (Figure 7-4) along with areas of low-density boulder field (<40 boulders per 10,000 m^2) (Next Geosolutions, 2022a). Beyond KP12, the seabed was generally featureless other than areas of smooth undulating sandwaves and megaripples between KP13.4 and KP14.4 and at KP15.3. Megaripples overlying sandwaves were then recorded as present throughout the remainder of Scottish territorial waters within the Marine Installation Corridor.

Notable features also included the PL721 Forties Field to Cruden Bay pipeline at KP16.4 and a wreck (15 m off the centre of the Marine Installation Corridor) at KP25.1 with the dimensions 41 m x 7 m x 5 m.

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Coordinate System: ETRS 1989 UTM Zone 30N

Scale @ A3 1:5,000

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PROJECT

Eastern Green Link 2

KEY

- Marine Installation Corridor
- Kilometre Point (KP)
- Bathymetry Contour (5m)
- Bathymetry Contour (1m)

TITLE

Figure 7-3
Nearshore Bathymetry Contours at the Scottish Landfall

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SHEET NUMBER	DATE
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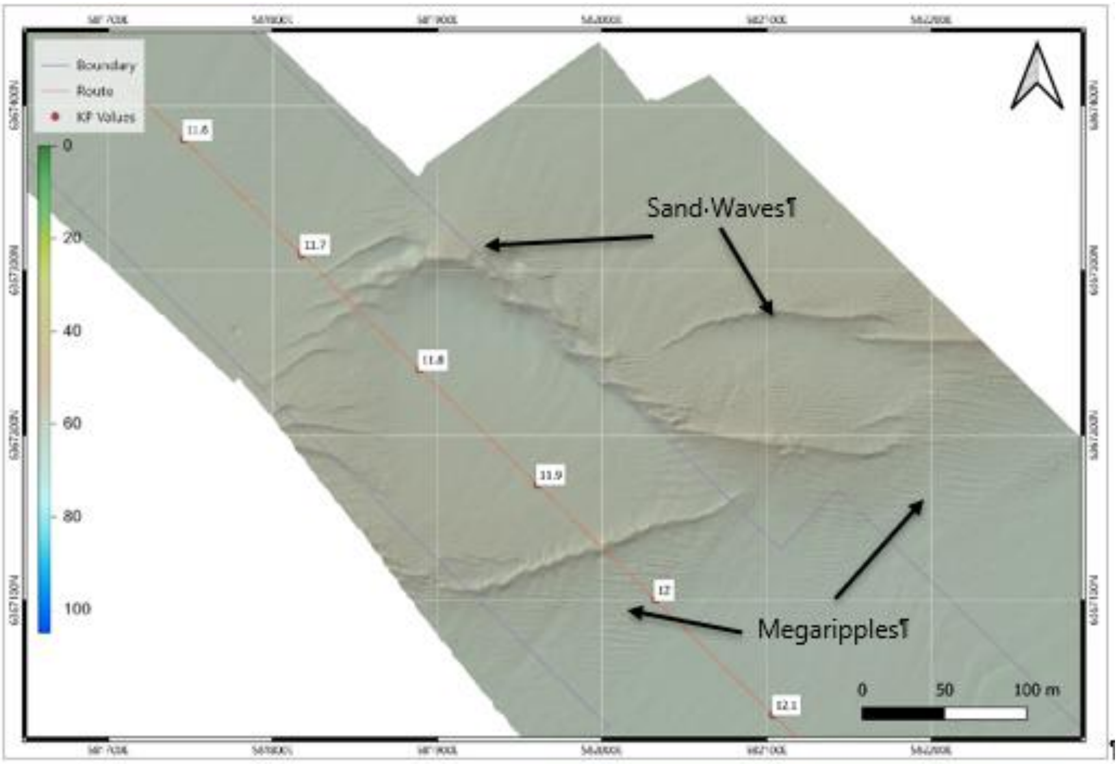

Figure 7-4: Example of megaripples and sandwaves between KP11.7 and KP12 (Next Geosolutions, 2022a).

7.5.1.2 Scottish Offshore Waters

From KP28.4 to KP48, the seabed continues to undulate with a maximum water depth of 101.2 m being recorded at KP47.1 within the Marine Installation Corridor. The water depths between KP46.7 and KP150.2 remain relatively steady, with a maximum depth of 70.4 m and a minimum of 55.1 m recorded (Next Geosolutions, 2022a).

Within this area, between KP28.4 and KP96, the seabed morphology consisted of areas of large undulating sandwaves with overlying megaripples and intermittent boulder fields between areas of smooth seabed. The largest sandwave field was recorded between KP52.3 and KP53.3. Between KP90 and KP150.2 the seabed was generally smooth with occasional patches of megaripples or isolated sandwaves (Figure 7-5) (Next Geosolutions, 2022a).

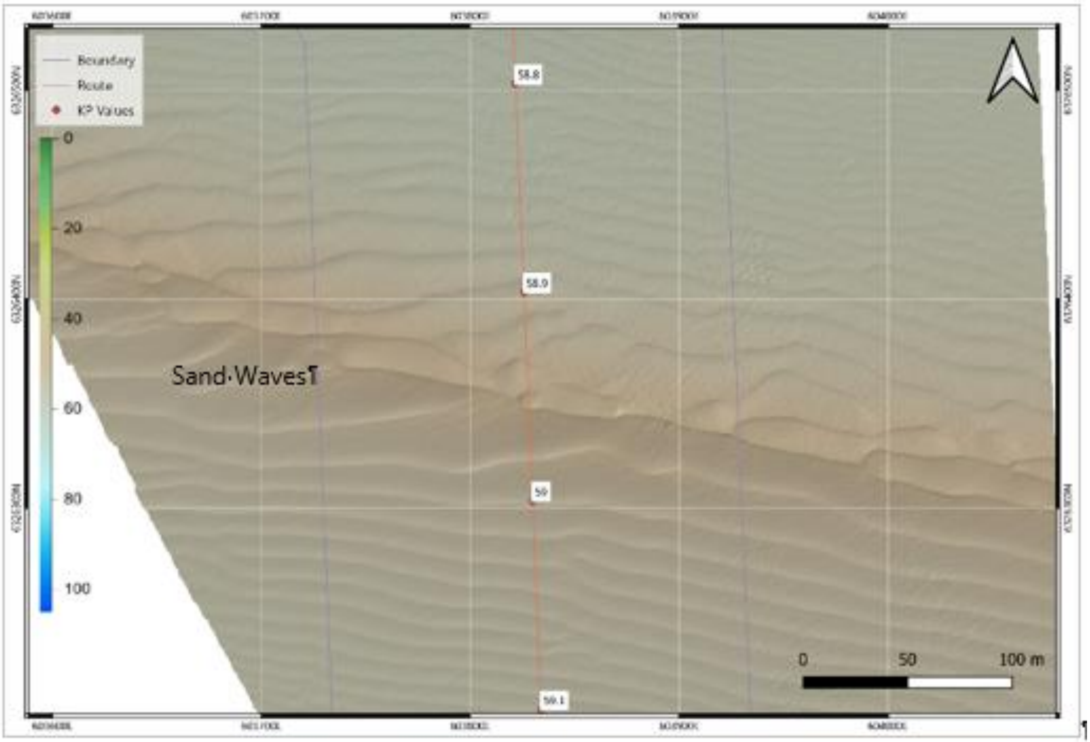

Figure 7-5: Example of isolated sandwaves between KP58.9 and KP59 (Next Geosolutions, 2022a).

7.5.1.3 English Offshore Waters

The water depths between KP150.2 and KP189.5 continued to remain relatively steady, with a maximum depth of 70.4 m and a minimum of 55.1 m recorded. Water depths gradually decreased to a maximum of 90.1 m between KP189.5 and KP213.3 with a notable depression observed at KP194.3. Gentle undulations were observed thereafter up to KP363.1, reaching a maximum of 94.6 m and a minimum of 55.1 m. Between KP363.1 and KP396.5, water depths continued to shallow (Next Geosolutions, 2022a).

Between KP150.2 and KP213.4, the seabed continued to be generally flat with no notable features. Smooth undulations were recorded between KP213.4 to KP363.1. Megaripples were present almost immediately at KP363.1 to KP388.6 before the seabed returned to being smooth. Areas of sandwaves and megaripples and areas of shallow megaripples were observed between up to KP396.5. At KP329, an area of outcropping bedrock was noted (Next Geosolutions, 2022a; Next Geosolutions, 2022b).

The North Sea Link (NSL) North and South power cables were recorded at KP240.8 and KP240.9 respectively, along with the Havhingsten fibre optic cable at KP267.8 and the PL774 Central Area Transmission System (CATS) gas pipeline at KP286.4. PL19 Ekofisk/Norpipe-Oljedling oil pipeline crossed the Marine Installation Corridor at KP299.5 and a 3 m x 7 m contact approximately south west of KP308.7 was recorded. Cantat 3 and Pangea North fibre optic cables were also crossed at KP317.6 and KP319.6 respectively. The Breagh chemical pipeline, gas pipeline and fibre optic cable was observed between KP355.8 and KP356.1 (Figure 7-6) (Next Geosolutions, 2022a).

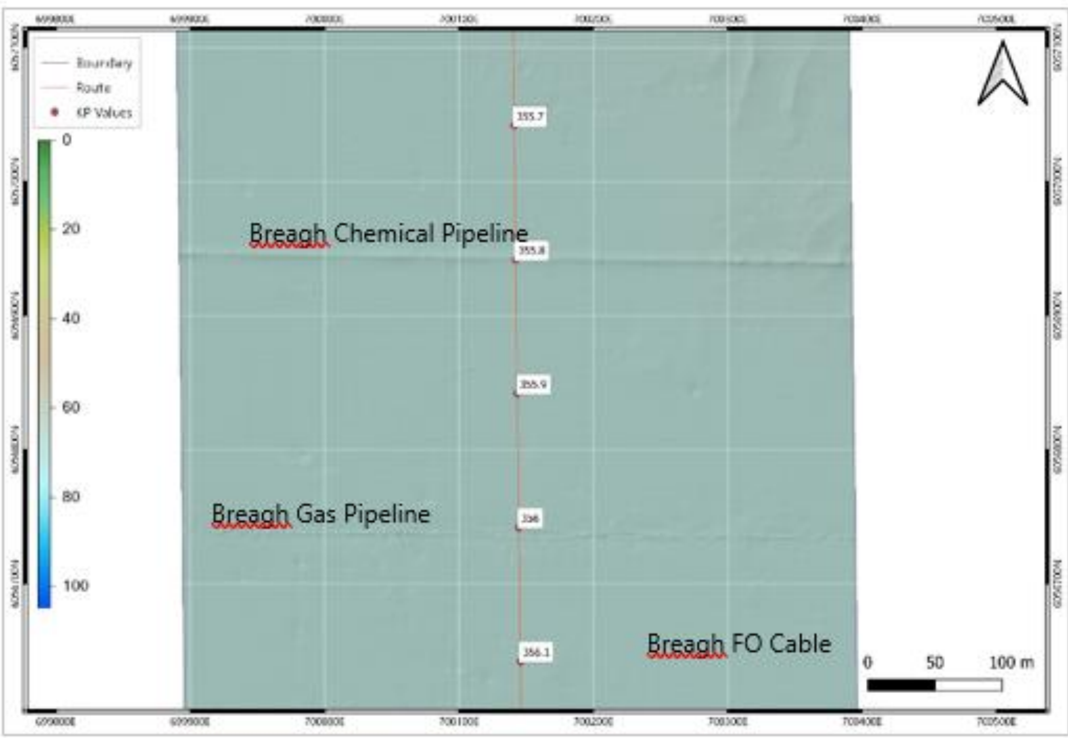

Figure 7-6: Breagh chemical pipeline, gas pipeline and fibre optic cable recorded between KP355.8 and KP356.1 (Next Geosolutions, 2022a).

7.5.1.4 English Territorial Waters

From KP396.5, water depths continued to shallow to a minimum of 9.8 m at KP426.9. The seabed at the English landfall, at KP436, had a very gentle slope of ~0.08°, where water depth decreased from 6 m to 0 m (Figure 7-7). At KP420, seabed morphology was noted to consist of shallow sandwaves and megaripples before transitioning back to a relatively flat seabed through to KP426.9. Extensive boulder fields were recorded between KP397.4 to KP403.2 and from KP427.2 to KP427.3 (Next Geosolutions, 2022b).

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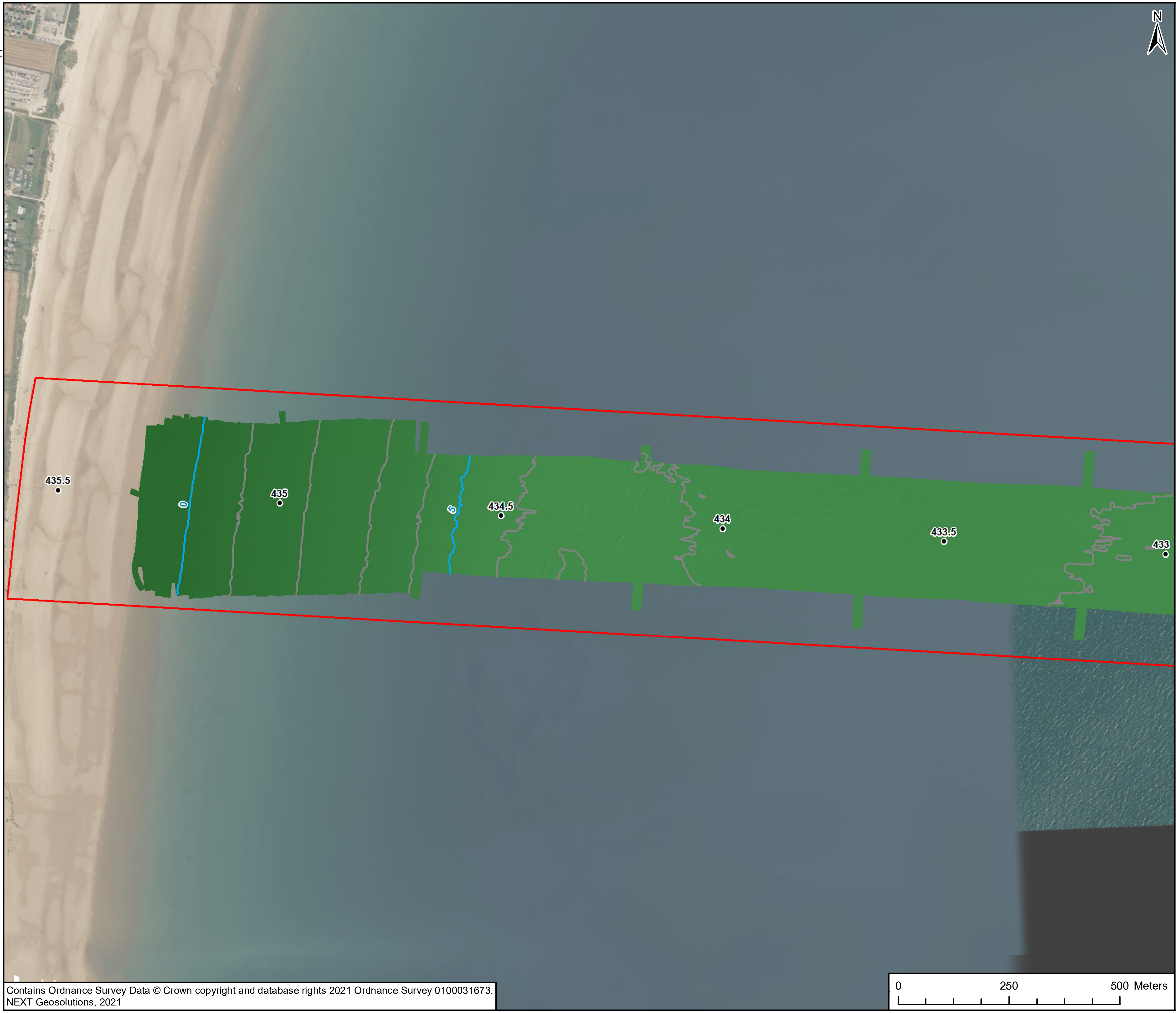

Coordinate System: ETRS 1989 UTM Zone 30N

Scale @ A3 1:8,000

nationalgrid
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PROJECT
Eastern Green Link 2

KEY
- Marine Installation Corridor
- Kilometre Point (KP)
- Bathymetry Contour (5m)
- Bathymetry Contour (1m)

TITLE
Figure 7-7
Nearshore Bathymetry Contours at the English Landfall

REFERENCE
SEGL2_M_EAR_7-7_v3_20220624

SHEET NUMBER 1 of 1

DATE 24/06/2022

7.5.2 Geology and Sediments

Previous studies (RSK, 2020 RPS, 2020) used high-resolution bathymetry, published geological information and survey data from National Grid and SHE Transmission (National Grid & SSE, 2013) to characterise the Study Area. These studies noted that along the majority of the Marine Installation Corridor, varying thicknesses of sands and gravels overlie predominantly glaciomarine sands and clays, especially between KP80 and KP200, and glacial till (firm to stiff clay with occasional cobbles and boulders) from KP200 onwards. For large parts of the Marine Installation Corridor, it was reported that surficial deposits were likely to consist of a veneer less than 1 m in thickness. Areas of sub/outcropping rock were reported to be expected on the approaches to the Scottish landfall and between KP250 and KP420 within English offshore and territorial waters.

The 2021 geophysical and geotechnical survey reported that for large parts of the Marine Installation Corridor, the surficial deposits were found to consist of a veneer less than 1 m thick in agreement with previous studies. Based on the geotechnical model derived using the 2012 data (MMT, 2012) and 2021 data (Next Geosolutions, 2022a), it was noted that, for the majority of the Marine Installation Corridor, a varying thickness of sands or gravelly sand was found to overlie predominantly higher strength glaciomarine sands and clays from KP0 to KP200. From KP200 onwards areas of sand are generally limited to a shallower thickness of 0.5 m which overly glacial till (firm to stiff clay with occasional cobbles and boulders), again in agreement with the previous studies.

The distribution of the representative median grain size (D_{50}) for the seabed material along the Marine Installation Corridor is illustrated in Figure 7-8. This shows that fine sediment fractions (D_{50} <0.063 mm), as indicated by the horizontal red line, were present in the majority of samples collected along the Marine Installation Corridor.

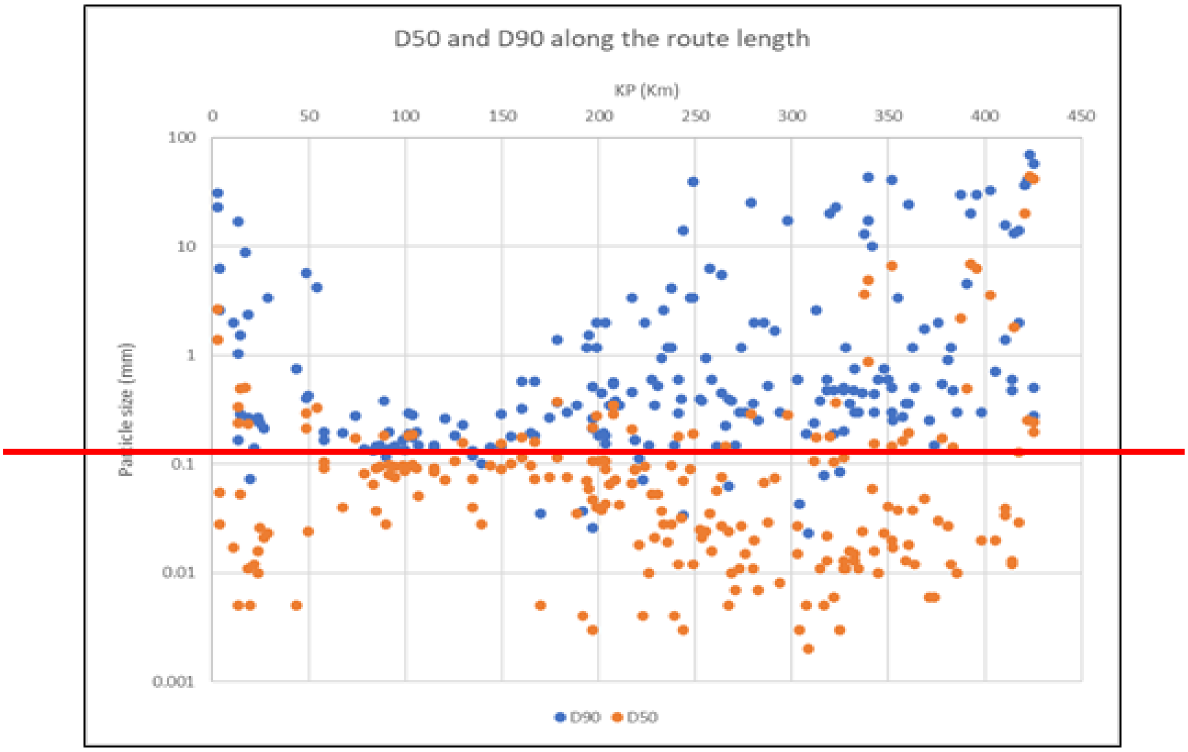

Figure 7-8: Variation in particle size along the Marine Installation Corridor.

7.5.2.1 Scottish Territorial Waters

Within Scottish territorial waters, sediment types were reported to consist of sand, sand and gravel, gravel and gravel with cobbles/boulders, with bedrock also recorded as present in some areas (Figure 7-9). The area interpreted in 2012 as diamicton was reinterpreted in 2021 as sand and gravel with cobbles/boulders due to no clay component in the environmental sampling undertaken at this location (Next Geosolutions, 2022a). Otherwise, in general, there is good agreement between the interpretation of the 2012 and 2021 data

Results of particle size analysis from geotechnical samples collected by Next Geosolutions (2022a) indicated that seabed sediments within this area generally consists of poorly or very poorly sorted sands. Fines (<0.063 mm) varied within the samples within Scottish territorial waters from 0% to 16.5%, sands varied between 49.5% to 100% and gravels varied from 0% to 43.5% (Next Geosolutions, 2022a).

7.5.2.2 Scottish Offshore Waters

Transitioning further offshore, seabed sediments consist of sand and gravel, sand, sand and gravel with cobbles/boulders. Beyond KP96, the seabed sediments included sand and gravel, sand and gravel with cobbles/boulders, till and silty sandy clay. Differences in the interpretation of seabed sediments were observed between the 2012 and 2021 surveys, for instance between KP78.6 to KP81.9 (Figure 7-10), with the more recent surveys suggesting a more uniform nature of sediment types.

Results of particle size analysis from geotechnical samples collected by Next Geosolutions (2022a) indicated that seabed sediments within this area generally consists of moderately or poorly sorted medium or fine sands. Fines (<0.063 mm) varied within the samples within Scottish offshore waters from 0% to 14.7%, sands varied between 66.8% to 93.5% and gravels varied from 0% to 22.5% (Next Geosolutions, 2022a).

7.5.2.3 English Offshore Waters

Within English offshore waters, seabed sediments were reported to include sand and gravel, sand and gravel with cobbles/boulders, till and silty sandy clay. Between KP166.3 and KP396.5, seabed sediments oscillated between areas of sand and gravel with cobbles/boulders and areas of sand. At KP329, an area of outcropping bedrock was noted. Comparison of the interpretation of seabed sediments between the 2012 and 2021 data (Figure 7-10) between KP189.5 to KP193.5 showed good agreement including the transitions between sand and gravel to sand, including the area of cobbles/boulders close to KP193.5 being identified in both surveys.

Results of particle size analysis from geotechnical samples collected by Next Geosolutions (2022a) indicated that seabed sediments within this area generally consists of poorly or very poorly sorted sands, varying from very fine sands to coarse sands. Fines (<0.063 mm) varied within the samples within English offshore waters from 5.1% to 32.8%, sands varied between 83.1% to 98% and gravels varied from 0.2% to 13.4% (Next Geosolutions, 2022a).

7.5.2.4 English Territorial Waters

On the approach to the English landfall from KP420, the seabed sediments transitioned back to areas of sand, sand and gravel with cobbles/boulders and sections of stiff clay. Results of particle size analysis from geotechnical samples collected by Next Geosolutions (2022a) indicated that seabed sediments within this area generally consists of very poorly to well sorted sediments varying between gravelly sands, sand and coarse sands. Fines (<0.063 mm) varied within the samples within English territorial waters from 0% to 22.7%, sands varied between 35.9% to 100% and gravels varied from 0% to 47.2% (Next Geosolutions, 2022a). These results correspond to the seabed lithology in the landfall and nearshore areas of the geophysical survey (Bibby Hydromap and Benthic Solutions, 2019) presented in the Hornsea Project Four: Environmental Statement (Orsted, 2021).

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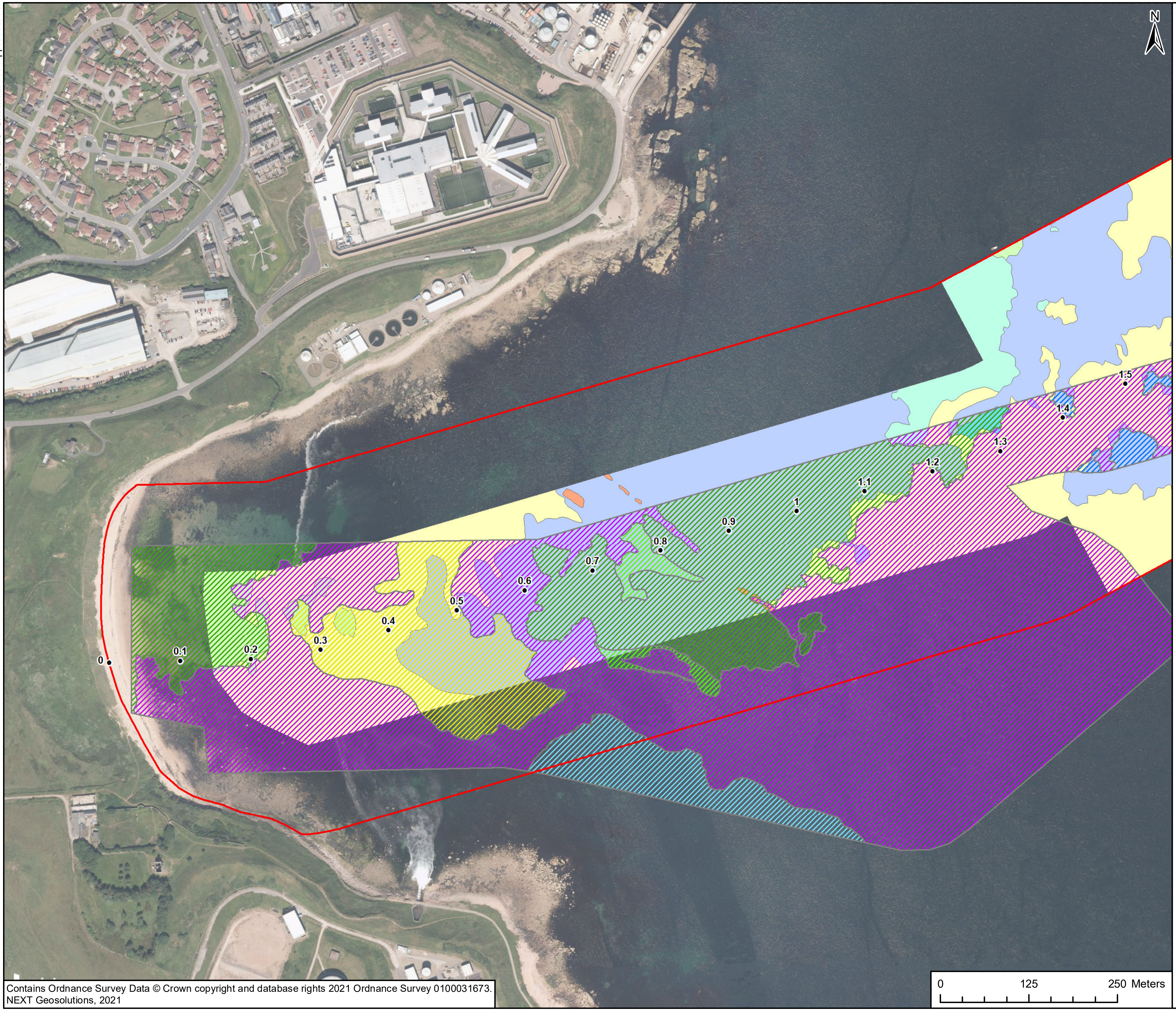

Coordinate System: ETRS 1989 UTM Zone 30N

Scale @ A3 1:5,000

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PROJECT
Eastern Green Link 2

KEY
- Marine Installation Corridor
- Kilometre Point (KP)

NEXT Geosolutions 2021 - Seabed Geology
- Bedrock
- Intervention
- Sand
- Sand and Gravel
- Sand and Gravel with Cobbles/Boulders
- Silty Sandy Clay

MMT 2012 Survey - Surface Geology
- Bedrock
- Diamicton
- Gravel
- Sand
- Sand and Gravel
- Sand and gravel with cobbles

TITLE
Figure 7-9
Nearshore Geology at the Scottish Landfall Site

REFERENCE
SEGL2_M_EAR_7-9_v3_20220606

SHEET NUMBER	DATE
1 of 1	06/06/2022

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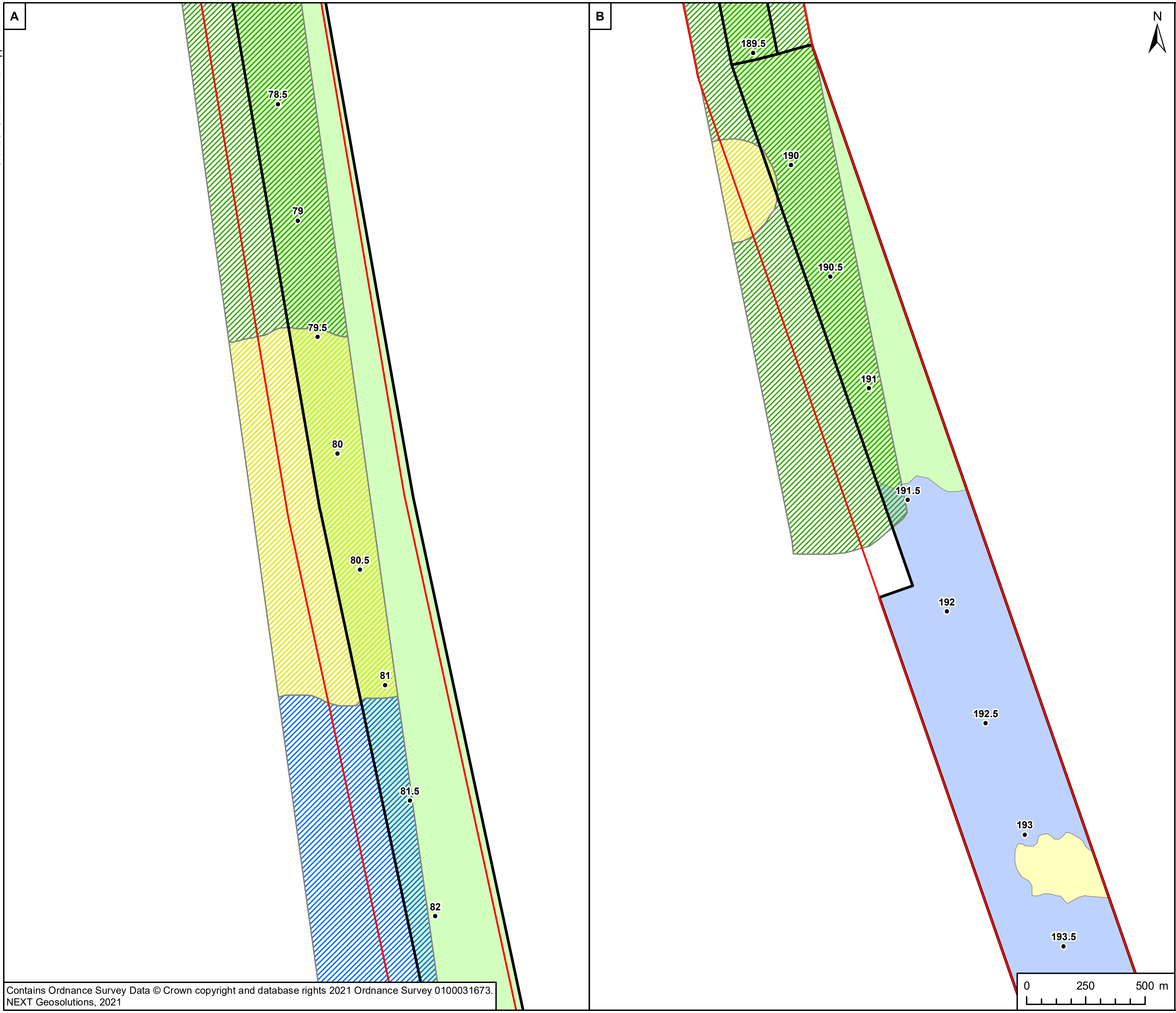

Coordinate System: ETRS 1989 UTM Zone 30N

Scale @ A3 1:15,000

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PROJECT
Eastern Green Link 2

KEY
- Marine Installation Corridor
- Kilometre Point (KP)
- Survey Block

NEXT Geosolutions 2021 - Surficial Geology
- Sand
- Sand and Gravel
- Sand and Gravel with Cobbles/Boulders

MMT 2012 Survey - Surficial Geology
- Sand
- Sand and Gravel
- Sand and gravel with cobbles

TITLE
Figure 7-10
Variation in Seabed Sediment Type between 2012 and 2021 Surveys
A: between KP78.6 and KP81.9
B: between KP189.5 and KP193.5

REFERENCE
SEGL2_M_EAR_7-10_v3_20220624

SHEET NUMBER
1 of 1

DATE
24/06/2022

7.5.3 Sediment Quality

As part of the geotechnical survey undertaken by Next Geosolutions (2022b), seabed sediment samples for chemical analysis were collected along the Marine Installation Corridor. This chemical analysis included for total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAHs) as well as heavy and trace metals.

7.5.3.1 Total Petroleum Hydrocarbons and Polycyclic Aromatic Hydrocarbons

The analysis revealed that TPH content within the sediment samples varied from below the detection limit of 10 mg/kg to:

- 15.1 mg/kg within Scottish territorial waters;
- 17.8 mg/kg in Scottish offshore waters;
- 27.5 mg/kg in English offshore waters; and
- 42.9 mg/kg within English territorial waters.

TPH concentrations peaked at 42.9 mg/kg at KP420.6 near to Bridlington Harbour. Throughout the Marine Installation Corridor, TPH concentrations were also found to positively correlate with the proportion of fines and proportion of Total Organic Matter (TOM) and negatively correlate with the proportion of sands.

PAH concentrations were recorded the highest concentrations at sampling stations located close to Bridlington Harbour, in contrast to limited variations elsewhere along the Marine Installation Corridor. PAHs and their alkyl derivatives have been historically recorded in a wide range of marine sediments with the majority of compounds produced from sources including the combustion of organic compounds from the present as well as historic shipping and industrial activity in nearby harbours (Next Geosolutions, 2022b).

PAH concentrations have been compared to OSPAR (2014) background concentrations[1] (BCs) and background assessment concentrations[2] (BACs). Contaminants in general tend to show a much higher affinity to fine particulate matter due to the increased adsorption capacity of organic matter and clay minerals. In sites where grain size is variable, effects due to point sources of contamination will at least partly be obscured by grain size differences.

Normalised PAH concentrations, where they could be calculated, in subtidal stations were found to exceed their respective BC and BAC values. Some PAHs such as acenaphthene, flourene and benzo[ghi]perylene, exceeded their respective effect range low[3] values. The approaches to the English landfall exhibited especially high normalised values. This could be attributed to the coastal industrial development and Bridlington Harbour as most PAHs analysed can be sourced from coal tar, crude oil and industrial waste. While the normalised PAHs were elevated above reference values, no PAHs were close to exceeding the effects range medium[4] at any of the stations.

7.5.3.2 Heavy and Trace Metals

Metals occur naturally in the marine environment and are widely distributed in both dissolved and sedimentary forms. Rivers, coastal discharges and the atmosphere are the principal modes of entry for metals into the marine environment, with anthropogenic inputs occurring as a result of industrial and municipal wastes. Historically, several metals are found in elevated concentrations in drilling fluids or produced waters discharged from oil and gas installations. The metals most characteristic in offshore sediments include barium, chromium, lead and zinc. Trace metals contaminants tend to more prone to various environmental interactions and transformations (physical, chemical and biological), potentially increasing their biological availability.

[1] BCs are concentrations of contaminants derived from analysis of core samples to reflect pre-industrial levels for the OSPAR area.
[2] BACs have been statistically derived from BCs and represent the level above which concentrations can be considered significantly higher than the relevant BC.
[3] ERL is defined as the lowest concentration producing adverse effects in 10% of studies
[4] ERM is defined as the concentration at which harmful effects are expected in 50% of studies.

In all stations, Next Geosolutions (2022b) recorded all concentrations of aluminium, barium, iron, cadmium, chromium, copper, lead, lithium, mercury, nickel, tin, vanadium and zinc below their respective Cefas Action Level 1 concentrations.

Action Levels (as detailed in MMO, 2014) are used in conjunction with a range of other assessment methods to make management decisions regarding the fate of dredged material and may be used to guide assessments of sediment quality in non-dredging activities. The action levels are not 'pass/fail' criteria but triggers for further assessment. In general, contaminant levels in dredged material below Action Level 1 (AL1) are of no concern and are unlikely to influence the licensing decision, therefore it is assumed that sediments of this quality pose no significant environmental risk and are an indicator of "good" sediment quality.

The exception was arsenic, where sampling stations at KP388.1, KP404.4 to KP428.7 and KP433.7 exceeded Cefas Action Level 1 and sampling stations at KP396 and KP431.3 exceeded Cefas Action Level 2. Dredged material with contaminant levels above Action Level 2 (AL2) is generally considered unsuitable for sea disposal. Dredged material with contaminant levels between AL1 and AL2 requires further consideration and testing before a decision can be made, therefore it is assumed that sediments of this quality are unlikely to pose significant environmental risk although further consideration would be required and they are an indication of "acceptable" sediment quality.

Higher levels of arsenic (exceeding Cefas Action Level 2) and copper and zinc (not exceeding Cefas Action Level 1) were recorded at KP431.3, the location of a spoil ground outside of Bridlington Harbour, however, the sampling station at KP432.5, at the neighbouring spoil ground, showed lower concentrations of the aforementioned metals (Next Geosolutions, 2022b).

7.5.4 Suspended Sediment

While no specific monitoring was undertaken as part of the data collected for the Project Marine Scheme, Cefas (2016) provides the spatial distribution of average non-algal Suspended Particulate Matter (SPM) between 1998 and 2015 for most of the UK continental shelf. Daily images of non-algal SPM between 01 January 1998 and 31 December 2015 were averaged monthly for 18 years; these were used to calculate a climatological average (Figure 7-11) as well as climatological monthly averages.

The highest sediment plume concentrations within the North Sea are associated with large rivers such as the Humber Estuary, 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 mg/l to 2 mg/l (Cefas, 2016). The winter suspended sediment distribution shows a similar pattern in the coastal areas, but the concentrations are generally higher reaching up to around 5 mg/l (Figure 7-12: Monthly Averaged SPM (a) January, (b) July Figure 7-12).

The winter data also shows that the main feature of the sediment concentration distribution is a plume-like feature in the suspended sediment field extending from northeast Norfolk, in a north easterly direction across the North Sea towards the island of Texel in the Netherlands. However, this plume-like feature is confined within the southern North Sea region. 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 intensity, changes to land use and river management, draining of wetlands and marine activities such as dredging and trawling (Cefas, 2016).

Based on the data presented in Cefas (2016), the annual averaged SPM associated with the Study Area has been estimated to be between 1 mg/l and 3 mg/l, although higher levels of SPM, up to 5 mg/l, may be found within the nearshore region of the Scottish and English landfalls.

Comprehensive measurements of Suspended Sediment Concentrations[5] (SSC) were collected in July 1995 and February 1996 at three sites (inner, middle, outer) in shallow water depths of between 9 m and 17 m approximately 2 km to 10 km from the coastline, respectively, along the Holderness Coast (approximately 30 km to the south of the English landfall) (Blewett & Huntley, 1998). Measurements in July at the inner site were found to typically range between 0 mg/l and 12 mg/l. The measurements in

[5] SSC can differ from SPM due to the presence of organic material included in the analysis of SPM which is unrelated to suspended sediment.

February varied over a much larger range, where SSC levels of up to 800 mg/l were recorded at the inner site and between 0 mg/l and 250 mg/l at the outer site following a storm event. Subsequently SSC levels decreased steadily to between approximately 40 mg/l to 150 mg/l at the inner site and between 20 mg/l to 75 mg/l at the outer site. Blewett and Huntley (1998) concluded that wave can increase SSC by up to two orders of magnitude off the Holderness coast, although a proportion of the increase in SSC [6]may come from erosion of the cliffs.

Measurements of SSC were also collected in the vicinity of Hornsea (approximately 14 km to the south of the English landfall) covering the period June 2010 to September 2011 which provide an indication of typical background SSC. Monitoring was carried out of tidal heights, currents, waves, SSC, and meteorological parameters at six offshore locations for the Hornsea Offshore Wind Farm - Project Two (SMart Wind, 2015). It was found that SSC values were typically in the range of 3 mg/l to 30 mg/l. During spring tides and storm conditions, elevated SSC values of up to 50 mg/l were recorded. These are in good agreement with the SSC reported by Blewett and Huntley (1998) for the English landfall.

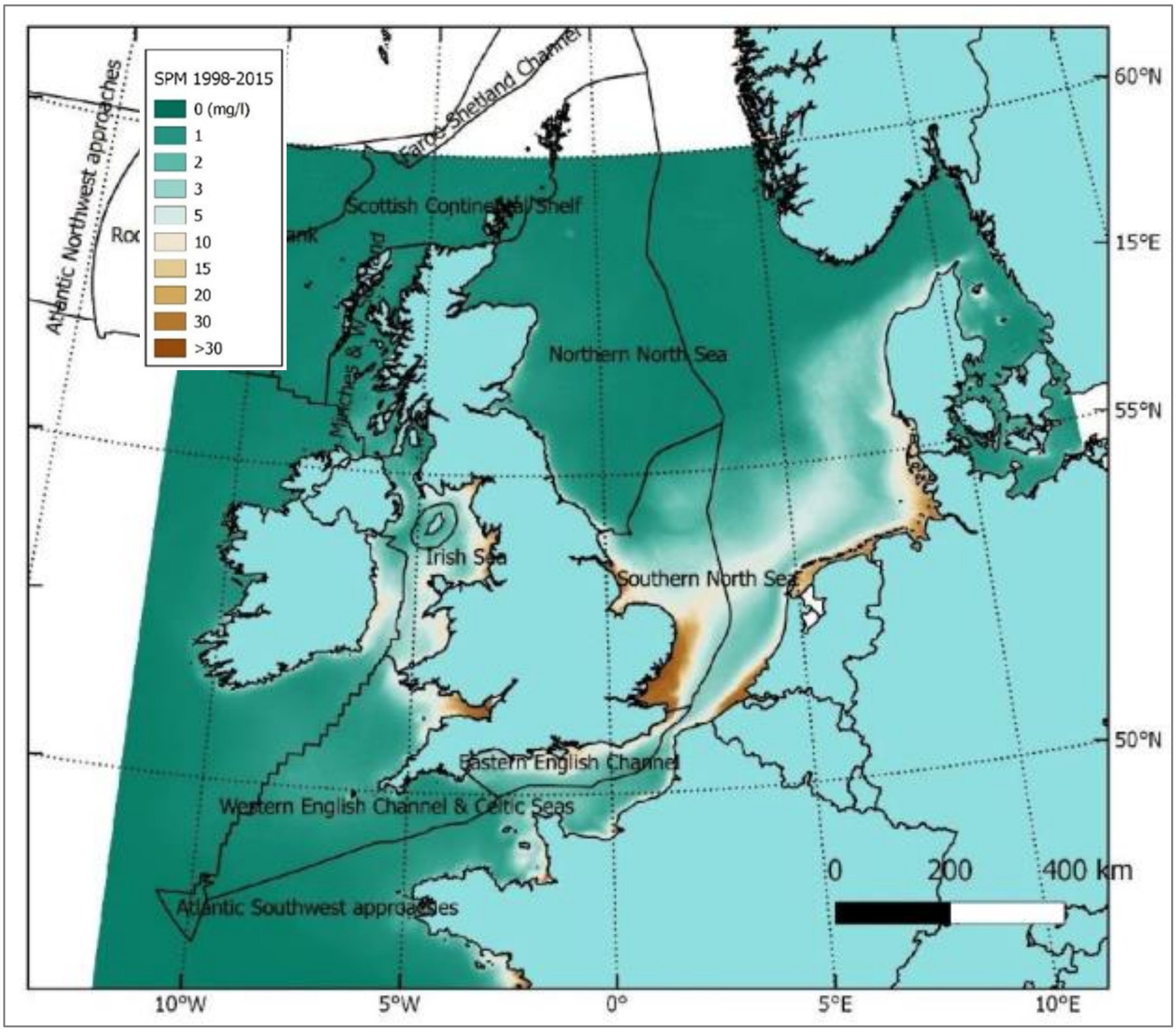

Figure 7-11: Average Suspended Sediment Around the UK (Cefas, 2016)

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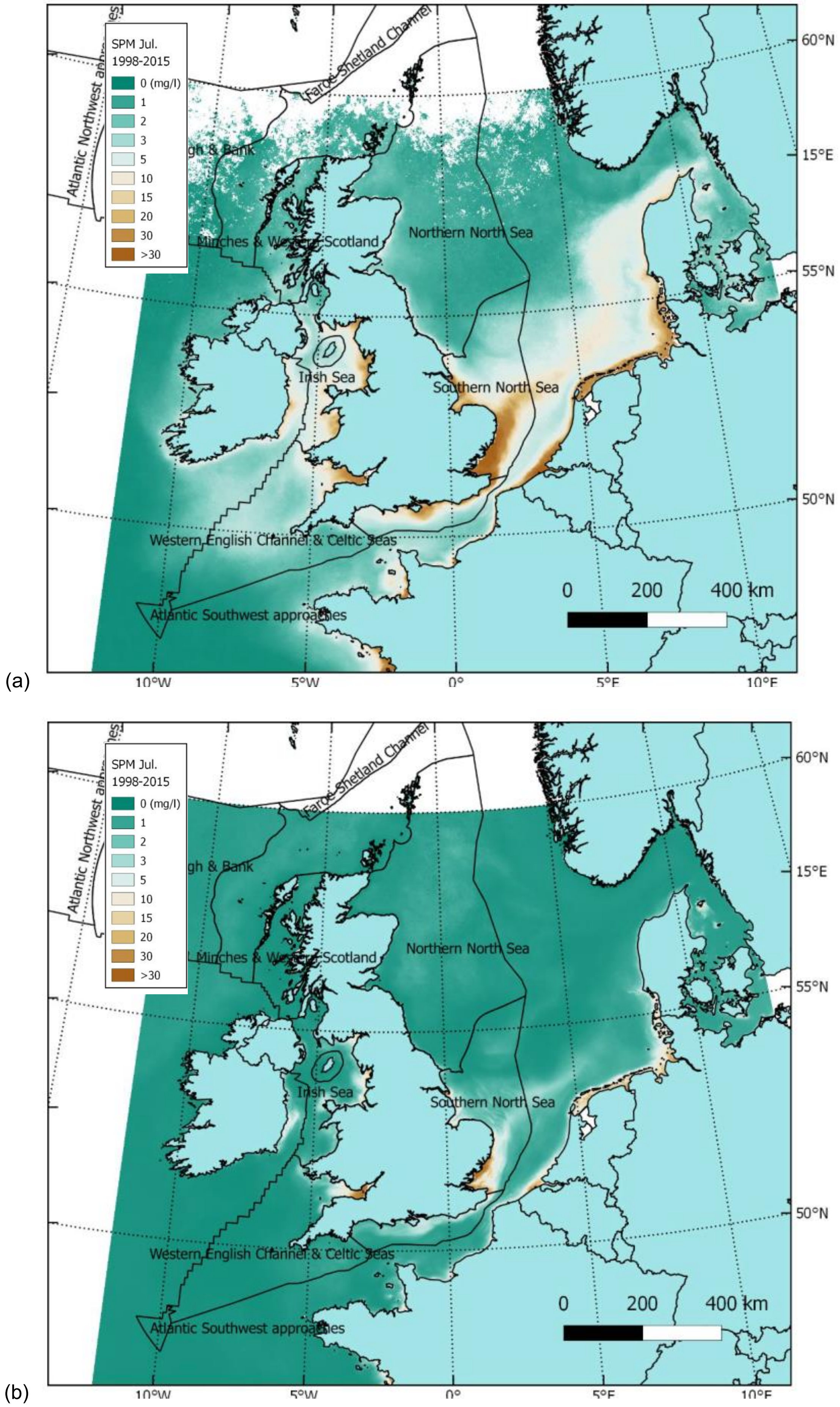

Figure 7-12: Monthly Averaged SPM (a) January, (b) July (Cefas, 2016)

7.5.5 Metocean Conditions

7.5.5.1 Data Sources

While noting that metocean impacts have been screened out of appraisal, details of metocean conditions along the Marine Installation Corridor have informed aspects of the wider environmental appraisal, such as tidal currents and their influence on sediment transport. The physical environment varies as a continuum along the length of the Marine Installation Corridor. In order to address this range of conditions, several metocean data sources within the North Sea have been identified and listed in Table 7-2 with the corresponding locations as shown on Figure 7-13.

The Atlas of UK Marine Renewables Resources (hereafter referred to as 'the Atlas') (ABPmer, 2008) provides a good indication of the hydrodynamic regimes in the nearshore 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 Tide Tables and measured datasets from the British Oceanographic Data Centre (BODC) for locations adjacent to the Marine Installation Corridor.

Table 7-2: Metocean Data Sources

Parameter	Source	Location (see Figure 7-13)
Tidal currents	Admiralty Tide Tables / TotalTide	SN024L, SN024C, SN020C, SN018I
	Atlas of UK marine renewables resources	EL2-A, EL2-B, EL2-C, EL2-D
	BODC	BODC01, BODC02, BODC03

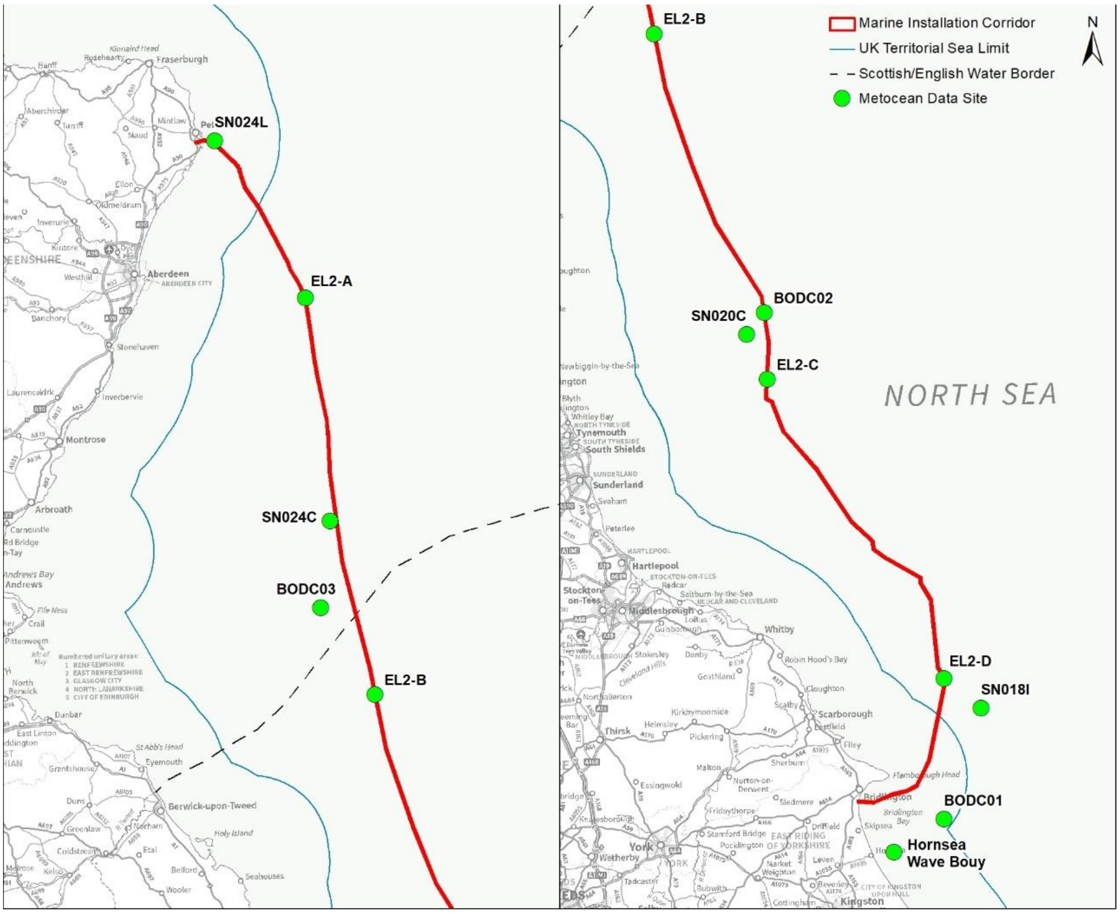

Figure 7-13: Metocean data sites

7.5.5.2 Tidal Currents

Tidal currents are an important component of the physical environment, influencing aspects including sediment transportation and dispersion of suspended sediment. A description of tidal currents has therefore been included in the EAR, but as previously stated potential changes in metocean conditions were scoped out, hence no further consideration is given to tidal currents as a receptor.

Table 7-3 provides the spring and neap peak flow speeds for the Marine Installation Corridor from the data sources detailed in Table 7-2. The peak flow speeds vary between 0.41 m/s to 1.08 m/s for a mean spring tide and between 0.26 m/s and 0.51 m/s for a mean neap tide along the Marine Installation Corridor.

Table 7-3: Tidal current speed

Location (Figure 7-13)	**Spring Peak Flow (m/s)**	**Neap Peak Flow (m/s)**
EL2-A	0.60	0.30
EL2-B	0.54	0.28
EL2-C	0.52	0.26
EL2-D	0.75	0.36
SN024L	1.08	0.51
SN024C	0.41	0.26
SN020C	0.51	0.26
SN018I	0.77	0.36
BODC01	0.90	0.45
BODC02	0.58	0.30
BODC03	0.62	0.30

The tidal excursion lengths are estimated by scaling from figures provided in the Atlas (ABPmer, 2008) to be between 9 km and 10 km closest to the Scottish landfall and between 6 km and 14 km closest to the English landfall. The Atlas indicates that the dominant tidal currents are transitioning to a south west / north east axis as the Marine Installation Corridor moves north of the Firth of Forth. In English waters, the dominant tidal currents are aligned with a south east / north west axis along the Marine Installation Corridor (ABPmer, 2008).

Observed and modelled currents indicate that flood (southwards) flowing currents are always stronger than ebb (northwards) currents. 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 (MEFEPO, 2019). 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. This is discussed further in Section 7.5.7.

7.5.6 Water Quality

The WFD is designed to protect the water environment by preventing deterioration, protecting, and enhancing aquatic ecosystems, promoting sustainable water use, and reducing pollution. In order to demonstrate compliance with the requirements of the WFD, a WFD Compliance Assessment Report has been produced, which is provided in Appendix 7.1. The WFD Compliance Assessment Report considers activities within the marine environment, extending 1 NM from MHWS, and therefore has bearing upon both landfalls and the approaches to them. The main regulatory bodies are the Scottish Environment Protection Agency (SEPA) and the Environment Agency (EA) for Scottish and English waters respectively. A programme of monitoring and water classification is undertaken by both SEPA and EA as part of the WFD and national legislative requirements.

The most recent classification data available from SEPA (2017) shows that the Scottish landfall falls within the Ugie Estuary to Buchan Ness waterbody and is classified as 'Good'. Peterhead Bay, located 2 km north west of the Marine Installation Corridor, is designated as a 'Bathing Water' of 'Good' status based on information for the Peterhead (Lido) bathing water. The classification data indicates that the Fraisthorpe bathing water near the English landfall at falls into the 'Good' waterbody category based on measurements (Environment Agency, 2020).

7.5.7 Sediment Transport

7.5.7.1 Scottish Landfall

As shown in Figure 7-14, the Scottish landfall in Sandford Bay is characterised by a soft sandy beach and cliffs, with an intertidal area extending approximately 100 m. The Dynamic Coast interactive GIS maps (2021) provide details of historical shoreline change in Sandford Bay. Those data indicate that the majority of the sandy beach has advanced (accreted) approximately 18 m over a period of 40 years (from 1972 to 2011) when compared to the present-day MHWS contour line. The analysis of future shoreline change suggests that coastal processes within Sandford Bay are 'self-contained' with erosion along the shorelines to the north and south providing a source of sediment to the east-facing beach.

Figure 7-14: Scottish landfall - panoramic view towards the south at low water

The coastline further to the north is governed by the headland feature immediately to the south of the port of Peterhead which acts as a 'hard-point' where erosion is effectively prevented. The breakwaters further to the north, which provide protection to the port from offshore waves, are expected to have foundations that extend down to unerodable bed material. This section of artificial coastline is therefore protected from erosion and can be considered to be fixed.

The coastline along the southern section of the bay is controlled by another headland feature which limits the rate of erosion due to the wide, rocky foreshore which reduces the intensity of wave action at this location. The foreshore is, however, narrower to the west of this point and is therefore more susceptible to erosion by waves, as predicted by the future shoreline change analysis (Dynamic Coast, 2021).

In summary, Sandford Bay can be considered as a 'closed system' in terms of coastal sediment transport processes.

7.5.7.2 English Landfall

The English landfall at Fraisthorpe Sands is characterised by sandy beaches backed by soft cliffs, gently shelving into a shallow sub-tidal environment, as shown in Figure 7-15. World War II tank traps were historically placed continuously from Bridlington to Barmston to protect the low-lying coastline from invasion, and sections of these remain on the beach in the vicinity of the Marine Installation Corridor and become visible at low tide. When submerged by the tide, these features are reported to be involved in local wave breaking (Orsted, 2021).

The erosion of the coastline in this area is known to be controlled by both tidal currents and waves, as well as the sediment that is contained within this sediment sub-cell. In the near-shore areas, waves strike the beach at an angle, whereas in deeper waters tidal currents control the movement of material. Beach levels within this area tend to further fluctuate due to interruptions in the southerly supply of beach sand or following storms that temporarily draw sand offshore. This lowering of beach levels leads to the exposure of the underlying clay surfaces, leading to coastal erosion (East Riding of Yorkshire Council, n.d.).

Figure 7-16 provides an illustration of local coastal processes and related features near the location of the English landfall. The arrows used to indicate the direction of net sediment transport from previous studies ((HR Wallingford, 2002) and (ABP Marine Environmental Research Ltd, 2005)) show a general pattern within the area. At Fraisthorpe Sands, there is weak net longshore drift to the north east, driven by infrequent waves from the southerly sectors with Flamborough Head sheltering this section of coast from the influence of larger and prevailing northerly waves, with sediment ultimately directed offshore towards Smithic Bank (see Section 7.5.8.3). The area immediately to the south of the landfall can be regarded as a drift divide for longshore drift with the sum of all drift rates and directions being effectively nil over the year (Orsted, 2021).

Figure 7-15: English landfall – panoramic view towards the north-west at low water.

7.5.8 Physical Environment Features of Interest

7.5.8.1 Scottish Territorial Waters

Southern Trench Marine Protected Area

The Southern Trench Marine Protected Area (MPA) lies off the Aberdeenshire coast in the outer Moray Firth, stretching from Buckie in the west to Peterhead in the east (Nature Scotland, 2020) (Figure 7-17). It is located 1.96 km to the north of the Marine Installation Corridor and is designated for its burrowed mud, which is a Priority Marine Feature and listed on the OSPAR list of Threatened and Declining Habitats. The site is also designed for its shelf deeps, which are comprised of valleys, canyons and troughs which support the formation of burrowed muds (Nature Scot, 2019).

7.5.8.2 Scottish Offshore Waters

Firth of Forth Banks Complex MPA

The Firth of Forth Banks Complex MPA is located in offshore waters to the east of Scotland, and includes the Berwick, Scalp and Montrose Banks, and the Wee Bankie shelf banks and mounds (JNCC, 2014) (Figure 7-17). The Marine Installation Corridor runs adjacent to this MPA between KP84 and KP118. This site is designated for the conservation of offshore subtidal sands and gravels, and shelf banks and mounds. The complex is made up of different types of sands and gravels which, although common around Scotland, are made unique by the dynamic currents within the Firth of Forth Banks that sort and distribute the different sediments into a mosaic of areas of coarse gravels and finer-grained sands that form habitats that support a variety of animals (JNCC, 2014).

The subtidal sands and gravels are listed under Section 2(4) of the Nature Conservation (Scotland) Act 2004 (formally UK BAP Priority Habitat), with the offshore sediments considered a Priority Marine Feature in Scottish offshore waters. Shelf banks and mounds are elevated areas of seabed. Created by strong currents, they are formed by the accumulation of great volumes of sediments (Nature Scot, 2020).

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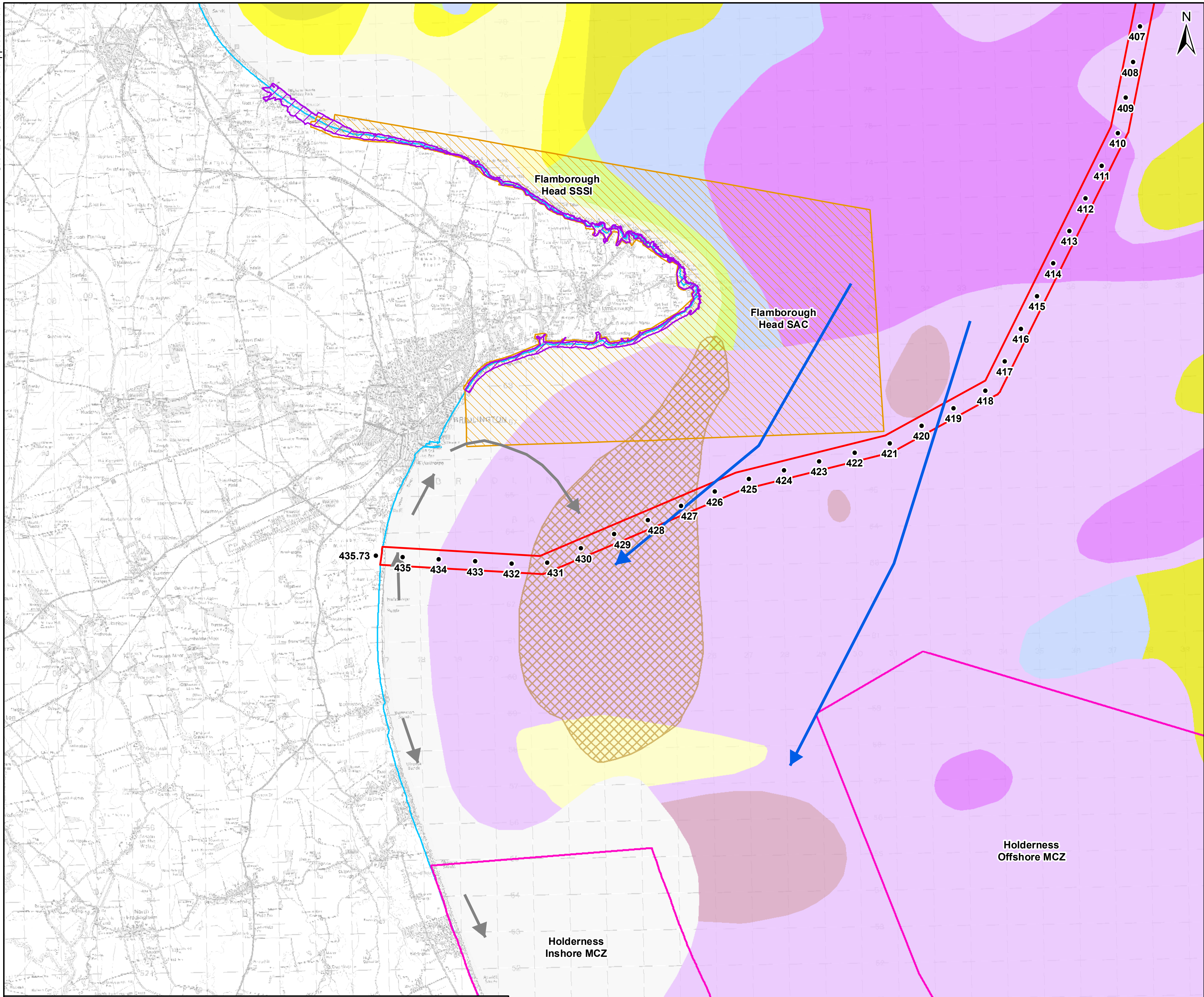


Coordinate System: ETRS 1989 UTM Zone 30N

Scale @ A3 1:100,000

nationalgrid
Scottish & Southern Electricity Networks

PROJECT

Eastern Green Link 2

KEY

- Marine Installation Corridor
- Kilometre Point (KP)
- Mean High Water Springs
- Direction of Net Longshore Drift
- Regional Bedload Sediment Pathways (Kenyon and Cooper, 2004)
- Site of Special Scientific Interest (SSSI)
- Special Area of Conservation (SAC)
- Marine Conservation Zone (MCZ)
- Smithic Bank

Seabed Substrate 1:250k (EMODnet)

- 1.3.1 Muddy Sand
- 1.3.2 (Gravelly) Muddy Sand
- 2.1.1 Sand
- 2.1.2 (Gravelly) Sand
- 3.1.1 Gravelly Sand
- 3.2.1 Sandy Gravel
- 3.3.1 Gravel
- 4.3.1 Gravelly muddy Sand
- 4.4.1 Muddy sandy Gravel

TITLE

Figure 7-16
Local Coastal Processes in the vicinity of the English Landfall

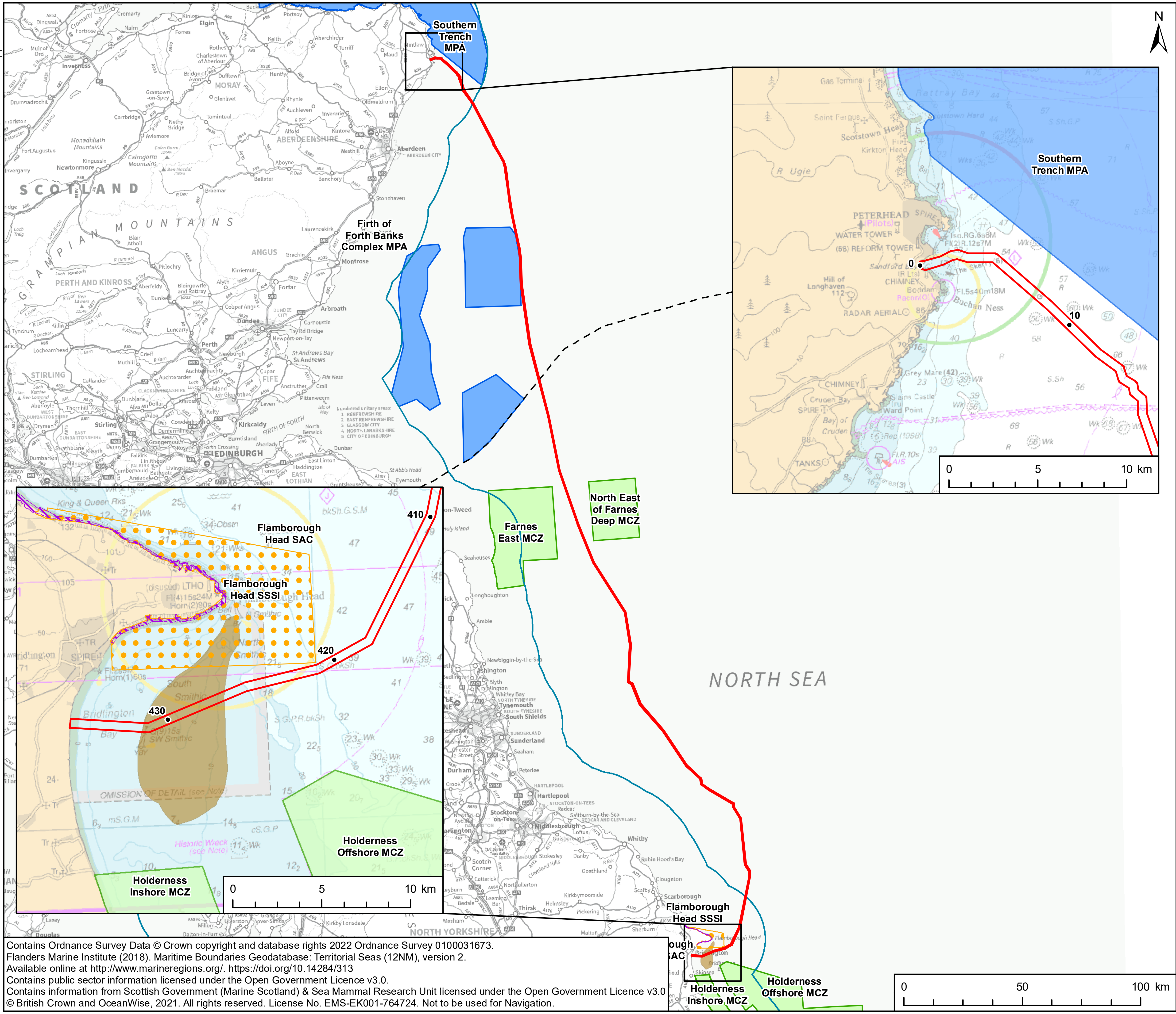
REFERENCE

SEGL2_M_EAR_7-16_v2_20220624

SHEET NUMBER | DATE

1 of 1 | 24/06/2022

GIS: LC Checked: KB Approved: FF



Coordinate System: WGS1984 Zone 30N

Scale @ A3 1:1,500,000 / 1:200,000

nationalgrid
Scottish & Southern Electricity Networks

PROJECT
Eastern Green Link 2

KEY
- Marine Installation Corridor
- UK Territorial Sea Limit
- Scottish Adjacent Waters Boundary
- Special Area of Conservation (SAC)
- Site of Special Scientific Interest (SSSI)
- Nature Conservation Marine Protected Area (MPA)
- Marine Conservation Zone (MCZ)
- Smithic Bank

TITLE
Figure 7-17
Physical Environment Features of Interest

REFERENCE
SEGL2_M_EAR_7-17_v2_20220627

SHEET NUMBER: 1 of 1
DATE: 27/06/2022

7.5.8.3 English Waters

Marine Conservation Zones

A number of Marine Conservation Zones (MCZs) designated for physical environment features[7] are in part located in English offshore and territorial waters, within 10 km of the Marine Installation Corridor (Figure 7-17), including:

- **North East of Farnes Deep MCZ** (extending into English offshore waters only): designated for its moderate energy circalittoral rock, subtidal coarse sediments, subtidal sand, subtidal mud, subtidal mixed sediments. The general management approach for these protected features is to maintain in favourable condition[8];
- **Farnes East MCZ** (extending into both English offshore and territorial waters): designated for its moderate energy circalittoral rock, subtidal coarse sediments, subtidal sand, subtidal mud and subtidal mixed sediments. The general management approach for these protected features is to maintain in favourable condition, with the exception of subtidal mud which is to recover to favourable condition[9];
- **Holderness Offshore MCZ** (extending into English offshore and territorial waters): designated for its subtidal coarse sediments, subtidal sand and subtidal mixed sediments. The general management approach for these protected features is to recover to favourable condition[10]; and
- **Holderness Inshore MCZ** (extending into English territorial waters only): designated for its intertidal sand and muddy sand, moderate energy circalittoral rock, high energy circalittoral rock, subtidal coarse sediment, subtidal mixed sediments, subtidal sand, subtidal mud. The general management approach for these protected features is to maintain in favourable condition[11].

Flamborough Head Site of Special Scientific Interest (SSSI) and Special Area of Conservation (SAC)

The Flamborough Head SSSI and SAC is located on the central Yorkshire coast of eastern England. The SAC covers an area north of Bridlington to Speeton (Figure 7-17). The SSSI is located 4.3 km from the Marine Installation Corridor, while the SAC is located 370 m to the north. The SAC is designated for various Annex I habitats, including reefs (including bedrock, boulders and cobbles)[12]. The reefs are considered important due to their substrate type, biogeographic position and the influences of hydrodynamic processes on reef topography and community structure. The reefs to the north of Flamborough Head are considered harder and more exposed than those to the south[13].

Smithic Bank

Smithic Bank is presently undesignated but is noted as a potential Annex I habitat features (subtidal sandbank) (Figure 7-17). The bank extends from south of Flamborough Head by over 12 km north to south, with the feature crossed by the Marine Installation Corridor between approximately KP426.5 and KP431.5. The bank is a headland or banner type bank formed by eddy flows moving south from Flamborough Head with a net clockwise circulation (HR Wallingford, 2002). The flood tide dominates the outer edge and an ebb tide dominates on the inner edge. The bank is maintained by local sediment supply from cliff erosion from the south, with further sediment supplied from sources north of Flamborough Head. The Smithic Bank is then thought to act as a local store of these sandy sediments within a tidal gyre (HR Wallingford, 2002).

During surge conditions material is likely to be driven from Smithic on to the coast, primarily towards Bridlington and Hornsea, making the Smithic Bank area potentially significant to the management of the rapidly eroding Holderness coastline and sediment for the Holderness Inshore (MCZ) (HR Wallingford, 2002).

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[7] Note that only physical environment features are discussed in this chapter. Ecological features of the MCZs are discussed in the relevant ecological topic specific chapters.
[8] https://data.jncc.gov.uk/data/5c5def7f-e1a0-4a7f-8078-a0ff3050a4fb/NEFD-2-ConservationObjectives-V1.0.pdf
[9] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/492371/mcz-farnes-east-factsheet.pdf
[10] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/805479/mcz-holderness-2019.pdf
[11] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/492320/mcz-holderness-factsheet.pdf
[12] https://sac.jncc.gov.uk/site/UK0013036
[13] European Site Conservation Objectives for Flamborough Head SAC - UK0013036 (naturalengland.org.uk)

The Bank's morphology suggests that it responds to both waves and tides, with tidal flows being the main influence on driving sandwave migration, whereas wave attenuation is the main cause of smoothing and broadening of the profile to the south of the Bank (Orsted, 2021).

The feature was observed at benthic transect EL_HG_B22_04 at KP431.3, which was over an area of raised shallow sand compared to the surrounding survey area. The sediment type was dominated by fine sand (Next Geosolutions, 2022b).

Holderness Coastline

Extending to the north and south of the English landfall area is the Holderness Coast which is reported to be one of the fastest eroding coastlines in Europe. East Riding of Yorkshire Council have undertaken land-based monitoring of the coastline every six months since 2003, which also includes the collection of beach profiles (East Riding of Yorkshire Council, n.d.). The surveys have shown that the cliffs are eroding rapidly at some locations; with average rates of loss up to 1.8 m per year. The recession rates vary along the Holderness coast, as well as year to year, but with a general increased rate towards the more southerly end of the coastline in this area, which is in line with increased exposure to north easterly waves.

The Shoreline Management Plan (SMP) policy for this area of coastline is defined as No Active Intervention for the short (present day to 2025), medium (2025 to 2055) or long terms (from 2055 to 2105) (Scott Wilson, 2010). The National Coastal Erosion Risk Mapping (NCERM) (2018 – 2021) identified the Holderness coastline as a natural defence and erodible. Assuming that the SMP policy remains unchanged in the future, the best estimates of retreat distance for the short term would be approximately 33 m and for the medium term would be up to approximately 82 m (Environment Agency, 2020), based on present conditions.

7.5.9 Future Baseline Condition

The baseline physical environment descriptions reflect the state of the existing environment. The earliest year for the start of installation is 2025, with the Marine Scheme planned to be operational from 2029.

The potential exists for the baseline environment to evolve over the period between this appraisal and the point of potential impact. Outside of short-term or seasonal variations, changes in physical environment typically occur over extended periods of time, as considered in the sections below; however, the baseline environment is not predicted to fundamentally alter from its current state at the point of time when potential impacts may occur for the Installation and Operation and Maintenance Phases. The baseline environment for the Decommissioning Phase is, however, expected to evolve as described in the following sections, with the additional consideration that any changes introduced as a consequence of the Installation Phase would have only locally modified the baseline environment.

7.5.9.1 Climate Change

Climate change is a global-scale issue which have the potential to modify existing weather patterns and increase average temperatures. One influence of climate change is the melting of icecaps and glaciers as a result of increased temperatures, which may in tern increase average sea levels. The most up to date climate change predictions are provided by the UK Climate Change Projections 2018 (UKCCP18) (Met Office, 2019). These predictions draw on a wide range of models which may also show contrasting results. The main physical environment parameters from the UKCCP18 are sea level rise, tidal levels and waves as described below.

Sea Level Rise

Over the operational life of the Marine Scheme, mean sea levels are expected to increase. The Representative Concentration Pathway (RCP) 8.5 scenario is a future scenario where greenhouse gas emissions continue to grow unmitigated and 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 predicted to be +0.38 m (at the Scottish landfall) and +0.33 m (at English landfall) by 2061.

7.5.9.2 Isostatic Rebound

In addition to climate change, isostatic rebound from the last ice age continues to adjust some land and seabed levels, with the southern parts of the UK slowly sinking and the northern parts (which were subject to greater glacial influence) slowly rising. For the Marine Scheme, the adjustment at the Scottish landfall is approximately +0.4 mm per year whereas between -0.6 mm per year and -0.8 mm per year is predicted for the English landfall (Figure 7-18).

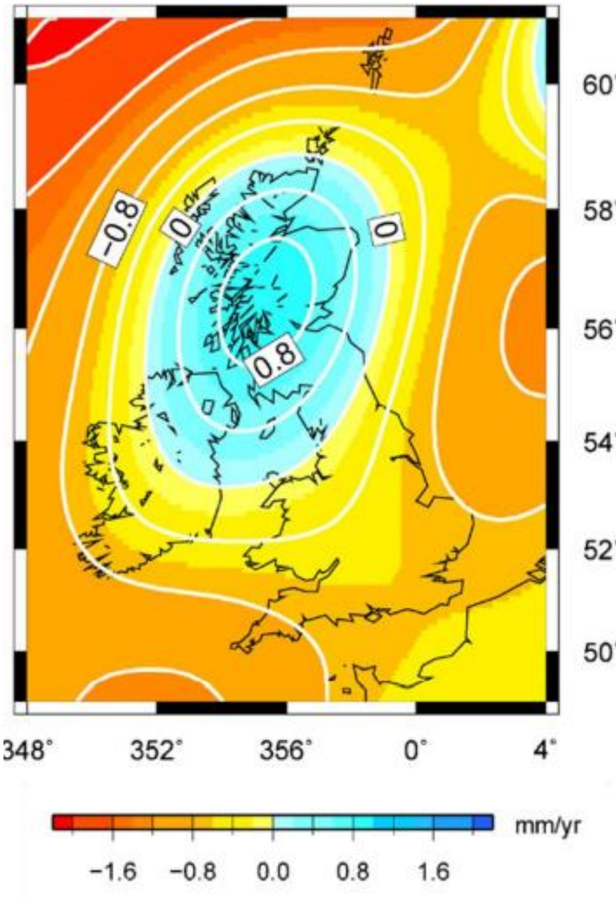

Figure 7-18: Predicted isostatic uplift rates (Bradley et al., 2011).

7.5.9.3 Likely Response to Relative Sea Level Rise

Relative sea level rise is the combination of climate changes and isostatic rebound and is considered of relevance for the future baseline for the operational life of the Marine Scheme. At the Scottish landfall, Dynamic Coasts (2021) predicts two potential areas of erosion of between 5 m and 10 m to the northern and southern coastlines of Sandford Bay, close to the beach, by 2060. However, as previously described the shoreline position of the MHWS mark is predicted to remain stable for the future high emissions scenario up to 2100.

Any increase in mean sea level at the English landfall is expected to increase the rate of coastal erosion (East Riding of Yorkshire Council, n.d.). Cliff erosion rates would also respond to changes in the frequency or severity of storm surges. The National Coastal Erosion Risk Mapping (2018-2021) identified that the best estimates of retreat distances for the medium term (20 to 50 years) would be around 82 m (Environment Agency, 2020) based on present conditions even before increases in mean sea level has been considered.

7.6 Appraisal of Potential Impacts

This section discusses the potential impacts on the physical environment receptors during the Installation, Operation and Maintenance 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.

Impact pathways appraised may affect both the physical environment directly, and other receptors that are indirectly influenced by the physical environment, such as benthic ecology, fish and shellfish ecology, and commercial fisheries.

7.6.1 Sediment Dispersion Zone of Influence

The subtidal section of the Marine Scheme is characterised by a range of different seabed types, but is dominated by long stretches of sublittoral sand, a mosaic of sublittoral sand with small patches of mixed sediment and extensive regions of mixed and coarse sediments in deeper waters. The mean particle size analysis (PSA) value across all stations sampled across the Marine Installation Corridor recorded an average of 10.5 ± 8.3% fines (i.e., silts and clays), 83.6 ± 11.4% sand and 5.9 ± 9.7% gravel (Next Geosolutions, 2022b). The classification of seabed sediments by their characteristic particle size makes it possible to understand how different types of sediment will behave after being brought into suspension due to mechanical disturbance during the cable trenching process. Coarse material would be expected to settle back to the seabed relatively quickly following disturbance, whilst fine particles may produce a more persistent plume.

There are a number of modelling studies which have been undertaken for other offshore developments in the North Sea with similar hydrodynamic conditions and substrate types to those which can be observed within the Marine Installation Corridor. These data indicate that sands (in the 0.062 mm to 2 mm size range) and coarse sediments (>2 mm) would disperse up to a maximum of 700 m and 100 m from source, respectively (Scira Offshore Energy Limited, 2006); (Royal Haskoning; GWFL, 2011); (Nemo Consortium, 2013); (National Grid Viking Link Limited; Energinet, 2017).

Consistent with the approach set during Scoping, detailed modelling studies have not been undertaken for the Marine Scheme. This notwithstanding, calculations have been undertaken to establish theoretical limits for a ZoI for sediment dispersion as a result of Marine Scheme activities that have the potential to disturb the seabed and generate sediment plumes. The level of agreement in terms of the ZoI established using very different methods, and the degree of conservatism provided by the more simplistic approach adopted here, provides further justification for the use of such an approach in similar situations.

The settling velocity (w_s) of coarse and fine sand has been estimated using Soulsby's (1997) equation[14]:

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

where v is the kinematic viscosity of water, d is the median grain size and D_* is the dimensionless particle diameter. A typical settling velocity equivalent to 0.5 mm/s is assumed for silt particles and clay (Soulsby, 1997), including HDD drilling fluid particulate matter which can contain substances such as bentonite clay.

Based on the settling velocity, the time required for the different grain sizes (coarse sand, fine sand, silt and clays) to fall 5 m was also estimated. The velocity for the bottom 2 m of the water column (0.41 m/s) was estimated based on the average velocity for offshore locations (0.47 m/s) (average of peak spring and neap flows (Table 7-3)), 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 presented in Table 7-4.

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

Table 7-4: Estimates of sediment settling velocity and distance travelled before deposition in the offshore setting

Grain size	Dimensionless particle diameter	Settling velocity (m/s) (Soulsby, 1997)	Time required to fall 5 m (secs)	Maximum Zone of Influence over which increase in suspended sediment concentration is detected (m)
Coarse sand (0.125 mm)	2.54	0.0087	575	240 m
Fine sand (0.05 mm)	1.02	0.0014	3,474	1,500 m
Silt-clays (0.005 mm)	-	0.0005	10,000	1,500 m

In the absence of any site-specific modelling of sediment dispersal processes, this approach has been used to provide an indication of the likely travel distance for a sediment particle brought into suspension during the cable trenching process. This is then used to define a maximum ZoI for different fractions (or size classifications) of suspended sediment. It includes an implicit assumption that the particle is not prevented from settling on the seabed and that after contact with the seabed, the particle is not re-suspended.

The mean PSA suggests that the majority of the sediment particles are larger than silt and will therefore settle to the seabed at least the rate for fine sand, which is within an hour, and likely to be within the Marine Installation Corridor. Fine sands and silts, however, may be transported beyond the Marine Installation Corridor with any fine sand settling on the seabed up to 1.5 km from the point where it is mobilised. The calculated 1.5 km distance travelled by fine sand particles is defined by the higher settling velocity of sand compared to that of silt-clay and therefore reaches the bed within 1.5 km, whilst being carried in suspension by the ambient tidal currents.

Based upon the calculated settling velocities, any silt-clay sized particles will remain in suspension for several days and may therefore travel further than 1.5 km. Dispersion processes (tidal currents) will also act to dilute the concentration of any particles carried in suspension over this time, therefore, whilst increased concentration levels of silt and clay sized sediment may travel beyond 1.5 km from the source they are not expected to be detectable against background suspended sediment concentrations.

Therefore, the ZoI for potential effects associated with elevated suspended sediment concentrations which are detectable above background concentrations is 1.5 km for all pathways.

7.6.2 Summary of Potential Impacts Considered

7.6.2.1 Potential Impacts Screened In

A summary of the potential impacts considered as part of this appraisal are provided in Table 7-5:

Table 7-5: Summary of the potential impacts

Potential impact	Zone of influence (ZoI)
Landfall preparation and installation	
HDD operations and cable pull in.	Up to 0.01 km^2 at each landfall
Vessel anchoring and use of spud legs	Up to 0.0003 km^2 at each landfall
Route preparation and cable installation	
Temporary physical disturbance to subtidal seabed sediments	106.0 km of boulder clearance plough (25 m swathe) and 340.0 km of mechanical trenching (15 m swathe). Giving a total footprint of 7.6 km^2 per cable, so 15.2 km^2 for separate lay.
Temporary increase in suspended sediment concentrations (SSC) sediment deposition leading to contaminant mobilization and changes in turbidity.	Footprint of the proposed works plus 1.5 km buffer; based on professional judgement and consideration of worst-case for fine particulates.

Potential impact	Zone of influence (ZoI)
Changes to marine water quality effects from the use of HDD drilling fluids and accidental leaks and spills from vessels, including loss of fuel oils	Footprint of the proposed works plus 1.5 km buffer; based on professional judgement and consideration of worst-case for fine particulates
Disturbance of sandwaves and sandwave fields by Mass Flow Excavator activities.	9 km Scottish territorial (within 12 NM), 8.5 km Scottish offshore (outside 12 NM), 5 km English offshore and 1.5 km English territorial, with up to 10 m wide swathe.
Operation and Maintenance	
Changes in hydrodynamic processes and scour from changes to seabed profile due to the presence of cable protection / cable crossings protection.	Local scouring around ends of rock berms at locations where parts of the seabed demonstrate active seabed mobility (Orsted, 2021).
Decommissioning	
Potential effects the same as route preparation and cable installation	Anticipated to be analogous to route preparation and cable installation.

7.6.2.2 Potential Impacts Screened Out

The majority of suspended sediment is not considered to be significantly elevated beyond 1.5 km. Potential impacts on the following receptors have been screened out of further consideration in this appraisal because no potential impact pathway has been identified:

- Southern Trench MPA (located 1.96 km from the Marine Installation Corridor);
- Farnes East MCZ (located 4.88 km from the Marine Installation Corridor);
- North East of Farnes Deep MCZ (located 3.12 km from the Marine Installation Corridor);
- Flamborough Head SSSI (located at closest 4.3 km from the Marine Installation Corridor). The SSSI, begins beyond the maximum potential extent of dispersed fine materials from HDD discharges and other works, with no overlap;
- Holderness Inshore MCZ (located 7.74 km from the Marine Installation Corridor); and
- Holderness Offshore MCZ (located 5.5 km from the Marine Installation Corridor).

The unintentional or inadvertent loss of drilling fluids during drilling operations from the borehole to the ground surface from points other than its entry and exit points (known as frac-out) has not been considered in the appraisal as drilling fluid parameters such as circulation pressure, gel strength, mud weight, and viscosity will be continuously monitored and regular inspection along the drill path during pilot hole drilling conducted.

7.6.3 Embedded Mitigation

Mitigation that has been embedded into the design of the Marine Scheme has been presented in Chapter 2: Project Description. Any that are specific to the physical environment are presented in Table 7-6.

Table 7-6: Physical environment embedded mitigation

Activity / Issue	Embedded mitigation commitment
All phases	
Marine Scheme vessel requirements	• All vessels will follow the International Regulations for Preventing Collisions at Sea 1972 (COLREGS) and International Convention for the Safety of Life at Sea 1974 (SOLAS); • All vessels will be in compliance with the International Convention for the Prevention of Pollution from Ships (MARPOL) regulations and will therefore be equipped with waste disposal facilities onboard. The discharging of contaminants is not permitted within 12 nm from the coast to preserve bathing waters; • Control measures and shipboard oil pollution emergency plans (SOPEP) will be in place and adhered to under MARPOL Annex I requirements for all vessels; • Where possible, vessels will operate with dynamic positioning which will minimise anchor disturbance on the seabed; • A temporary 500 m Recommended Clearance Zone will be established around all vessels associated with the works; • Limits to wave height / wind speed conditions for operations / activities will be followed by all vessels.
Installation Phase	
Micro-routeing / detailed design post-consent	Detailed route development and micro-routeing will be undertaken within the Marine Installation Corridor, informed by pre-installation evaluation of site-specific survey data to avoid or minimise localised engineering and environmental constraints. This will include minimising the footprint as much as possible; Navigational features such as charted or known anchorages, maintained channel depths and prohibited regions will be avoided; Changes to the sedimentary and metocean environments will be minimised by careful route selection and the use of appropriate burial techniques and cable protection methods such as fall pipes for the laying of rock placement; Reduction in charted water depth to LAT will be limited to less than 5% where possible; and A Cable Burial and Protection Plan will be submitted to include detailed micro-routeing, trenching methods and external protection measures for the final design of the Marine Scheme prior to commencement of Installation Phase activities.
Construction Environmental Management Plan (CEMP)	Prior to cable installation activities commencing, a CEMP, including an Emergency Spill Response Plan (ESRP) and Waste Management Plan will be developed and agreed with relevant stakeholders in accordance with the coastal and marine environment site guide.
Landfall installation	Horizontal Directional Drilling (HDD) will be used at both landfalls for the installation of the cables in the transition zone between the Onshore Schemes and the Marine Scheme which avoids any works in the intertidal environment; and This will keep sediment disturbance to a minimum, minimising the use of cable protection measures inshore of the 11 m depth contour at Sandford Bay and the 5 m depth contour at Fraisthorpe Sands. This avoids direct impacts on sensitive coastal and intertidal habitats and features.
Drilling fluids	Drilling fluids for HDD operations will be biologically inert and selected from the OSPAR List of Substances/Preparations Used and Discharged Offshore which are Considered to Pose Little or No Risk to the Environment (PLONOR); During drilling, drilling fluids will be recycled, treated, and reused as far as possible, and any waste drilling fluid will be transported offsite for treatment and disposal; and Losses of drilling fluids are unavoidable; however they will be minimised insofar as practicable through the implementation of industry best practice for example, clearing runs or reducing the volume of drilling fluids in the borehole prior to breakout to the marine environment.
Rock placement	Berms will be designed to reduce snagging risk in so far as is practicable, with 1:3 slopes and flat crests in line with industry guidance; Rock utilised in berms will be igneous, clean with low fines; and A vessel able to undertake a targeted placement method will be used, such as one fitted with a flexible fall pipe.

7.6.4 Installation Phase

Cable installation will be carried out in a number of campaigns. It is anticipated that between five and 10 campaigns of cable laying will be required, with the potential for trenching and cable route preparation between campaigns. While cable laying is expected to avoid the winter season wherever possible, other works, such as route clearance and trenching could occur at other times of the year. Works are expected to take two to three years, and potentially up to five years as worst case.

Various cable installation and cable protection measures are currently being considered. For the purpose of the appraisal of potential impacts on the physical environment, surface lay and post-lay trenching in two trenches up to a maximum separation of 30 m, using boulder clearance plough and mechanical trencher is considered the worst-case scenario, as this would result in the greatest overall seabed disturbance. However, jet trenching and the use of MFE, are considered as the worst case with regard to mobilsation of seabed sediments into suspension.

7.6.4.1 Changes to seabed features in water depths >10 m

This section considers the potential impacts of the Marine Scheme on the seabed features such as sandbanks, sandwaves and protected sites. Both large isolated sandwaves (up to 12 m high) and sandwave fields are present within the Marine Installation Corridor, particularly within the first 80 km.

Route Clearance

During pre-lay grapnel runs, there will be localised disturbance of the seabed associated with a maximum ZoI of up to 3 m wide for full length of the Marine Installation Corridor. Boulder clearance activities have a maximum ZoI of up to 25 m, and are limited to the seabed surface, with no significant penetration of the seabed and therefore no significant change to underlying sediment conditions. Both pre-installation activities may cause potentially permanent disturbance to the seabed bathymetry due to the change in location of large boulders, but the physical environment is not considered to be sensitive to the movement of boulders a small distance (up to approximately 12.5 m) in location. Any seabed disturbance and associated changes to processes will be localised and despite the potential permanent nature of the change, the magnitude of the change is considered **low**. The significance of the effect is assessed to be **negligible**, which is considered to be **not significant**.

Sandwave Lowering

Cable installation offshore will result in temporary disturbance to the seabed. Cable route clearance will include the lowering of the sandwaves using Mass Flow Excavator (MFE). The footprint of this activity may be up to 10 m in width in loosely packed sands, but typically less than 6 m. Smaller scale sandwaves (and smaller bedforms i.e., ripples and megaripples) may be destroyed by cable route clearance activities. Larger sandwaves (>10 m in length) and sandwave fields are likely to only be partially disturbed. The sensitivity of sandwaves and sandwave fields is considered low as the footprints of the Installation Phase activities are not likely to influence the overall form and function of the bedform system and recovery is expected via natural sediment transport processes. Therefore, the magnitude of the impact is considered low, and the significance of the effect is **negligible**, which is considered to be **not significant**.

Trenching Activities

Trenching activities will locally disturb the seabed with a maximum ZoI of up to 25 m in width per trench and up to 1.5 m in depth to allow the target depth of lowering to be achieved for the displacement plough which is limited in use as described in Chapter 2: Project Description. Trenching has the potential to destroy seabed features such as small bedforms and alter underlying sediment conditions as a result of sediment disturbance. The impact of this change may cause a localised change to sediment transport regimes as sediments become newly exposed to wave and current action on the seabed. This may result in change to the local bed morphology compared to baseline conditions, as different bedforms develop from the newly exposed sediment. The sensitivity of the receptor is considered to be low as the footprints of the Installation Phase activities are not likely to influence the overall form and function of the seabed and its forms. Furthermore, recovery is expected via natural sediment transport processes. Therefore, magnitude of the impact is considered low and the significance of this impact is considered to be **negligible** which is considered to be **not significant**.

7.6.4.2 Changes to seabed bathymetry and morphology in shallow water depths

Changes to seabed morphology caused by anchor deployment

Anchors will be used to maintain the position of vessels in shallow waters impacting various points of the seabed up to 800 m from the vessel. There are no sandwaves or megaripples within in water depths <20 m at Sandford Bay. Between KP425 and KP427 (approximately 4 km off Fraisthorpe Sands in water depths <10 m), there is an area of sandwaves / megaripples which might be impacted by anchor deployment. The areas of seabed disturbed by anchor deployment are localised and limited in number, therefore the magnitude of the impact is considered low. The sensitivity of these bed features is considered low as sediment transport driven by natural wave and tidal action will return the bed to equilibrium conditions. The significance of the effect is assessed to be **negligible**, which is considered to be **not significant**.

Changes to seabed morphology caused by HDD

At both landfall sites, 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 pits at each landfall is estimated to cause an area of up to approximately 5,000 m^2 of seabed disturbance, with the same area (5,000 m^2) for pre trenching works to facilitate pull in of cables to the HDD exit pit, with the excavated sediment being sidecast within the Marine Installation Corridor, allowing re-distribution of sediments by hydrodynamic processes. The magnitude of the impact is considered to be low. The sensitivity of the seabed in shallow water depths to sediment disturbance is considered low due to its dynamic nature where sediment transport driven by natural wave and tidal action will evenly disperse and return the bed to equilibrium conditions. The significance of the effect is assessed to be **negligible**, which is **not significant**.

7.6.4.3 Increased suspended sediment

Cable trenching (during the Installation Phase) will cause sediment to become suspended into the water column. As described in Section 7.5.2, the 2021 geophysical and geotechnical survey shows that for large parts of the Marine Installation Corridor, the surficial deposits are a veneer (less than 1 m thick) made of sands and gravelly sand. Therefore, trenching will likely include the removal of the underlying shallow geology, including higher strength glaciomarine sands and clays from KP0 to KP200 and glacial till (firm to stiff clay with occasional cobbles and boulders) (KP200 onwards).

The disturbance of this sediment (sand-clay sized particles) will result in a temporary increase in near bed SSC and the subsequent deposition of sediment back onto the seabed having been carried in suspension. These effects are considered to be impact pathways that have potential to alter receptors such as the seabed morphology, habitats and species.

The magnitude of the impact in shallow waters on seabed morphology is considered low, as any measurable change in SSC will be temporary and localised, i.e., near bed and within 1.5 km of the source of suspended sediments. The finer fractions (including silts, clays and HDD drilling fluid particulate matter) that are transported further will be diluted so that the sediment settling out of suspension will be low in concentration. Given the naturally dynamic nature of the seabed in shallow waters, influenced by tidal and wave action, the sensitivity of the seabed to a temporary increase in deposition of sediment is considered low and the magnitude of the impact is low. At locations >250 m from any cable trenching works, the effect of the impact on changes to the seabed morphology is assessed as **negligible**, increasing to **minor** at locations <250 m from cable trenching works, both of which are **not significant**.

Calculations in Section 7.6.1 estimate setting velocity and extent of sediment dispersion in deep water, show that coarse sands will settle back onto the seabed within the hour and within the marine installation corridor. Fine sands, silts and clays, however, may be transported beyond the Marine Installation Corridor with fine sands settling onto the seabed up to 1.5 km from the point where it was mobilised. Silt and clay sized material will remain in suspension for several days and may therefore travel even further.

The mean PSA suggests that the majority of the sediment particles in deep waters are larger than silt and therefore the majority of sediment suspended into deep waters will settle back onto the seabed either within the Installation Corridor or within 1.5 km from where it became suspended. Any measurable increase in SSC in deeper waters will be temporary and localised, i.e., near bed and within 1.5 km of the Marine Installation Corridor.

Given the naturally dynamic nature of the seabed and seabed features in deeper waters, the sensitivity of the seabed to a temporary increased deposition of sediment is considered low as any alterations to morphology caused by an increase in sediment deposition will return to equilibrium conditions via natural sediment transport processes driven by current action, and the magnitude of the impact is low. The effect of the impact on changes to the seabed morphology in deep water is assessed as **negligible**, increasing to **minor** at locations <1.5 km from cable trenching works, both of which are **not significant.**

The potential impact of increased SSC from both trenching and HDD drilling fluid, and subsequent sediment deposition on habitats and species caused by increased turbidity and smothering is assessed in Chapter 8: Benthic Ecology, and in Chapter 9: Fish and Shellfish.

7.6.4.4 Changes to Physical Environment - Features of Interest

The most sensitive physical environment features in the vicinity of the Marine Installation Corridor in Scottish offshore waters is the Firth of Forth Banks Complex MPA, which is adjacent to the Marine Installation Corridor. In English waters, physical environment features include the Flamborough Head SAC, situated 120 m to the north west of the Marine Installation Corridor.

Whilst appreciating it is not a designated site or protected feature, the Marine Installation Corridor passes through the southern half of the Smithic Bank between KP426.5 and KP431.5, a geomorphological feature which is formed and maintained by the supply of sediment transported as bedload, southwards around Flamborough Head (noting that it is a potential Annex I feature, which is not currently designated or subject to any formal consultation in support of onward designation). This feature also acts as a source supplying sediment to Bridlington Bay, part of the eroding Holderness coastline.

The Firth of Forth Banks Complex MPA, Flamborough Head SAC, Smithic Bank and Holderness Coast are all considered to be of medium sensitivity to potential changes to the physical environment. The increase in quantities of SSC associated with cable trenching has potential to affect these features of interest in the short term by altering their surficial sedimentary makeup, as sediment is transported in suspension and deposited onto them.

Firth of Forth Complex MPA

For some parts of Firth of Forth Banks Complex MPA, the Marine Installation Corridor runs adjacent to the MPA, the magnitude of the impact is assessed to be low as although it is likely that the MPA will experience deposition of sediment onto some parts of the complex <250 m from the trenching activities it is not considered that this deposition will alter the overall sediment types within the MPA. The significance of this effect is assessed to be **minor**, which is considered to be **not significant**.

Flamborough Head SAC

For Flamborough Head SAC, which is situated 120 m from the Marine Installation Corridor, the magnitude of this impact is considered to be low as although it is likely that the MPA will experience deposition of sediment onto some parts of the complex <250 m from the trenching activities it is not considered that this deposition will alter the overall sediment types within the MPA. The significance of this effect is assessed to be **minor**, which is considered to be **not significant.**

Smithic Bank and the Holderness Coastline

The Smithic Bank is recognised as a key geomorphological feature which is formed and maintained by the supply of sediment transported as bedload, southwards around Flamborough Head, it is described as primarily a ‘sink’ for sediment. This feature acts as a source supplying sediment to Bridlington Bay, part of the eroding Holderness coastline at a location where littoral transport occurs in opposite directions (Figure 7-16). Much as the feature may help to provide a source of sediment to Bridlington Bay. The Smithic Bank may also have a relationship with the Holderness Inshore MCZ and may be a source of sediment for it. Due to the inter-related nature of physical processes, interruption of the sediment supply from Smithic Bank to the Holderness coast has the potential to reduce sediment supply along the coastline, thus potentially creating increased risks of coastal erosion at Fraisthorpe Sands.

Given that Smithic Bank is of a sand composition, it is assessed that the minimum depth of lowering should be achievable by trenching, and consequently no rock placement is planned over this feature which has the potential to result in changes to the physical environment associated with the Smithic Bank and the Holderness Coast. Additionally, there are no third-party assets to be crossed in the vicinity of the Smithic Bank, which would also require the use of rock placement or concrete mattresses (see Section 7.6.5.5).

The sensitivity of Smithic Bank and the Holderness coast is considered to be medium, with the Bank and sediment transport process to the coast likely to naturally recover, following transient Installation Phase activities. There is no mechanism for trenching activities (see Section 7.6.4.1) to permanently disrupt sediment transport pathways across Smithic Bank, making the impact magnitude low. The effect significance is **minor**, which is considered to be **not significant**.

As the Marine Installation Corridor passes through the Smithic Bank, the Bank will experience deposition of sediment settling out from suspension having been suspended during trenching activities. The Smithic Bank acts as a natural sediment sink for sediment being transported south from Flamborough Head, so the redeposition of sediment onto the Smithic Bank, which will be naturally redistributed by wave and tidal action will have little impact on the feature's geomorphology or the Holderness coast. Therefore, the magnitude of this impact is assessed to be low. The effect significance is assessed to be **minor**, which is considered **not significant**.

7.6.4.5 Reduction in water quality

Release of HDD drilling fluid and associated particulates

The release of drilling fluids and drilled solids at HDD breakout (Chapter 2: Project Description) will reduce water quality at the locally for a period of time during and immediately after release of the fluids. Any drilled solids released are predicted to settle rapidly in the vicinity of the breakout. Constituents of the drilling fluids, including silt-clay sized particles such as bentonite have a maximum theoretical range beyond 1.5 km, however, dilution processes over this distance will result in no detectable changes from the baseline beyond 1.5 km, therefore the ZoI is considered to be 1.5 km.

Coastal tidal currents recorded closest to both breakout locations are the most dispersive recorded along the Marine Installation Corridor and dilution of fine materials will be rapid to background suspended sediment levels, with a low magnitude of impact predicted. The quantity of solid materials settling between breakout and maximum dispersion is not assessed as sufficient to affect coastal process and sensitivity to this impact is considered low. The significance of this impact is assessed as **negligible** and therefore **not significant**.

Mobilisation of contaminants

Sediment contamination is typically associated with finer materials (silt-clay sized particles) within disturbed sediments, adsorbed to the surface of organic matter, silt and clay particles. Dispersion of these fine materials and associated contaminants during trenching and cable installation has the potential to impact upon biological receptors such as benthic ecology. As detailed in the baseline, several locations with elevated levels of hydrocarbon and heavy metals have been identified and are thought to be associated with dredge spoil disposal and /or historic industrial harbour / estuarine contamination. In the context of the receiving open sea environment and tidal regime, dispersion of contaminated sediments with a silt-clay particle size has a ZoI of 1.5 km as described above, resulting in a low magnitude impact.

The concentrations of hydrocarbon and heavy metal encounters along the Marine Installation Corridor are not considered significant in the context of contaminants already present within the receiving environment (Next Geosolutions, 2022a), and sensitivity is considered low. The significance of the effect of this impact is therefore assessed as **negligible** and **not significant**.

In the shallow water setting, the water quality assessment for 2021 has been classified as 'excellent' at the Scottish landfall (SEPA, 2021), and 'good' at the English landfall (EA, 2021). It can therefore be assumed that the natural suspension of sediment regularly experienced in the nearshore environment due to storm, current and wave action, does not lead to the re-mobilsation of contaminants resulting in a significant reduction in water quality. Furthermore, the Installation Phase activities resulting in the re-suspension of fine-grained material which is associated with sediment contamination is not permanent and any reduction in water quality will be temporary. As such, the magnitude of the impact of re-suspension of sediment caused by cable installation activities, resulting re-dissolution of contaminants is low. Therefore, the effect significance is assessed to be **negligible**, which is considered to be **not significant**.

Discharges, leaks and spills from vessels, including loss of oils

The potential for accidental release of oils, lubricants, fuels and other chemicals exists for any of the vessels operating during installation, as does planned release of wastewater. Such materials are expected to generally be 'light' in nature and their potential to reach the seabed is considered to be low, with accidental and wastewater discharges expected to be rapidly dispersed by the tidal currents present throughout the Marine Installation Corridor (Table 7-4).

Embedded mitigation is detailed in Table 7-6. To ensure the risk of accidental spills is as low as reasonably practicable, relevant pollution prevention guidance will be followed and a Construction Environmental Management Plan (CEMP) including an Emergency Spill Response Plan and Waste Management Plan implemented. Control measures and Shipboard Oil Pollution Emergency Plans (SOPEP) will also be in place and adhered to under MARPOL Annex I requirements for all vessels. Planned discharges will be compliant with MARPOL Annex IV 'Prevention of Pollution from Ships' standards.

Wastewater discharges will be appropriately managed and rapidly dispersed. Risk of an accidental spill is unlikely, and should such an accidental spill or leak occur, it would be limited in extent / volume and subject to immediate dilution and rapid dispersal within the marine environment, having a low magnitude. The physical environment has a low sensitivity to such discharges and effects are appraised as **negligible** and therefore **not significant**.

7.6.5 Operation and Maintenance Phase

7.6.5.1 Changes to seabed bathymetry caused by placement of external cable protection

As part of the Installation Phase activities, there is a requirement to use rock protection and/or concrete mattresses within the subtidal (including nearshore and offshore zones) Marine Installation Corridor to protect the HDD exits, third-party asset crossings, cable joints, and in locations where the minimum depth of lowering cannot be achieved through trenching (Chapter 2: Project Description).

Rock protection will be required at locations to protect the cable where the target depth of lowering cannot be achieved through trenching (see Chapter 2: Project Description). The actual amount of rock placement will vary depending on seabed conditions and not all of the identified areas will need full coverage by rock. Categories 1, 2, 3, 4 and 5 (3%, 25%, 50%, 75% and 100% length of each zone of the Marine Installation Corridor requiring rock placement respectively) have been used to estimate the anticipated levels of rock protection required within each section of the Marine Installation Corridor, based on worst case assumptions of trenching success taking account of seabed conditions and available trenching tools (Chapter 2: Project Description). This results in a worst-case estimate of approximately 138 km of rock berm being required to protect each cable.

The total length of rock berm anticipated to be required for protection at crossings, cable joints, and the HDD exit pits is approximately 16.6 km per cable. As such the total length of rock berm per cable is approximately 154.3 km, equating to 308.6 km if the cables are laid separately.

At the HDD exit pits the trench will be backfilled to the original mean seabed level by rock and possibly underlain by concrete mattressing. However, at most other locations, the seabed profile will be raised due to the placement of material which will remain in place for at least the lifetime of the cables (40 years, this maybe longer depending on the condition of the cable). The widths and heights for rock berms and third-party asset crossings will vary depending on their design, although will vary between 8 m and 12 m wide and between 1 m and 2 m in height (representative designs are provided in Chapter 2: Project Description).

Although the rock berms have limited elevation in context of the depth of the water column, their interaction with the flow may cause scour to develop around the edge of cable protection by increasing the local current velocity around the structure to above the critical velocity for sediment transport (Larsen *et al.*, 2018). However, current speeds along the route listed in Table 7-3, suggest scour is unlikely to be a significant issue. Further, most placement of rock protection will be in areas of coarse or hard sediments limiting the depth of scour possible, making the seabed sensitivity to scour, low. The magnitude of the impact will be low and the scour effect significance is assessed as **negligible**, which is considered to be **not significant**.

In less energetic environments it is also possible that some increased deposition of sediment may occur over the rock berms. Whilst this may make it more difficult to undertake maintenance inspections, such deposition would effectively provide a reduction to the direct impact of the rock berm with the seabed returning to a more natural state. Where such deposition as described occurs, this would therefore have a moderate beneficial impact. The quantity of sediment deposited in association with rock berms will have a negligible impact on wider sediment transport pathways. The impact of increased deposition on rock berms is assessed as **negligible** and considered to be **not significant**.

7.6.5.2 Changes to seabed morphology, bedforms and suspended sediment concentration

Maintenance and cable repair activities, where required, will be carried out using the same or similar methods as the Installation Phase activities, and therefore the potential pathways for impact on the physical environment would be the same as those identified for the Installation Phase of the Marine Scheme.

Repair works are likely to be highly localised to the area of concern and therefore the spatial extent of any impacts would be small in extent. Furthermore, any maintenance or repairs works would be of a significantly shorter duration.

Maintenance and unforeseen cable repair (although unlikely) are routine, and the procedures and processes are well defined and common in the industry. Impacts of maintenance and cable repair works would be of smaller magnitude than cable installation, and the effect is predicted to be **negligible** and therefore **not significant**.

7.6.5.3 Impact of cable exposure

Cable exposure and any associated impacts will be localised and transient (as remedial works will be carried out as soon as is practicable), therefore the magnitude of this impact is considered low. The sensitivity in both nearshore and offshore environments is considered low and the significance of the effect is assessed to be **negligible** and therefore considered to be **not significant**.

7.6.5.4 Changes to water quality

The impact of water contamination is the same as described for the Installation Phase activities on the dispersion of fine materials and adsorbed contaminants, but on a spatially limited scale. Quantities of any operational discharges will be small relative to the other direct inputs to the water column making the magnitude of the impact low, therefore, the effect significance is appraised to be **negligible**, which is **not significant**.

Potential for accidental discharges and losses from vessels undertaking work during operation will be as for operation, although the frequency and intensity of works will be lower, and risk of incident also lower. Effects are appraised as **negligible** and therefore **not significant**.

7.6.5.5 Changes to coastal processes impacting the Holderness Coast

Possible adverse effects on the eroding Holderness coast have the potential to be significant should the sediment transport pathways from Smithic Bank to the coast be interrupted for a longer period of time than the duration of the Installation Phase activities, such as rock berms persisting in the environment throughout the Operation and Maintenance Phase.

The placement of rock protection within the Marine Installation Corridor as it passes though the southern portion of Smithic Bank, could potentially cause disruption to those sediment pathways. However, given that Smithic Bank is of a sand composition, it is assessed that the minimum depth of lowering should be achievable by trenching, and consequently no rock placement is planned over this feature. Additionally, there are no third-party assets to be crossed in the vicinity of the Smithic Bank, which would also require the use of rock placement or concrete mattresses.

Since it is anticipated that the cables will be trenched into the seabed within Smithic Bank, the marine scheme will not result in any permanent changes to the morphology of the area, and hence will not disrupt the sediment transport and sediment transport processes, which in turn feeds the Holderness Coast. Although no rock placement is planned, or anticipated, the potential remains for unforeseen events or circumstance potentially requiring some limited rock placement. If required, this would be highly localised and not form a continuous berm across the Smithic Bank. This would therefore have no significant permanent disruption of the sediment supply which would in turn not significantly effect the Holderness Coast. No such placement is indicated by data available currently, and if required, such placement would be limited and highly localised with no resulting potential for impacts on sediment movement. The Smithic Bank and Holderness Coast is considered to be of medium sensitivity. With no interruption to coastal processes the magnitude impacts on Smithic Bank and the Holderness coast assessed to be **low**. The significance of the effect is also **minor**, which is considered to be **not significant**.

7.6.5.6 Coastal erosion

Sea level rise has the potential to increase erosion at the Scottish and English landfalls which in turn could increase the risk of cable exposure. Coastal erosion during the design life of the project and beyond has been considered during project design, and in particular during HDD feasibility studies, undertaken to determine appropriate locations for HDD. The HDDs indicative designs are sufficiently set back from the coastline to accommodate the predicted coastal recession during the lifetime of the project.

Any potential impacts resulting from remedial works required to protect and/or re-trench the cable after a significant change in beach profile, will be on a much smaller scale than potential impacts which may arise during installation. The sensitivity of the coastline is considered negligible at the Scottish landfall and medium at the English landfall. The Holderness Coast within which the English landfall is located has shown erosion over the last decade would be expected to continue to erode in the future under rising sea levels and increasing storminess. The magnitude of the impact is considered to be low due to the localised and short-term nature of maintenance works. The effect significance is considered to be **negligible** to **minor**, which is considered to be **not significant**.

7.6.6 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. This maybe longer depending on the condition of the cable after 40 years.

At the end of the cable's life the options for decommissioning will be evaluated as described in Chapter 2: Project Description. Options include:

- Leave *in situ*, buried;
- Leave *in situ* and provide additional protection;
- Remove sections of the cable that present a risk; or
- Remove the entire cable.

There is the option for the cables and external protection to be left in place if the environment is best served by doing so, recognising that recovering cables and protection materials may lead to more damage to the physical environment or other seabed interests compared to leaving them in place.

Any impacts from Decommissioning Phase activities involved in cable removal, will be the same as those carried out during the Installation Phase. As is the case for Installation Phase activities, the effects of those impacts are predicted to be overall **negligible to minor**, which are considered to be **not significant**.

Should the cable and cable protection be left in situ, there would be no further impact on the physical environment and physical processes than has already been recognised in Section 7.6 associated with the presence of the cable and cable protection over the 40-year lifespan of the Project Marine Scheme. Therefore, based on previous assessment, the effect of leaving the cable and cable protection in situ is assessed to be **negligible to minor**, which is **not significant**.

7.7 Mitigation and Monitoring

No significant effects are anticipated from the Installation, Operation and Maintenance or Decommissioning Phases of the Project Marine Scheme and therefore no additional mitigation or monitoring is required.

7.8 Residual Effects

No significant effects on the physical environment are predicted.

7.9 Summary of Appraisal

Table 7-7: Summary of environmental appraisal

Project Phase	Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Project Specific Mitigation	Magnitude after Mitigation	Significance of Residual Effect
Installation	Changes to seabed features in water depths >10 m	Route Clearance	Low	Low	Negligible	None required	Low	Not significant
		Sandwave lowering	Low	Low	Negligible	None required	Low	Not significant
		Trenching activities	Low	Low	Negligible	None required	Low	Not significant
	Changes to seabed bathymetry and morphology in shallow water depths	Changes to seabed morphology caused by anchor deployment	Low	Low	Negligible	None required	Low	Not significant
		Changes to seabed morphology caused by HDD	Low	Low	Negligible	None required	Low	Not significant
	Increased suspended sediment	Seabed morphology	Low	Low to medium	Negligible to minor	None required	Low to medium	Not significant
	Changes to physical environment – features of interest	Firth of Forth Complex MPA	Low	Low	Minor	None required	Low	Not significant
		Flamborough Head SAC	Low	Low	Negligible	None required	Low	Not significant
		Smithic Bank and Holderness Coastline	Medium	Low	Minor	None required	Low	Not significant
	Reduction in water quality	Release of HDD drilling fluids	Low	Low	Negligible	None required	Low	Not significant
		Mobilisation of contaminants	Low	Low	Negligible	None required	Low	Not significant
		Discharges, leaks and spills from vessels, including loss of oils	Low	Low	Negligible	None required	Low	Not significant

Project Phase	Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Project Specific Mitigation	Magnitude after Mitigation	Significance of Residual Effect
Operation and Maintenance	Changes to seabed bathymetry caused by placement of external cable protection	Seabed	Low	Low	Negligible	None required	Low	Not significant
	Changes to seabed morphology, bedforms and suspended sediment concentration	Seabed	Low	Low	Negligible	None required	Low	Not significant
	Impact of cable exposure	Seabed	Low	Low	Negligible	None required	Low	Not significant
	Changes to water quality	Water environment	Low	Low	Negligible	None required	Low	Not significant
	Changes to coastal process impacting the Holderness Coast	Holderness Coast Smithic Bank	Medium	Low	Minor	None required	Low	Not significant
	Coastal erosion	Coastline at Scottish and English landfalls. Holderness Coast	Low to medium	Low	Negligible to minor	None required	Low	Not significant
Decommissioning	Effects of decommissioning the same as for Installation Phase							

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