Chapter 7: Seabed Quality

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7.1 Introduction

This chapter describes the seabed conditions and processes along the proposed marine HVDC cable consenting corridor, as identified in drawings NCOFF-NCT-X-XG-0001-01 to NCOFF-NCT-X-XG-0001-04. Any potential effects on seabed quality caused by the installation. Mitigation measures are suggested where necessary and any predicted cumulative effects are assessed.

Marine hydrology and coastal processes were not assessed for this project. This is due to the fact that the marine cable infrastructure is not expected to result in any significant changes to hydrology or coastal processes. The marine cables will be buried for the majority of the UK consenting corridor (as detailed in the Construction Method Statement (NorthConnect, 2018)), and as such have no potential to affect hydrological conditions. In areas where burial is not possible, external protection such as rock berms will be used to protect the cables. While rock berms will be elevated from the seabed, the height of the berms are very small relative to the water depths in the UK consenting corridor. The worst case is at the horizontal directional drilling exit point, where the existing water depth is approximately 26m, and external protection may be elevated by approximately 1.5m. This equates to an extremely localised depth reduction of approximately 5%, which will not result in any significant change to the local hydrology or coastal processes.

It is noted that the operation and decommissioning phases were scoped out of the assessment, in agreement with Marine Scotland, as detailed in Chapter 3: Methodology.

7.2 Sources of Information

7.2.1 Policy Framework

The Scottish National Marine Plan provides specific policies and objectives for the installation of subsea cables (Scottish Government, 2015). The relevant marine plan policies for seabed quality include:

- **CABLES 2**: Which states that:
    - *The following factors will be taken into account on a case by case basis when reaching decisions regarding submarine cable development and activities:*
        - *Cables should be suitably routed to provide sufficient requirements for installation and cable protection.*
        - *New cables should implement methods to minimise impacts on the environment, seabed and other users, where operationally possible and in accordance with relevant industry practice.*
        - *Cables should be buried to maximise protection where there are safety or seabed stability risks and to reduce conflict with other marine users and to protect the assets and infrastructure.*
        - *Where burial is demonstrated not to be feasible, cables may be suitably protected through recognised and approved measures (such as rock or mattress placement or cable armouring) where practicable and cost-effective and as risk assessments direct.*
        - *Consideration of the need to reinstate the seabed, undertake post-lay surveys and monitoring and carry out remedial action where required.*

7.2.2 Key Reference Documents

The following documents formed the basis of this assessment:

- Final Survey Report: NorthConnect – UK Nearshore, North Sea, and Norwegian Ford Survey – Rev. C. (MMT, 2018)
- Benthic Survey Report: NorthConnect – UK Nearshore, North Sea, and Norwegian Ford Survey – Rev. A. (MMT, 2018) ; and
- Unexploded Ordnance (UXO) Threat and Risk Assessment with Risk Mitigation Strategy for Cable Installation – Rev 2. (6 Alpha, 2017).

7.3 Assessment Methodology

7.3.1 Baseline Data Collection

7.3.1.1 Marine Surveys

The MMT Sweden AB Final Survey Report: NorthConnect – UK Nearshore, North Sea, and Norwegian Fjord Survey (MMT, 2018) (hereafter 'The Survey Report') details the methods and findings of the combined geophysical and geotechnical surveys along the UK Nearshore and North Sea Sections of the subsea cable corridor. The results in this report are based upon interpretations of geophysical data as well as the geotechnical investigations. For the geophysical survey, a combination of Side Sonar Scan (SSS), and Multi Beam Echosounder (MBES) inputs provided information on the bathymetry and surficial geology. A Sub Bottom Profiler (SBP) allowed investigation of the shallow geology and stratigraphy, while the Magnetometer provided information on ferrous objects located on or just below the seabed. The geotechnical investigation included vibro-coring (VC), and Cone Penetration Testing (CPT). The results of the geotechnical survey provided detailed information on the geological and engineering properties of the sediments present within the survey corridor. This in turn allowed the interpretation of the geophysical survey results to be ground-truthed.

Within the UK Exclusive Economic Zone (UK EEZ), the survey corridor was divided into two sections: the UK Nearshore corridor; and the UK North Sea corridor. The UK Nearshore survey corridor extended from the UK landfall at Long Haven Bay, to approximately 4km along the survey corridor. The UK North Sea corridor extended from the end of the nearshore corridor to the limit of the UK EEZ. The survey methodology employed in the Nearshore and North Sea surveys differed slight, and further details are provided below.

The UK Nearshore Survey corridor is located south of Peterhead. The survey corridor is approximately 500 m wide and reaches approximately 4 km from the coast at Long Haven Bay. The geophysical survey was conducted in two phases. Firstly, a hull MBES survey was conducted as close to shore as possible. Then a geophysical survey with WROV (Work Class Remotely Operated Vehicle) mounted MBES, SSS, SBP and magnetometer, following nine survey lines with a separation of 65 m, was completed. Additional crosslines were run close to shore in order to fill gaps in the coverage resulting from the complex coastline. The geotechnical sampling programme included VCs and CPTs. Four sampling sites in total were selected. Two sites along the survey route and two sites near each of the HDD exit points. Each site was sampled with both the VC and CPT. The VC was fitted with a barrel and liner length of 3 m and the CPT with a coil length of 6 m.

The North Sea survey work included hull mounted MBES and remotely operated towed vehicle (ROTV) mounted SSS and SBP. A magnetometer was towed 10.7 m behind the ROTV. The survey included three survey lines with 125 m line spacing covering a 500 m wide corridor. Additional survey lines were run in challenging areas to widen the corridor, in order to locate the optimal conditions for cable installation. SSS range was set to 100 m for the high frequency (HF) data and 150 m range for the low frequency (LF) data. The LF data was only processed where HF data was not available (nadir and wing lines (WL) outer range). The geotechnical sampling programme included VCs and CPTs. A total of 27 sampling sites were selected, and were sampled using either the VC, CPT or both. The total number of VCs and CPTs in the UK North Sea survey corridor was 19 and 18 respectively. The VC was fitted with a barrel and liner length of 3 m and the CPT with a coil length of 6 m.

7.3.1.2 Chemical Analysis

Full details of the chemical assessment sampling and analysis methodologies are provided in the Benthic Survey Report (MMT, 2018). A summary is provided below, and all supporting literature references can be found in the full report.

Samples for chemical analysis were taken at 17 locations within the UK Consenting Corridor during the benthic survey operations as shown in Figure 7.1. The samples were analysed for metals, and hydrocarbons, including polycyclic aromatic hydrocarbons (PAHs), and total petroleum hydrocarbons (TPH).

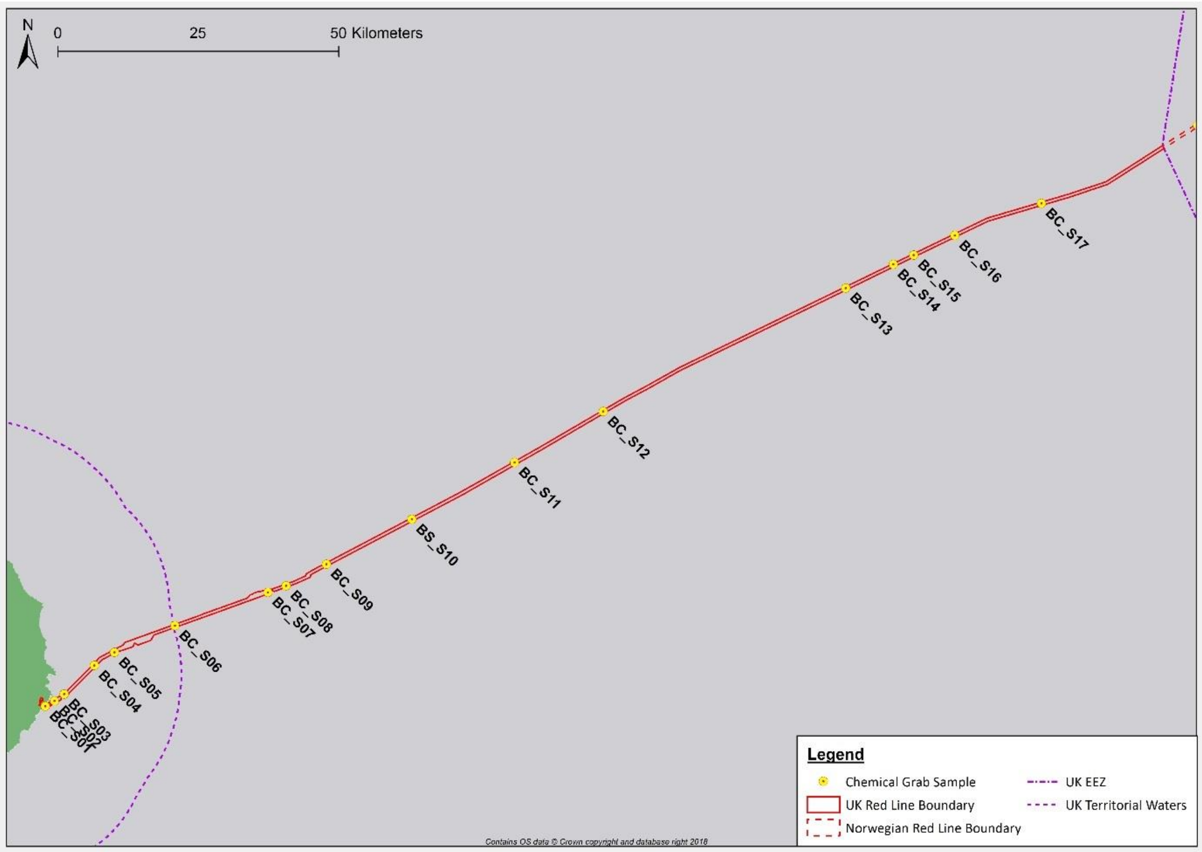

Figure 7.1. Chemical Analysis Sample Locations within UK Waters

To minimise risk of sample contamination, undisturbed sediments were collected with a plastic spoon for the metals, and a metal spoon for the hydrocarbon samples. The grab sampler was thoroughly cleaned using a seawater hose between samples and sample locations. Samples collected for hydrocarbon analysis were stored in 120 ml amber glass jars with Polytetrafluoroethylene (PTFE) inner lid caps, while one litre plastic containers were used for the metal analysis samples. All samples were stored in a refrigerator according to the analysing lab's recommendations, both before and during shipment for analysis.

The TPH analysis was conducted via Gas Chromatography-Flame Ionisation Detector (GC-FID). An overview of the hydrocarbon analysis with detection limits is presented in Table 7.1. The metal suite is also presented in Table 7.1, and used the following methods: hydrofluoric acid and boric acid extraction; followed by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS), of which Arsenic (As), Copper (Cu), Lead (Pb), Tin (Sn) are accredited by United Kingdom Accreditation Service (UKAS).

In order to put the results of the chemical analysis results into context, assessment criteria are required to evaluate the potential environmental effects which could result from the level of contamination identified. The preference would be to utilise the OSPAR Environmental Assessment Criteria (EAC), however, these have not yet been developed for PAHs and some metals. Therefore, the assessment criteria developed by the United States Environmental Protection Agency (USEPA) and/or the Canadian Council of Ministers of the Environment (CCME) are used as guidelines. In addition, the Dutch National Institute for Public Health and the Environment (RIVM) criteria for aquatic sediments were used for TPH, as there are no CCME or USEPA contamination threshold values regarding TPH. Details of the assessment criteria are provided in Table 7.2.

Table 7.1. Parameters for chemical analysis of sediment samples.

Chemical Contaminant	Detection Limits (µg/g)	Method of Analysis
Hydrocarbons		
Total Oil Content by GC-FID plus Saturates by GC-FID	0.001	Documented in-house method using marine specification by GC-FID, TPHSED
PAHs: 2 to 6 ring aromatics by GC-MS*	0.001	Documented in-house method using DTI specification by GS-MS, PAHSED
Metals		
As[¥]	1	Hydrofluoric acid and boric acid extraction followed by ICP-MS
Cadnium (Cd)	0.1	Hydrofluoric acid and boric acid extraction followed by ICP-MS
Cu[¥], Pb[¥]	2	Hydrofluoric acid and boric acid extraction followed by ICP-MS
Mercury (Hg)	0.01	Hydrofluoric acid and boric acid extraction followed by ICP-MS
Selenium (Se), Sn[¥]	0.5	Hydrofluoric acid and boric acid extraction followed by ICP-MS
Nickel (Ni), Valadium (V), Zinc (Zn)	1	Hydrofluoric acid and boric acid extraction followed by ICP-MS
Chromium (Cr)	1.5	Hydrofluoric acid and boric acid extraction followed by ICP-MS

** = UKAS accreditation (16 USEPA + Dibenzthiophene and Benzo(e)pyrene only).*

¥ = UKAS accreditation

Table 7.2. Summary of sediment contamination assessment criteria.

Criteria	Source	Definition	Application
Threshold Effect Level (TEL)	CCME	A concentration above which adverse effects may occasionally occur.	Used for metals only, as not available for PAHs or TPH.
Effect Range Low (ERL)	USEPA	A concentration, below which adverse effects on organisms are rarely observed.	Used for PAHs where no TEL criteria are available.
Probable Effect Level (PEL)	CCME	The probable effect range within which adverse effects frequently occur.	Used for metals and PAH, not available for TPH.
Dutch Target Value	RIVM	A level below which there is sustainable sediment quality.	Used for TPH where no other criteria are available.

7.3.1.3 UXO Desktop Study and Survey Operations

Full details of the UXO desktop study are provided in the UXO threat and Risk Assessment report (6 Alpha, 2017). A summary is provided below, and all supporting literature references can be found in the full report.

The study consisted of a desk-based collation and review of readily available documentation and records, generated by detailed archive research relating to the possibility of encountering UXO and/or dangerous Explosive Ordnance (EO) related paraphernalia, within the survey corridor. The risk management methodology was based on best practice for UXO risk management within the marine environment, in accordance the Construction Industry Research and Information Association's (CIRIA's) publications, covering the management of offshore UXO risk, as well as fulfilling the legal requirements associated with UK and EU Law. The following sources of information were consulted in order to inform the study:

- Royal Navy (Diving Units);
- The National Archives, Kew;
- Naval Historical Centre, Portsmouth;
- UK Hydrographic Office, Taunton;
- Archaeology Data Service; and
- The "6 Alpha Azimuth ©" data-base which contains digitised historic maps, aerial photographs and records.

In addition, the magnetometer used during the geophysical survey operations (as detailed in section 7.3.1.1) identified magnetic contacts that had the potential to be UXO. Magnetic contacts with the potential to be UXO were visually inspected using an ROV. However, a dedicated UXO survey was not conducted in UK waters and the distance between the survey lines meant that the magnetometer coverage only comprised a small percentage of the Consenting Corridor. As such, there is the potential to miss UXO located between the magnetometer lines.

7.3.2 Impact Assessment Methodology

This assessment has been undertaken primarily using a qualitative assessment based on analysis of baseline data, statutory and general guidance, combined with professional judgment. The assessment follows the methodology provided within Chapter 3: Methodology, with the significance of effect being determined through a combination of sensitivity / value of a receptor and the magnitude of impact. The sensitivity / value of the receptor under consideration are defined in accordance with the criteria set out in Table 7.3, while the magnitude of impact criteria is set out within Table 7.4. The significance of effect then follows the matrix set out in Table 7.5.

Table 7.3 Environmental Value of Seabed Geology and Sediments.

Value	Criteria	Example
Very high	Very high importance and rarity, international scale and very limited potential for substitution.	• International designated sites with geological / geomorphological qualifying interest. • Internationally important geological and geomorphological formations. • All inorganic/organic contaminants below TEL/ERL values.
High	High importance and rarity, national scale, and limited potential for substitution.	• National designated sites with geological / geomorphological qualifying interest. • Nationally important geological and geomorphological formations. • Majority of inorganic/organic contaminants below TEL/ERL values.
Medium	High or medium importance and rarity, regional scale, limited potential for substitution.	• Regionally important geological and geomorphological formations. • Inorganic/organic contamination between TEL/ERL and PEL values. • Dutch Target value exceeded.
Low (or Lower)	Low or medium importance and rarity, local scale.	• Geological and geomorphological formations on relevant to interpretation at a local scale. • Occasional exceedances of PEL or Dutch Intervention Value.
Negligible	Very low importance and rarity, local scale.	• Area of commonly encountered geology. Changes will not result in any loss to the scientific understanding of geological processes, or any loss to geological integrity. • Significant contamination present: PEL or Dutch Intervention value exceeded in a wide area.

Table 7.4. Magnitude of Impacts Descriptions

Magnitude of Impact	Criteria
Major	• Loss of resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements (Adverse). • Large scale or major improvement of resource quality; extensive restoration or enhancement; major improvement of attribute quality (Beneficial).
Medium	• Loss of resource, but not adversely affecting the integrity; partial loss of/damage to key characteristics, features or elements (Adverse). • Benefit to, or addition of, key characteristics, features or elements; improvement of attribute quality (Beneficial).
Low	• Some measurable change in attributes, quality or vulnerability; minor loss of, or alteration to, one (maybe more) key characteristics, features or elements (Adverse). • Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduced risk of negative impact occurring (Beneficial).
Negligible	• Very minor loss or detrimental alteration to one or more characteristics, features or elements (Adverse). • Very minor benefit to or positive addition of one or more characteristics, features or elements (Beneficial).
No change	• No loss or alteration of characteristics, features or elements; no observable impact in either direction.

Table 7.5. Significance of Effects Categories

Magnitude of Impact	Value of Receptor				
	Very High	High	Medium	Low	Negligible
Large	Major	Major	Moderate	Minor	Negligible
Medium	Major	Moderate	Moderate	Minor	Negligible
Low	Moderate	Minor	Minor	Negligible	Negligible
Negligible	Minor	Negligible	Negligible	Negligible	Negligible

Key

(orange)	Significant Effect
(blue)	Non-Significant Effect

7.3.3 Identification and Assessment of Mitigation

Mitigation measures have been identified in line with best practice to prevent, minimise and mitigate impacts.

7.3.4 Assessment of Residual Effects

Where mitigation has been identified, the magnitude of the impact will be reassessed as per Table 7.4 and the overall significance of effect reassessed in line with Table 7.5 to understand the resultant residual effect.

7.3.5 Limitations of the Assessment

Chemical analysis and geotechnical sample data are only of specific locations and sampling depths within the seabed strata. From this, trends and extrapolations can be made to establish the level of risk associated with the assessment, but a residual risk will always remain that ground conditions between two points may differ greatly from those measured at the two points in question. However, considering the concurrent interpretation of the geophysical survey data, this residual risk is estimated as being relatively low.

7.4 Baseline Information

7.4.1 Designated Sites

The only site designated for geological seabed features in the vicinity of the consenting corridor is the Southern Trench proposed Marine Protected Area (pMPA). The geological features for which this site is designated include sub-glacial tunnel valleys and moraines, as well as submarine mass movement – slide scars (SNH, 2014). However, a review of the data confidence assessment for the site indicates that the sub-glacial tunnel valleys and slide scars are located in the northern reaches of the designated site, far from the consenting corridor (SNH, 2014). Some moraine features are present within the southern end of the designated site, however, these are not crossed by the consenting corridor (SNH, 2014). The absence of the geological features for which the Southern Trench pMPA is designated within the consenting corridor is confirmed by the results of the Marine Survey Report (MMT, 2018). As such the installation and operation of the proposed NorthConnect interconnector do not have the potential to affect the site's designated features, and hence will not be considered further.

7.4.2 Bathymetry and Geology

Full details of the bathymetric and geological conditions within the consenting corridor are provided in the Survey Report (MMT, 2018). A summary is provided below, and all supporting literature references are included in the full Survey Report.

The UK Nearshore survey corridor which extents approximately 4km north east of the UK landfall, is characterised by a rocky seabed with very steep to steep seabed gradients, followed by a smooth seabed surface with very gentle to gentle seabed gradients. Within the first 1.5km of the survey corridor the water depth increases from 6.7m close to the coast, to 42.0m. The surficial geology shows outcropping BEDROCK at the coastal cliffs, followed by gravelly SAND and silty fine SAND. The shallow geology is characterised by loose, fine surficial sediments overlying dense, sandy sediments. Both units may locally contain pebbles, cobbles, and boulders. BEDROCK and TILL is seen as an underlying unit close to shore.

The outer section of the nearshore corridor, from 1.5km north east of the UK landfall to the limit of the nearshore corridor, 4km north east of the landfall, is characterised by a coarser seafloor. The area is dominated by gentle seabed gradients but increase to moderate, steep, or very steep where bedrock outcrops, or where large ripples, megaripples, or boulders are present. The water depth increases from 42.0m at the start of this section, to 59.6m at the north eastern end of the nearshore corridor. The surficial geology is dominated by SAND and GRAVEL but locally, areas with till and coarse sediments are present at the seabed surface. Boulder fields, classified as high-density boulders, dominate almost the entire section. The shallow geology shows surficial gravelly and sandy sediments where pebbles, cobbles and boulders are common. Underlying units are stiff to very stiff CLAY, overlying a dense sand, which overlie TILL deposits. BEDROCK occasionally outcrops.

The UK North Sea survey corridor can be categorised into 2 main sections based primarily on the surficial geology:

- The seabed at the start of the UK North Sea Survey corridor, from approximately 4km north east of the UK landfall to 50km along the survey corridor, is characterised as very gentle to gentle with steeper gradients associated with a variety of mobile sediment features (ripples, large ripples, megaripples and sandwaves) and outcropping bedrock. Water depths within this section range from approximately 60m in the south west to 113m in the north east. Maximum seabed gradients along the corridor are up to 11° and are associated with the mobile sediment features and bedrock present in the southwestern half of this section. The geology comprised of mixed coarse sediments including BEDROCK, gravelly SAND and sandy GRAVEL. Sediments begin to fine towards the northeast, away from the UK coastline. Boulder fields (occasional, numerous and high density) are present throughout. The underlying geology is characterised by the presence of acoustically chaotic to heterogeneous CLAY or acoustically heterogeneous, laterally discontinuous SAND, at or near the seabed. The SAND underlies the CLAY when not present near the seabed. Acoustically transparent more recent CLAY is observed towards the southwest of this section; and then
- The second section extends from 50km north east of the UK landfall to the limit of the UK EEZ, and into Norwegian waters. Here a smooth, featureless seabed with very gentle gradients overall defines the bathymetry in this section. Water depths range between approximately 97m and 157 m, with maximum gradients along the corridor of 16° associated with pockmarks. Seabed sediments comprise mixed SILT and SAND with extensive pockmarks, which locally increase in concentration to the northeast. Limited discrete areas of SAND or mixed SAND and GRAVEL are also observed as a minor sediment fraction. Trawl marks are extensive throughout

this section. The subsurface geology comprises of a predominately layered sequence of SAND, SILT and CLAY, that onlap and overlie a topographically irregular glacial CLAY surface. Towards the northeast a transition in to a transparent recent CLAY overlies SAND, before the CLAY pinches out with a layered SAND unit overlying interbedded glaciomarine to marine CLAY, SILT and SAND in a massive unit.

In general, the geological and geomorphological features identified within the UK consenting corridor are considered to be common in the North Sea region. No features of geological or geomorphological interest were identified during the survey operations.

It is noted that all areas of exposed bedrock identified by the survey to the east of the HDD exit location have been excluded from the consenting corridor. This is through a combination of the challenges they pose to cable installation, and the benthic habitat value as detailed further in Chapter 14: Benthic Ecology.

7.4.3 Sediment Quality and Contamination

Full details of the chemical assessment analysis results are provided in the Benthic Survey Report (MMT, 2018). A summary is provided below, and all supporting literature references can be found in the full report.

7.4.3.1 Inorganic

Concentrations of metals from sediment samples along the consenting cable corridor were generally low, as shown in Table 7.6. Cells highlighted in yellow in Table 7.6 indicate exceedance of TELs. None of the metal concentrations exceeded the PEL threshold within Scottish Territorial Waters (STW) or the UK EEZ. Levels of lead, cadmium, mercury, and chromium did not exceed TELs at any sample location.

However, three samples S03-S05, within the STW exceeded the arsenic TEL of 7.24µg/g, the highest being 14.9µg/g at S03. This is well below the arsenic PEL of 41.6µg/g. Nickel levels of 16.2µg/g present in S05 within the STW, also exceeded TEL of 15.9µg/g, but were below the PEL of 42.8µg/g. No other metal concentrations were identified to exceed TELs in the STW.

In the region between STW and the limits of the UK EEZ, levels of lead and cadmium increased, with higher concentrations in areas containing high fractions of silt and clay (S13-S17). No sample contained concentrations of lead or cadmium exceeding TELs. S08 contained 10µg/g of arsenic, above the TEL of 7.24µg/g but well below PEL of 41.6µg/g. The maximum concentration of copper of 90.9µg/g was identified in S06, exceeding the TEL value of 18.7µg/g. The TEL value for nickel of 15.9µg/g was exceeded in 6 samples between the STW and the limit of the UK EEZ, at locations S06, and S13 to S17. The maximum recorded nickel value was 30.6µg/g, at location S06. S13 was the only sample to exceed the TEL of Zinc with 135µg/g. Generally, Zinc concentrations were higher closer to the limits of the UK EEZ compared to STW.

Table 7.6. Metal Concentrations from Grab Samples in UK Waters.

Metals											
Site No.	ARSENIC	COPPER	LEAD	TIN	CADMIUM	SELENIUM	MERCURY	CHROMIUM	NICKEL	VANADIUM	ZINC
Units	µg/g										
TEL	7.24	18.7	30.2	N/A	0.7	N/A	0.13	52.3	15.9	N/A	124
PEL	41.6	108	112	N/A	4.2	N/A	0.7	160	42.8	N/A	271
S01	4.5	5.4	17.8	0.8	<0.1	<0.5	0.01	20.4	8.4	32.4	30.1
S02	5	3.8	6.7	0.7	<0.1	<0.5	0.01	11.9	5.9	26.9	17.2
S03	14.9	4.1	10.4	<0.5	<0.1	<0.5	0.01	9.1	8	36.9	23.5
S04	10.9	8.4	13.1	0.9	0.2	<0.5	<0.01	13.8	7	32.4	103.5
S05	11.7	15.5	20.4	<0.5	0.3	<0.5	<0.01	29.8	16.2	39	93.9
S06	7.1	90.9	13.4	<0.5	0.3	<0.5	<0.01	18.2	30.6	35.8	119.9
S07	5	9.5	9.6	<0.5	0.2	<0.5	<0.01	14	4.4	28.7	85.6
S08	10	8	11.4	<0.5	0.1	<0.5	<0.01	17	4.6	37.2	78.2
S09	4.3	9.1	10	<0.5	0.1	<0.5	<0.01	15.3	3.9	24.3	88.1
S10	3	7	11.3	0.6	0.4	<0.5	<0.01	22.9	8.4	29.9	77.1
S11	2.7	10.9	10.2	0.6	0.2	<0.5	<0.01	21.6	8.4	26.2	80.9
S12	2.8	10.7	11.1	0.9	0.4	<0.5	0.01	30.5	11.6	35.5	92.9
S13	5.1	13.5	20.1	1.5	0.5	0.9	0.02	49.1	21.7	53.2	135
S14	6.6	17	26.4	1.9	0.4	1.1	0.03	49.3	22.9	56	95.5
S15	5.1	10.9	25.3	1.6	0.4	<0.5	0.02	46	20.4	54.1	65.3
S16	4.9	9.6	21.7	1.6	0.4	<0.5	0.02	46.4	20.5	52.9	113
S17	4.1	9.1	16.7	1.6	0.4	0.9	0.02	37.9	16.5	44.9	77.1

7.4.3.2 Organic

The PAH concentrations in the UK consenting corridor are shown in Table 7.7, along with the ERL and PEL and ERL. Levels of PAHs were generally very low at all sample location within the STW and UK EEZ, and often fell below the limit of detection. No sample locations had recorded PAH levels which exceeded the ERL or PEL levels. The highest PAH concentrations were found at grab sample locations S01 and S02, S12, and S14 to S17.

Table 7.7. Polycyclic Aromatic Hydrocarbon Concentrations from Grab Samples in UK Waters.

Site No.	Polycyclic Aromatic Hydrocarbons																	
	NAPHTHALENE	ACENAPHTHYLENE	ACENAPHTHENE	FLUORENE	PHENANTHRENE	DIBENZOTHIOPHENE	ANTHRACENE	FLUORANTHENE	PYRENE	BENZO[A]ANTHRACENE	CHRYSENE	BENZO[B]FLUORANTHENE	BENZO[K]FLUORANTHENE	BENZO[E]PYRENE	BENZO[A]PYRENE	INDENO[123,CD]PYRENE	DIBENZO[A,H]ANTHRACENE	BENZO[GHI]PERYLENE
Units	**ng/g (dry weight)**																	
ERL	**160**	**N/A**	**N/A**	**N/A**	**240**	**190**	**85**	**600**	**665**	**261**	**384**	**N/A**	**N/A**	**N/A**	**430**	**240**	**N/A**	**85**
PEL	**391**	**128**	**88.9**	**144**	**544**	**N/A**	**245**	**1494**	**1398**	**693**	**846**	**N/A**	**N/A**	**N/A**	**763**	**N/A**	**135**	**N/A**
S01	1.5	<1	<1	<1	4.6	<1	1.7	10.7	10.4	6.7	8	8.2	4.4	-	8.2	6.9	1	7.3
S02	1.2	<1	<1	<1	4.9	<1	1.4	5.7	5.4	3.2	3.9	4.3	2.6	-	3.7	4	<1	4.2
S03	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	<1	<1	<1	<1
S04	<1	<1	<1	<1	1.0	<1	<1	1.7	1.4	<1	1.4	1.4	1.0	1.2	<1	1.4	<1	1.5
S05	<1	<1	<1	<1	1.1	<1	<1	1.3	1.1	<1	1.3	3.6	1.3	2.4	2.5	4.2	<1	3.7
S06	<1	<1	<1	<1	1.3	<1	<1	2.6	2.3	2.0	2.6	4.3	2.0	3.2	3.4	4.9	<1	4.1
S07	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.7	<1	<1	<1	1.8	<1	1.7
S08	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.5	1.1	1.1	<1	2.4	<1	2.0
S09	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.7	<1	1.2	<1	2.6	<1	2.3
S10	<1	<1	<1	<1	1.5	<1	<1	1.8	1.7	1.3	1.8	5.2	2.7	3.4	2.1	6.5	<1	5.9
S11	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	2.2	<1	1.4	<1	3.1	<1	2.8
S12	2.2	<1	<1	1.1	7.0	<1	<1	7.9	5.6	4.6	7.4	27.9	8.7	16.2	7.9	45.4	5.9	36.8
S13	<1	<1	<1	<1	2.3	<1	<1	3.4	2.4	1.7	2.5	9.0	4.9	6.9	3.3	14.3	1.9	12.4
S14	4.0	<1	<1	1.7	11.0	1.2	1.4	13.0	9.4	7.9	12.7	44.0	19.3	26.4	12.7	75.6	9.6	59.3
S15	2.2	<1	<1	1.1	7.1	<1	<1	8.3	6.1	4.7	7.4	27.8	11.0	16.9	8.1	43.8	5.5	35.0
S16	4.5	<1	<1	1.8	10.9	1.2	1.7	13.4	9.9	8.1	12.3	45.0	20.4	27.1	13.8	74.0	9.5	60.5
S17	2.5	<1	<1	1.2	7.3	<1	1.0	8.8	6.5	5.3	7.8	28.7	11.2	17.8	9.2	51.8	6.2	39.9

The Total Petroleum Hydrocarbons (TPH) values from the sample locations in the UK consenting corridor are presented in Table 7.8. The Dutch Target Value was not exceeded at any grab sample location. The TPH concentration was markedly higher at grab sample locations S12 and S14 to S17, the same stations were the PAH concentrations and several metal concentrations were elevated.

Table 7.8. Total Petroleum Hydrocarbon Concentrations from Grab Samples in UK Waters

Total Petroleum Hydrocarbons						
Site No.	**TOTAL PETROLEUM HYDROCARBON**	**TOTAL ALKANES**	**PRISTANE**	**PHYTANE**	**PRISTANE/ PHYTANE RATIO**	**CARBON PREFERENCE INDEX**
Units	**ng/g**				**N/A**	**N/A**
Dutch Target Value	**50,000**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
S01	7,105.0	172.8	4.49	2.62	1.7	3.8
S02	10,706.9	297.3	2.7	4.2	0.6	3.15
S03	2,520.8	53.3	<1	<1	-	1.78
S04	2,693.9	103.0	18.9	2.4	7.8	2.4
S05	2,873.5	153.7	10.8	2.4	4.5	3.5
S06	1,652.8	139.1	12.6	1.3	9.5	3.6
S07	2,993.1	93.3	21.3	<1	-	4.0
S08	2,223.6	135.9	11.0	1.4	8.0	3.6
S09	2,626.4	113.4	29.2	1.1	25.6	3.9
S10	3,721.5	165.6	10.2	3.0	3.4	2.8
S11	2,074.5	86.8	7.4	<1	-	3.5
S12	13,348.3	654.6	19.9	7.6	2.6	2.2
S13	5,399.0	300.9	16.6	4.3	3.8	3.4
S14	20,170.5	924.2	28.1	14.4	2.0	2.2
S15	16,788.1	735.2	27.5	8.3	3.3	2.7
S16	19,590.6	996.4	25.9	10.7	2.4	2.2
S17	16,928.7	813.4	17.4	7.8	2.2	2.3

7.4.4 UXO

The UXO desktop study assessed and identified the risk of UXO encounter within the UK consenting corridor. Full details are provided in the UXO desktop Study Report (6 Alpha, 2017), and a summary for STW and the UK EEZ are provided below.

No anomalies or records were noted during the Marine Survey that were interpreted as potentially historic unexploded ordnance from historic conflict (MMT, 2018). However, this report noted that, due to the limitations of the single towed magnetometer system, a further survey for UXO was appropriate.

7.4.4.1 Scottish Territorial Waters

It is possible that unexploded bombs (UXB) may be in Peterhead and/or its adjacent shoreline region as remnants from aerially deployed World War II bombs. High Explosive (HE) bombs are more likely to affect the UK near-shore end of the consenting corridor, than further offshore. No World War II minefields are known to be present within the most westerly 5km of the consenting corridor, however, it was noted that munitions can migrate both across the seafloor and within mobile sediments.

Defensive measures were taken to protect the beaches in the Peterhead area from amphibious assault, which included barbed wire entanglements, pillboxes containing machine gun positions, antitank obstructions, and minefields. Intentions to strongly defend Peterhead can be confirmed by the fact that at least two defensive coastline pillboxes and one long-range coastal artillery battery were located within the Peterhead area. Artillery projectiles and dumped munitions are considered to present a relatively low risk in first 5km of the consenting corridor.

The assessment identified that the main UXO threat items in the most westerly 5km of the consenting corridor are primarily: HE and incendiary bombs; ferrous metal sea mines; torpedoes; shipwreck related munitions; depth charges and mortars; artillery projectiles; and conventional dumped munitions; together with a background threat posed by non-ferrous metal sea mines, anti-invasion devices, and land mines.

The region from 5km along the consenting corridor to the limit of STW has been classed as having a medium to high probability of UXO encounter. It was found that there is a high likelihood of sea mines, munitions relating to wrecks, and training areas (Artillery projectiles and training munitions). There is the possibility of naval battles (depth charges, torpedoes and artillery projectiles) and aerial bombing (HE bombs) having taken place. There is a remote possibility of munitions dumping.

7.4.4.2 UK EEZ (Excluding STW)

The consenting corridor in the region between the STW limit and approximately 105km along the corridor from the UK landfall is classed as having a high probability of UXO encounter. Further offshore, between 105km and the limit of the UK EEZ, the probability is reduced to low.

The UXO risk in the offshore reaches of the consenting corridor is dominated by sea mines, munitions relating to wrecks, and training areas (Artillery projectiles and training munitions). There is the possibility of naval battles (depth charges, torpedoes and artillery projectiles) and aerial bombing (HE bombs) having taken place. It is noted that nine known mine lays are located within 40km of the consenting corridor in UK EEZ, which formed part of a North Sea German Minefield, situated close to the limit of the UK EEZ, three of which are located in close proximity to the consenting corridor.

7.4.5 Identification of Receptors

As detailed in Section 7.4.2 the bathymetric and geomorphological features identified during the marine survey operations within the UK consenting corridor are considered to be common within the North Sea region, and no features of geological or geomorphological are present. As such, it can be said that the features present are commonly encountered, and only likely to be relevant to the interpretation of geology on a local scale. Changes to these features will not result in any loss to the scientific understanding of geological processes, or any loss to geological integrity. As such, the value of the bathymetric and geological features present within the UK consenting corridor is assessed as **low to negligible**, according to the criteria set out in Table 7.3.

With regard to sediment quality, Section 7.4.3 outlines that the chemical analysis of grab samples conducted during the surveys operations found that, generally, contamination levels were very low. PEL levels were not exceeded at any site for organic or inorganic contaminants, and TPH levels were below the Dutch Target Value at all sites. All PAHs were also below the ERL criteria at all sites. Some heavy metals, notably arsenic and nickel, were present at levels exceeding the TEL criteria at 10 of the 17 sample locations, however, PEL levels were not exceeded. As such, it can be said that the sediments within the UK consenting corridor are relatively pristine, and their value is assessed as **high to very high**, with regard to contamination levels, as per the criteria set out in Table 7.3.

7.5 Impact Assessment

The potential impacts of the project during the installation phase have been assessed to determine their magnitude of impact upon the geological receptors described in Section 7.4, and the subsequent significance of effect.

The assessment is based on the information available to date in relation to methods of installation of the NorthConnect marine HVDC cables. Some aspects of the installation works are not yet finalised, as discussed in Chapter 2: Project Description, and so, as a precautionary approach, a series of worst-case assumptions have been made for the purposes of the assessment. The various worst-case assumptions for the purposes of the assessment are:

- **Number of cables and bundling arrangements** – there will be two High Voltage Direct Current (HVDC) cables laid in up to two trenches (either bundled and laid in one trench, or laid separately in two trenches). The fibre-optic cable will be laid in the same trench as one of the HVDC cables (or both if bundled). The assessment will consider unbundled cables in two trenches as a worst-case for cable trenching and installation, and associated effects on geological features;
- **Micro-siting of the cables within the consenting corridor and cable separation distances** – the separation distance between the cables, if not laid bundled, is likely to vary along the consenting corridor. Separation will be a minimum of 20 m and a maximum of 40 m within STW. Separation will then likely be a minimum of 20 m and maximum of the entire consenting corridor beyond STW to the UK EEZ limit;
- **Cable depth of lowering along the consenting corridor** – the minimum depth of lowering will be 0.4 m in hard substrates and 0.5 m in soft substrates, with an aim to achieve a 0.8 m depth of lowering if possible, and a likely maximum depth of lowering of 1.5 m. The maximum depth of lowering will be used for the assessment as a worst case;
- **Cable burial methods** – a combination of jet-trenching, mechanical trenching or ploughing may be required to protect the cables. Burial will be assumed to be via natural infill rather than active infilling techniques as a worst-case for habitat recovery times. Within UK waters (to the limit of the EEZ), rock placement will be in the region of 25m either side of the 4 cable crossings and 70m either side of the 14 surface laid pipeline crossings and, at a worst-case for lateral extent, using a 1:3 slope. Rock placement at the HDD exit point will be to a depth of 0.8 m for a 70 m distance at a 1:3 slope;
- **Cable trench** – methods of trenching will generate disturbance of the seabed around the trench and, depending upon the method used, the trench and excavated material footprint will be a maximum of 5 m distance either side of the centre-line of the cable (a total of 10 m width) as a worst-case; and
- **HDD** – a number of different drilling materials could be used, but it is assumed that the drilling fluid will solely comprise Bentonite.

7.5.1 Installation

7.5.1.1 Disturbance and Loss of Seabed Features

The surficial and shallow geology within the consenting corridor will be disturbed, and may be permanently lost as a result of seabed preparation, laying and trenching of the cable and from cable protection such as rock placement. Cable protection will be used in areas where the cable cannot be buried to the required depth (such as at crossing points with other cables or pipelines).

The cables will be approximately 230km long within UK waters. A ‘worst-case scenario’ has been assumed for this assessment that an area of seabed up to 10m wide along the length of each cable laid may be disturbed during trenching (5 m either side of each cable). The surficial geology within an area of approximately 2.3 km^2 for each cable will therefore be affected during the seabed preparation and cable laying phase. The shallow geology may be affected to the depth of lowering, which is not likely to exceed 1.5m in the UK consenting corridor.

The trenches will be naturally infilled in the majority of the consenting corridor. Natural infilling allows the trench to be filled in over time by the collapse of the trench walls and settling of suspended material. In some areas the trenches may be rock backfilled during the installation process (see Chapter 2: Project Description and the CMS for details). In areas where the trench is allowed to naturally back fill, changes to the surficial and shallow geology are considered temporary, since the natural infilling process will result in the seabed returning to a similar condition to pre-installation. However, where backfilling rock placement is employed, this will involve the placement of rock to fill the cable trench and restore the seabed to the original level. The required backfill rock placement therefore results in a permanent change to the seabed.

The removal of the two out of service cables will disturb around a 4 km length of seabed within the consenting corridor. Assuming a 10m disturbance width, this will result in a total disturbed area of approximately 0.04km^2.

The rock placement at crossing points will be up to a 1 m burial depth for the four cable crossings and 2 m burial depth for the 14 surface laid pipeline crossings. The area affected by crossings rock placement in UK waters will therefore be a maximum of approximately 300 m^2 for each cable crossing, 1,680 m^2 for each surface laid pipeline crossing, and 336 m^2 at the HDD exit point, giving a total of approximately 0.025km^2. As detailed in the Construction Method Statement (NorthConnect, 2018), crossing designs are subject to agreement with the relevant asset owners, hence the figures utilised here, based on standard designs, are subject to change.

Rock will also be placed as cable protection on areas of rocky ground or hard substrate along the consenting corridor, where it is not possible to adequately protect the cables via trenching alone. A worst-case prediction is that remedial rock placement may be required for approximately 2% of the of the length of the cables in the UK EEZ, which equates to a total affected area of approximately 0.5km^2 assuming 1m berm heights, and a 1:3 slope. The installation of rock berms will result in permanent changes to the bathymetry and surficial geology within the affected area of seabed.

Due to the extremely localised nature of the potential effects of the seabed preparation and cable installation phase on the seabed bathymetry and geological features, the magnitude of the effect is assessed as **low**. As detailed in Section 7.5.1, the value of the bathymetric and geomorphological features within the UK consenting corridor is assessed as **low to negligible**, and hence the resulting impact is assessed as **negligible: non-significant**.

7.5.2 Release of Hazardous Substances

The installation of the marine HVDC cables will require the use of vessels and ROVs. The ROVs will be operating in close proximity to, and within, the seabed. A mechanical failure of an ROV, vessel, or other associated equipment could result in a release of hazardous substances which may reach the seabed. A release of oils or other potential pollutants into or onto the seabed has the potential to result in both short and long-term impacts on sediment quality, through contamination of the sediments.

The magnitude of potential impacts arising from a release of contaminants would depend on the nature and quantity of material released into the environment. There is the potential for a spill of hazardous material to have long term major impacts, through a reduction of seabed quality on a regional scale. However, as detailed in Chapter 11: Water Quality (Marine Environment), all vessels working on the project will be compliant with the conventions of the International Maritime Organisation (IMO), including the International Convention for the Prevention of Pollution from Ships (MARPOL). Compliance with the MARPOL convention provides rigorous pollution prevention and incident response procedures, which significantly reduces or removes the risk of a release of hazardous substances occurring. As such, it is considered extremely unlikely that release of hazardous material of a scale with the potential to negatively impact sediment quality will occur. Due to the extremely low risk of a loss of containment occurring at a scale that could result in a reduction of sediment quality, the potential effect is assessed as **negligible**. As detailed in Section 7.5.1, the value of the seabed within the UK consenting corridor is assessed as **high to very high**, and in light of the very low levels of contamination, hence, the resulting impact is assessed as **minor: non-significant**.

7.5.3 Unexploded Ordnance

There is the potential that the equipment used during seabed preparation, cable laying, trenching, and protection operations could come into contact with items of UXO. If this should occur, the UXO may be inadvertently detonated. The primary impacts of inadvertent UXO detonation are risks of injury to personnel on the installation spread, as well as damage to equipment and vessels. Secondary risks include localised destruction and disturbance of seabed features in the vicinity of the detonation, as well as releases of harmful substances from damaged vessels or equipment.

As detailed in Section 7.4.4, no items of UXO were identified during the marine survey operations, however, it is acknowledged that there was not 100% MAG coverage of the consenting corridor, since the survey line spacing was too great. As such, it is possible that items of UXO are present between survey lines that would not have been identified. Furthermore, the UXO desktop study found that the risk of UXO encounter is medium to high for much of the UK consenting corridor.

Due to the risk of UXO encounter identified during the desk top study, and the lack of MAG coverage during the initial marine surveys, the installation contractor will be required to conduct a UXO survey prior to the installation works commencing. The UXO survey will utilise a multipin gradiometer deployed on an ROV, and the survey coverage will be 100% of the contractor's cable route corridor. It is noted that the contractor's cable route corridor will be considerably smaller than the consenting corridor, as it will only include the final cable routes and an appropriate buffer, to be advised by a UXO specialist. Visual inspections of magnetic contacts may be conducted in order to confirm whether the item is possible UXO. Where possible potential UXO contacts are identified during the survey, they will be avoided by an appropriate safety buffer during the final route engineering process. If avoidance is not possible, the items of UXO will be disposed of by an appropriately licenced explosives ordnance disposal contractor, or by the Royal Navy. The installation contractor will be required to perform a UXO risk assessment, in order to demonstrate that the risk of inadvertent UXO detonation during the seabed preparation and cable installation operations is as low as reasonably practicable.

It is therefore considered that the risk of inadvertent UXO detonation is extremely low, hence, the magnitude of this effect is assessed as **low**. The value of the seabed receptors is assessed as **low to negligible**, hence the resulting impact is **negligible: non-significant**.

7.6 Mitigation Measures

As no effects were considered to be significant under the provisions of the EIA Regulations, then no secondary mitigation is required to be implemented.

7.7 Residual Effects

No effects were assessed to be of moderate or greater significance. As such, no mitigation measures were required and there was no reduction in the residual significance of effects.

7.8 Cumulative Effects

The potential impacts on seabed quality associated with the seabed preparation and installation of the NorthConnect marine HVDC cables are extremely localised in nature. This will also be true of the seabed quality impacts resulting from the other marine developments detailed in Chapter 6: Cumulative Effects. With the exception of the Norwegian section of the NorthConnect project, the closest marine development to the UK consenting corridor is the Peterhead Port Authority Harbour Masterplan, which is 3km to the north of the consenting corridor at its closest point. All other projects are located 20km or more from the consenting corridor. As such there is no potential for any interaction between the NorthConnect seabed quality impacts, and those resulting from the other marine developments. The cumulative effects are therefore assessed as **no-change**.

With regard the Norwegian section of the NorthConnect project, the Norwegian operations may be conducted concurrently, and adjacent to the UK installation works. The installation techniques used in Norwegian waters will be analogous to those described here, and in the supporting chapters. As such, the seabed quality impacts associated with the seabed preparation and cable installation works in the Norwegian EEZ will be the same as those expected in the UK EEZ, hence the resulting cumulative effects are assessed as **non-significant**.

7.9 Summary of Effects

This chapter has assessed the potential environmental impacts on seabed quality resulting from the seabed preparations and installation of the proposed NorthConnect marine HVDC cables. No impacts were assessed as being significant under the terms of the EIA Regulations. A summary of the assessment is provided in Table 7.9 below.

Table 7.9. Summary of Seabed Quality Impacts Assessment

Receptor and Value Relevant Species		Phase	Predicted Impact	Impact Magnitude	Likelihood of Impact	Significance (Absence of Secondary Mitigation)	Mitigation Summary	Residual Impact Magnitude	Significance of Residual Effect
Southern Trench pMPA	High	Installation	No Change expected for the qualifying geological features of this site, since the features are not proximal to the consenting corridor. Not assessed further.						
Bathymetric and Geological Seabed Features	Low to Negligible	Installation	Disturbance and loss of seabed features during cable trenching operations.	Low Negative Localised Long Term	Certain	Negligible: non-significant	No Specific mitigation required.	Low Negative Localised Long Term	Negligible: non-significant
		Installation	Disturbance and loss of seabed features and changes to bathymetry through use of rock placement.	Low Negative Localised Permanent	Certain	Negligible: non-significant	No Specific mitigation required.	Low Negative Localised Permanent	Negligible: non-significant
		Installation	Disturbance and loss of seabed features through inadvertent UXO detonation.	Low Negative Localised Permanent	Very Unlikely	Negligible: non-significant	Pre-installation UXO route survey to be conducted, items of UXO avoided or disposed of.	Low Negative Localised Permanent	Negligible: non-significant
Seabed Sediments (Low Contamination)	High to Very High	Installation	Reduction in sediment quality through contamination from loss of containment of hazardous substances by installation spread.	Negligible Negative Localised Permanent	Very Unlikely	Minor: non-significant	Pollution prevention as per Chapter 11: Water Quality.	Negligible Negative Localised Permanent	Minor: non-significant
		Installation	Reduction in sediment quality through contamination from loss of containment of hazardous substances following inadvertent UXO detonation.	Negligible Negative Short Term Reversible	Very Unlikely	Minor: non-significant	Pre-installation UXO route survey to be conducted, items of UXO avoided or disposed of.	Negative Negligible Short Term Reversible	Minor: non-significant

7.10 References

6 Alpha. (2017). Unexploded Ordnance (UXO) Threat Risk Assessment with Risk Mitigation Strategy for Cable Installation - Revision 2.

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