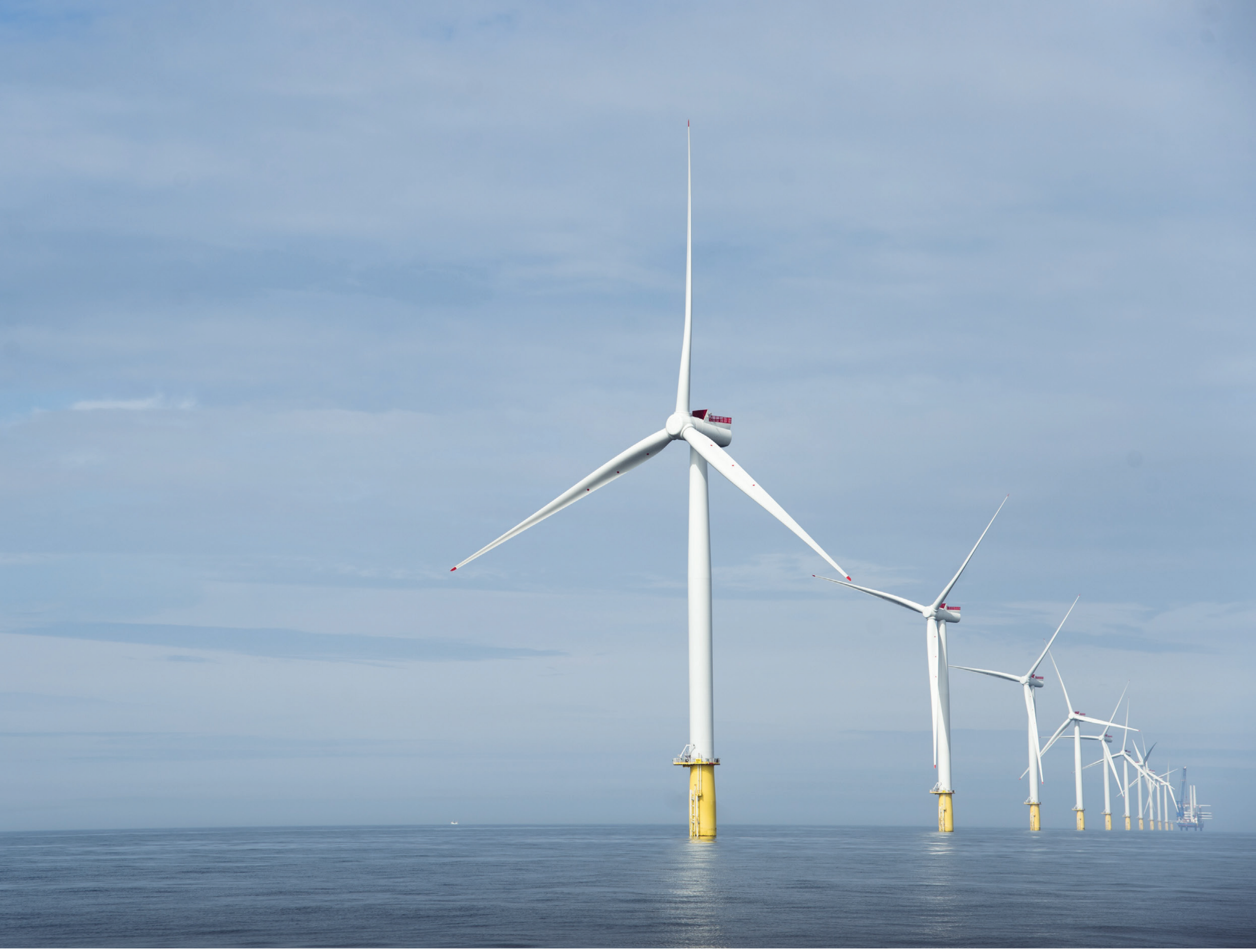

Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects

Environmental Statement

Volume 1

Chapter 7 - Marine Water and Sediment Quality

August 2022
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Glossary of Acronyms

Afl	Agreement for Lease
BAC	Background Assessment Concentration
cAL	Chemical Action Level
CCME	Canadian Council of Ministers of the Environment
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CEMP	Coordinated Environmental Monitoring Programme
CIA	Cumulative Impact Assessment
CSCB	Cromer Shoal Chalk Beds
CSQG	Canadian Sediment Quality Guidelines
CSIMP	Cable Specification, Installation and Monitoring Plan
DBT	Dibutyl Tin
DCO	Development Consent Order
DECC	Department for Energy and Climate Change
DEFRA	Department for the Environment and Rural Affairs
DEP	Dudgeon Offshore Wind Farm Extension Project
DEPN	Dudgeon Offshore Wind Farm Extension Project North
DOW	Dudgeon Offshore Wind Farm
EC	European Commission
EEA	European Economic Area
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EPP	Evidence Plan Process
EQS	Environmental Quality Standards
ERL	Effects Range-Low
ES	Environmental Statement
ETG	Expert Topic Group
EU	European Union

GBS	Gravity Base Structure
HDD	Horizontal Directional Drilling
HVAC	High-Voltage Alternating Current
IFCA	Inshore Fisheries Conservation Authority
IPMP	In-principle Monitoring Plan
IPC	Infrastructure Planning Commission
km	Kilometre
MBT	Monobutyl Tin
MCZ	Marine Conservation Zone
MMO	Marine Management Organisation
MPS	Marine Policy Statement
MSFD	Marine Strategy Framework Directive
MW	Megawatts
NNDC	North Norfolk District Council
NPPF	National Planning Policy Framework
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
OSP	Offshore Substation Platform
OSPAR	Oslo Paris Agreement
OWF	Offshore Wind Farm
PAH	Polycyclic Aromatic Hydrocarbon
PBDE	Polybrominated Diphenyl Ethers
PCB	Polychlorinated Biphenyl
PEIR	Preliminary Environmental Information Report
PEL	Probable Effects Level
PEMP	Project Environmental Management Plan
PSA	Particle Size Analysis
QSR	Quality Status Report
RBMP	River Basin Management Plan

SOW	Sheringham Shoal Offshore Wind Farm
SEP	Sheringham Shoal Offshore Wind Farm Extension Project
SQGL	Sediment Quality Guidelines
TBT	Tributyl Tin
TEL	Threshold Effects Level
THC	Total Hydrocarbons
TSHD	Trailing Suction Hopper Dredger
UK	United Kingdom
US	United States
WCS	Worst Case Scenario
WFD	Water Framework Directive
NOAA	National Oceanographic Assessment Administration
SQuiRTs	Screening Quick Reference Tables
ERM	Effects Range Medium

Glossary of Terms

Canadian Sediment Quality Guidelines	Guideline contaminant concentration levels which can be used to provide a basic indication on the degree of contamination and likely impact on ecology.
Cefas Action Levels	Guideline contaminant concentration levels used as part of a weight of evidence approach for decision-making on the suitability of dredged material for disposal to sea.
Dudgeon Offshore Wind Farm Extension Project (DEP)	The Dudgeon Offshore Wind Farm Extension onshore and offshore sites including all onshore and offshore infrastructure.
DEP offshore site	The Dudgeon Offshore Wind Farm Extension consisting of the DEP wind farm site, interlink cable corridors and offshore export cable corridor (up to mean high water springs).
DEP onshore site	The Dudgeon Offshore Wind Farm Extension onshore area consisting of the DEP onshore substation site, onshore cable corridor, construction compounds, temporary working areas and onshore landfall area.
DEP North array area	The wind farm site area of the DEP offshore site located to the north of the existing Dudgeon Offshore Wind Farm
DEP South array area	The wind farm site area of the DEP offshore site located to the south of the existing Dudgeon Offshore Wind Farm
DEP wind farm site	The offshore area of DEP within which wind turbines, infield cables and offshore substation platform/s will be located and the adjacent Offshore Temporary Works Area. This is also the collective term for the DEP North and South array areas.
Evidence Plan Process (EPP)	A voluntary consultation process with specialist stakeholders to agree the approach, and information to support, the EIA and HRA for certain topics.
Expert Topic Group (ETG)	A forum for targeted engagement with regulators and interested stakeholders through the EPP.
Horizontal directional drilling (HDD) zones	The areas within the onshore cable corridor which would house HDD entry or exit points.

Infield cables	Cables which link the wind turbine generators to the offshore substation platform(s).
Interlink cables	Cables linking two separate project areas. This can be cables linking: 1) DEP South array area and DEP North array area 2) DEP South array area and SEP 3) DEP North array area and SEP 1 is relevant if DEP is constructed in isolation or first in a phased development. 2 and 3 are relevant where both SEP and DEP are built.
Interlink cable corridor	This is the area which will contain the interlink cables between offshore substation platform/s and the adjacent Offshore Temporary Works Area.
Integrated Grid Option	Transmission infrastructure which serves both extension projects.
Landfall	The point at the coastline at which the offshore export cables are brought onshore and connected to the onshore export cables.
Offshore cable corridors	This is the area which will contain the offshore export cables or interlink cables, including the adjacent Offshore Temporary Works Area.
Offshore export cable corridor	This is the area which will contain the offshore export cables between offshore substation platform/s and landfall, including the adjacent Offshore Temporary Works Area.
Offshore export cables	The cables which would bring electricity from the offshore substation platform(s) to the landfall. 220 – 230kV.
Offshore substation platform (OSP)	A fixed structure located within the wind farm area, containing electrical equipment to aggregate the power from the wind turbine generators and convert it into a more suitable form for export to shore.
Offshore Temporary Works Area	An Offshore Temporary Works Area within the offshore Order Limits in which vessels are permitted to carry out activities during construction, operation and decommissioning encompassing a 200m buffer

	around the wind farm sites and a 750m buffer around the offshore cable corridors. No permanent infrastructure would be installed within the Offshore Temporary Works Area.
PEIR boundary	The area subject to survey and preliminary impact assessment to inform the PEIR.
Separated Grid Option	Transmission infrastructure which allows each project to transmit electricity entirely separately.
Study area	Area where potential impacts from the project could occur, as defined for each individual EIA topic.
Sheringham Shoal Offshore Wind Farm Extension Project (SEP)	The Sheringham Shoal Offshore Wind Farm Extension onshore and offshore sites including all onshore and offshore infrastructure.
SEP offshore site	Sheringham Shoal Offshore Wind Farm Extension consisting of the SEP wind farm site and offshore export cable corridor (up to mean high water springs).
SEP onshore site	The Sheringham Shoal Wind Farm Extension onshore area consisting of the SEP onshore substation site, onshore cable corridor, construction compounds, temporary working areas and onshore landfall area.
SEP wind farm site	The offshore area of SEP within which wind turbines, infield cables and offshore substation platform/s will be located and the adjacent Offshore Temporary Works Area.
The Applicant	Equinor New Energy Limited.

7 MARINE WATER AND SEDIMENT QUALITY

7.1 Introduction

1. This chapter of the Environmental Statement (ES) describes the potential impacts of the proposed Sheringham Shoal Offshore Wind Farm Extension Project (SEP) and Dudgeon Offshore Wind Farm Extension Project (DEP) on marine water and sediment quality. The chapter provides an overview of the existing environment for the proposed offshore sites, followed by an assessment of the potential impacts and associated mitigation for the construction, operation, and decommissioning phases of SEP and DEP.

2. This assessment has been undertaken with specific reference to the relevant legislation and guidance, of which the primary sources are the National Policy Statements (NPS). Details of these and the methodology used for the Environmental Impact Assessment (EIA) and Cumulative Impact Assessment (CIA) are presented in **Chapter 5 EIA Methodology** and **Section 7.3.4**.

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

- **Chapter 6 Marine Geology, Oceanography and Physical Processes**;
- **Chapter 8 Benthic Ecology**;
- **Chapter 9 Fish and Shellfish Ecology**;
- **Chapter 12 Commercial Fisheries**; and
- **Appendix 18.1 Water Framework Directive (WFD) Compliance Assessment.**

4. Additional information to support the marine water and sediment quality assessment includes:

- Sediment survey data specifically collected for SEP and DEP including particle size analysis (PSA) and chemical data;
- The existing evidence base of the effects of offshore wind farm (OWF) developments on the environment; and
- Discussion of the main effects with key stakeholders.

7.2 Consultation

5. Consultation with regard to marine water and sediment quality has been undertaken in line with the general process described in **Chapter 5 EIA Methodology** and the **Consultation Report** (document reference 5.1). The key elements to date have included scoping; the ongoing Evidence Plan Process (EPP) via the Seabed Expert Topic Group (ETG) (held in August 2019, June 2020, February 2021, August 2021 and March 2022) which includes Natural England, the Marine Management Organisation (MMO), Centre for Environment, Fisheries and Aquaculture Science (Cefas), The Wildlife Trusts, and Eastern Inshore Fisheries and Conservation Authority (Eastern IFCA); and the consultation on the Preliminary Environmental Information Report (PEIR).

6. The feedback received throughout this process has been considered in preparing the ES. This chapter has been updated following consultation to produce the final assessment submitted within the Development Consent Order (DCO) application. **Table 7-1** provides a summary of the consultation responses received to date relevant to this topic, and details of how the Project team has had regard to each comment and how they have been addressed within this chapter.

7. The consultation process is described further in **Chapter 5 EIA Methodology**. Full detail of the consultation process is presented in the **Consultation Report** (document reference 5.1), which has been submitted as part of the DCO application.

Table 7-1: Consultation Responses

Consultee	Date/ Document	Comment	Project Response
Scoping Responses			
The Planning Inspectorate	November 2019	The Scoping Report acknowledges the potential for scour of the sea bed to result in increased suspended sediments in the water column; however, it considers these would be localised and short lived (i.e. only during storm conditions). The proposal to scope out impacts from this aspect chapter is inconsistent with the proposal to scope in effects on suspended sediment concentrations during operation in the Marine Geology, Oceanography and Physical Processes chapter (paragraph 214). Given the acknowledgement within the Scoping Report that there is potential for the resuspension of sediment during the operational phase, the Inspectorate is unable to rule out potential significant effects to Marine Water and Sediment Quality and therefore does not agree this matter can be scoped out.	Potential effects relating to resuspension of sediment during operation is discussed in **Section 7.6.2**. Potential scour resulting from SEP and DEP is not assessed because scour protection will be used wherever scour will occur, reducing sediment release to nugatory quantities.
The Planning Inspectorate	November 2019	The Scoping Report states that any sediment contamination within suspended sediment resulting from scour of the sea bed is unlikely to give rise to changes in marine water quality. The Scoping Report does not justify this statement. It states that contamination in the existing Sheringham Shoal and Dudgeon wind farm sites are considered to be low, however no site-specific data for SEP/DEP has been provided at this stage. The Inspectorate acknowledges that the majority of contaminant disturbance would likely be during the construction phase. However, in the absence of site-specific data on contaminant levels, the Inspectorate does not consider it has sufficient information to rule out a likely significant effect resulting from re- suspension of contaminants	Site specific contamination concentrations are presented in **Section 7.5.4**, and the potential impacts arising from the disturbance of this sediment during construction and operation are discussed in **Section 7.6.1** and **Section 7.6.2** respectively. Potential scour resulting from SEP and DEP is not assessed because scour protection will be used wherever scour will occur, reducing sediment release to nugatory quantities.

Consultee	Date/ Document	Comment	Project Response
		from scouring effects. As such, the Inspectorate does not agree this can be scoped out of the ES.	
The Planning Inspectorate	November 2019	The Scoping Report states that all construction vessels would be required to comply with the International Convention for the Prevention of Pollution from Ships (MARPOL 73/38) and notes that a Project Environmental Management and Monitoring Plan (or similar) would be put in place to ensure works are undertaken in line with best practice for working in the marine environment. For operation, the Scoping Report states best practice measures would be put in place to reduce risks as far as possible. The Inspectorate agrees that, with the implementation of such measures, any potential impacts on water and sediment quality are unlikely to result in significant effects and therefore further assessment is not required. However, the Inspectorate seeks assurances that such measures would be employed and therefore considers the matter should still be covered within the ES, along with details of the measures to be employed and how they are secured by the DCO (or through the Marine Licence or other suitable mechanism). The ES should include a draft version (with sufficient detail) of any plans containing such measures.	An **Outline Project Environmental Management Plan (PEMP)** (document reference 9.10) is included in the DCO application.
The Planning Inspectorate	November 2019	The Scoping Report states that effects on Marine Water and Sediment Quality are likely to be restricted to the project boundary and the immediate surrounding area. As with the Marine Geology, Oceanography and Physical Processes chapter, the Applicant has not provided references to studies to back up this claim, nor has it identified a study area for this aspect chapter within which it considers effects are likely. Nevertheless, having regard to the location of the Proposed Development (a minimum of 100km from any	A study area for this topic is presented in **Section 7.3.1** and modelling results illustrating the extent of any sediment plumes are discussed in **Section 7.6.1.** Transboundary impacts have been scoped out of the assessment.

Consultee	Date/ Document	Comment	Project Response
		international territory boundary), the nature of potential impacts to water and sediment quality, the Inspectorate considers that transboundary impacts associated with this matter are unlikely to result in significant effects and can therefore be scoped out of the ES.	
The Planning Inspectorate	November 2019	Table 2-5 of the Scoping Report refers to information in the Marine Geology, Oceanography and Physical Processes chapter to be collected in 2020. It states that this will provide baseline information on sediment type and suspended solid concentrations. As noted in Table 4.1 of this Opinion, it is currently unclear how suspended baseline sediment concentrations will be established. The ES should clearly identify the data sources used to inform the suspended sediment baseline.	Data sources for the baseline information that has been collected are presented and discussed within **Section 7.5**.
The Planning Inspectorate	November 2019	It is unclear at this stage what site-specific information will be obtained to inform the baseline. The Scoping Report states that the analysis of the grab samples proposed in Table 2-5 (which would be conducted as part of the Benthic Ecology survey) will be agreed with stakeholders including the MMO, Cefas and Natural England. For the avoidance of doubt, the Inspectorate expects the contaminant levels from grab samples to be analysed to inform the baseline contaminant levels across the site.	Contaminant levels present within the grab samples collected are presented in **Section 7.5.4**
Natural England	November 2019	The Scoping Report states that where high levels of contamination are identified (i.e. close to or above Cefas Action Level 2), consideration against Water Framework Directive Environmental Quality Standards will be undertaken. The Inspectorate understands that Cefas Action Levels between Level 1 and 2 generally trigger further investigation of the material proposed for disposal at sea, and contaminants in dredged material	The approach taken to characterise and assess any contamination present in the sediment is discussed in **Section 7.5.4**. The impact assessment is presented in **Section 7.6**.

Consultee	Date/ Document	Comment	Project Response
		above chemical Action Level 2 (cAL2) are generally considered unsuitable for sea disposal. The ES should explain the approach taken in order to characterise the receiving environment for cALs, including how they relate to the assessment of likely significant effects and any measures necessary to mitigate any such effects. Overall, the proposed approach seems appropriate.	
Natural England	November 2019	There is currently no reference to specific impacts of suspended sediment concentrations from disposal of dredged material at specific disposal grounds offshore. This needs to be considered further and scoped into the assessment.	Sea bed levelling may be carried out for interlink cable installation (between the SEP wind farm site and DEP North array area) and sea bed preparation may be required for gravity base structure (GBS) foundations. Excavated sediment will be redeposited within the wind farm sites and/or cable corridors and where possible in an adjacent area of sea bed with similar sediment type. From a suspended sediment perspective, the worst-case scenario assumes that sediment would be dredged and released at or near the sea surface in the vicinity of the removal location (see **Chapter 4 Project Description**). An assessment of the potential effects associated with the sea bed preparation and sediment release is presented in **Section 7.6.1**.
Natural England	November 2019	Increased concentrations of suspended sediments and release of contaminants due to ongoing scour during operation should be scoped in. This has been recognised by the scoping in of increased suspended sediment concentrations during operation in regard to Benthic and intertidal ecology.	Potential scour resulting from SEP and DEP is not assessed because scour protection will be used wherever scour will occur, reducing sediment release to nugatory quantities.
ETG Meetings			
MMO	1st Sea bed ETG meeting response July 2020	Tributyltin (TBT) contamination (mobilisation of contaminated sediments) has been screened out of assessment. In the ETG meeting there was a request to screen this pressure back in due to the potential presence of a whelk fishery within the MCZ. TBT has	See **Section 7.5.4** – Organotins were included within the sediment analysis suite. Concentrations of organotins were below Cefas Action Level 1.

Consultee	Date/ Document	Comment	Project Response
		the potential to cause imposex in gastropod molluscs. If organotins (TBT/dibutyltin (DBT)) were present in the sediment and resuspended, they could become bioavailable to fauna and have detrimental impacts on the viability of the fishery.	
Cefas	2nd Sea bed ETG Meeting response 2nd June 2020	In the ETG meeting Cefas requested a Day grab be used at stations where there will be an analysis for sediment contaminants. As acknowledged by Cefas at the meeting, the success rate of the Day grab is lower than the Hamon grab in coarse sediment so it is possible that repeat attempt(s) with a Day grab could be required. We would appreciate clarification on this point against the comment that the type of grab used should enable a successful sample to be taken first time	Please refer to **Appendix 8.1 DEP Benthic Characterisation Report** (document reference 6.3.8.1) (Fugro, 2020a) and **Appendix 8.2 SEP Benthic Characterisation Report** (document reference 6.3.8.2). Sea bed fauna and Particle Size Analysis (PSA) samples were taken using a Hamon grab. Chemistry samples were taken with a Day grab outside the Cromer Shoal Chalk Beds Marine Conservation Zone (MCZ) and with a Shipek grab inside the MCZ.
Cefas	3rd Sea bed ETG meeting 3rd February 2021	Arsenic levels might require further consideration as the project will lead to the disturbance of sediment where these are elevated. Cefas to check if there are papers and information that can be used to support the assessment. Applicant encouraged to search the available literature for the same.	Survey data indicates low levels of arsenic in the sediments (see **Section 7.5.4.1**). Additional information regarding regional context is provided in **Section 7.5.5**.
MMO	4th Sea bed ETG Meeting 16th August 2021	Comment regarding a reference to sampling being based on the United States (US) Environmental Protection Agency (EPA) priority list to be added to the chapter. The MMO also queried which lab undertook the contaminants analysis and whether this was an MMO accredited lab.	The Applicant confirmed at the ETG meeting that Fugro undertook the sediment contaminant analysis (see **Section 7.4.2.1**) and reference to US EPA priority list has been added (see **Section 7.5.4**). Whilst it is recognised that Fugro are not an MMO accredited lab, Fugro's environmental laboratory teams have a proven track record of delivering high-quality analytical results to oil and gas clients, marine renewables, ports and harbours, mineral and aggregates as well as government agencies for over 30 years. Fugro has a fully integrated quality, health, safety, security and environmental management system certified to the

Consultee	Date/ Document	Comment	Project Response
			international standards ISO 9001, ISO 14001 and OHSAS 18001. The Fugro sediment and benthic laboratories in Portchester and chemistry laboratory in Edinburgh are UKAS accredited testing laboratories (ISO/IEC 17025:2017, Laboratory No. 0919). In addition to in-house quality checks, the Fugro environmental laboratories participate in a range of external proficiency tests including the National Marine Biological Analytical Quality Control, QUASIMEME, CONTEST and Aquacheck. Fugro's laboratories are MMO validated for particle size analysis.
Natural England	Response to 4th Sea bed ETG meeting minutes	Characterisation report Appendix 10.2 details the data for the 2-6 ring PAHs, which includes parent compounds and derivatives. This includes the C-group Naphthalenes commented by the MMO in power point slide 13. Therefore, Equinor can include these within the ES. The Naphthalene C1 to ;C4 derivatives in particular are more volatile and of concern and should be discussed in the ES. The PAHs the MMO require to be tested, reported and compared against CEFAS action levels are detailed Chemical determinands -GOV.UK (www.gov.uk)–checking against the baseline report, all are tabulated by the 2-6 ring and/or or USEPA priority 16 results except Benzo[e]pyrene and perylene. The CEFAS Action Levels are provided at Marine Licensing: sediment analysis and sample plans -GOV.UK (www.gov.uk). The US priority EPA16 parent compounds are a recognised group of parent compounds of most concern and if presented, context of their meaning within the ES should be outlined and appropriately compared to toxicity thresholds. Note The CSQG PAH thresholds does not include the threshold for all the EPA16 parent compounds	C1 – C3 naphthalene and C1 phenanthrene have been added to **Table 7-2** and compared with Cefas Action Level 1 of 0.1mg/kg for all individual PAHs (this includes both parent and alkylated homologues listed by the MMO as being required for disposal to sea licence applications). Given that none of the PAHs exceed any of the sediment guidelines including an additional assessment against OSPAR Coordinated Environmental Monitoring Programme (CEMP) background assessment concentrations (BAC) and US EPA Effects Range Low (ERLs) presented in **Section 7.5.4**, it is not considered necessary to provide further assessment/commentary on naphthalene and alkylated naphthalenes specifically. The Applicant notes that the only parameters not included in the Fugro data that the MMO require for disposal to sea licence applications are perylene and benzo(e)pyrene, however given that all other PAH parameters recorded such low concentrations, it is not anticipated that these two parameters would exhibit a different trend. Whilst it is acknowledged that the US EPA16 is a list of parent PAHs, the requirement to consider parent compounds is consistent across the board in all sediment guideline data

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			sets available, including those listed in the National Oceanographic Assessment Administration (NOAA) Screening Quick Reference Tables (SQuiRTs) (NOAA, 2008). The only sediment guideline set that specifically acknowledges alkylated homologues is the MMO's list of parameters but the Cefas action level 1 for all PAH parameters including these alkylated PAHs is currently 0.1mg/kg. There is an ongoing consultation by Cefas regarding the introduction of the Gorham Test (Cefas, 2020) to account for the lack of Cefas Action Level 2 for PAH parameters and this requires assessing groups of PAHs (including C1 naphthalene) depending on their molecular weight (so a set of low molecular weight PAHs and a set of high molecular weight PAHs). These values are then compared to an ERL and an effects range medium (ERM) for each set. This test would only be applied where individual PAH concentrations appear elevated in the datasets. Given this was not the case for the site specific survey data, it was not considered necessary to apply this test. It is noted that none of the sediment guideline sets available have a full set of PAH thresholds, rather all focus on different PAHs depending on data availability and/ or the reason for sediment guideline development.
Section 42 Responses			
North Norfolk District Council	10th June 2021	Chapter 9 - Marine Water and Sediment Quality NNDC would defer to the advice of Natural England and the Marine Management Organisation and other experts in respect of matters within this Chapter of the PEIR	Noted
Natural England	10th June 2021	As per comments to the other chapters, the project parameters are defined by four separate approaches to the project. These are not always clearly defined,	Further information has been provided in **Chapter 4 Project Description** and **Table 7-2** to clearly describe the differences

Consultee	Date/ Document	Comment	Project Response
		particularly with regards to interchanging between the scenarios, for example between interlink and export cables. There is an assumption the reader accepts and can utilise the summarised information provided in reviewing the assessment, however this has proved difficult in our experience. It would be helpful if expanded detail is provided so the reader is able to find the detailed and clear information they need to understand the parameters given for each scenario. Further detail and more transparency for each scenario would enable comparison of the potential impacts for each – SEP in isolation, DEP in isolation, SEP& DEP simultaneous and SEP& DEP sequential. This would enable additional analysis relevant to any mitigation required and any required adjustment to the project parameters. It was not always possible to follow the calculation of the different scenarios. Cross-referencing to the appropriate table / paragraph within Chapter 5 Project description would help. Additional columns detailing the components for the calculations would help.	between the different options and the reasons for the selection of the WCS. The construction programme for SEP and DEP (built sequentially or concurrently) is not referenced in the WCS table (**Table 7-2**) as it does not have a bearing on the worst case project parameters described in the table. However, where relevant, it is considered in the impact assessment in **Section 7.6** as it does potentially have a bearing on the magnitude of impacts. For each impact assessment, where relevant, it is stated whether it is a sequential or concurrent construction programme which is considered to be the worst case for the impact in question. In relation to the grid options when SEP and DEP are both built, the worst case scenario table (**Table 7-2**) has been differentiated by the number of OSPs required (i.e. one or two) as this determines the worst case footprints and volumes that are assessed. The worst case scenario for each project component for SEP and DEP has been specified in the table to show what has been assessed in **Section 7.6**. With respect to the three distinct array areas, the focus is on identifying and assessing the worst case scenario (in line with the Planning Inspectorate's s51 advice on this matter dated 21 May 2021). In this manner, any differences between the different areas are assessed by exception.
Natural England	10th June 2021	As above, the WCS not only interchanges between the development options, but also the methodology utilised. Therefore, there is a wide range for WCS. Further transparency or cross referencing to the data used from Chapter 5 is required. In addition, it would be useful to understand the WCS for each of the development scenarios to better understand the implications for each of the four potential options. Also, we advise that the impacts from each of the three distinct array areas is set out separately as well as for the total project.	
Natural England	10th June 2021	The plume modelling, as presented in Chapter 7, relies on conceptual studies and previous surveys for the Dudgeon and Sheringham offshore windfarms (OWF).	The use of existing data is proportionate to the potential effects on suspended sediment concentrations because most of the sea bed sediments in this area are sand. In these

Consultee	Date/ Document	Comment	Project Response
		Suspended sediment concentrations are based on HR Wallingford data. Further oceanographic and water quality survey work should be undertaken to establish a more recent baseline.	environments, the potential for release of sediment into the water column as a plume is limited as the sediment is too coarse to be lifted off the bed or remain in suspension. Also, ambient suspended sediment concentrations are unlikely to change over time and so the collection of new data would not add value and therefore the use of the existing data is justified.
Natural England	10th June 2021	The sampled stations targeted the low variability sea bed type with low proportion of sediment fines (5%). The range of fine material across the site is much greater (up to 22%) and therefore it is possible the true range of baseline contaminant concentrations is mis-represented. The heterogeneity in sediment type should be acknowledged, and any possible further indicative survey or published information to support any inference that can be made should be included. PSA samples were acquired with use of a Hamon grab, for which it is widely accepted can be the most suitable / successful sampling method for mixed sediments. However, the chemistry samples were acquired with a Day grab. The two types of grab differ in that the Hamon grab can result in some mixing of the sediment horizons within the grab, in contrast to the Day grab acquires samples in situ. As such, any link between the sediment properties, notably adsorption/binding capacity of the finer fraction, should be treated with some caution.	It was not possible to target areas with the greatest proportion of fines because at the time the sampling strategy was agreed there were no grab sample data on which to base this. The majority of the sea bed sediment samples contained less than 5% mud and almost 100% of the samples contained less than 10% mud. Therefore, the sample containing 22% mud is a single sample from a total 98 samples (i.e. approximately 1% of the samples). Sampling was agreed in advance through the ETG process in April 2020 and the MMO has confirmed the number and sites are appropriate in response to the PEIR (see below). Sampling at offshore wind farms is to confirm the generally accepted principle that offshore sediments are unlikely to be significantly contaminated and the samples collected here are in line with this expectation. The survey is indicative only. No further sampling work is therefore planned.
Natural England	10th June 2021	The methodology for analysis of sediment samples is appropriate and consistent with CEFAS and MMO guidelines. The comparison of data with CEFAS AL and Canadian SQGL is appropriate. The Applicant also draws on regional information, however further explanation of this context would be useful. The regional context for elevated concentrations recorded off the	Comments regarding the methodology are noted. Further information including information from Whalley *et al.,* (1999) has been provided in **Section 7.5.5**.

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		northeast coast of Norfolk as explored by Whalley et al, 1999 should be acknowledged – as described in this paper, the source may be derived from oil and gas drilling which have arsenic-rich marine shales to the surface, and therefore concentrations are not considered atypical from expected for the region.	
Natural England	10th June 2021	The potential pressures/impacts have been identified.	Noted.
Natural England	10th June 2021	No other projects are listed as the potential for cumulative impact was screened out. This may require review and update if further baseline data is acquired.	No further baseline data has been acquired and therefore the CIA remains as that assessed for the PEIR. A check has been made to confirm that no other projects have arisen that require consideration.
Natural England	10th June 2021	Construction Impact 1, Please add sea bed preparation volume per turbine to the notes, as presented in Chapter 5, to ensure calculations are transparent within this chapter and between chapters. Using sea bed volume per foundation from Chapter 5 of 16,592m3, the total volumes for GBS foundations slightly differ: x 32= 530944m3 x24 = 398208 and x56 = 929152. This is assumed to be a result of rounded figures presented in Chapter 5. Please confirm that sea surface disposal is at the dredging location. Also related comment: Please clarify that sediment returned to the water column at the sea surface as overflow would be from the vessel position at the GBS foundation location. This ensures sediment is returned to the area of origin and therefore similar sediment type.	The worst case sea bed preparation volume for a single GBS foundation is for an 18MW turbine (of which there could be up to 19 at SEP and up to 24 at DEP) with a 60m base plate diameter = 16,964.60m^3. This has been reflected in the notes column in **Table 7-2** which has been updated since the PEIR. **Table 4-13** within **Chapter 4 Project Description** has been updated. Offshore disposal of sediment will take place at or near the sea surface or at the sea bed using a fall pipe in the vicinity of the disposal location. Further information has been provided in the **Disposal Site Characterisation Report** (document reference 9.13) which has been submitted with the DCO application. **Table 7-2** has been checked and updated for consistency across chapters.

Consultee	Date/ Document	Comment	Project Response
Natural England	10th June 2021	Construction Impact 2: The notes provide the volume per monopile foundation, please also add the volume for the OSP, so the calculations are transparent.	The worst case volume of sediment disturbed by OSP monopile foundations has been added to **Table 7-2** for construction impact 2.
Natural England	10th June 2021	Construction Impact 3, please check the combined calculation for SEP and DEP together should be 2 x 6,148m3 or justify in the notes column why this not the case. Explain the reason why the volume of disturbance the HDD exit point for SEP and DEP is 700m3 (can cross reference to Chapter 5 project description if required). Under impact 4 is it stated that excavated sediment for sand wave levelling would be disposed of within the SEP and DEP site. It is assumed this also applies to sand wave levelling for the DEP export cable under Impact 3 and should be clarified in the notes section.	**Table 7-2** has been updated. As above regarding disposal of sediment.
Natural England	10th June 2021	Construction Impact 4, Please add further information to clarify the calculations or cross reference to appropriate information within Chapter 5. For example, the total WCS for sandwave levelling for SEP & DEP together is stated to be 360,200m3, however in Chapter 5 the WCS is stated to be 376,400. Also, it is noted that it is the intention for excavated sediment from sand wave levelling to be disposed of within the SEP and DEP site. Therefore, there is a distinction between sea bed disturbance (remobilisation and re-suspension) and disposal deposition resulting in suspended sediments). It is assumed cable burial will result in disturbance and re-mobilisation at location and this should be clarified within the notes. Recommendation: Provide further clarification to the scenarios presented.	**Table 7-2** has been updated. As above regarding disposal of sediment.

Consultee	Date/ Document	Comment	Project Response
		Provide further detail on sea bed disturbance and dispersal in situ and excavated sediment for disposal at a site within the site.	
Natural England	10th June 2021	Operation and decommissioning – description of impacts. Update the description of Impacts to be consistent throughout the document.	The impact titles have been updated and made consistent between all phases.
Natural England	10th June 2021	Operation Impact 1, Please provide transparency in calculation of the area of Worst Case Obstruction using the notes section. Also, provide further information or expanded table to understand the footprint calculation for cable and crossing protection. Recommendation: Provide further clarity or cross reference to appropriate table / paragraph in Chapter 5.	Potential scour resulting from SEP and DEP is not assessed because scour protection will be used wherever scour will occur, reducing sediment release to nugatory quantities.
Natural England	10th June 2021	We question the Applicant's outline plan to decommission scour protection, crossing and cable protection and possibly offshore cables in situ. Decommissioning should aim to remove infrastructure to avoid irreversible (permanent) habitat loss, thus returning the sea bed habitat to its pre-developed baseline status. However, we recognise there is merit in decommissioning buried infrastructure such as cables in situ to avoid or minimise habitat disturbance. Natural England welcomes that a decommissioning plan will be produced.	The Applicant notes that no final decision has yet been made regarding the final decommissioning policy for the offshore project infrastructure. It is also recognised that legislation and industry best practice change over time. External cable protection systems installed within the MCZ will be removed at the decommissioning stage (see the **Outline Cromer Shoal Chalk Beds (CSCB) MCZ Cable Specification, Installation and Monitoring Plan (CSIMP)** (document reference 9.7)). A Decommissioning Programme will be provided at the pre-construction stage which will further outline the decommissioning strategy in light of more detailed project design information. At the time of decommissioning, a final decommissioning strategy for the project will be developed

Consultee	Date/ Document	Comment	Project Response
			and will follow the relevant guidance and statutory advice available at the time.
Natural England	10th June 2021	Table 9.3 Foundations – micro-siting is mentioned here, with little detail on how the sea bed preparations would be minimised.	**Table 7-3** has been updated to reflect that micro-siting around, for example, sand waves would be undertaken to minimise sea bed preparation requirements.
Natural England	10th June 2021	Please amend incorrect reference to Table 9-4. Should be to reference Table 9-3	The cross reference has been amended.
Natural England	10th June 2021	Cables – Natural England welcome the intention to bury cables where possible minimising the requirement for cable protection and scour. Suggest amending the wording 'where burial is required… to 'where burial is undertaken' as it is assumed it is the default approach.	This has been amended.
Natural England	10th June 2021	Natural England welcomes the intention for a pollution environmental management plan (PEMP)	Noted. An **Outline PEMP** (document reference 9.10) has been submitted with the DCO application.
Natural England	10th June 2021	Can the typical mean winter and summer suspended sediment concentrations be placed into context in terms of water quality? What are the thresholds for which water quality is decreased?	There are no water quality standards for suspended solids concentrations. Effects are assessed on the basis of significant changes to the natural baseline.
Natural England	10th June 2021	En-3 NPS for Renewable Energy Infrastructure. Under Section reference column for the Potential impacts during construction – please also add and operation and decommissioning	This has been amended.
Natural England	10th June 2021	Para 9.5.5 Please re-summarise the issue with water quality within 1nm from Section 9.5.1.	This has been amended.
Natural England	10th June 2021	It is noted that 7 of the 10 intended chemistry samples were successful. Please expand to explain the locations of the three unsuccessful samples. For example, does this explain a gap in information at DEP South, the cable corridor between DEPN and SEP, the northwestern portion of SEP.	Unsuccessful sample locations and all PSA samples with sediment proportions have been added to **Figure 7.3**. The survey was informed by the outputs of the geophysical surveys to cover the proposed wind farm extensions and cable corridors. It was not possible to target areas with the

Consultee	Date/ Document	Comment	Project Response
		See comments below regarding Appendix 10.1 and 10.2 regarding station selection – justification of station location selection could be summarised here. The PSA results for the chemistry stations suggest the majority targeted low variability sea bed type with low proportion of sediment fines (5%). Were the sediment types sampled considered representative of the range in encountered across the site?	greatest proportion of fines because at the time the sampling strategy was agreed there were no grab sample data on which to base this. **Figure 7.3** has been updated to show all sample results for PSA showing good coverage of the study area and illustrates that the majority of the sea bed sediment samples contained less than 5% mud and almost 100% of the samples contained less than 10% mud. So, the sample containing 22% mud is a single sample from a total of 98 samples (i.e. approximately 1% of the samples).
Natural England	10th June 2021	For clarity, it could be explained here it is the low proportion of fine material to which contaminants bind or adsorb to that reduces the potential to accumulate. To demonstrate this link, the proportion of fines, gravel and sand could be included in the results Table 9-14. However, while we do not disagree with the generalised conclusion regarding the dominance of sand and gravels and their link to sediment retention, examination of Appendix 10.1 and 10.2 Benthic report notes that a few stations recorded higher proportions of fine sediment notably EC-16 (22%), SS-10 (9%) SS-19 (17%), SS-23 (13%) and D-07 (10%) in areas of mixed sediment. As chemistry samples were not acquired at these stations, it is not possible to establish any baseline variation in sediment chemistry associated with these higher proportions of finer material, with consideration a bioavailable aqua regia digest was utilised for metals analyses. Therefore, it is possible the true range of baseline contaminant concentrations is mis-represented.	Further explanation has been added to **Section 7.5.3** and **Figure 7.3** has been updated. As described in response to the previous comment, the majority of the sea bed sediment samples contain less than 5% mud and almost 100% of the samples contained less than 10% mud. So, the sample containing 22% mud is a single sample from a total of 98 samples (i.e. approximately 1% of the samples). It is therefore considered that the baseline contaminant concentrations are a true reflection of sediments across the study area.
Natural England	10th June 2021	Does the plume concentration account for the maximum proportion of finer sediment recorded (23%)? Can the direction of the plume be anticipated as paragraph 80?	The majority of the sea bed sediment samples contain less than 5% mud and almost 100% of the samples contained less than 10% mud. So, the samples containing higher proportions

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			of mud, for example the sample showing 22% mud is a single sample from a total of 98 samples (i.e. approximately 1% of the samples) and it would be unrealistic in the worst-case scenario to account for this one sample. However, even so, the dimensions of, and concentrations in, the plume are assessed conceptually, and not using a numerical model. Hence, they are only semi-quantitative based on the evidence base for similar sea bed substrates. The potential plume directions are described in **Section 7.6.1.2.1**, and the initial direction will depend on when construction activities begin relative to the tidal cycle.
Natural England	10th June 2021	If dredged material is surface released at the GBS foundation site, then the plumes are unlikely to interact. Please clarify if this is not the case. Further the suspended sediment plume increase for SEP and DEP together is stated to be less than 10mg/l, however the increase for SEP or DEP in isolation in paragraph 76 is cited to be tens of mg/l. This seems contradictory.	The worst case assumes that dredged material would be released at or near to the surface. The impact assessment has been amended (see **Section 7.6.1.1**).
Natural England	10th June 2021	What is the length of cable route that would potentially result in the release of chalk fines into the water column? Is subcropping chalk known to occur to the west in the direction of the plume?	The geology of SEP and DEP, including the offshore export cable corridor, consists of Holocene deposits overlying a series of Pleistocene sands and clays, with a bedrock of Upper Cretaceous Chalk. It is not possible to specify the length of the cable corridor that would potentially result in the release of chalk fines into the water column, as this depends on the thickness of the overlying unit of sand and gravel. However, the assessment is based on a worst case scenario where all the displaced sediment is assumed to be suspended, although in reality, due to the low proportion of mud/fines in the areas concerned, only a small proportion of disturbed sediments will be suspended for any length of time, if at all.

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			The **Outline CSCB MCZ CSIMP** (document reference 9.7) provides further detail on offshore export cable installation within the Cromer Shoal Chalk Beds MCZ. In addition, an interpretation of the Sheringham Shoal Offshore Wind Farm (SOW) and Dudgeon Offshore Wind Farm (DOW) sediment plume dispersion modelling results has been provided in **Section 7.6.1.3.1**.
Natural England	10th June 2021	The depth of disturbance is defined in 9.6.1.4.1. Please also define the width of disturbance. Please define what is considered a “small proportion of disturbed sediments”	The depth and width of cable burial with respect to displacement of sediment has been defined in **Table 7-2**.
Natural England	10th June 2021	Paragraph 94 highlights the WCS of sediment returned to the water column at the sea surface and that this would occur within the DEP wind farm site and cable corridor. It should be stated here if surface disposal will be at the locality of dredging or redeposited at a disposal site within the windfarm boundary (as described in Chapter 5 para 147). If it is the latter, further detail is required as to the volume and frequency of disposal as this would affect the suspended sediment concentration. Please also see our comments in relation to Chapter 7 and the importance of maintaining the sandbanks in this area.	Excavated sediment will be redeposited within the wind farm sites and/or cable corridors and where possible in an adjacent area of sea bed with similar sediment type. **Chapter 4 Project Description** and **Section 7.6.1.1** have been updated. Responses to Natural England’s comments on **Chapter 6 Marine Geology, Oceanography and Physical Processes** are provided in that chapter. Sandbanks have been added as a sensitive receptor within the Chapter 6 assessment.
Natural England	10th June 2021	We welcome the intention for monitoring to be outlined within an In-principle Monitoring Plan (IPMP). We consider sediment and water quality monitoring is not required.	Noted. The **Offshore IPMP** (document reference 9.5) has been submitted with the DCO application. Provision for monitoring of water and sediment quality has not been included.
Natural England	10th June 2021	Re Figure 9.3, it would be useful to have included the sediment pie charts to illustrate the fines, sand, and gravel proportions at the sediment chemistry sample locations.	The sediment fractional composition of the sediment samples has been added to **Figure 7.3**.

Consultee	Date/ Document	Comment	Project Response
MMO	10th June 2021	The MMO note that evidence used for the PEIR comprises ten sediment samples which were collected to support a Benthic Ecology Survey. Seven of these samples were analysed for a selection of contaminants, as, the applicant states, three samples could not recover an adequate volume of sediment due to rock obstructions present in the sampling methods. Under the Oslo and Paris Convention (OSPAR) guidelines, seven samples would represent approximately 100,000 m^3 of dredging or sediment disturbance. Table 9-1 details the realistic Worst-Case scenario design parameters, and states that the total worst-case volume of sediment which would be disturbed is 929,126 m^3 for sea bed preparation, 220,442 m^3 for the export cabling, and 774,200 m^3 for the infield cabling, if SEP and DEP were constructed concurrently. Therefore, under the OSPAR guidelines, the sampling which has been conducted greatly underrepresents the volumes proposed. However, contaminant sampling under the OSPAR guidelines can be reduced or even vetoed altogether if the sediment to be disturbed is sufficiently coarse. Coarse-grained sediments, such as sand and gravel, have a reduced affinity for sorbing contaminants when compared with fine-grained sediments such as silts, and so, if an area of sediment is shown to be sufficiently coarse, it may not need to be sampled for contaminants. Chapter 8 of the PEIR (section 8.5) details the results of a grab-sampling campaign conducted by Fugro (August 2020), where 98 sea bed samples were taken and analysed for particle size. MMO could not ascertain the depth from which these samples were taken, and so, for the purpose of this exercise, assume that they were surficial samples (0 m depth). These 98 samples	The Applicant notes and welcomes that the MMO consider adequate evidence has been gathered and presented which show that the working area (array and cable corridors) is sufficiently coarse so as not to warrant additional contaminant analysis, and that the area is likely low risk for contaminant release.

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		provide adequate spatial representation of the working area as relevant to the OSPAR guidelines based on the volumes proposed. The MMO note that the data presented indicate very low levels of contaminants (trace metals, organotins, Polycyclic Aromatic Hydrocarbons [PAHs]) in the offshore sediments. Based on the information presented, the MMO agree with the Applicants conclusion that the levels presented appear very low. Given the points outlined above and the assumptions made the MMO, in consultation with its scientific advisors Cefas, consider adequate evidence has been gathered and presented which show that the working area (array and cable corridors) is sufficiently coarse so as not to warrant additional contaminant analysis, and that the area is likely low risk for contaminant release. The report discusses potential embedded mitigation measures. At this early stage of the application process, MMO would not expect mitigation to be finalised, and do not currently recommend any based on the sediment data presented.	
MMO	10th June 2021	The MMO were unable to locate any information detailing which laboratory was contracted to perform the various analyses, and which methods were used for detection. This is a key point, as different analytical methods can lead to widely varying results, particularly for some analyses such as Total Hydrocarbon Content. The MMO request that this point is clarified before drafting their Environmental Statement (ES). The Applicant appears to have tested for the United States Environmental Protection Agency (US EPA) list of 16 priority PAH congeners. Whilst this comprises most PAHs of concern in the UK, it notably omits several congeners (e.g., C-group Naphthalenes) which are	The Applicant confirmed at the Sea bed ETG4 meeting that Fugro undertook the sediment contaminant analysis (see **Section 7.4.2.1**). Reference to EPA priority list has been added (see **Section 7.5.4**). The mud fraction is confirmed to be particles less than 63 micrometres.

Consultee	Date/ Document	Comment	Project Response
		essential to determining risk to the marine environment. The MMO suggest that the PEIR is modified to more accurately reflect that PAHs tested for comprise the US EPA 16 PAHs, and are not comprehensive of PAH congeners routinely tested for in the UK. The results show that samples were mostly medium sand to fine gravels (0.3 millimetres 'mm' to 4.2mm), with less than 10% "mud" in all samples. The report does not appear to specify the sediment range that "mud" is described as, though the MMO presume that it is ~63 micrometres (µm): Further clarification is recommended.	

7.3 Scope

7.3.1 Study Area

8. The study area for marine sediment quality has been defined on the basis of the following project elements:

- The area within the offshore boundary comprising:
  - The SEP and DEP wind farm sites (defined by Agreement for Lease (Afl) areas) including the wind turbine foundations, infield cables and offshore substation platforms; and
  - Offshore cable corridors outside of the wind farm sites (either interlink cable or offshore export cable corridors).
- The wider area that may be impacted by sediment plumes – this is informed by **Chapter 6 Marine Geology, Oceanography and Physical Processes** which considers the spatial extent of any potential sediment plumes.

7.3.2 Realistic Worst Case Scenario

7.3.2.1 General Approach

9. The final design of SEP and DEP will be confirmed through detailed engineering design studies that will be undertaken post-consent to enable the commencement of construction. In order to provide a precautionary but robust impact assessment at this stage of the development process, realistic worst-case scenarios have been defined in terms of the potential effects that may arise. This approach to EIA, referred to as the Rochdale Envelope, is common practice for developments of this nature, as set out in Planning Inspectorate Advice Note Nine: Rochdale Envelope (v3, 2018). The Rochdale Envelope for a project outlines the realistic worst-case scenario for each individual impact, so that it can be safely assumed that all lesser options will have less impact. Further details are provided in **Chapter 5 EIA Methodology**.

10. The realistic worst case scenarios for the marine water and sediment quality assessment are summarised in **Table 7-2**. These are based on the project parameters described in **Chapter 4 Project Description**, which provides further details regarding specific activities and their durations.

11. In addition to the design parameters set out in **Table 7-2**, consideration is also given to:

- How SEP and DEP will be built out as described in **Section 7.3.2.2** to **Section 17** below. This accounts for the fact that whilst SEP and DEP are the subject of one DCO application, it is possible that only one Project could be built out (i.e. build SEP or DEP in isolation) or that both of the Projects could be developed. If both are developed, construction may be undertaken either concurrently or sequentially.
- A number of further development options which either depend on pre-investment or anticipatory investment, or that relate to the final design of the wind farms.

- Whether one OSP or two OSPs are required.
- The design option of whether to use all of the DEP North and DEP South array areas, or whether to use the DEP North array area only.

12. In order to ensure that a robust assessment has been undertaken, all development scenarios and options have been considered to ensure the realistic worst-case scenario for each topic has been assessed. Further details are provided in **Chapter 4 Project Description**.
13. In relation to the different OSP scenarios where both SEP and DEP are built (i.e. where there are one or two OSPs), each scenario has been presented, however only the overall realistic worst-case for each impact has been assessed in **Section 7.6**. The worst-case parameter for each activity / footprint in the SEP and DEP one or two OSP scenario has been denoted with an asterisk and underlined in **Table 7-2**. In addition, cells have been shaded grey to indicate which scenario represents the worst-case in relation to each of the impacts assessed.

7.3.2.2 Construction Scenarios

14. In the event that both SEP and DEP are built, the following principles set out the framework for how SEP and DEP may be constructed:
    - SEP and DEP may be constructed at the same time, or at different times;
    - If built at the same time both SEP and DEP could be constructed in four years;
    - If built at different times, either Project could be built first;
    - If built at different times, each Project would require a four year period of construction;
    - If built at different times, the offset between the start of construction of the first Project, and the start of construction of the second Project may vary from two to four years;
    - Taking the above into account, the total maximum period during which construction could take place is eight years for both Projects; and
    - The earliest construction start date is 2025.
15. The impact assessment for benthic ecology considers the following development scenarios in determining the worst-case scenario for each topic:
    - Build SEP or build DEP in isolation – one OSP only; and
    - Build SEP and DEP concurrently or sequentially – with either two OSPs, one for SEP and one for DEP, or with one OSP only to serve both SEP and DEP

16. For each of these scenarios it has been considered whether the build out of the DEP North and DEP South array areas, or the build out of the DEP North array area only, represents the worst-case for that topic. Any differences between SEP and DEP, or differences that could result from the manner in which the first and the second projects are built (concurrent or sequential and the length of any gap) are identified and discussed where relevant in the impact assessment section of this chapter (**Section 7.6**). For each potential impact, where necessary, only the worst-case construction scenario for two Projects is presented, i.e. either concurrent or sequential. The justification for what constitutes the worst-case is provided, where necessary, in **Section 7.6**.

7.3.2.3 Operation Scenarios

17. Operation scenarios are described in detail in **Chapter 4 Project Description**. Where necessary, the assessment considers the following three scenarios:

- Only SEP in operation;
- Only DEP in operation; and
- The two Projects operating at the same time, with a gap of two to four years between each Project commencing operation.

18. The operational lifetime of each Project is expected to be 40 years.

7.3.2.4 Decommissioning Scenarios

19. Decommissioning scenarios are described in detail in **Chapter 4 Project Description**. Decommissioning arrangements for the onshore elements of SEP and DEP will be agreed through the submission of an onshore decommissioning plan to the relevant planning authority for approval within six months of the permanent cessation of commercial operation (unless otherwise agreed in writing by the relevant planning authority), however for the purpose of this assessment it is assumed that decommissioning of SEP and DEP could be conducted separately, or at the same time.

Table 7-2: Realistic Worst Case Scenarios

Impact	DEP in Isolation	SEP in Isolation	SEP and DEP: Two OSPs (one in SEP wind farm site and one in DEP North array area)	SEP and DEP: One OSP (located in SEP wind farm site)	Notes and Rationale
Construction					
Impact 1: Deterioration in water quality due to an increase in suspended sediment through sea bed preparation for foundations	Sea bed preparation for up to 24 18MW GBS foundations = **407,150m³**	Sea bed preparation for up to 19 18MW GBS foundations = **322,327m³**	Sea bed preparation for up to 43 18MW GBS foundations = **729,477m³***		The worst case for a single 18 MW GBS foundation with a 60m base plate diameter = 16,964.60m³. Worst case for a single 15MW GBS foundation with a 45m base plate diameter = 9,543m³. Therefore, the overall worst case is associated with 24 18MW GBS foundations at DEP and 19 18MW GBS foundations at SEP. Sea bed preparation (dredging using a trailing suction hopper dredger (TSHD) and installation of a bedding and levelling layer) may be required up to a sediment depth of 5m. The worst-case scenario assumes that sediment would be dredged and returned to the water column at the sea surface during disposal from the dredger vessel. The worst case scenario is associated with SEP and DEP and is the same whether there is one or two OSPs.
Impact 2: Deterioration in water quality due to an increase in suspended sediment associated with drill arisings for foundation installation of piled foundations	Drill arisings at 2 15MW wind turbines = 11,946m³ Drill arisings at 1 OSP = 425m³ **Total = 12,371m³**	Drill arisings at 2 15MW wind turbines = 11,946m³ Drill arisings at 1 OSP = 425m³ **Total = 12,371m³**	Drill arisings at 4 15MW wind turbines = 23,892m³ Drill arisings at 2 OSPs = 850m³* **Total = 24,742m³***	Drill arisings at 4 15MW wind turbines = 23,892m³ Drill arisings at 1 OSP = 425m³ **Total = 24,292m³**	For wind turbine monopile foundations, the maximum percentage anticipated to require drilling is 5%. As a precautionary worst case, up to two 15MW wind turbines each for SEP and DEP are considered to require drilling. An average drill penetration depth for the 15MW wind turbine of 45m and a maximum drill diameter of 13m is assumed. This equates to 5,973m³ of drill arisings per 15MW wind turbine. OSPs jacket foundations would have up to 8 legs, 1 of which could be drilled. An average drill penetration depth of 60m and a maximum drill diameter of 4m is assumed
Impact 3: Deterioration in water quality due to an increase in suspended sediment during export cable installation	Displaced sediment during export cable installation • Export cable = 31,000m³ • HDD exit point = 650m³ (600m³ initial exit point trench and 50m³ further transition zone) • Sand wave levelling = 144,200m³ **Total = 175,850m³**	Displaced sediment during export cable installation • Export cable = 20,000m³ • HDD exit point = 650m³ (600m³ initial exit point trench and 50m³ further transition zone) • Sand wave levelling = 0m³ **Total = 20,650m³**	Displaced sediment during export cable installation • Export cable = 51,000m³* • HDD exit point = 700m³ (600m³ initial exit point trench and 100m³ further transition zone) • Sand wave levelling = 144,200m³* **Total = 195,900m³***	Displaced sediment during export cable installation • Export cable = 40,000m³ • HDD exit point = 700m³ (600m³ initial exit point trench and 100m³ further transition zone) • Sand wave levelling = 0m³ **Total = 40,700m³**	Export cables would be buried up to 1m below the sea bed. Calculations are based on an indicative sediment displacement width of 1m for jetting and assume a v-shaped trench. For the HDD exit pit, the SEP and DEP scenario assumes both export cables are within the same initial trench meaning the volume of disturbance is the same as the SEP or DEP in isolation scenario. However, for the transition zone it assumes two trenches and therefore the area of disturbance is double the SEP or DEP in isolation scenario.

Impact	DEP in Isolation	SEP in Isolation	SEP and DEP		Notes and Rationale
			Two OSPs (one in SEP wind farm site and one in DEP North array area)	One OSP (located in SEP wind farm site)	
	Drilling mud / bentonite A small amount of drill fluid (up to 25m³ total for two HDD ducts) may be discharged into the sea during punchout at the exit point.	**Drilling mud / bentonite** A small amount of drill fluid (up to 25m³ total for two HDD ducts) may be discharged into the sea during punchout at the exit point.	**Drilling mud / bentonite** A small amount of drill fluid (up to 50m³ total for four HDD ducts) may be discharged into the sea during punchout at the exit point.	**Drilling mud / bentonite** A small amount of drill fluid (up to 50m³ total for four HDD ducts) may be discharged into the sea during punchout at the exit point.	Sand wave levelling (pre-sweeping) for export cables is required in specific areas prior to export cable installation for DEP in isolation and SEP and DEP. Material would be discharged at or near the sea surface in the vicinity of the removal location. No sand wave levelling (pre-sweeping) is required in SEP as no sand waves are present.
Impact 4: Deterioration in water quality due to an increase in suspended sediment during offshore cable installation (infield and interlink cables)	Displaced sediment during infield and interlink cable installation • Infield = 151,875m³ • Interlink = 74,250m³ • Sand wave levelling = 232,200m³ (216,000m³ infield and 16,200m³ interlink) **Total = 458,325m³**	Displaced sediment during infield and interlink cable v • Infield = 101,250m³ • Interlink = 0m³ • Sand wave levelling = 0m³ **Total = 101,250m³**	Displaced sediment during infield and interlink cable installation • Infield = 253,125m³ • Interlink = 74,250m³ • Sand wave levelling = 232,200m³ (216,000m³ infield and 16,200m³ interlink) **Total = 559,575m³**	Displaced sediment during infield and interlink cable installation • Infield = 253,125m³ • Interlink = 160,875m³ • Sand wave levelling = 360,200m³* (216,000m³ infield and 144,200m³ interlink) **Total = 774,200m³***	Infield and interlink cables would be buried up to 1.5m below the sea bed. Calculations are based on an indicative sediment displacement width of 1m for jetting and assume a v-shaped trench. Sand wave levelling (pre-sweeping) is required in specific areas prior to infield and interlink cable installation. Material discharged at or near the sea surface in the vicinity of the removal location.
Impact 5: Deterioration in water quality due to the release of contaminated sediment	As described for construction impacts 1-4.				
Operation					
Impact 1: Deterioration in water quality through an increase in suspended sediment due to cable repairs / reburial	Volumes of Sediment Disturbed Cable repair or replacement • One export cable repair every 10 years, up to 800m, = **800m³** • One interlink cable repair every 10 years, up to 800m = **1,800m³** • Two infield cable repairs every 10 years, up to 5km each, = **22,500m³.** Cable reburial • Up to 200m of export cable subject to reburial works every 10 years, 1m width of sediment displacement with jetting and 1m maximum burial depth = **200m³**.	Volumes of Sediment Disturbed Cable repair or replacement • One export cable repair every 10 years, up to 800m = **800m³** • Two infield cable repairs every 10 years, up to 5km each, = **22,500m³.** Cable reburial • Up to 200m of export cable subject to reburial works every 10 years, 1m width of sediment displacement with jetting and 1.5m maximum burial depth = **200m³**. • 0m³ for interlink cables since there are no interlink cables for SEP in isolation.	Volumes of Sediment Disturbed Cable repair or replacement • One export cable repair every 10 years, up to 800m = **800m³** • One interlink cable repair every 10 years, up to 800m, = **1,800m³** • Two infield cable repairs every 10 years, up to 5km each, 1.5m width of sediment displacement with mechanical cutting and 1.5m maximum burial depth = **22,500m³.**	Volumes of Sediment Disturbed Cable repair or replacement • Same as for SEP and DEP 2 OSP scenario Cable reburial • Up to 200m per export cable subject to reburial works every 10 years, 1m width of sediment displacement with jetting and 1m maximum burial depth = **400m³**. • Reburial of 1% of up to 143km of interlink cabling every 10 years (1.43km), 1.5m width of sediment displacement with mechanical cutting and 1.5m maximum burial depth = **3,218m³***.	Up to 10 jack-up movements per year for each of SEP and DEP (i.e. 20 in total). Jack-up vessel with a sea bed footprint of 1,200m² (up to four legs, each with a footprint of up to 300m²). 1m width of sediment displacement with jetting and 1m maximum burial depth is assumed for export cable repair, replacement or reburial. 1.5m width of sediment displacement with mechanical cutting and 1.5m maximum burial depth is assumed for interlink and infield cable repair, replacement or reburial. Further detail on maximum temporary O&M footprints in the wind farm sites and cable corridors is provided in **Table 4-9** of **Chapter 4 Project Description.** Export cable repair and reburial would be undertaken using a jetting cable burial method. The worst case repair and reburial method for infield and interlink cables is mechanical cutting.

Impact	DEP in Isolation	SEP in Isolation	SEP and DEP		Notes and Rationale
			Two OSPs (one in SEP wind farm site and one in DEP North array area)	One OSP (located in SEP wind farm site)	
	• Reburial of 1% of up to 66km of interlink cabling every 10 years (0.66km), 1.5m width of sediment displacement with mechanical cutting and 1.5m maximum burial depth = **1,485m^3** • Reburial of 1% of 135km (90km in the DEP North array area and 45km in the DEP South array area) of infield cabling every 10 years (1.35km), 1.5m width of sediment displacement with mechanical cutting and 1.5m maximum burial depth = **3,038m^3**. **Total = 29,823m^3 per 10 year period**	• Reburial of 1% of 90km of infield cabling every 10 years (0.90km), 1.5m width of sediment displacement with mechanical cutting and 1.5m maximum burial depth = **2,025m^3**. **Total = 25,525m^3 per 10 year period**	Cable reburial • Up to 200m per export cable subject to reburial works every 10 years, 1m width of sediment displacement with jetting and 1m maximum burial depth = **400m^3**. • Reburial of 1% of up to 66km of interlink cabling every 10 years (0.66km), 1.5m width of sediment displacement with mechanical cutting and 1.5m maximum burial depth = **1,485m^3**. • Reburial of 1% of 225km of infield cabling every 10 years (2.25km), 1.5m width of sediment displacement with mechanical cutting and 1.5m maximum burial depth = **5,063m^3**. **Total = 32,048m^3 per 10 year period**	• Reburial of 1% of 225km of infield cabling every 10 years (2.25km), 1.5m width of sediment displacement with mechanical cutting and 1.5m maximum burial depth = **5,063m^{3*}**. **Total = 33,781m^3* per 10 year period**	SEP and DEP have an operational design life of 40 years.
Impact 2: Deterioration in water quality through the resuspension of contaminated sediment due to maintenance activities	As described for operation Impact 1				
Decommissioning					

No final decision has yet been made regarding the final decommissioning policy for the offshore project infrastructure. It is also recognised that legislation and industry best practice change over time. However, the following infrastructure is likely be removed, reused or recycled where practicable:

- Turbines including monopile, steel jacket and GBS foundations;
- OSPs including topsides and steel jacket foundations;
- Offshore cables may be removed or left *in situ* depending on available information at the time of decommissioning; and
- External cable protection in the Cromer Shoal Chalk Beds MCZ.

The following infrastructure is likely to be decommissioned *in situ* depending on available information at the time of decommissioning:

- Scour protection;
- Offshore cables may be removed or left *in situ*; and
- Crossings and external cable protection outside the Cromer Shoal Chalk Beds MCZ.

The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and will be agreed with the regulator. For the purposes of the worst case scenario, it is anticipated that the impacts will be no greater than those identified for the construction phase.

7.3.3 Summary of Mitigation Embedded in the Design

20. This section outlines the embedded mitigation relevant to the marine water and sediment quality assessment, which has been incorporated into the design of SEP and DEP (**Table 7-3**). Where other mitigation measures are proposed, these are detailed in the impact assessment (**Section 7.6**).

Table 7-3: Embedded Mitigation Measures

Parameter	Mitigation Measures Embedded into the Project Design
Foundations	For piled foundation types, such as monopiles and jackets with pin piles, pile-driving would be used in preference to drilling where it is practicable to do so (i.e. where ground conditions allow). This would minimise the quantity of sub-surface sediment that is released into the water column from the installation process.
	Micro-siting of foundations around for example sand waves would be used where possible to minimise the requirements for sea bed preparation prior to foundation installation.
	Scour protection to be used where required.
Cables	The Applicant will make reasonable endeavours to bury cables, minimising the requirement for external cable protection measures and thus effects related to scour. Where burial is undertaken, jetting, ploughing or cutting will be used depending on the ground conditions. Where possible sediment removed from the trench will be used as infill. Use of external cable protection would be minimised in all cases and in the nearshore is only included for potential use at the HDD exit point.
	Route selection and micro-siting of the cables will be used to avoid areas of sea bed that pose a significant challenge to their installation, including for example areas of sand waves and megaripples. This will minimise the requirement for sea bed preparation (levelling) and the associated sea bed disturbance. This is reflected in the allowances that have been made for these works as described in **Table 7-2**, based on the information from the geophysical surveys conducted to date.

7.3.4 Pollution prevention

21. Equinor is committed to the use of best practice techniques and due diligence regarding the potential for pollution throughout all construction, operation and maintenance, and decommissioning activities. An **Outline PEMP** (document reference 9.10) sets out the details of the measures that will be taken in relation to accidental pollution events. The final PEMP would be agreed with the MMO prior to construction.

22. In view of the above and the commitment to the PEMP, this risk is not considered further in this chapter.

7.4 Impact Assessment Methodology

7.4.1 Policy, Legislation and Guidance

7.4.1.1 National Policy Statements

23. The assessment of potential impacts upon marine water and sediment quality has been made with specific reference to the relevant National Policy Statements (NPS). These are the principal decision making documents for Nationally Significant Infrastructure Projects (NSIPs). Those relevant to SEP and DEP are:

- Overarching NPS for Energy (EN-1) (Department of Energy and Climate Change (DECC) 2011a); and
- NPS for Renewable Energy Infrastructure (EN-3) (DECC 2011b).

24. The specific assessment requirements for marine water and sediment quality, as detailed in the NPS, are summarised in **Table 7-4** together with an indication of the section of the ES chapter where each is addressed.

25. It is noted that the NPS for Energy (EN-1) and the NPS for Renewable Energy Infrastructure (EN-3) are in the process of being revised. Draft versions were published for consultation in September 2021 (Department for Business Energy and Industrial Strategy (BEIS), 2021a and BEIS 2021b respectively). A review of these draft versions has been undertaken in the context of this ES chapter.

Table 7-4: NPS Assessment Requirements

NPS Requirement	NPS Reference	Section Reference
NPS for Energy (EN-1)		
Infrastructure development can have adverse effects on the water environment, including transitional waters and coastal waters. During the construction, operation and decommissioning phases, discharges would occur. There may also be an increased risk of spills and leaks of pollutants to the water environment. These effects could lead to adverse impacts on health or on protected species and habitats and could, in particular, result in surface waters, ground waters of protected areas failing to meet environmental objectives established under the Water Framework Directive.	Paragraph 5.15.1	Potential impacts on water quality are assessed in **Section 7.6** and in the **WFD Compliance Assessment** found in **Appendix 18.1**. Impacts on habitats and species are assessed in **Chapter 8 Benthic Ecology** and **Chapter 9 Fish and Shellfish Ecology**.
Where the project is likely to have adverse effects on the water environment, the application should undertake an assessment of the existing status of, and impacts of the proposed project, on water quality, water resources and physical characteristics of the water environment as part of the Environmental Statement or equivalent.	Paragraph 5.15.2	The existing baseline and the baseline for relevant WFD marine bodies is presented in **Section 7.5**.
NPS for Renewable Energy Infrastructure (EN-3)		
The construction, operation and decommissioning of offshore energy infrastructure can affect marine water quality through the disturbance of sea bed sediments or the release of contaminants with subsequent indirect effects on habitats, biodiversity and fish stocks.	Paragraph 2.6.189	Potential impacts during construction, operation and maintenance are assessed in **Section 7.6**. Contaminant analysis of samples collected from the sea bed indicate very low levels of contaminants within the offshore sites. Potential impacts on commercial fisheries receptors

NPS Requirement	NPS Reference	Section Reference
		are assessed in **Chapter 12 Commercial Fisheries**. Potential impacts on habitats and biodiversity are assessed in **Chapter 8 Benthic Ecology** and **Chapter 9 Fish and Shellfish Ecology**.
The Environment Agency regulates emissions to land, air and water out to 3 nautical miles (nm). Where any element of the wind farm or any associated development included in the application to the Infrastructure Planning Commission (IPC) (now the Planning Inspectorate) is located within 3nm of the coast, the Environment Agency should be consulted at the pre-application stage on the assessment methodology for impacts on the physical environment.	Paragraph 2.6.191	Consultation with the Environment Agency has been undertaken throughout the EIA process for SEP and DEP. In addition, consultation has been undertaken through the Evidence Plan Process (EPP) and ETG meetings which agreed assessment methodologies.
Beyond 3nm, the Marine Management Organisation (MMO) is the regulator. The applicant should consult the MMO and Centre for Environment, Fisheries and Aquaculture Science (Cefas) on the assessment methodology for impacts on the physical environment at the pre-application stage.	Paragraph 2.6.192	Consultation with the MMO and Cefas has been undertaken throughout the EIA process for SEP and DEP. In addition, consultation has been undertaken through the Evidence Plan Process (EPP) and ETG meetings which agreed assessment methodologies.
Draft overarching NPS for Energy (EN-1) (BEIS, 2021a)		
Infrastructure development can have adverse effects on the water environment, including groundwater, inland surface water, transitional waters and coastal waters. During the construction, operation and decommissioning phases, it can lead to increased demand for water, involve discharges to water and cause adverse ecological effects resulting from physical modifications to the water environment. There may also be an increased risk of spills and leaks of pollutants to the water environment.	Paragraph 5.16.1	Potential impacts on water quality are assessed in **Section 7.6** and in the **WFD Compliance Assessment found in Appendix 18.1.** Impacts to habitats and species are assessed in **Chapter 8 Benthic Ecology** and **Chapter 9 Fish and Shellfish Ecology**.
Where the project is likely to have effects on the water environment, the applicant should undertake an assessment of the existing status of, and impacts of the proposed project on, water quality, water resources and physical characteristics of the water environment as part of the ES or equivalent.	Paragraph 5.16.2	Baseline information is provided in **Section 7.5** and impacts on the marine environment are provided in **Section 7.6**

NPS Requirement	NPS Reference	Section Reference
The ES should in particular describe the existing quality of waters affected by the proposed project and the impacts of the proposed project on water quality, noting any relevant existing discharges, proposed new discharges and proposed changes to discharges	Paragraph 5.16.5	Baseline information is provided in **Section 7.5** and impacts on the marine environment are provided in **Section 7.6**.
The risk of impacts on the water environment can be reduced through careful design to facilitate adherence to good pollution control practice.	Paragraph 5.16.12	An **Outline PEMP** (document reference 9.10) has been submitted with the DCO application which details best practice and embedded mitigation measures that will ensure good pollution control practice.
Draft NPS for Renewable Energy Infrastructure (EN-3) (BEIS, 2021b)		
The construction, operation and decommissioning of offshore energy infrastructure (including the preparation and installation of the cable route) can affect the following elements of the physical offshore environment, which can have knock on impacts on: • water quality – disturbance of the sea bed sediments or release of contaminants can result in direct or indirect effects on habitats and biodiversity, as well as on fish stocks thus affecting the fishing industry. The release of sediment during construction, operation and decommissioning can cause indirect effects on marine ecology and biodiversity.	Paragraph 2.25.1	Baseline information is provided in **Section 7.5** and impacts on the marine environment are provided in **Section 7.6**. Potential impacts on commercial fisheries receptors are assessed in **Chapter 12 Commercial Fisheries.** Impacts on marine ecology and biodiversity are assessed in **Chapter 8 Benthic Ecology** and **Chapter 9 Fish and Shellfish Ecology**.

7.4.1.2 Other

26. In addition to the NPS, there are a number of pieces of legislation and policy applicable to the assessment of marine water and sediment quality as outlined in the following sections

7.4.1.2.1 Legislation

27. The following legislation is relevant to marine water and sediment quality:

- Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy (the WFD);
- Directive 2008/105/EC Priority Substances establishing Environmental Quality Standards for contaminants in water;

- Directive 2008/56/EC establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive (MSFD)); and;
- Directive 2006/7/EC concerning the management of bathing water quality.

28. The above Directives have been transposed into UK law by:
    - Water Environment (WFD) (England and Wales) Regulations 2017;
    - Marine Strategy Regulations 2010; and
    - Bathing Water Regulations 2013.
29. The International Convention for the Prevention of Marine Pollution by Ships (MARPOL Convention) 73/78 is also relevant to the protection of marine water and sediment quality.

7.4.1.2.2 Policy

30. Other UK policies and plans of relevance to this chapter are the Marine Policy Statement (MPS) (HM Government, 2011) and the East Inshore and East Offshore Marine Plans (HM Government, 2014). These documents guide decision making with regard to marine developments and signpost the relevant legislation to be followed. These are discussed further in **Chapter 2 Policy and Legislative Context**.
31. The MPS provides the high-level approach to marine planning and general principles for decision making. It also sets out the framework for environmental, social and economic considerations that need to be taken into account in marine planning. Section 2.6.4 of the MPS states that:
32. "*Developments and other activities at the coast and at sea can have adverse effects on transitional waters, coastal waters and marine waters. During the construction, operation and decommissioning phases of developments, there can be increased demand for water, discharges to water and adverse ecological effects resulting from physical modifications to the water environment. There may also be an increased risk of spills and leaks of pollutants into the water environment and the likelihood of transmission of invasive non-native species, for example through construction equipment, and their impacts on ecological water quality need to be considered.*"
33. With regard to the East Inshore and East Offshore Marine Plans (HM Government 2014) Objective 6 "To have a healthy, resilient and adaptable marine ecosystem in the East Marine Plan areas" is of relevance to this chapter as this covers policies and commitments on the wider ecosystem, set out in the MPS including those to do with the MSFD and the WFD, as well as other environmental, social and economic considerations. Elements of the ecosystem considered by this objective include:
34. "*water quality characteristics critical to supporting a healthy ecosystem and pollutants that may affect these*".
35. Further detail where relevant is provided in **Chapter 2 Policy and Legislative Context**.

7.4.2 Data and Information Sources

7.4.2.1 Site Specific Surveys

36. To provide site specific and up to date information on which to base the impact assessment, a site characterisation survey was undertaken in the SEP and DEP wind farm sites and offshore cable corridors by Fugro between the 10th and 19th August 2020 (Fugro, 2020a and 2020b). The site characterisation reports are available in **Appendix 8.1 DEP Benthic Characterisation Report** (Fugro, 2020a) and **Appendix 8.2 SEP Benthic Characterisation Report** (Fugro, 2020b).

37. Grab samples were collected for particle size analysis (PSA) and chemical analysis for polycyclic aromatic hydrocarbons (PAHs), heavy metals and tributyl tins (TBT). The results of the chemical analysis are presented in **Section 7.5.4**.

7.4.2.2 Other Available Sources

38. Other sources that have been used to inform the assessment are listed in **Table 7-5**.

Table 7-5: Other Available Data and Information Sources

Data set	Spatial coverage	Year	Notes
OSPAR assessments	OSPAR regions including UK Seas	OSPAR 2010 assessment (OSPAR 2010) OSPAR Intermediate Assessment 2017 (OSPAR 2017)	The Interim Assessment 2017 provides background information and assessments of human pressures on the marine environment and biological diversity of the OSPAR Maritime Area. The Quality Status Report 2010 evaluates the quality status.
OSPAR Coordinated Environmental Monitoring Programme (CEMP) assessment reports (OSPAR Commission 2020)	UK seas – water and sediment quality	2019-2020	2019-2020 report summarises the 2019-2020 annual CEMP assessment of levels and trends of contaminants and their biological effects.
Environment Agency Catchment Data Explorer (Environment Agency, 2021a)	Rivers, estuaries and coastal water bodies around England	2019	Database for information related to river basin management plans (RBMP) in England. Contains information on river basin districts and catchments and WFD compliance data
Environment Agency Bathing Waters Information and classification (Environment Agency, 2021b)	Coastal water bodies designated as bathing waters	Up to and including bathing season 2021 to date	Data for designated bathing waters. Note there is no data available for 2020 due to Covid-19.

7.4.3 Impact Assessment Methodology

39. **Chapter 5 EIA Methodology** provides a summary of the general impact assessment methodology applied to SEP and DEP. The following sections confirm the methodology used to assess the potential impacts on marine water and sediment quality.

40. The impact assessment in this chapter generally follows that outlined in **Chapter 5 EIA Methodology** with topic specific definitions for sensitivity and magnitude provided below.

7.4.3.1 Definitions of Sensitivity and Magnitude

41. For each effect, the assessment identifies receptors sensitive to that effect and implements a systematic approach to understanding the impact pathways and the level of impacts on given receptors. The definitions of sensitivity and magnitude for the purpose of the marine water and sediment quality assessment are provided in **Table 7-6** and **Table 7-7**.

42. The sensitivity of a receptor, in this case marine water quality, is dependent upon its:

- Tolerance to an effect (i.e. the extent to which the receptor is adversely affected by a particular effect);
- Adaptability (i.e. the ability of the receptor to avoid adverse impacts that would otherwise arise from a particular effect); and
- Recoverability (i.e. a measure of a receptors ability to return to a state at, or close to, that which existed before the effect caused a change).

43. Sensitivity is described using a standard semantic scale, definitions for each term are provided in **Table 7-6.**

Table 7-6: Definition of Sensitivity for Marine Waters

Sensitivity	Definition
High	The water quality of the receptor supports or contributes towards the designation of an internationally or nationally important feature and/or has a very low capacity to accommodate any change to current water quality status, compared to baseline conditions.
Medium	The water quality of the receptor supports high biodiversity and/or has low capacity to accommodate change to water quality status.
Low	The water quality of the receptor has a high capacity to accommodate change to water quality status due, for example, to large relative size of the receiving water and capacity for dilution. Background concentrations of certain parameters already exist.
Negligible	Specific water quality conditions of the receptor are likely to be able to tolerate proposed change with very little or no impact upon the baseline conditions detectable.

44. Water quality in the SEP and DEP offshore sites is considered to be of low sensitivity because it is not within a confined area and therefore has a high capacity to accommodate change due to its size and ability to dilute any alterations to water quality parameters. Similarly, it is also considered that the nearshore extent of the offshore export cable corridor is of low sensitivity. The nearest designated bathing water is over 4km from the offshore export cable corridor and due to the exposed coastal nature of the area, there is a high capacity to accommodate change through dilution of any water quality effects.

45. The descriptions of magnitude are specific to the assessment of marine water quality impacts and are considered in addition to the generic descriptors of impact magnitude that are presented in **Chapter 5 EIA Methodology**. Potential impacts have been considered in terms of whether they are permanent or temporary and have resulting adverse or beneficial effects. The magnitude of an effect is dependent upon its:

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

46. The magnitude of effect is described using a standard semantic scale and definitions for each term are provided in **Table 7-7**.

Table 7-7: Definition of Magnitude for Marine Waters

Magnitude	Definition
High	Large scale change to key characteristics of the water quality status of the receiving water feature. Water quality status degraded to the extent that a permanent or long term change occurs. Inability to meet (for example) Environmental Quality Standard (EQS) is likely.
Medium	Medium scale changes to key characteristics of the water quality status taking account of the receptor volume, mixing capacity, flow rate, etc. Water quality status likely to take considerable time to recover to baseline conditions.
Low	Noticeable but not considered to be substantial changes to the water quality status taking account of the receiving water features. Activity not likely to alter local status to the extent that water quality characteristics change considerably or EQSs are compromised.
Negligible	Although there may be some impact upon water quality status, activities predicted to occur over a short period. Any change to water quality status would be quickly reversed once activity ceases.

7.4.3.2 Impact Significance

47. In basic terms, the potential significance of an impact is a function of the sensitivity of the receptor and the magnitude of the effect (see **Chapter 5 EIA Methodology** for further details). The determination of significance is guided by the use of an impact significance matrix, as shown in **Table 7-8**. Definitions of each level of significance are provided in **Table 7-9**.

48. Potential impacts identified within the assessment as major or moderate are regarded as significant in terms of the EIA regulations. Potential impacts should be described using impact significance, followed by a statement of whether the impact significance is significant in terms of the EIA regulations, e.g. "*minor adverse impact, not significant in EIA terms / moderate adverse impact, significant in EIA terms*". Appropriate mitigation has been identified, where possible, in consultation with the regulatory authorities and relevant stakeholders. The aim of mitigation measures is to avoid or reduce the overall impact in order to determine a residual impact upon a given receptor.

Table 7-8: Impact Significance Matrix

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

Table 7-9: Definition of Impact Significance

Significance	Definition
Major	Very large or large change in receptor condition, both adverse or beneficial, which are likely to be important considerations at a regional or district level because they contribute to achieving national, regional or local objectives, or could result in exceedance of statutory objectives and / or breaches of legislation.
Moderate	Intermediate change in receptor condition, which is likely to be an important consideration at a local level.
Minor	Small change in receptor condition, which may be raised as a local issue but is unlikely to be important in the decision making process.
Negligible	No discernible change in receptor condition.
No change	No impact, therefore, no change in receptor condition.

7.4.4 Cumulative Impact Assessment Methodology

49. The cumulative impact assessment (CIA) considers other plans, projects and activities that may impact cumulatively with SEP and DEP. As part of this process, the assessment considers which of the residual impacts assessed for SEP and/or DEP on their own have the potential to contribute to a cumulative impact, the data and information available to inform the cumulative assessment and the resulting confidence in any assessment that is undertaken. **Chapter 5 EIA Methodology** provides further details of the general framework and approach to the CIA.

50. For marine water and sediment quality, these activities include the construction of other OWFs, O&M activities at operational OWFs, construction and maintenance of coastal projects and other offshore projects.

7.4.5 Transboundary Impact Assessment Methodology

51. The transboundary assessment considers the potential for transboundary effects to occur on marine water and sediment quality as a result of SEP and DEP; either those that might arise within the Exclusive Economic Zone (EEZ) of European Economic Area (EEA) states or arising on the interests of EEA states e.g. a non UK fishing vessel. **Chapter 5 EIA Methodology** provides further details of the general framework and approach to the assessment of transboundary effects.

52. The Scoping Report concluded that potential impacts on marine water and sediment quality are likely to be restricted to the project boundary and immediate surrounding area. In their Scoping Opinion, the Planning Inspectorate also considered that transboundary impacts associated with this topic are unlikely to result in significant effects (Planning Inspectorate, 2019). Therefore, transboundary effects are scoped out and are not considered further in this chapter.

7.4.6 Assumptions and Limitations

53. Given the limited data regarding site specific offshore water quality, information from more general monitoring programmes such as those undertaken by OSPAR and WFD water body status have been used to inform this assessment.

54. This limitation is not considered to significantly affect the certainty or reliability of the impact assessments presented in **Section 7.6**.

7.5 Existing Environment

7.5.1 Water Quality - contaminants

55. The offshore cable corridor routes through WFD coastal water bodies, the Norfolk East coastal water body (GB650503520000) and the Norfolk North coastal water body (GB640503300000) (see **Figure 7.1**). A WFD compliance assessment is presented in **Appendix 18.1** however the information available for these water bodies regarding water quality is also relevant to this chapter and is therefore summarised below.

56. Both water bodies are 'heavily modified'; Norfolk North due to flood protection and Norfolk East due to flood and coastal protection. Both water bodies are currently classified to have an overall status of 'moderate' (Environment Agency, 2021a).

57. Classification for physico-chemical parameters in both water bodies is considered moderate due to dissolved inorganic nitrogen concentrations in the water. In the River Basin Management Plan for the area (Environment Agency, 2021a), reasons for the elevated inorganic nitrogen concentrations are listed as diffuse pollution (field runoff from arable land), and point sources associated with sewage discharges. In terms of chemical contaminants, both water bodies are considered to have a status of 'fail' due to levels of polybrominated diphenyl ethers (PBDEs), and mercury and its compounds.

58. There are five designated bathing waters located along the coast from the cable corridor (**see Figure 7.2**). The WFD bathing waters in closest proximity to the offshore cable corridor are Sheringham, and West Runton, 4.6km and 7.7km from the proposed offshore export cable corridor respectively. These bathing waters have been classified as having excellent bathing water quality since 2016 (Environment Agency, 2021b).

59. In terms of the offshore sites, the Interim QSR 2017 (OSPAR, 2017) states that overall, in the OSPAR region, including the North Sea, contaminant concentrations have continued to decrease in the majority of areas assessed. Although concentrations are generally below levels likely to harm marine species in the areas assessed, in most cases they have not yet reduced to background levels (where these are specified). Concerns remain in some localised areas with respect to high levels of mercury, lead, and CB118 (one of the most toxic polychlorinated biphenyl (PCB) congeners), and locally increasing concentrations of PAHs and cadmium.

7.5.2 Water Quality – Suspended sediment concentrations

60. As set out in **Chapter 6 Marine Geology, Oceanography and Physical Processes**, typical mean summer suspended sediment concentrations across the study area are less than 10mg/l whereas mean winter concentrations are 30mg/l, although concentrations may increase significantly during storm events (HR Wallingford et al., 2002). More recently, Cefas (2016) published average suspended sediment concentrations between 1998 and 2015 for the seas around the UK.

61. More recently, Cefas (2016) published average suspended sediment concentrations between 1998 and 2015 for the seas around the UK (**Figure 6.10** of **Chapter 6 Marine Geology, Oceanography and Physical Processes**). They showed that over this time period, the average suspended sediment concentrations across SEP and DEP were 5-10mg/l.

7.5.3 Sediment – Physical characteristics

62. PSA data from sea bed samples taken within the study area are described in full in **Chapter 6 Marine Geology, Oceanography and Physical Processes**. The results of the sediment sampling campaign are summarised in **Table 7-10** and sediment fractional composition at each sample site is shown in **Figure 7.3** and **Figure 7.4**.

Table 7-10: Summary of Sediment PSA Collected During Site Specific Sampling Campaign

Area	Description
DEP North array area	The dominant sediment type is medium sand. The mud content is less than 10% in all samples
DEP South array area	The dominant sediment type is medium sand. Samples have a particularly high sand content, with 82% of samples containing greater than 75% sand. Mud content is less than 10% in all samples.
Interlink Cable Corridors	The majority of samples in the DEP North array area to SEP wind farm site interlink cable corridor are composed primarily of medium to coarse sand. Three samples contain a high percentage of gravel. Mud content is low - less than 10% in all samples. In the DEP South array area to SEP wind farm site interlink cable corridor, sediment is dominated by medium sand and low mud content (also less than 10% in all samples). The DEP South array area to SEP wind farm site part of the interlink cable corridor is dominated by medium sand. Mud content is less than 10% in 100% of samples.

Area	Description
	Samples from the western portion of the southern corridor have a greater range of sediment size compared to samples in the east, which are more homogenous. The DEP North array area to DEP South array area interlink cable corridor is dominated by sandy gravel (66% of samples). Mud content is less than 6% in all samples.
SEP (wind farm site)	The predominant sediment type is sandy gravel. Mud content is less than 10% in 88% of samples, with two samples in the northwest of the SEP wind farm site containing 17% and 13% mud.
Export Cable Corridor	The landward 500m of the export cable corridor (from the SEP wind farm site to landfall) is mainly outcropping chalk (N.B. the export cables at the landfall will be installed by HDD, exiting the sea bed approximately 1000m from shore). From 500m to 4.5km offshore along the export cable corridor, the sea bed is composed of alternating zones of coarse sediment comprising gravelly sand/gravel, and Holocene sand. From 4.5km from the coast to the SEP wind farm site the sea bed is gravelly sand or gravel. 10km offshore, the sea bed is composed of sand forming the eastern end of Sheringham Shoal sand bank. Sediment samples collected within the offshore export cable corridor are predominantly composed of medium sand to coarse gravel. Many samples closer to the coast contain greater than 56% gravel and the majority of samples contain less than 10% mud. Only one sample (sample EC_16 located approximately 12km from the coast) contained a higher percentage of mud at 22%.

7.5.4 Sediment – Contaminants

63. To inform the baseline for sediment quality, seven grab samples were taken for chemical analysis during benthic surveys of the SEP and DEP wind farm sites and offshore cable corridors. Ten samples were originally planned, however, at three sites (SS_18, D_04 and EC_07), sampling was unsuccessful because of repeated failure of the grab to take a sample due to rocks in the grab jaws and insufficient sediment recovered. All ten sample locations are shown in **Figure 7.5**. Consultation with Natural England following submission of the PEIR indicated a concern regarding this apparent gap in sampling. However given the failed sampling indicated areas consisted of coarse material and that the majority of the PSA samples returned high proportions of sand and gravel (see **Figure 7.3**), the risk that more contaminated areas have been missed by these failed samples is considered to be low given that contaminants tend to bind to finer material, especially organic-rich fine grains (Cefas, 2020).

64. On completion of the survey, all samples were frozen and stored on the survey vessel until demobilisation, following which they were transferred to Fugro for analysis. Analysis was undertaken for the following contaminants:

- Metals - aluminium, arsenic, barium, mercury, cadmium, chromium, copper, iron, lithium, lead, nickel and zinc;

- Aromatic compounds naphthalenes (2 ring aromatics), 3 to 6 ring Polycyclic Aromatic Hydrocarbons (PAHs) and the dibenzothiophenes (sulphur containing heteroaromatics) including the United States Environmental Protection Agency's (US EPA) 16 PAHs – these are 16 priority PAHs designated as high priority pollutants based on their potential human and ecological health effects. Individual aromatic hydrocarbon concentrations and their alkyl homologue concentrations were also recorded for naphthalene, phenanthrene/anthracene, dibenzothiophene, fluoranthene/pyrene, benzphenanthrenes/benzanthracenes;
- Organotins (monobutyltin (MBT), dibutyltin (DBT) and tributyltin (TBT)); and
- Total hydrocarbons (THC).

65. The full data set is presented in **Appendix 8.1 DEP Benthic Characterisation Report** (Fugro, 2020a) and **Appendix 8.2 SEP Benthic Characterisation Report** (Fugro, 2020b).

7.5.4.1 Comparison with Cefas Action Levels

66. The context of the contaminants found within sediments is established through the use of recognised guidelines and action levels, in this case the Cefas Action Levels have been applied as a first stage because they provide good coverage of contaminants, across a broad range of contaminant types (MMO, 2018).

67. The majority of the material assessed against these standards arises from dredging and disposal activities as part of the MMO's marine licensing process for disposal of material to sea, but they are also considered a good way of undertaking an initial risk assessment with respect to determining risks to water quality from other marine activities as part of the EIA and associated WFD compliance assessments.

68. If, overall, levels do not generally exceed the lower threshold values of these guideline standards (i.e. Action Level 1), then contamination levels are considered to be low risk in terms of the potential for impacts on water quality. This approach is recommended by the Environment Agency in their WFD compliance assessment guidance 'Clearing the Waters for All', for example (Environment Agency, 2017). Whilst the sediment sampling was not undertaken by an MMO accredited lab (required for licensing procedures), the Cefas Action Levels can be applied to the data where contaminants correlate with those in the MMO's list for the purposes of informing EIA and WFD compliance assessments, as these assessments do not have the same accreditation requirements.

69. Selected Action Levels based on the contaminant groups selected for analysis are set out in **Table 7-11**.

Table 7-11: Selected Cefas Action Levels (Based on Contaminant Groups Selected for Analysis)

Contaminant	Action Level 1 (mg/kg)	Action Level 2 (mg/kg)
Arsenic	20	100
Cadmium	0.4	5
Chromium	40	400

Contaminant	Action Level 1 (mg/kg)	Action Level 2 (mg/kg)
Copper	40	400
Nickel	20	200
Mercury	0.3	3
Lead	50	500
Zinc	130	800
Organotins (MBT, TBT, DBT)	0.1	1
Polyaromatic hydrocarbons (PAH)	0.1 for each individual PAH (exception dibenz[a,h]anthracene which is 0.01)	None
Total Hydrocarbons (THC)	100	None

70. The data for parameters which correlate with the MMO's list of contaminants of concern is presented in **Table 7-12**. No samples exceed the lower Cefas Action Level 1 and therefore for the purposes of assessing risks to water quality as part of the EIA and WFD compliance assessment process, the sediment contaminant concentrations are deemed to be low risk.

Table 7-12: Data from Site Specific Survey Compared to Cefas Action Levels

Contaminant	Sample site (all in mg/kg)							Cefas Action Levels (mg/kg)	
	CC-06	D-17	D-26	EC-04	EC-05	EC-15	SS-03	1	2
Arsenic	5.90	8.73	11.3	10.5	14.3	9.42	9.41	20	100
Cadmium	<0.0800	<0.0800	<0.0800	<0.0800	<0.0800	<0.0800	<0.0800	0.4	5
Chromium	4.53	3.94	10.2	8.67	10.2	5.03	10.0	40	400
Copper	1.44	<0.0800	1.10	1.80	2.06	0.915	1.75	40	400
Nickel	3.27	1.86	4.70	4.82	5.04	3.24	5.13	20	200
Mercury	<0.0400	<0.0400	<0.0400	<0.0400	<0.0400	<0.0400	<0.0400	0.3	3
Lead	7.28	4.59	7.53	6.34	9.93	5.34	8.34	50	500
Zinc	9.12	6.43	14.7	16.2	18.7	11.6	17.7	130	800
TBT	0.00105	0.00126	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	0.1	1
DBT	0.00167	<0.0004	<0.0004	<0.0004	0.000568	<0.0004	<0.0004	0.1	1
MTB	<0.0004	<0.0004	0.0399	0.00042	<0.0004	<0.0004	<0.0004	0.1	1
Naphthalene	0.0007	0.0005	0.0021	0.0042	0.0037	0.0002	0.0035	0.1	-
C1 Naphthalene	0.0019	0.0017	0.0048	0.0098	0.0093	0.0005	0.0081	0.1	-
C2 Naphthalene	0.0031	0.0030	0.0045	0.0142	0.0125	0.0007	0.0116	0.1	-
C3 Naphthalene	0.003	0.0032	0.0072	0.014	0.0137	0.0008	0.0108	0.1	-
Acenaphthylene	<0.0001	<0.0001	<0.0001	0.0001	0.0001	<0.0001	<0.0001	0.1	-
Acenaphthene	0.0001	0.0001	0.0001	0.0004	0.0003	<0.0001	0.0003	0.1	-
Fluorene	0.0002	0.0002	0.0004	0.0011	0.0009	0.0001	0.0008	0.1	-
Phenanthrene	0.0027	0.0028	0.0061	0.0086	0.0089	0.0005	0.0073	0.1	-
C1 Phenanthrene	0.0026	0.0024	0.0067	0.0088	0.0088	0.0005	0.0073	0.1	-

Contaminant	Sample site (all in mg/kg)							Cefas Action Levels (mg/kg)	
	CC-06	D-17	D-26	EC-04	EC-05	EC-15	SS-03	1	2
Anthracene	0.0001	0.0001	0.0004	0.0008	0.0009	0.0001	0.0005	0.1	-
Fluoranthene	0.0013	0.0015	0.0048	0.0058	0.0053	0.0005	0.0041	0.1	-
Pyrene	0.0012	0.0012	0.0041	0.0054	0.0049	0.0004	0.0038	0.1	-
Benzo(a)anthracene	0.0007	0.0006	0.0019	0.0028	0.0026	0.0002	0.0022	0.1	-
Chrysene	0.0011	0.0008	0.0026	0.0032	0.0028	0.0003	0.0027	0.1	-
Benzo(b)fluoranthene	0.0019	0.0020	0.0047	0.0066	0.0059	0.0012	0.0056	0.1	-
Benzo(k)fluoranthene	0.0005	0.0005	0.001	0.0017	0.0015	0.0003	0.0014	0.1	-
Benzo(a)pyrene	0.0006	0.0006	0.0017	0.0030	0.0028	0.0002	0.0022	0.1	-
Indeno(1,2,3-cd)pyrene	0.0008	0.0008	0.0017	0.0031	0.0030	0.0004	0.0024	0.1	-
Benzo(ghi)perylene	0.0014	0.0015	0.0031	0.0046	0.0045	0.0004	0.0038	0.1	-
Dibenzo(a,h)anthracene	0.0002	0.0002	0.0005	0.0008	0.0008	<0.0001	0.0007	0.01	-
Total Hydrocarbons	1.4	1.4	3.3	4.0	3.6	1.2	2.4	100	-

7.5.4.2 Comparison with Canadian Sediment Quality Guidelines

71. The data has also been compared to the Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CSQG) (Canadian Council of Ministers of the Environment (CCME), 2002) as an additional stage in the assessment. These guidelines involved the derivation of Interim Marine Sediment Quality Guidelines (ISQGs) or Threshold Effect Levels (TEL) and Probable Effect Levels (PEL) from an extensive database containing direct measurements of toxicity of contaminated sediments to a range of aquatic organisms exposed in laboratory tests and under field conditions (CCME, 2002). It should be noted that these guidelines were designed specifically for Canada and are based on the protection of pristine environments. The findings of the comparison should therefore be treated with caution and are indicative only.

72. Selected Canadian guidelines correlating with the contaminants included in the site specific survey are presented in **Table 7-13**. The lower level is referred to as the TEL and represents a concentration below which adverse biological effects are expected to occur only rarely (in some sensitive species for example). The higher level, the PEL, defines a concentration above which adverse effects may be expected in a wider range of organisms.

73. Sediment contamination data (Fugro, 2020a and 2020b) is presented in **Table 7-14** and shows that only marginal exceedances of TEL for arsenic concentrations are present but all other parameters are below their respective lower TEL concentration. This confirms the conclusions in **Section 7.5.4.1** that sediments are relatively low risk in terms of potential risks to water quality. Additionally, it can also be concluded that the sediments present relatively low risks to marine organisms. Whilst arsenic is indicated as being elevated, the TEL concentration of 7.24mg/kg is considerably lower than the Cefas Action Level 1 for Arsenic at 20mg/kg which is considered by Cefas to be suitably protective to the UK marine environment in making offshore disposal to sea licensing decisions (Cefas, 2020).

Table 7-13: Selected CSQG Values (Taken from CCME, 2002)

Contaminant	TEL (mg/kg)	PEL (mg/kg)
Arsenic	7.24	41.6
Cadmium	0.7	4.2
Chromium	52.3	160
Copper	18.7	108
Mercury	0.13	0.7
Lead	30.2	112
Zinc	124	247
Acenaphthene	0.00671	0.0889
Acenaphthylene	0.00587	0.128
Anthracene	0.0469	0.245
Benzo(a)anthracene	0.0748	0.693
Benzo(a)pyrene	0.0888	0.763

Contaminant	TEL (mg/kg)	PEL (mg/kg)
Chrysene	0.108	0.846
Dibenzo(a,h)anthracene	0.00622	0.135
Fluoranthene	0.113	1.494
Fluorene	0.0212	0.144
Naphthalene	0.0346	0.391
Phenanthrene	0.0867	0.544
Pyrene	0.153	1.398

Table 7-14: Data from Site Specific Survey Compared to the Canadian Interim Sediment Quality Guidelines (Yellow Indicates Exceedances of TEL. There were no Exceedances of the PEL).

Contaminant	Sample site (all in mg/kg)							Canadian Sediment Quality Guidelines (mg/kg)	
	CC-06	D-17	D-26	EC-04	EC-05	EC-15	SS-03	TEL	PEL
Arsenic	5.90	8.73	11.3	10.5	14.3	9.42	9.41	7.24	41.6
Cadmium	<0.0800	<0.0800	<0.0800	<0.0800	<0.0800	<0.0800	<0.0800	0.7	4.2
Chromium	4.53	3.94	10.2	8.67	10.2	5.03	10.0	52.3	160
Copper	1.44	<0.0800	1.10	1.80	2.06	0.915	1.75	18.7	108
Mercury	<0.0400	<0.0400	<0.0400	<0.0400	<0.0400	<0.0400	<0.0400	0.13	0.7
Lead	7.28	4.59	7.53	6.34	9.93	5.34	8.34	30.2	112
Zinc	9.12	6.43	14.7	16.2	18.7	11.6	17.7	124	247
Naphthalene	0.0007	0.0005	0.0021	0.0042	0.0037	0.0002	0.0035	0.0346	0.391
Acenaphthylene	<0.0001	<0.0001	<0.0001	0.0001	0.0001	<0.0001	<0.0001	0.00587	0.128
Acenaphthene	0.0001	0.0001	0.0001	0.0004	0.0003	<0.0001	0.0003	0.00671	0.0889
Fluorene	0.0002	0.0002	0.0004	0.0011	0.0009	0.0001	0.0008	0.0212	0.144
Phenanthrene	0.0027	0.0028	0.0061	0.0086	0.0089	0.0005	0.0073	0.0867	0.544
Anthracene	0.0001	0.0001	0.0004	0.0008	0.0009	0.0001	0.0005	0.0469	0.245
Fluoranthene	0.0013	0.0015	0.0048	0.0058	0.0053	0.0005	0.0041	0.113	1.494
Pyrene	0.0012	0.0012	0.0041	0.0054	0.0049	0.0004	0.0038	0.153	1.398
Benzo(a)anthracene	0.0007	0.0006	0.0019	0.0028	0.0026	0.0002	0.0022	0.0748	0.693
Chrysene	0.0011	0.0008	0.0026	0.0032	0.0028	0.0003	0.0027	0.108	0.846
Benzo(a)pyrene	0.0006	0.0006	0.0017	0.0030	0.0028	0.0002	0.0022	0.0888	0.763

Contaminant	Sample site (all in mg/kg)							Canadian Sediment Quality Guidelines (mg/kg)	
	CC-06	D-17	D-26	EC-04	EC-05	EC-15	SS-03	TEL	PEL
Dibenzo(a,h)anthracene	0.0002	0.0002	0.0005	0.0008	0.0008	<0.0001	0.0007	0.00622	0.135

7.5.4.3 Comparison with other sediment quality guidelines

74. Consultation with Natural England following submission of the final Sea bed ETG meeting minutes for comment still highlighted concerns with the analysis undertaken and sediment guidelines used therefore additional information is presented here with respect to PAH parameters, as these were the specific parameters queried.

75. PAHs are natural components of coal and oil and are also formed during the combustion of fossil fuels and organic material. PAHs enter the marine environment through atmospheric deposition, road run-off, industrial discharges and oil spills. In the marine environment, PAHs become trapped in lower layers unless the sediments are disturbed.

76. The OSPAR Hazardous Substances Strategy aims to achieve concentrations in the marine environment to near natural background values for naturally occurring substances and close to zero for man-made synthetic substances. Due to their persistence in the marine environment, their potential to bioaccumulate and their toxicity, analyses of PAH concentrations in sediment is reported in the OSPAR environmental monitoring programme CEMP (see **Section 7.4.2**).

77. PAHs are hydrocarbons composed of two or more fused aromatic rings, encompassing both parent (non-alkylated) compounds and alkylated homologues. Most datasets contain analysis for parent compounds only, with the exception of the MMO contaminant list for disposal to sea which requires analysis of three alkylated homologues of naphthalene (C1 to C3) and one of phenanthrene (C1).

78. CEMP compare selected PAH concentrations against two assessment criteria: the OSPAR Background Assessment Concentration (BAC) and the US EPA's Effects Range-Low (ERL). The ERL value is defined as the lower tenth percentile of the data set of concentrations in sediments which were associated with biological effects. Adverse effects on organisms are rarely observed when concentrations fall below the ERL value. The ERL developed by the US EPA is used in the CEMP assessments because there are no OSPAR Environmental Assessment Criteria (EACs) currently available. It is also acknowledged that there is a need for EACs to be developed for both alkylated and parent PAHs in sediment.

79. Background assessment concentrations (BACs) are statistical tools defined in relation to the background concentrations which enable statistical testing of whether observed concentrations can be considered to be near background concentrations.

80. The PAH parameters for which ERLs and BACs are available are presented in **Table 7-15**. It can be seen that all parameters are below the BAC, the lower of the guideline values.

Table 7-15: Data from Site Specific Survey Compared to the CEMP BAC and ERLs

Contaminant	Sample site (all in mg/kg)							CEMP sediment guidelines applied to sediment data (mg/kg) by OSPAR	
	CC-06	D-17	D-26	EC-04	EC-05	EC-15	SS-03	BAC	ERL
Naphthalene	0.0007	0.0005	0.0021	0.0042	0.0037	0.0002	0.0035	0.008	0.160
Phenanthrene	0.0027	0.0028	0.0061	0.0086	0.0089	0.0005	0.0073	0.032	0.240
Anthracene	0.0001	0.0001	0.0004	0.0008	0.0009	0.0001	0.0005	0.005	0.085
Fluoranthene	0.0013	0.0015	0.0048	0.0058	0.0053	0.0005	0.0041	0.039	0.600
Pyrene	0.0012	0.0012	0.0041	0.0054	0.0049	0.0004	0.0038	0.024	0.665
Benzo(a)anthracene	0.0007	0.0006	0.0019	0.0028	0.0026	0.0002	0.0022	0.016	0.261
Chrysene	0.0011	0.0008	0.0026	0.0032	0.0028	0.0003	0.0027	0.020	0.384
Benzo(a)pyrene	0.0006	0.0006	0.0017	0.0030	0.0028	0.0002	0.0022	0.030	0.430
Indeno(1,2,3-cd)pyrene	0.0008	0.0008	0.0017	0.0031	0.0030	0.0004	0.0024	0.103	0.240
Benzo(ghi)perylene	0.0014	0.0015	0.0031	0.0046	0.0045	0.0004	0.0038	0.080	0.085

7.5.5 Baseline Summary

81. From the data presented above it can be concluded that the baseline water quality for the offshore and coastal waters surrounding the wind farm sites and offshore export cable corridors is good and site-specific information in relation to the sediment contaminant concentrations do not contain elevated levels of contaminants likely to present a risk to water quality when disturbed.

82. For the area of the offshore export cable corridor within the WFD 1nm boundary, WFD water quality data indicates elevated inorganic nitrogen concentrations, PBDEs and mercury and its compounds (**Section 7.5.1**) but sediment quality reflects that of the offshore area i.e. very low levels of contamination recorded. These findings are supported by historic data gathered for the existing Dudgeon OWF and Sheringham Shoal OWF, which also showed that contamination levels throughout the study area were below Cefas Action Level 1 (Dudgeon Offshore Wind Farm, 2009; and Scira Offshore Energy Ltd, 2006). The predominantly coarse sea bed sediments (sand and gravel) indicated in the site specific information collected, significantly reduces both the potential for any contaminants to accumulate due to the coarse nature of the material (see **Figure 7.3**), and for sediments to be re-suspended into the water column and transported over long distances, thus reducing the potential for far-field effects.

83. Whilst there were no Cefas Action Level 1 exceedances of arsenic, consultation still indicated potential concerns (Cefas and Natural England) and therefore additional information is provided against two other sets of sediment guidelines, the Canadian Sediment Quality Guidelines (all contaminant groups) and the OSPAR BAC and ERLs for PAHs. The only parameter to exceed any of the sediment quality guidelines was arsenic and given concerns raised regarding this finding, the results are considered against regional information available for this parameter.

84. Specifically, Whalley *et al.* (1999) analysed archived samples from historical surveys and combined the data with results for the Dogger Bank to examine the distribution of total arsenic in sediments from the western North Sea and Humber Estuary. This identified a range of concentrations falling between 14 to 70mg/kg. Historically, the Humber has been subjected to large point discharges of arsenic from industrial sources and samples collected during various North Sea surveys have identified numerous areas with high raw arsenic concentrations, particularly off north Yorkshire and the Humber Estuary.

85. However, the same study demonstrated that after normalisation against iron, the levels of arsenic in these historical samples were much reduced in significance but that there were elevated arsenic concentrations present in sediments from the outer Thames and off north east Norfolk. Although arsenical waste disposal could explain the high arsenic concentrations in sediments from the outer Thames, the causes for those off north east Norfolk were considered to be unclear. The authors hypothesize that the circulation pattern of the North Sea might lead to the suggestion that arsenic from the Humber is being transported to this area but evidence to support this theory is not available. An alternative explanation offered by the authors is that drilling could have brought arsenic-rich marine shales to the surface, since the affected area coincides with the main group of English North Sea gas fields.

86. The arsenic concentrations within sediments in the SEP and DEP area (range between 5 and 15mg/kg) are considerably below those reported by Whalley *et al.* (1999) and therefore do not represent excessive levels for the region.

7.5.6 Climate Change and Natural Trends

87. The existing environment within the study area has been largely shaped by a combination of the physical processes which exist within the southern North Sea (**Chapter 6 Marine Geology Oceanography and Physical Processes**) and anthropogenic inputs (which influence pollutant levels). These processes will continue to influence the area in the future although any release of pollutants should continue to reduce due to better regulation and diffuse pollution control initiatives. As such, climate change and natural trends are not considered to have a material bearing on the outcome of the assessment presented in this chapter.

7.6 Potential Impacts

88. There is the potential for SEP and DEP construction, operation and decommissioning activities to suspend sediment and if present, sediment-bound contamination, which may have a detrimental effect on water quality.

89. The worst-case layout scenario (discussed in **Section 7.3.2**) is assessed for construction of SEP or DEP in isolation, and for SEP and DEP.

90. Conceptual analysis undertaken within **Chapter 6 Marine Geology, Oceanography and Physical Processes** has been used to inform the assessment and is based on the previous numerical modelling and theoretical work undertaken specifically for the existing Dudgeon OWF and the Sheringham Shoal OWF located in close proximity to SEP and DEP. The basis for using the previous modelling and theoretical results is that the designs of both of these wind farms and the prevailing marine geology, oceanography and physical processes at the sites are similar to SEP and DEP and therefore provide suitable analogues to support the assessment of effects.

7.6.1 Potential Impacts During Construction

7.6.1.1 Impact 1: Deterioration in water quality due to an increase in suspended sediment through sea bed preparation for foundations

91. Sea bed sediments and shallow near-bed sediments within SEP or DEP would be disturbed during sea bed preparation to create a suitable base prior to GBS foundation installation and where required to level the sea bed (sand wave levelling / pre-sweeping) prior to cable installation. As described within the **Disposal Site Characterisation Report** (document reference 9.13), where possible excavated sediment would be redeposited within the wind farm sites and/or cable corridors in an adjacent area of sea bed with similar sediment type.

92. This process would cause increases in suspended sediment concentrations both at the point of dredging at the sea bed and at the point of its discharge back into the water column.

7.6.1.1.1 Magnitude of Effect – SEP or DEP in Isolation

93. The conceptual evidence-based assessment for sea bed preparation is informed by the findings of a review of the evidence base into the physical impacts of marine aggregate dredging on sediment plumes and sea bed deposits (Whiteside *et al*., 1995; John *et al*., 2000; Hiscock and Bell, 2004; Newell *et al*., 2004; Tillin *et al*., 2011; Cooper and Brew, 2013). This is because aggregate dredging requires dredging of coarser grained material, similar to that found within SEP and DEP.

94. Due to the predominance of medium and coarse grained sand across the study area, the sediment disturbed by the drag head of the dredger at the sea bed would remain close to the bed and settle back to the bed rapidly. Most of the sediment released at the water surface from the dredger vessel during disposal, would fall rapidly (minutes or tens of minutes) to the sea bed upon its discharge, within a few tens of metres along the axis of tidal flow (see **Chapter 6 Marine Geology, Oceanography and Physical Processes**, **Section 6.6.4.1**).

95. Some of the finer sand fraction and the very small proportion of mud that is present are likely to stay in suspension for longer and form a passive plume which would become advected by tidal currents. Due to the sediment sizes present, this is likely to exist as a measurable but modest concentration plume (tens of mg/l) for around half a tidal cycle (i.e. up to six hours). Sediment would eventually settle to the sea bed within a few hundred metres up to approximately a kilometre from the source. Whilst lower suspended sediment concentrations are likely to extend further, the magnitudes would be indistinguishable from background levels. The magnitude of effect is therefore predicted to be negligible.

7.6.1.1.2 Magnitude of Effect – SEP and DEP

96. The worst-case scenario and impacts associated with foundation installation at SEP and DEP will be comparable to those outlined in **Section 7.6.1.1.1**. This is because is it unlikely that plumes would overlap due to tidal currents driving the plumes in similar directions at both sites and the distance between SEP and DEP i.e., the plumes would be parallel to each other. The magnitude of effect is therefore predicted to be the same, i.e. negligible.

7.6.1.1.3 Impact Significance – SEP or DEP in Isolation

97. The magnitude of effect is predicted to be negligible. Since the receptor is considered to be of low sensitivity, an increase in suspended sediment from dredging and disposal activities is expected to have a **negligible adverse** impact on water quality.

7.6.1.1.4 Impact Significance – SEP and DEP

98. The magnitude of effect is predicted to be negligible. Since the receptor is considered to be of low sensitivity, an increase in suspended sediment from dredging and disposal activities is expected to have a **negligible adverse** impact on water quality.

7.6.1.1.5 Mitigation

99. No mitigation has been identified as being required.

7.6.1.1.6 Residual Impacts – SEP or DEP in Isolation

100. The significance of the impact remains at **negligible adverse** significance.

7.6.1.1.7 Residual Impacts – SEP and DEP

101. The significance of the impact remains at **negligible adverse** significance.

7.6.1.2 Impact 2: Deterioration in water quality due to an increase in suspended sediment associated with drill arisings for foundation installation of piled foundations

102. It is estimated, via ground condition examination, that approximately 5% of turbine foundations would require drilling (i.e. two foundations each for SEP and DEP based on a precautionary worst case). During drilling, sediments from below the sea bed within SEP or DEP would be disposed of within the SEP or DEP wind farm sites in close proximity to each foundation. This could give rise to increases in suspended sediment concentrations.

7.6.1.2.1 Magnitude of Effect – SEP or DEP in Isolation

103. The results of the conceptual analysis presented in **Chapter 6 Marine Geology, Oceanography and Physical Processes** show that due to the small quantities of fine sediment released (most of the sediment will be sand or aggregated clasts), any plume is likely to be widely and rapidly dispersed, resulting in low suspended sediment concentrations and net movement of fine-grained sediment to the northwest or southeast, depending on state of the tide at the time of release.

104. Away from the immediate release locations, elevations in suspended sediment concentration above background levels would be very low (less than 10mg/l) and within the range of natural variability.

105. The magnitude of effect is therefore predicted to be negligible.

7.6.1.2.2 Magnitude of Effect – SEP and DEP

106. Sediment concentrations arising from one foundation installation are unlikely to persist for sufficiently long to interact with subsequent operations, and therefore no cumulative effect is predicted from multiple installations. As a result, the magnitude of effect remains at negligible.

7.6.1.2.3 Impact Significance – SEP or DEP in Isolation

107. The magnitude of effect is predicted to be negligible. Since the receptor is considered to be of low sensitivity, an increase in suspended sediment from dredging and disposal activities is expected to have a **negligible adverse** impact on water quality.

7.6.1.2.4 Impact Significance – SEP and DEP

108. The magnitude of effect is predicted to be negligible. Since the receptor is considered to be of low sensitivity, an increase in suspended sediment from dredging and disposal activities is expected to have a **negligible adverse** impact on water quality.

7.6.1.2.5 Mitigation

109. No mitigation has been identified as being required.

7.6.1.2.6 Residual Impacts – SEP or DEP in Isolation

110. The significance of the impact remains at **negligible adverse** significance.

7.6.1.2.7 Residual Impacts – SEP and DEP

111. The significance of the impact remains at **negligible adverse** significance.

7.6.1.3 Impact 3: Deterioration in water quality due to an increase in suspended sediment during export cable installation

112. Sand wave levelling (pre-sweeping) may be required at the northern end of the offshore export cable corridor at the DEP North array area prior to export cable installation (see **Figure 4.9** of **Chapter 4 Project Description**). Sand wave levelling is not required for SEP as there are no sand waves present. The worst-case scenario for sand wave levelling assumes that sediment would be dredged and returned to the water column at or near the sea surface as overflow from the dredger vessel in the vicinity of the removal location. This process would cause localised and short-term increases in suspended sediment concentrations both at the point of dredging at the sea bed and at the point of its discharge back into the water column. The worst-case cable laying technique is considered to be jetting due the higher potential for sediment to become resuspended using this cable burial technique.

113. The assessment of changes in suspended sediment concentrations during export cable installation has been considered separately from those for the infield and interlink cables because parts of the offshore cable corridor are in shallower water and closer to coastal designations such as bathing waters and WFD water bodies.

114. There is a requirement to use drilling fluid consisting of a mixture of water and natural inert clays such as bentonite, in order to undertake HDD activities and make landfall. This in turn may result in the release of drilling mud in the subtidal area at the HDD exit point. Bentonite is a non-toxic, natural clay mineral (<63μm particle diameter) and is included in the List of Notified Chemicals approved for use and discharge into the marine environment and is classified as a Group E substance under the Offshore Chemical Notification Scheme. Substances in Group E are defined as the group least likely to cause environmental harm and are "readily biodegradable and non-bioaccumulative". This is further supported by bentonite being included on the OSPAR List of Substances Used and Discharged Offshore which are considered to Pose Little or No Risk to the Environment (PLONOR) (Cefas, 2021).

7.6.1.3.1 Magnitude of Effect – SEP or DEP in Isolation

115. With respect to sand wave levelling (pre-sweeping), the effects are likely to be similar to those as outlined in Impact 1. Note that sand wave levelling would only be required at the northern end of the cable corridor at the DEP North array area prior to export cable installation.

116. The assessment for cabling is based on the overall sediment release volumes being low and confined to near the sea bed (rather than higher in the water column) along the alignment of the offshore export cable corridor, and the rate at which the sediment is released into the water column from the installation process being relatively slow. Scira (2006) completed sediment dispersion modelling to define the extent of plume dispersion due to the SOW cable installation and the extent of the depositional footprint. Given the similar positions of the SOW export cable corridor and the SEP and DEP export cable corridor, the modelling of the SOW installation is a suitable analogy for the potential effect of the installation of the SEP and DEP cable.

117. The modelling indicates that sand and gravel-sized sediment (which represents most of the disturbed sediment) would settle out of suspension rapidly to the bed in the immediate location of the export cable corridor (majority within 20m) with almost no sand being transported further than 100m of the cable. Fine sand will most likely remain in the bottom 1-2m of the water column, and with settling velocities of around 10mm/s, this will ensure the fine sand settles within half an hour or less or become part of the ambient near bed transport (Soulsby, 1997). Mud-sized material (which represents only a very small proportion of the disturbed sediment) would be advected a greater distance up to 2km and persist in the water column for hours to days. The plume created by the finer sediment may therefore be visible at the Sheringham and West Runton designated bathing waters, however, this plume is anticipated to dissipate within a single tidal cycle, i.e. would disperse within a day. Resulting concentrations of suspended sediment (modelling indicates maximum suspended concentrations of up to 20mg/l) are predicted to be within natural variation caused by storms for example, especially near the coast where concentrations have been recorded up to 170mg/l at Great Yarmouth (ABPmer, 2012).

118. DOW (2009) also completed sediment dispersion modelling for the DOW export cable laying activity, to simulate the potential increase in suspended sediment concentrations above background levels. The model predicted a spring tide footprint for silt which extended less than 1km from the cable with maximum concentrations less than 5mg/l.

119. For both SOW and DOW, the footprint of mud deposition was found to extend over a wide area, but at an unmeasurable rate. Even under slack water conditions, the maximum rate of deposition over a six-tide simulation was less than 0.5mm in the areas of greatest deposition, and in most of the footprint area the rate was much less. This result was anticipated as the deposited fines would be re-suspended on each tide, with no measurable sediment left in place.

120. During the excavation process at the HDD exit point, in the subtidal zone approximately 1,000m offshore, suspended sediment concentrations will be elevated but again are likely to remain within the range of background nearshore levels. Also, once completed, the high energy nearshore zone is likely to rapidly disperse the suspended sediment (i.e., over a period of a few hours) in the absence of any further sediment input.

121. Regarding potential bentonite release at the HDD exit point in the subtidal, as this is a clay-based substance, it may persist in suspension for hours to days or longer, becoming diluted to very low concentrations (indistinguishable from natural background levels and variability) within timescales of around one day. The suspended sediment concentrations at the HDD exit point would decrease notably within one tidal cycle. The total volume of HDD bentonite drilling fluid loss would be up to 25m^3 for a SEP or DEP in isolation. Any fine material being dispersed from the exit pits during excavation is likely to be widely dispersed and quickly form part of the background concentration of suspended sediments along the nearshore. The magnitude of effect is therefore predicted to be negligible.

7.6.1.3.2 Magnitude of Effect – SEP and DEP

122. In a SEP and DEP scenario there will be two export cables installed, parallel to each other within the offshore export cable corridor. Although more sediment would be resuspended under the SEP and DEP scenario, combined concentrations are likely to be lower than concentrations that would develop in the water column during storm conditions. Additionally, tidal currents are likely to rapidly disperse the suspended sediment (i.e. over a period of a few hours) in the absence of any further sediment input. Therefore, the potential deterioration in water quality due to sediment resuspended during export cable installation is the same for SEP and DEP as it is for SEP or DEP in isolation i.e. negligible.

7.6.1.3.3 Impact Significance – SEP or DEP in Isolation

123. The magnitude of effect is predicted to be negligible. Since the receptor is considered to be of low sensitivity, an increase in suspended sediment from dredging and disposal activities is expected to have a negligible adverse impact on water quality.

7.6.1.3.4 Impact Significance – SEP and DEP

124. The magnitude of effect is predicted to be negligible. Since the receptor is considered to be of low sensitivity, an increase in suspended sediment from dredging and disposal activities is expected to have a negligible adverse impact on water quality.

7.6.1.3.5 Mitigation

125. No mitigation has been identified as being required.

7.6.1.3.6 Residual Impacts – SEP or DEP in Isolation

126. The significance of the impact remains at **negligible adverse** significance.

7.6.1.3.7 Residual Impacts – SEP and DEP

127. The significance of the impact remains at **negligible adverse** significance.

7.6.1.4 Impact 4: Deterioration in water quality due to an increase in suspended sediment during offshore cable installation (infield and interlink cables)

128. Sand wave levelling may be required in the DEP North and South array areas and adjacent sections of offshore cable corridors prior to offshore cable installation. There is no requirement for sand wave levelling for SEP given that no sand waves are present.

129. Any sediment excavated during sand wave levelling would be disposed of within the DEP wind farm sites and cable corridors and the worst-case scenario assumes that sediment would be dredged and returned to the water column at or near the sea surface as overflow from a dredger vessel in the vicinity of the removal location. This process would cause localised and short-term increases in suspended sediment concentrations both at the point of dredging at the sea bed and at the point of its discharge back into the water column.

130. The installation of the cabling by jetting or mechanical cutting has the potential to disturb the sea bed sediments and suspend them in the water column. The assessment is based on a worst-case scenario where all the displaced sediment is suspended, although due to the general composition of sea bed sediments in the area and the low proportion of mud/fines, only a small proportion of disturbed sediments will be suspended for any length of time, if at all.

7.6.1.4.1 Magnitude of Effect – SEP or DEP in Isolation

131. The conceptual assessment undertaken to inform **Chapter 6 Marine Geology, Oceanography and Physical Processes** indicates that the changes in suspended sediment concentration due to infield and interlink cable installation would be similar to those arising from the disturbance of near-surface sediments during foundation installation activities including sea bed preparation.

132. As described in **Section 7.6.1.1**, some of the finer sand fraction and the very small proportion of mud that is present are likely to stay in suspension for longer and form a passive plume which would become advected by tidal currents. Due to the sediment sizes present, this is likely to exist as a measurable but modest concentration plume (tens of mg/l) for around half a tidal cycle (i.e. up to six hours). Sediment would eventually settle to the sea bed within a few hundred metres up to approximately a kilometre from the source within hours. Whilst lower suspended sediment concentrations are likely to extend further, the magnitudes would be indistinguishable from background levels. The magnitude of effect is therefore predicted to be negligible.

7.6.1.4.2 Magnitude of Effect – SEP and DEP

133. It is anticipated that the changes in suspended sediment concentration due to infield and interlink cable installation would be similar those arising from the disturbance of near-surface sediments during foundation installation activities including sea bed preparation (see **Section 7.6.1.1**). The magnitude of effect is therefore predicted to be negligible.

7.6.1.4.3 Impact Significance – SEP or DEP in Isolation

134. The magnitude of effect is predicted to be negligible. Since the receptor is considered to be of low sensitivity, an increase in suspended sediment from dredging and disposal activities is expected to have a negligible adverse impact on water quality.

7.6.1.4.4 Impact Significance – SEP and DEP

135. The magnitude of effect is predicted to be negligible. Since the receptor is considered to be of low sensitivity, an increase in suspended sediment from dredging and disposal activities is expected to have a negligible adverse impact on water quality.

7.6.1.4.5 Mitigation

136. No mitigation has been identified as being required.

7.6.1.4.6 Residual Impacts – SEP or DEP in Isolation

137. The significance of the impact remains at **negligible adverse** significance.

7.6.1.4.7 Residual Impacts – SEP and DEP

138. The significance of the impact remains at **negligible adverse** significance.

7.6.1.5 Impact 5: Deterioration in water quality due to the release of contaminated sediment

139. Any sediment that is disturbed and released during construction, could give rise to impacts on water quality via the release of contaminants bound to the sediment particles. The worst-case scenarios for this impact are defined by the impacts relating to effects on suspended solid concentrations above.

7.6.1.5.1 Magnitude of Effect – SEP or DEP in Isolation

140. **Table 7-14** shows that the levels of contaminants within SEP and DEP project boundary are all below relevant Cefas Action Level 1 concentrations and levels of arsenic only marginally exceed CSQG TEL levels in six of the seven sampled locations. Regional information available indicates that these levels are below the range identified as being typical for the area.

141. Sediments remaining in suspension for long periods of time are not predicted given that the sea bed material is predominantly sand/gravel thus reducing the risk of exposure to the water column for partitioning to occur.

142. The magnitude of effect is therefore considered to be negligible.

7.6.1.5.2 Magnitude of Effect – SEP and DEP

143. Given that the levels of contaminants are relatively low and that significant suspension of sediment is not predicted due to the coarse nature of the material, any localised effects on water quality are not anticipated to combine to give rise to increased impacts on water quality if the projects are built in parallel. The magnitude of effect is therefore the same as that for SEP or DEP in isolation i.e. negligible.

7.6.1.5.3 Impact Significance – SEP or DEP in Isolation

144. The magnitude of effect is predicted to be negligible. Since the receptor is considered to be of low sensitivity, an increase in suspended sediment from dredging and disposal activities is expected to have a negligible adverse impact on water quality.

7.6.1.5.4 Impact Significance – SEP and DEP

145. The magnitude of effect is predicted to be negligible. Since the receptor is considered to be of low sensitivity, an increase in suspended sediment from dredging and disposal activities is expected to have a negligible adverse impact on water quality.

7.6.1.5.5 Mitigation

146. No mitigation has been identified as being required.

7.6.1.5.6 Residual Impacts – SEP or DEP in Isolation

147. The significance of the impact remains at **negligible adverse** significance.

7.6.1.5.7 Residual Impacts – SEP and DEP

148. The significance of the impact remains at **negligible adverse** significance.

7.6.2 Potential Impacts During Operation

7.6.2.1 Impact 1: Deterioration in water quality through an increase in suspended sediment due to cable repairs / reburial

149. Disturbance of sea bed sediments by maintenance activities that impact the sea bed (e.g. cable repair, reburial or replacement) has the potential to re-suspend sediment and increase suspended sediment concentrations (see **Table 7-2**). The **Outline CSCB MCZ CSIMP** (document reference 9.7) provides further information on the potential repair and reburial of cables during the operational period.

7.6.2.1.1 Magnitude of Effect – SEP or DEP in Isolation

150. The scale of these effects will be small, infrequent and of short-term duration; and of a lower magnitude than during the construction phase. The magnitude of effect is therefore predicted to be negligible.

7.6.2.1.2 SEP and DEP

151. The scale of these effects will be small, infrequent and of short-term duration; and of a lower magnitude than during the construction phase. The magnitude of effect is therefore predicted to be negligible.

7.6.2.1.3 Impact Significance – SEP or DEP in Isolation

152. The magnitude of effect is predicted to be negligible. Since the receptor is considered to be of low sensitivity, an increase in suspended sediment from dredging and disposal activities is expected to have a negligible adverse impact on water quality.

7.6.2.1.4 Mitigation

153. No mitigation has been identified as being required.

7.6.2.1.5 Residual Impacts – SEP or DEP in Isolation

154. The significance of the impact remains at **negligible adverse** significance.

7.6.2.1.6 Residual Impacts – SEP and DEP

155. The significance of the impact remains at **negligible adverse** significance.

7.6.2.2 Impact 2: Deterioration in water quality through the resuspension of contaminated sediment due to maintenance activities

156. The re-suspension of sediment could lead to the release of any sediment-bound contaminants, which may in turn affect compliance with water quality standards.

7.6.2.2.1 Magnitude of Effect – SEP or DEP in Isolation

157. Given that the sample data does not indicate elevated levels of contaminants, the magnitude of effect is considered to be negligible.

7.6.2.2.2 Magnitude of Effect – SEP and DEP

158. Given that the sample data does not indicate elevated levels of contaminants, the magnitude of effect is considered to be negligible.

7.6.2.2.3 Impact Significance – SEP or DEP in Isolation

159. The magnitude of effect is predicted to be negligible. Since the receptor is considered to be of low sensitivity, an increase in suspended sediment from dredging and disposal activities during operation is expected to have a negligible adverse impact on water quality.

7.6.2.2.4 Impact Significance – SEP or DEP

160. The magnitude of effect is predicted to be negligible. Since the receptor is considered to be of low sensitivity, an increase in suspended sediment from dredging and disposal activities during operation is expected to have a negligible adverse impact on water quality.

7.6.2.2.5 Mitigation

161. No mitigation has been identified as being required.

7.6.2.2.6 Residual Impacts – SEP or DEP in Isolation

162. The significance of the impact remains at **negligible adverse** significance.

7.6.2.2.7 Residual Impacts – SEP and DEP

163. The significance of the impact remains at **negligible adverse** significance.

7.6.3 Potential Impacts During Decommissioning

164. The scope of the decommissioning works would be informed by the Decommissioning Programme to be produced at the pre-construction stage and would most likely involve removal of the accessible installed components. This is outlined in **Section 4.4.12** of **Chapter 4 Project Description** and the detail would be agreed with the relevant authorities at the time of decommissioning. Offshore, this is likely to include removal of all the wind turbine components, part of the foundations (those above sea bed level), removal of some or all of the infield cables, interlink cables, and export cables. Scour and external cable protection (except that installed within the Cromer Shoal Chalk Beds MCZ) would likely be decommissioned *in situ*.

165. During the decommissioning phase, there is potential for wind turbine foundation and cable removal activities to cause changes in suspended sediment concentrations and disturb contaminated sediments. The types of effect would be comparable to those identified for the construction phase:

- Impact 1: Deterioration in water quality due to an increase in suspended sediment during foundation removal
- Impact 2: Deterioration in water quality due to an increase in suspended sediment during removal of parts of the export cable
- Impact 3: Deterioration in water quality due to an increase in suspended sediment during removal of parts of the infield and interlink cables
- Impact 4: Deterioration in water quality due to release of contaminated sediment during decommissioning activities.

166. The magnitude of effects would be comparable to or less than those identified for the construction phase. Accordingly, given the construction phase assessments concluded impacts of negligible adverse significance for marine water and sediment quality, it is anticipated that the same would be valid for the decommissioning phase. The magnitude of effects will be the same for SEP or DEP in isolation and for SEP and DEP.

167. The significance of effects on other receptors is addressed within relevant chapters of this ES (**Chapter 6 Marine Geology, Oceanography and Physical Processes**, **Chapter 8 Benthic Ecology**, **Chapter 9 Fish and Shellfish Ecology** and **Chapter 12 Commercial Fisheries**).

7.7 Cumulative Impacts

7.7.1 Identification of Potential Cumulative Impacts

168. The first step in the cumulative assessment is the identification of which residual impacts assessed for SEP and/or DEP on their own have the potential for a cumulative impact with other plans, projects and activities (described as 'impact screening'). This information is set out in **Table 7-16** below. Only potential impacts assessed in **Section 7.6** as negligible or above are included in the CIA (i.e. those assessed as 'no impact' are not taken forward as there is no potential for them to contribute to a cumulative impact).

Table 7-16: Potential Cumulative Impacts (Impact Screening)

Impact	Potential for Cumulative Impact	Rationale
Construction Impact 1 Deterioration in water quality due to an increase in suspended sediment through sea bed preparation	No	Majority of impacts occur at discrete locations, are temporary in nature and are negligible in magnitude. This applies to SEP or DEP in isolation, and SEP and DEP.
Construction Impact 2 Deterioration in water quality due to an increase in suspended sediment associated with drill arisings for foundation installation of piled foundations	No	
Construction Impact 3 Deterioration in water quality due to an increase in suspended sediment during export cable installation	No	
Construction Impact 4 Deterioration in water quality due to an increase in suspended sediment during offshore cable installation (infield and interlink cable)	No	
Construction Impact 5 Deterioration in water quality due to the release of contaminated sediment	No	Contaminant concentrations within the sediment are present at levels below Cefas Action Level 1 and therefore are considered to be low risk in relation to the potential for effects on water quality

Impact	Potential for Cumulative Impact	Rationale
Operational Impact 1 Deterioration in water quality through an increase in suspended sediment due to cable repairs / reburial	No	Impacts would be highly localised around the cables and therefore there is no risk of cumulative impacts.
Operational Impact 2 Deterioration in water quality through re-suspension of contaminated sediment due to maintenance activities	No	Contaminant concentrations within the sediment are present at levels below Cefas Action Level 1 and therefore are considered to be low risk in relation to the potential for effects on water quality

7.7.2 Other Plans, Projects and Activities

169. The second step in the cumulative assessment is the identification of the other plans, projects and activities that may result in cumulative impacts for inclusion in the CIA (described as ‘project screening’). This information is set out in **Table 7-17** below, together with a consideration of the relevant details of each, including current status (e.g. under construction), planned construction period, closest distance to SEP and DEP, status of available data and rationale for including or excluding from the assessment.

170. The project screening has been informed by the development of a CIA Project List which forms an exhaustive list of plans, projects and activities in a very large study area relevant to SEP and DEP. The list has been appraised, based on the confidence in being able to undertake an assessment from the information and data available, enabling individual plans, projects and activities to be screened in or out.

Table 7-17: Summary of Projects Considered for the CIA in Relation to Marine Water and Sediment Quality (Project Screening)

Project	Status	Construction Period	Closest Distance from the Project (km)	Confidence in Data	Included in the CIA (Y/N)	Rationale
SOW	Operational	N/A	0 (cable corridor) 0 (array area)	High	N	SOW and DOW are operational. Impacts from operation and maintenance activities are considered to be non-significant for both projects, as shown in the environmental assessments accompanying the marine licence applications for operational and maintenance (O&M) activities: • Sheringham O&M generation (MLA/2020/00095) • Sheringham O&M Transmission (MLA/2020/00096) • Dudgeon O&M generation (MLA/2018/00511 • Dudgeon O&M Transmission (MLA/2019/00049) Indirect impacts to SEP and DEP are considered to be small scale and localised, meaning there is no pathway for interaction with SOW and DOW.
DOW	Operational	N/A	0 (cable corridor) 0 (array area)	High	N	
Hornsea Project Three	Consented	2023-2031 (offshore export cable construction 2026-2027, possibly also 2030-2031)	0 (cable corridor) 83 (array area)	High	N	The Hornsea Project Three export cable corridor bisects the SEP and DEP export cable corridor. No impact or non-significant impacts are predicted. Indirect impacts to SEP and DEP are considered to be small scale and localised, meaning there is no pathway for interaction.
Viking Link interconnector project	Planned	2023	43 (to SEP array)	High	N	The project is over 40km away from SEP and DEP and there is therefore no potential for cumulative impact on the identified receptors.

Project	Status	Construction Period	Closest Distance from the Project (km)	Confidence in Data	Included in the CIA (Y/N)	Rationale
Aggregate resource areas (AGG3)	N/A	N/A	0	N/A	N	The AGG3 area is identified as having a high potential aggregate resource. There are no specific plans that the Applicant is aware of to undertake aggregate dredging in the vicinity of SEP and DEP on which to base an assessment and this plan is therefore screened out of the CIA.
Blythe Hub Development	Under construction	2021	1 (array area), (4 cable corridor)	High	N	First gas is expected in Q3 2021 therefore the project will be operational before SEP and DEP construction begins in 2024 at the earliest.

7.7.3 Assessment of Cumulative Impacts

171. **Table 7-17** indicates that there are no projects for which there is the potential for a cumulative effect to occur.

7.8 Transboundary Impacts

172. As noted in **Table 7-1**, the Planning Inspectorate agreed during the scoping phase that potential transboundary impacts on marine water and sediment quality receptors could be scoped out of the assessment and therefore no further assessment has been undertaken.

7.9 Inter-relationships

173. There are inter-relationships between the marine water and sediment quality topic and several other topics that have been considered within this ES. **Table 7-18** provides a summary of the principal inter-relationships and signposts to where those issues have been addressed in relevant chapters.

Table 7-18: Marine Water and Sediment Quality Inter-Relationships

Topic and Description	Related Chapter	Where Addressed in this Chapter	Rationale
Construction			
Deterioration in water quality (increase in suspended sediment concentrations and suspension of contaminants)	**Chapter 8 Benthic Ecology** **Chapter 9 Fish and Shellfish Ecology** **Chapter 12 Commercial Fisheries**	**Section 7.6.1.1** and **Section 7.6.1.2** (foundation installation) **Section 7.6.1.3** (export cable installation) **Section 7.6.1.4** (infield and interlink cable installation) **Section 7.6.1.5** (contaminated sediments)	Increased suspended sediment concentrations and potential contaminant concentrations within suspended sediment or as a result of a pollution event could adversely impact benthic communities and fish species.
Operation			
Deterioration in water quality (increase in suspended sediment concentrations and suspension of contaminants)	**Chapter 8 Benthic Ecology** **Chapter 9 Fish and Shellfish Ecology** **Chapter 12 Commercial Fisheries**	**Section 7.6.2.1** (suspended sediment concentrations) **Section 7.6.2.2** (contaminated sediments)	Increased suspended sediment concentrations and potential contaminant concentrations within suspended sediment could adversely impact benthic communities and fish species.
Decommissioning			

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

7.10 Interactions

174. The impacts identified and assessed in this chapter have the potential to interact with each other. The areas of potential interaction between impacts are presented in **Table 7-19**. This provides a screening tool for which impacts have the potential to interact. **Table 7-21** provides an assessment for each receptor (or receptor group) as related to these impacts.

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

Table 7-19: Interaction Between Impacts - Screening

Potential Interaction between Impacts					
Construction					
	Impact 1 Deterioration in water quality due to an increase in suspended sediment through sea bed preparation	Impact 2 Deterioration in water quality due to an increase in suspended sediment associated with drill arisings for foundation installation of piled foundations	Impact 3 Deterioration in water quality due to an increase in suspended sediment during export cable installation	Impact 4 Deterioration in water quality due to an increase in suspended sediment during offshore cable installation (infield and interlink cables)	Impact 5 Deterioration in water quality due to the release of contaminated sediment
Impact 1 Deterioration in water quality due to an increase in suspended sediment through sea bed preparation	-	No	Yes	Yes	Yes
Impact 2 Deterioration in water quality due to an increase in suspended sediment associated with drill arisings for foundation installation of piled foundations	No	-	Yes	Yes	Yes
Impact 3 Deterioration in water quality due to an increase in suspended sediment during export cable installation	Yes	Yes	-	Yes	Yes
Impact 4 Deterioration in water quality due to	Yes	Yes	Yes	-	Yes

Potential Interaction between Impacts					
an increase in suspended sediment during offshore cable installation (infield and interlink cables)					
Impact 5 Deterioration in water quality due to the release of contaminated sediment	Yes	Yes	Yes	Yes	-
Operation					
	Impact 1 Deterioration in water quality through an increase in suspended sediment due to cable repairs / reburial	Impact 2 Deterioration in water quality through the resuspension of contaminated sediment due to scouring effects and maintenance activities	-	-	-
Impact 1 Deterioration in water quality through an increase in suspended sediment due to cable repairs / reburial	-	Yes	-	-	-
Impact 2 Deterioration in water quality through the resuspension of contaminated sediment due to maintenance activities	Yes	-	-	-	-
Decommissioning					
Interactions between impacts during the decommissioning phase will be the same as those outlined above for the construction phase.					

Table 7-20: Interaction Between Impacts – Phase and Lifetime Assessment

	Highest Significance Level				
Receptor	Construction	Operation	Decommissioning	Phase Assessment	Lifetime Assessment
Water Quality	Negligible	Negligible	Negligible	No greater than individually assessed impact	No greater than individually assessed impact

7.11 Potential Monitoring Requirements

176. Monitoring requirements are described in the **Offshore IPMP** (document reference 9.5) submitted alongside the DCO application and will be further developed and agreed with stakeholders prior to construction, taking account of the final detailed design of the Projects. However, given the outcomes of the assessment, no monitoring specifically targeting marine sediment and water quality parameters is proposed which is agreed by Natural England (see **Table 7-1**).

7.12 Assessment Summary

177. This chapter has provided a characterisation of the existing environment for marine water and sediment quality based on both existing and site specific survey data, which has established that the potential residual impacts during construction, operation and decommissioning phases of SEP and DEP are considered to be negligible. A summary is presented in **Table 7-21**.

Table 7-21: Summary of Potential Impacts on Marine Water and Sediment Quality

Potential impact	Receptor	Sensitivity	Magnitude	Pre-Mitigation Impact	Mitigation Measures Proposed	Residual Impact	Cumulative Residual Impact
Construction							
Impact 1 Deterioration in water quality due to an increase in suspended sediment through sea bed preparation for foundations	Water Quality	Low	Low	Negligible	N/A	Negligible	Negligible
Impact 2: Deterioration in water quality due to an increase in suspended sediment associated with drill arisings for foundation installation of piled foundations	Water Quality	Low	Low	Negligible	N/A	Negligible	Negligible
Impact 3: Deterioration in water quality due to an increase in suspended sediment during export cable installation	Water Quality	Low	Low	Negligible	N/A	Negligible	Negligible

Potential impact	Receptor	Sensitivity	Magnitude	Pre-Mitigation Impact	Mitigation Measures Proposed	Residual Impact	Cumulative Residual Impact
Impact 4: Deterioration in water quality due to an increase in suspended sediment during offshore cable installation (infield and interlink cables)	Water Quality	Low	Low	Negligible	N/A	Negligible	Negligible
Impact 5: Deterioration in water quality due to the release of contaminated sediment	Water Quality	Low	Low	Negligible	N/A	Negligible	Negligible
Operation							
Impact 1: Deterioration in water quality through an increase in suspended sediment due to cable repairs / reburial	Water Quality	Low	Low	Negligible	N/A	Negligible	Negligible
Impact 2: Deterioration in water quality through the	Water Quality	Low	Low	Negligible	N/A	Negligible	Negligible

Potential impact	Receptor	Sensitivity	Magnitude	Pre-Mitigation Impact	Mitigation Measures Proposed	Residual Impact	Cumulative Residual Impact
resuspension of contaminated sediment due to maintenance activities							
Decommissioning							
The impacts during the decommissioning phase would be comparable to those identified for the construction phase. Accordingly, given that no significant impact was assessed for marine water and sediment quality during the construction phase, it is anticipated that the same applies to the decommissioning phase.							

References

BEIS (2021a). Draft Overarching National Policy Statement for Energy (EN-1). [Online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1015233/en-1-draft-for-consultation.pdf. Accessed 08/10/2021.
BEIS (2021b). Draft National Policy Statement for Renewable Energy Infrastructure (EN-3). [Online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1015236/en-3-draft-for-consultation.pdf. Accessed 08/10/2021.
CCME (2002). Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. [Online] Available online at: [redacted] Accessed 08/10/2021.
Cefas (2016). Suspended Sediment Climatologies around the UK. Report for the UK Department for Business, Energy & Industrial Strategy offshore energy Strategic Environmental Assessment Programme. [Online] Available at: http://marine.gov.scot/sma/content/suspended-sediment-climatologies-around-uk-report-uk-department-business-energy-industrial. Accessed 08/10/2021.
Cefas (2020). Review of Action Levels used for assessing dredging and disposal marine licences. [Online] Available at: Defra, UK - Science Search. Accessed 08/10/2021.
Cefas (2021). OSPAR List of Substances Used and Discharged Offshore which Are Considered to Pose Little or No Risk to the Environment (PLONOR) – Update 2021. [Online] Available at: [redacted] Accessed 08/10/2021.
Cooper, N.J. and Brew, D.S. (2013). Impacts on the physical environment. In: R.C. Newell and T.A. Woodcock (Eds.). *Aggregate dredging and the marine environment: an overview of recent research and current industry practice*. Accessed 08/10/2021.
Defra (2016) Charting Progress 2. The State of UK Seas. [Online] Available online at: https://webarchive.nationalarchives.gov.uk/20141203170558/http://chartingprogress.defra.gov.uk/. Accessed 08/10/2021.
Department of Energy and Climate Change (2011a). Overarching NPS for Energy (EN-1). [Online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47854/1938-overarching-nps-for-energy-en1.pdf. Accessed 08/10/2021.
Department of Energy and Climate Change (2011b). NPS for Renewable Energy Infrastructure (EN-3). [Online] Available at: 1940-nps-renewable-energy-en3.pdf (publishing.service.gov.uk). Accessed 08/10/2021.
Dudgeon Offshore Wind Farm (2009) Environmental Statement. Accessed 08/10/2021.
Environment Agency (2017) Clearing the Waters for All. [Online] Available at: Water Framework Directive assessment: estuarine and coastal waters - GOV.UK (www.gov.uk). Accessed 08/10/2021.

Environment Agency (2021a). Catchment Data Explorer. [Online] Available at: https://environment.data.gov.uk/catchment-planning/. Accessed 08/10/2021.
Environment Agency (2021b). Bathing Water quality. [Online] Available at: https://environment.data.gov.uk/bwq/profiles/. Accessed 08/10/2021.
Equinor (2019). Dudgeon OWF ST18692. Environmental Post Construction Survey Report. North Sea. August – September 2018. Accessed 08/10/2021.
Fugro (2020a) Dudgeon Extension Benthic Characterisation Report. Ref: 200270-R-004 01. [Online] Available at: [redacted] Accessed 22/11/2020.
Fugro (2020b) Sheringham Shoal Extension Benthic Characterisation Report. Ref: 200270-R-005 01. [Online] Available at: [redacted] Accessed 05/12/2020.
Hiscock, D.R. and Bell, S. (2004). Physical impacts of aggregate dredging on sea bed resources in coastal deposits. *Journal of Coastal Research*, 20 (10), 101-114. Accessed 08/10/2021.
John, S.A., Challinor, S.L., Simpson, M., Burt, T.N. and Spearman, J. (2000). *Scoping the assessment of sediment plumes from dredging*. CIRIA Publication Accessed 08/10/2021.
MMO (2018). Marine Licensing: sediment analysis and sample plans. Guidance. [Online] Available at: https://www.gov.uk/guidance/marine-licensing-sediment-analysis-and-sample-plans###Suitability%20of%20material. Accessed 08/10/2021.
Newell, R.C., Seiderer, L.J., Robinson, J.E., Simpson, N.M., Pearce, B and Reeds, K.A. (2004). Impacts of overboard screening on sea bed and associated benthic biology community structure in relation to marine aggregate extraction. Technical Report to the Office of the Deputy Prime Minister and Minerals Industry Research Organisation. Project No. SAMP 1.022, Marine Ecological Surveys Ltd, St. Ives, Cornwall. Accessed 08/10/2021.
NOAA (2008). Screening Quick Reference Tables (SQuiRTs). [Online] Available at: https://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf. Accessed 08/10/2021.
OSPAR (2010) Quality Status Report. [Online] Available at: [redacted]. Accessed 08/10/2021.
OSPAR (2017) Intermediate Assessment Quality Status Report. [Online] Available at: [redacted].
OSPAR (2020) Levels and trends in marine contaminants and their biological effects – CEMP Assessment report 2019 – 2020. [Online] Available at: [redacted]
OSPAR (undated) OSPAR Hazardous Substances Strategy. [Online] Available at: [redacted]

The Planning Inspectorate (2018). Planning Inspectorate Advice Note Nine: Rochdale Envelope. [Online] Available at: https://infrastructure.planninginspectorate.gov.uk/legislation-and-advice/advice-notes/advice-note-nine-rochdale-envelope/. Accessed 08/10/2021.
Scira (2014). Sheringham Shoal Offshore Wind Farm. Second Post-Construction Benthic Monitoring Survey. Prepared for Scira Ltd by Marine Ecological Surveys Limited. Accessed 08/10/2021.
Scira Offshore Energy Ltd (2006) Sheringham Shoal Offshore Wind Farm Environmental Statement: Chapter 7 Marine Water and Sediment Quality. Accessed 08/10/2021.
Soulsby, R.L. (1997). Dynamics of Marine Sands. Thomas Telford. Accessed 08/10/2021.
Tillin, H.M., Houghton, A.J., Saunders, J.E. Drabble, R. and Hull, S.C. (2011). Direct and indirect impacts of aggregate dredging. *Science Monograph Series No. 1*. MEPF 10/P144. Accessed 08/10/2021.
Whalley, C., Rowlatt, S., Bennett, M., and Lovell, D. (1999) Total arsenic in sediments from the Western North Sea and the Humber Estuary. Marine Pollution Bulletin; 38, 394–400. Accessed 08/10/2021.
Whiteside, P.G.D., Ooms, K. and Postma, G.M. (1995). Generation and decay of sediment plumes from sand dredging overflow. *Proceedings of the 14th World Dredging Congress*. Amsterdam, The Netherlands. World Dredging Association, 877 – 892. Accessed 08/10/2021.