NORTH FALLS

Offshore Wind Farm

PRELIMINARY ENVIRONMENTAL INFORMATION REPORT

Chapter 9 Marine Water and Sediment Quality

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Glossary of Acronyms

AL	Action Level
BAC	Background Assessment Concentration
BEIS	Department for Business, Energy and Industrial Strategy
CEA	Cumulative Effects Assessment
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CESAMP	Clean Seas Environmental Monitoring Programme
DCO	Development Consent Order
DECC	Department of Energy and Climate Change
EEA	European Economic Area
EEZ	Economic Exclusion Zone
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EPP	Evidence Plan Process
ERL	Effects Range low
ES	Environmental Statement
ETG	Expert Topic Group
EQS	Environmental Quality Standard
GBS	Gravity Base Structures
GGOW	Greater Gabbard Offshore Windfarm
GWF	Galloper Offshore Windfarm
HDD	Horizontal Directional Drilling
km	Kilometre
LAT	Lowest Astronomical Tide
MMO	Marine Management Organisation
MPS	Marine Planning Statement
nm	Nautical miles
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
OSP	Offshore Substation Platform
OSPAR	Oslo and Paris Conventions
PAH	Polyaromatic Hydrocarbons
PBDE	Polybrominated diphenyl ethers
PCBs	Polychlorinated biphenyls
PEIR	Preliminary Environmental Information Report
PEMP	Project Environmental Management Plan
PSA	Particle Size Analysis
SSC	Suspended Solids Concentrations
US	United States
WFD	Water Framework Directive
WTG	Wind Turbine Generators

ZoI	Zone of Influence

Glossary of Terminology

Array areas	The two distinct offshore wind farm areas (including the 'northern array area' and 'southern array area') which together comprise the North Falls offshore wind farm.
Array cables	Cables which link the wind turbine generators with each other and the offshore substation platform(s).
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.
Climate change	A change in global or regional climate patterns. Within this chapter this usually relates to any long-term trend in mean sea level, wave height, wind speed etc, due to climate change
Evidence Plan Process	A voluntary consultation process with specialist stakeholders to agree the approach to the EIA and information to support the HRA
Expert Topic Group	A forum for targeted engagement with regulators and interested stakeholders through the EPP.
Gravel	Loose, rounded fragments of rock larger than sand but smaller than cobbles. Sediment larger than 2mm (as classified by the Wentworth scale used in sedimentology)
Gravity Base Structures	Foundation option included within the design envelope which would use ballast to secure wind turbine structures and/or offshore substation(s) to the seabed
Horizontal directional drill	Trenchless technique to bring the offshore cables ashore at the landfall
Interconnector cable	Cable between the northern and southern array areas
Interconnector cable corridor	The corridor of the seabed between the northern and southern array areas within which the interconnector cable will be installed
Intertidal	Area on a shore that lies between Lowest Astronomical Tide (LAT) and Highest Astronomical Tide (HAT)
Landfall	The location where the offshore cables come ashore.
Landfall search area	Locations being considered for the landfall, comprising the Essex coast between Clacton-on-Sea and Frinton-on-Sea
Offshore	Area seaward of nearshore in which the transport of sediment is not caused by wave activity
Offshore cable corridor	The corridor of seabed from the North Falls south array to the landfall site within which the offshore export cables will be located
Offshore export cables	The cables which bring electricity from the array areas to the landfall.
Offshore project area	The overall area of the array areas and the offshore cable corridor.
Offshore substation platform(s)	Fixed structure(s) located within the array areas, containing electrical equipment to aggregate the power from the wind turbine generators and convert it into a more suitable voltage for export to shore via offshore export cables.
Scour protection	Protective materials to avoid sediment being eroded away from the base of the wind turbine generator foundations and offshore substation platform (OSP) foundations as a result of the flow of water.
Sediment	Particulate matter derived from rock, minerals or bioclastic matter
Sediment transport	The movement of a mass of sediment by the forces of currents and waves
Silt	Sediment particles with a grain size between 0.002mm and 0.063mm, i.e., coarser than clay but finer than sand

Study area	Area where potential impacts from the Project could occur, as defined for each individual PEIR topic
Suspended sediment	The sediment moving in suspension in a fluid kept up by the upward components of the turbulent currents or by the colloidal suspension
The Applicant	North Falls Offshore Wind Farm Limited (NFOW).
The Project or 'North Falls	North Falls Offshore Wind Farm, including all onshore and offshore infrastructure.
Wind Turbine Generator (WTG)	Power generating device that is driven by the kinetic energy of the wind

9 Marine Water and Sediment Quality

9.1 Introduction

1. This chapter of the Preliminary Environmental Information Report (PEIR) considers the likely significant effects of the North Falls Offshore Wind Farm (OWF) (hereafter 'North Falls' or 'the Project) on marine sediment and water quality. The chapter provides an overview of the existing environment for the proposed offshore project area, followed by an assessment of the likely significant effects for the construction, operation, and decommissioning phases of the Project.

2. This chapter has been written by Royal HaskoningDHV, with the assessment 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 Effects Assessment (CEA) are presented in Section 9.4.4.

3. The assessment should be read in conjunction with following linked chapters (Volume I) and appendices (Volume III):
   - Chapter 8 Marine Geology, Oceanography and Physical Processes;
   - Chapter 10 Benthic and Intertidal Ecology;
   - Chapter 11 Fish and Shellfish Ecology;
   - Chapter 12 Marine Mammals;
   - Chapter 14 Commercial Fisheries;
   - Appendix 10.1 Intertidal-Benthic Ecology Monitoring Report; and
   - Appendix 21.2 Water Framework Directive Compliance Assessment.

4. Additional information to support the marine water and sediment quality assessment includes:
   - Interpretation of survey data specifically collected for the Project including sediment data;
   - Sediment data collected for other linked projects;
   - Information presented in Chapter 8 Marine Geology, Oceanography and Physical Processes (Volume I) which is based on numerical modelling and theoretical studies undertaken for Galloper Offshore Wind Farm (GWF) and Greater Gabbard Offshore Wind Farm (GGOW) and their associated Environmental Statement (ES) chapters; and
   - Discussion and agreement with key stakeholders.

9.2 Consultation

5. Consultation with regard to marine water and sediment quality has been undertaken in line with the general process described in Chapter 6 EIA Methodology (Volume I). The key elements to date have included the EIA scoping report and scoping opinion, and the ongoing technical consultation via the combined Seabed Expert Topic Group (ETG) (covering physical processes,

marine water and sediment quality, benthic ecology and fish ecology) as part of the Evidence Plan Process (EPP).

6. Through the EPP, consultation regarding marine sediment and water quality has been conducted on the North Falls EIA Methodology – Marine Geology Oceanography Physical Processes Method Statement submitted to the ETG in June 2021. This document provided a method for the assessment of potential effects and proposed data collection and analysis to inform this topic.

7. The feedback received has been considered in preparing the PEIR. Table 9.1 provides a summary of how the consultation responses received to date have influenced the development of this chapter.

8. This chapter will be further updated following the consultation on the PEIR to produce the final assessment, which will be presented in an ES. Full details of the consultation process will also be presented in the Consultation Report to be submitted as part of the Development Consent Order (DCO) application.

Table 9.1 Consultation responses

Consultee	Date / Document	Comment	Response / where addressed in the PEIR
Natural England	August 2021 Scoping Opinion	North Falls array areas and export cable corridor overlap closed disposal sites. The interconnector cable overlaps the Inner Gabbard East disposal site. Construction (and decommissioning) activities could potentially release contaminated sediment or sediment that is not the same as the surrounding seabed during construction. Offshore surveys should be considered for the North Falls OWF site and offshore export cable corridor to determine if any contaminants from previous disposal activities are present.	Site specific sediment data was collected. See Section 9.5.
Planning Inspectorate	August 2021 Scoping Opinion	Paragraph 86 of the Scoping Report (detailing the overarching assessment methodology for the EIA) states that study areas defined for each receptor are based on the Zone of Influence (ZoI) and relevant characteristics of the receptor (e.g., mobility / range). However, the Inspectorate notes that for many of the aspect chapters included, study areas and ZoIs have not been stated. Where this detail has been provided, it is not clear how these study areas relate to the extent of the impacts and likely significant effects associated with the Proposed Development, how they have been used to determine a ZoI, and what receptors have been identified within the ZoI. The Environmental Statement (ES) should provide a robust justification as to how study areas have been defined and why the defined	The study area for marine water and sediment quality is outlined in Section 9.3.1.

Consultee	Date / Document	Comment	Response / where addressed in the PEIR
		study areas are appropriate for assessing potential impacts.	
Planning Inspectorate	August 2021 Scoping Opinion	Some aspect sections of the Scoping Report have identified specific receptors, whereas others identify broad categories of receptors only. Specific receptors should be identified within the ES, alongside categorisation of their sensitivity and value. Section 1.8.2.1 of the Scoping Report explains the generic approach to defining receptor sensitivity in order to assess the potential impacts upon each receptor. The inspectorate expects a transparent and reasoned approach to be applied to assigning receptor sensitivity to be defined and applied across the aspect chapters.	The definition of sensitivity is outlined in Table 9.7.
Planning Inspectorate	August 2021 Scoping Opinion	The ES should include details of difficulties (for example technical deficiencies or lack of knowledge) encountered compiling the required information and the main uncertainties involved.	This is stated where appropriate.
Planning Inspectorate	August 2021 Scoping Opinion	Section 1.7.2 and Table 1.4 of the Scoping Report explains that an Evidence Plan Process (EPP) with specialist stakeholders commenced in 2021 to agree the 'detailed methodologies for data collection and undertaking the impact assessments' in respect of certain aspects to be scoped into the ES. This approach to agreeing the finer details of the assessment is welcomed.	Noted
Planning Inspectorate	August 2021 Scoping Opinion	Section 1.9.3 of the Scoping Report sets out the planning policy and legislation context for the Proposed Development. It would be beneficial for the aspect chapters of the ES to also include reference to aspect specific planning policy and legislation, where this has been used to inform the methodology used for assessment.	Aspect specific planning policy and legislation is outlined in Section 9.4.
Planning Inspectorate	August 2021 Scoping Opinion	Any mitigation relied upon for the purposes of the assessment should be explained in detail within the ES. The likely efficacy of the mitigation proposed should be explained with reference to residual effects. The ES should also address how any mitigation proposed is secured, with reference to specific DCO requirements or other legally binding agreements.	Embedded mitigation is detailed in Section 9.3.3. The DCO application will include information on how each mitigation measure is secured.
Planning Inspectorate	August 2021 Scoping Opinion	Based on the conclusions of the Galloper Wind Farm (GWF) in 2011, whose ZoI is stated to be similar to that of the Proposed Development, the	Noted

Consultee	Date / Document	Comment	Response / where addressed in the PEIR
		Applicant proposes to scope transboundary effects in relation to Marine water and sediment quality out of the assessment. The Proposed Development is also 20km from the Economic Exclusion Zone (EEZ). The Inspectorate agrees that this matter can be scoped out of the ES.	
Planning Inspectorate	August 2021 Scoping Opinion	The ES should set out the spatial scope for the marine water and sediment quality chapter.	The study area for marine water and sediment quality is outlined in Section 9.3.1.
Planning Inspectorate	August 2021 Scoping Opinion	The ES should detail how the proposed site surveys have been used to support existing desk-based information on water quality, and further survey should be carried out, where necessary, to provide a robust baseline and support a sufficiently detailed assessment.	Please refer to Section 9.5 for a description of the existing environment using existing and site-specific data.
Planning Inspectorate	August 2021 Scoping Opinion	The Inspectorate notes the potential for the use of Horizontal Directional Drilling (HDD) as a method for cable laying which could affect coastal locations. The ES should consider the potential for contamination of sediments and marine water quality from drilling fluids where significant effects are likely to occur.	Control of accidental release would be managed through pollution control measures within the Project Environmental Management Plan (PEMP) to be submitted with the DCO application. Additionally, all chemicals used would be checked against the Oslo and Paris Conventions (OSPARs) List of Substances Used and Discharged Offshore which Are Considered to Pose Little or No Risk to the Environment (PLONOR) (OSPAR, 2021).
Planning Inspectorate	August 2021 Scoping Opinion	The ES should consider the potential for significant effects on water quality from construction or operational discharges.	There are no planned discharges for the construction and operational phase.
Planning Inspectorate	August 2021 Scoping Opinion	The ES should include details of proposed mitigation measures to address effects, including any proposed measures to ensure that sediment and water quality does not deteriorate to the detriment of protected and/ or commercial fish and shellfish species. Cross-reference should be made to relevant assessments of the ES, e.g., Fish and Shellfish and Commercial Fisheries.	The effects assessment is presented in Section 9.6 and includes proposed mitigation measures where required.
MMO	August 2021 Scoping Opinion	All impacts relevant to sediment quality will be scoped in for further assessment, other than transboundary impacts. With regard to my specific remit, The Applicant will scope in “Remobilisation of existing contaminated sediments”. The Marine Management Organisation (MMO) agree with this scoping decision.	Noted

Consultee	Date / Document	Comment	Response / where addressed in the PEIR
MMO	August 2021 Scoping Opinion	To establish a proxy baseline, The Applicant has used contaminant data from similar projects in the surrounding area, notably those which supported the licensing of GGOW. Whilst these data can be useful to inform the history of sediment quality in the area, their use should be informative only. In this regard, more weight should be applied to sediment data which The Applicant intends to generate through sediment sampling.	The baseline environment uses the site specific sediment data. The information from previous projects is used as context only. See Section 9.5.1 for further information.
MMO	August 2021 Scoping Opinion	With regard to The Applicant's proposed EIA, they state that "Where concentrations are at, or below, Action Level 1, no additional assessment is considered necessary as the risk to water quality is considered to be low. Where concentrations fall close to, or above Action Level 2, then more quantitative assessment might be required". The MMO mostly agree with this statement, though defer final assessment until the data are generated and presented for review. However, The Applicant should note that only trace metals, organotins and Total 25 Polychlorinated biphenyls (PCBs) hold respective Action Level 2 (AL2) values. Where no appropriate AL2 is available, Cefas will utilise other resources such as Gorham-Test (1999) (for PAHs) and Canadian sediment quality guidelines (for PBDEs).	Noted. Sediment data was compared against OSPAR assessment criteria and Cefas Action Levels. Given the levels of contamination (see Section 9.5.1) further consideration against additional or the revised Action Levels being considered under the current Defra consultation (see Cefas 2021) regarding the Gorham Test and individual polychlorinated biphenyls (PCBs) congeners, was not considered necessary.
MMO	August 2021 Scoping Opinion	The MMO have not been able to ascertain what the contaminant sampling will comprise. Whilst The Applicant does not necessarily need to inform the MMO what they intend to sample, they should endeavour to formulate their sampling strategy to be in line with OSPAR guidelines. Notably, the number of samples which will provide adequate spatial representation should adhere to OSPAR guidance, and analyses to be tested for should be relevant for their intended purpose, i.e., for example, testing for all listed 24 PAH analytes, rather than only the United Stated (US) 16 priority PAHs. A full list of analyses tested for can be found in the MMO Results Template	A Marine Management Organisation (MMO) accredited lab undertook the analysis (Section 9.4.2.1) and all polyaromatic hydrocarbons (PAH) parameters were included. Further detail is provided in Section 9.5.1.
MMO	August 2021 Scoping Opinion	Any analyses for contaminants must be completed by a laboratory which ghas been validated by the MMO, to ensure that methods used are appropriate	SOCOTEC is MMO accredited (Section 9.4.2.1).

Consultee	Date / Document	Comment	Response / where addressed in the PEIR
MMO	August 2021 Scoping Opinion	The Applicant should note, however, that the OWF Array area and, potentially, the cable route, may need to be designated as disposal sites. The MMO could not locate any detail concerning this in the report provided.	Noted. Worst case is for material to be released at the surface in the location in which it was removed
MMO	August 2021 Scoping Opinion	Cumulative and in-combination effects are mentioned in the report, but, as this is a scoping report, no formal assessment of the extent of such impacts is presented. This is acceptable	Noted
Natural England	ETG July 2021	Are cumulative impacts only operational or will the assessment consider construction at the same time as FEOW?	The assessment considers the potential for both construction and operational CEA. See Section 9.8.
Natural England	ETG July 2021	Will disposal be included in the list of construction activities?	The worst-case scenario, that sediment would be dredged during foundation installation and returned to the water column at the sea surface during disposal from the dredger vessel is considered within Impact 1 (Section 9.6.1.1).
MMO	Letter dated 30 November 2021 titled 'Benthic Contaminants Survey data'	MMO recommend that the applicant provide some justification as to their selection of samples for contaminant analysis in the ES. Whilst MMO agree that metals and PAHs are appropriate, and that organotins, OCs and Polybrominated diphenyl ethers (PBDE) are not, in this case, necessary, MMO recommend that PCBs be analysed ahead of the ES, due to their consistent presence within a range of marine biota in the North Sea, and to the importance of sediment as an input pathway for contaminants.	Sediment chemistry samples were taken from 26 of the 49 sample locations across the array sites, interconnector and export cable routes to provide adequate spatial coverage. The specific location of these was determined based on a review of publicly available data and the findings of the geophysical data. Rationale for the location of each sample is provided in Appendix 10.1, Volume III. The samples were analysed for PCBs in addition to the other contaminants. The results show PCBs are present at levels below the limit of detection (LOD) and are presented in Appendix 10.1, Volume III

9.3 Scope

9.3.1 Study area

9. The study area for marine sediment and water quality has been defined on the basis of both the near-field (within the offshore project area) and far-field (beyond the offshore project area over which sediment plumes may extend) environment. The study area extends over the array areas (northern and southern), the interconnector cable corridor which links the array areas and the export cable corridor which links the southern array area to the landfall search area between Clacton-on-Sea and Frinton-on-Sea.

9.3.2 Realistic worst case scenario

10. The final design of North Falls will be confirmed through detailed engineering design studies that will be undertaken post-consent. 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 (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 other scenarios within the design envelope will have less impact. Further details are provided in Chapter 6 EIA Methodology (Volume I).

11. The realistic worst case scenarios for the likely significant effects scoped into the EIA for the marine water and sediment quality assessment are summarised in Table 9.2. These are based on North Falls parameters described in Chapter 5 Project Description (Volume I), which provides further details regarding specific activities and their durations.

Table 9.2 Realistic worst case scenarios

Potential impact	Parameter	Worst case	Notes
Construction			
Impact 1: Increase in suspended sediment associated with seabed preparation, foundation installation for the turbines and array and interconnector cables	Volume of sediment disturbed	• Seabed preparation area for gravity base structures (GBS) of 70m diameter each x 72 wind turbine generators (WTG) x average 5m sediment depth = 1,385,440m^3 • Two OSPs seabed preparation x average 5m sediment depth = 33,185m^3 Worst case scenario volume for seabed preparation for foundation installation = **1.4Mm^3** • Cable sandwave levelling = 228km length with average 24m disturbance width x average 5m sediment depth = 27,360,000m^3 • Cable burial = 228km length with average 1m trench width x average 1.2m burial depth = 273,600m^3 Worst case scenario volume due to offshore cable installation = **27,633,600m^3**	Seabed preparation (dredging using a trailing suction hopper dredger 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. Sandwave levelling may be required prior to offshore cable installation. Any excavated sediment due to sandwave levelling would be disposed of within the North Falls offshore project area, meaning there will be no net loss of sediment from the site. A range of burial techniques are being considered as described in Section 5.6.7 in Chapter 5 Project Description (Volume I) and are included in the worst case scenario. Sediment displacement assumes a box shaped dimension.
Impact 2: Increase in suspended sediment due to drill arisings for installation of piled foundations for wind turbines and OSP	Volume of drill arisings	Drill arisings at 10% of largest wind turbines = **38,133m^3** Drill arisings at 1 x monopile OSPs = **10,688m^3** **Total = 48,820m^3** NB, drill arising would not occur in the event that the GBS is used and therefore this parameter cannot be added to the maximum seabed levelling for GBS described above.	Assumes drilling at up to 10% wind turbine locations (average 42m drill depth, 17m drill diameter) Assumes drilling at one OSP location (42m drill depth, 18m drill diameter)

Potential impact	Parameter	Worst case	Notes
Impact 3: Increase in suspended sediment due to export cable installation	Volume of sediment disturbed	• Export cable sandwave levelling = 250.8km length with average 24m disturbance width x average 5m sediment depth = 30,096,000 m^3 • Export cable burial = 250.8km length with average 1m trench width x max 1.2m burial depth = 300,960m^3 Worst case scenario volume due to export cable installation = 30.4**Mm^3**	A range of burial techniques are being considered as described in Section 5.6.7 in Chapter 5 Project Description (Volume I) and are included in the worst case scenario. The offshore HDD exit location will be subtidal in 1 to 8m water depth. Sediment displacement assumes a box shaped dimension.
Impact 4: Deterioration in water quality related to release of sediment bound contaminants	Total volume of sediment disturbed	The worst case total volume of sediment disturbed during the construction of North Falls is 59.4**Mm^3**.	The total suspended sediment from installation of foundations, array cables, interconnector cables and offshore export cables. NB, drill arising would not occur in the event that the GBS is used and therefore this parameter cannot be added to the maximum seabed levelling for GBS
Operation			
Impact 1: Increase in suspended sediment associated with cable repairs and reburial	Volume of sediment disturbed	Unplanned repairs and reburial of cables may be required during O&M, the following estimates are included: • Reburial of c. 5km of array/interconnector cable is estimated over the life of the Project (24m disturbance width) = 120,000m^2 • Reburial of c. 5km of export cable is estimated over the life of the Project (24m disturbance width) = 120,000m^2 • Five array/interconnector cable repairs are estimated over the Project life. 600m section removed x 24m disturbance width = 72,000m^2 • Four export cable repairs are estimated over the Project life. 600m section removed x 24m disturbance width = 57,600m^2 Anchored vessels placed during the no. of cable repairs include above = 4,914m^2 Maintenance of offshore infrastructure would be required during O&M. An estimated 180 major	

Potential impact	Parameter	Worst case	Notes
		component replacement activities may be required per year, using jack up vessels and/or anchoring = 297,000m^2	
Impact 2: Deterioration in water quality resulting from the resuspension of contaminated sediment due to maintenance activities	Total volume of sediment disturbed	As above	
Decommissioning			

Impact 1: Potential impacts during decommissioning	Volume of sediment disturbed	Foundations
		Cutting of piles below the seabed surface:
		• 300 pin-piles of 3.5m diameter
		  ○ 72 wind turbines x 4 piles
		  ○ 2 OSPs x 6 piles
		Or
		• 74 monopiles of 17m diameter (72 wind turbines + 2 OSPs)
		Or
		Removal of largest foundations (GBS):
		• 72 wind turbines x 65m diameter
		• 2 OSPs x 60m diameter
		Export cables
		Up to 250.8km of export cable (removal to be determined in consultation with key stakeholders as part of the decommissioning plan)
		Array cables
			No decision has yet been made regarding the final decommissioning arrangements for the offshore project infrastructure. It is also recognised that legislation and industry best practice change over time. However, the following infrastructure is likely to be removed, reused or recycled where practicable:
			• Turbines including monopile, steel jacket and GBS foundations;
			• OSPs including topsides and steel jacket foundations; and
			• Offshore cables may be removed or left in situ depending on available information at the time of decommissioning.
			The following infrastructure is likely to be decommissioned in situ depending on available information at the time of decommissioning, however where it represents the worst case scenario (e.g., for disturbance, removal is assessed):
			• Scour protection;
			• Offshore cables may be removed or left in situ; and
			• Crossings and cable protection.
			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.

Potential impact	Parameter	Worst case	Notes
		Up to 228km of array/interconnector cable (removal to be determined in consultation with key stakeholders as part of the decommissioning plan)	Decommissioning arrangements will be detailed in a Decommissioning Plan, which will be prepared in accordance with the Energy Act 2004.

9.3.3 Summary of mitigation embedded in the design

12. This section outlines the embedded mitigation relevant to the marine water and sediment quality assessment, which has been incorporated into the design of North Falls (Table 9.3). No further mitigation is proposed for marine water and sediment quality.

Table 9.3 Embedded mitigation measures

Parameter	Mitigation measures embedded into North Falls design
Accidental pollution	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. As a result, an outline PEMP will be developed to accompany the DCO application. The final PEMP would be agreed with the MMO prior to construction and would include, for example, measures to control accidental release of drilling fluids whilst ensuring that any chemicals used are listed on the OSPAR List of Substances Used and Discharged Offshore which Are Considered to Pose Little or No Risk to the Environment (PLONOR) (OSPAR, 2021).
Sediment release	For piled foundation types, such as monopiles and jackets with pin piles, pile-driving will be used in preference to drilling where it is practicable to do so (i.e., where ground conditions allow). This would minimise the quantity of sub-surface sediment released into the water column from the installation process.
	Micro-siting will be used where possible to minimise the requirements for seabed preparation prior to foundation and cable installation.
	Cables will be buried where possible, minimising the requirement for cable protection measures and thus effects on sediment transport.

9.4 Assessment methodology

9.4.1 Legislation, guidance and policy

9.4.1.1 National Policy Statements

13. The assessment has been made with specific reference to the relevant NPS. These are the principal decision making documents for Nationally Significant Infrastructure Projects (NSIPs). Those relevant to the Project are:

- Overarching NPS for Energy (EN-1) (Department of Energy and Climate Change (DECC) 2011a);
- NPS for Renewable Energy Infrastructure (EN-3) (DECC 2011b);
- Draft Overarching NPS for Energy (EN-1) (BEIS 2021a); and
- Draft NPS for Renewable Energy Infrastructure (EN-3) (BEIS 2021b).

14. The specific assessment requirements for marine sediment and water quality, as detailed in the NPS, are summarised in Table 9.4 together with an indication of the section of the PEIR chapter where each is addressed. It is noted that the NPSs 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 PEIR chapter (Table 9.4). Any further updates to the NPSs will be considered in the ES.

Table 9.4 NPS assessment requirements

NPS Requirement	NPS Reference	PEIR 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, it can lead to … discharges to water…. 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, groundwaters or protected areas failing to meet environmental objectives established under the Water Framework Directive.	EN-1 Paragraph 5.15.1	Potential impacts of the Project on water quality are assessed in Section 9.6 and in the Water Framework Directive (WFD) Compliance Assessment found in Appendix 21.2, Volume III. Impacts to habitats and species are assessed in Chapter 10 Benthic and Intertidal Ecology, Chapter 11 Fish and Shellfish Ecology and Chapter 12 Marine Mammals and Chapter 14 Commercial Fisheries (Volume I).
Where the project is likely to have 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 ES or equivalent.	EN-1 Paragraph 5.15.2	The existing baseline is presented in Section 9.5 and the baseline for relevant WFD marine bodies is provided in, Appendix 21.2, Volume III.
NPS for Renewable Energy Infrastructure (EN-3)		
The construction, operation and decommissioning of offshore energy infrastructure can affect … [marine] water quality [through] disturbance of the seabed sediments or the release of contaminants with subsequent indirect effects on habitats and biodiversity and fish stocks.	EN-3 Paragraph 2.6.189	Potential impacts during construction are assessed in Section 9.6.1. Contaminant analysis of samples collected from the seabed indicate very low levels of contaminants.
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.	EN-3 paragraph 2.6.191	The Environment Agency has been consulted with through the Scoping Opinion and Evidence Plan Process (see Chapter 7 Technical Consultation (Volume I) for further detail).
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.	EN-3 paragraph 2.6.192	The MMO have been consulted with through the Evidence Plan Process (see Chapter 7 Technical Consultation (Volume I) for further detail).
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 9.6 and in the WFD Compliance Assessment found in, Appendix 21.2, Volume III.

NPS Requirement	NPS Reference	PEIR Reference
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 9.5 and impacts on the marine environment are provided in Section 9.6.
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 9.5 and impacts on the marine environment are provided in Section 9.6.
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	Table 9.3 outlines the commitment to adhere to best practice techniques and due diligence for pollution control.
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 other biodiversity receptors: water quality – disturbance of the seabed sediments or release of contaminants can result in direct or indirect effects on habitats and biodiversity, as well as on fish stocks thus affecting the fishing industry. suspended solids – 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 9.5 and impacts on the marine environment are provided in Section 9.6 Potential impacts on commercial fisheries receptors are assessed in Chapter 14 Commercial Fisheries (Volume I).

15. 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 3, Policy and Legislative Context (Volume I).

9.4.1.2 National legislation

16. In addition to the NPS, there are a number of pieces of national legislation and policy applicable to the assessment of marine sediment and water quality. These include:

- Water Environment (Water Framework Directive) (England and Wales) Regulations 2017;
- Marine Strategy Regulations 2010;
- Bathing Water Regulations 2013; and
- The International Convention for the Prevention of Marine Pollution by Ships (MARPOL Convention) 73/78.

17. Further detail is provided in Chapter 3 Policy and Legislative Context (Volume I).

9.4.1.3 Guidance

18. There is no specific guidance available for the impact assessment of marine sediment and water quality. Where the data available supports it, sediment quality guidelines used by OSPAR Commission 2014, and the Marine Management Organisation (MMO) have been used.

19. With respect to OSPAR, assessments are undertaken using Background Assessment Concentration (BAC) and the US Environmental Protection Agency's (EPA) 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. 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. Relevant BACs and ERLs are provided in Table 9.5.

20. In the UK, licensing authorities for dredge material disposal to sea, regulate the activity using guidelines, part of which require characterisation of the sediments for disposal to enable the consideration of potential adverse environmental effects. To undertake this assessment, regulating authorities apply action levels (ALs) (sediment quality criteria) for contaminants on a primary list. These ALs are then used as part of a 'weight of evidence' approach to decision making on the disposal of dredged material. There are two levels – Action Level 1 (AL1) and Action Level 2 (AL2). Contaminant levels below AL1 are generally assumed to be of no concern and are unlikely to influence the licensing decision. Contaminant levels between Level 1 and 2 generally trigger further investigation of the material, and contaminants in dredged material above AL2 are generally considered unsuitable for sea disposal (MMO, 2015).

21. Although the majority of the material assessed against these standards arises from a specific activity i.e., dredging and disposal activities, they are also considered a good way of undertaking an initial risk assessment with respect to determining risks to marine waters from other marine activities as part of the EIA and associated WFD compliance assessments. If, overall, levels do not generally exceed AL1 then contamination levels are considered to be low risk in terms of the potential for impacts on water quality. This approach is recommended by the Environment Agency in their WFD compliance assessment guidance 'Clearing the Waters for All' for example (Environment Agency, 2017). Relevant values are presented in Table 9.5.

Table 9.5 Sediment quality guidelines used in this assessment

Contaminant	Units	OSPAR BAC	OSPAR ERL	Cefas AL1	Cefas AL2
Arsenic	mg/kg	25	8.2[1]	20	100
Cadmium		0.31	1.2	0.4	5

[1] The ERLs for arsenic and nickel are below the OSPAR Background Concentrations of 25 and 36 mg/kg respectively; arsenic and nickel concentrations are only assessed against the BAC

Contaminant	Units	OSPAR BAC	OSPAR ERL	Cefas AL1	Cefas AL2
Chromium		81	81	40	400
Copper		27	34	40	400
Mercury		0.07	0.15	0.3	3
Nickel		36	21	20	200
Lead		38	47	50	500
Zinc		122	150	130	800
Acenaphthene	µg/kg	-	-	100	-
Acenaphthylene		-	-	100	-
Anthracene		5	85	100	-
Benz(a)anthracene		16	261	100	-
Benzo(a)pyrene		30	430	100	-
Chrysene		20	-	100	-
Dibenzo(a,h)anthracene		-	-	10	-
Fluoranthene		39	600	100	-
Fluorene		-	-	100	-
Naphthalene		8	160	100	-
Phenanthrene		32	240	100	-
Pyrene		24	665	100	-
Benzo(ghi)perylene		80	-	100	-
Indeno[1,2,3-cd]pyrene		103	-	100	-

9.4.2 Data sources

9.4.2.1 Site specific

22. To provide site specific and up to date information on which to base the impact assessment, a geophysical survey of the array areas, interconnector cable corridor and export cable corridor was completed between May and August 2021 (Fugro, 2021a,b). A benthic survey of the offshore development area was also undertaken between May and August 2021 (Fugro, 2021c provided in Appendix 10.1, Volume III) where grab sampling was undertaken, and samples sent for Particle Size Analysis (PSA) and chemical contaminant analysis for the following parameters:

- Trace metals;
- Polyaromatic Hydrocarbons (PAHs); and
- Polychlorinated Biphenyls (PCBs).

23. Chemical analysis was undertaken by SOCOTEC, in line with the MMO accreditation scheme regarding sediment sampling for disposal to sea licensing.

9.4.2.2 Other available sources

24. Information to support this PEIR has been drawn from the existing environment and effects assessment presented in Chapter 8 Marine Geology, Oceanography and Physical Processes (Volume I) regarding predicted plumes as well as a series of data sources and associated studies as detailed in Table 9.6.

Table 9.6 Other available data and information sources

Data Set	Spatial Coverage	Year	Notes
Clean Seas Environmental Monitoring Programme (CESAMP) – water quality	UK Seas – water quality	Various	The Quality Status Report 2010 describes the current status and trends in water quality for regional seas including the North Sea.
Benthic survey – grab samples and particle size analysis (Centre for Marine and Coastal Studies)	GGOW array area and offshore cable route	November 2004 and April 2005	None
Benthic survey – grab samples and particle size analysis (Centre for Marine and Coastal Studies)	GWF array area and offshore cable route	December 2009	None
Bathing water profiles (Environment Agency, 2022)	England	Updated annually	Water quality at designated bathing water sites in England are assessed by the Environment Agency between May and September. Data is published by the Environment Agency online.
Environment Agency Catchment Data Explorer (Environment Agency, 2019)	Rivers, estuaries and coastal waters around England.	Updated at each River Basin Planning round	Database for information related to river basin management plans (RBMP) in England. Contains information on river basin districts and catchments and WFD compliance data.

9.4.3 Impact assessment methodology

25. Chapter 6 EIA Methodology (Volume I) explains the general impact assessment methodology applied to North Falls. The following sections describe the methods used to assess the likely significant effects on marine sediment and water quality.

9.4.3.1 Definitions

26. For each potential impact, the assessment identifies receptors within the study area which are sensitive to that impact and implements a systematic approach to understanding the impact pathways and the level of impacts (i.e., magnitude) on given receptors.

27. 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).

Table 9.7 Definition of sensitivity for water quality

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.

28. Topic specific definitions of magnitude are provided in Table 9.8. 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).

Table 9.8 Definition of magnitude for water quality

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.

9.4.3.2 Significance of effect

29. The assessment of significance of an effect is a function of the sensitivity of the receptor and the magnitude of the impact (see Chapter 6 EIA Methodology (Volume I) for further details). The determination of significance is guided by the use of a significance of effect matrix, as shown in Table 9.9. Definitions of each level of significance are provided in Table 9.10.

30. Likely significant effects identified within the assessment as major or moderate are regarded within this chapter as significant. 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 significance of effect to determine a residual effect upon a given receptor.

Table 9.9 Significance of effect matrix

	Adverse magnitude				Beneficial magnitude			
Sensitivity	**High**	**Medium**	**Low**	**Negligible**	**Negligible**	**Low**	**Medium**	**High**
High	*Major*	*Major*	*Moderate*	*Minor*	*Minor*	*Moderate*	*Major*	*Major*
Medium	*Major*	*Moderate*	*Minor*	*Minor*	*Minor*	*Minor*	*Moderate*	*Major*
Low	*Moderate*	*Minor*	*Negligible*	*Negligible*	*Negligible*	*Minor*	*Minor*	*Moderate*
Negligible	*Minor*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Minor*

Table 9.10 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 national, 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 are likely to be important considerations at a local level.
Minor	Small change in receptor condition, which may be raised as local issues but are unlikely to be important in the decision making process.
Negligible	No discernible change in receptor condition.
No change	No impact, therefore, no change in receptor condition.

9.4.4 Cumulative effects assessment methodology

31. The CEA considers other plans, projects and activities that may result in cumulation with North Falls. As part of this process, the assessment considers which of the residual impacts assessed for the Project 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 6 EIA Methodology (Volume I) provides further details of the general framework and approach to the CEA.

32. For marine water and sediment quality, these activities include construction of other offshore windfarms and large coastal defence/protection schemes.

9.4.5 Transboundary effects assessment methodology

33. The transboundary assessment considers the potential for transboundary effects to occur on marine sediment and water quality as a result of North Falls; either those that might arise within the Exclusive Economic Zone (EEZ) of

European Economic Area (EEA) states or arising on the interests of EEA states e.g., a non-UK fishing vessel. Chapter 6 EIA Methodology (Volume I) provides further details of the general framework and approach to the assessment of transboundary effects.

34. Due to the distance of North Falls from the EEZ it is unlikely that sediment plumes will extend past the EEZ boundary. Combined with findings from the GWF transboundary assessment (ABPmer, 2011a; Royal Haskoning, 2011) transboundary impacts are unlikely to occur and therefore transboundary impacts are scoped out of further assessment in accordance with the scoping opinion (Planning Inspectorate, 2021).

9.4.6 Assumptions and limitations

35. 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.

36. This limitation is not considered to significantly affect the certainty or reliability of the impact assessments presented in Section 9.6.

9.5 Existing environment

9.5.1 Sediment quality

9.5.1.1 Physical characteristics

37. The physical characteristics of the sediments at risk of being disturbed are important because this influences the increase in sediment concentrations in the water column, geographical spread and the period of suspension within the water column. Lighter sediments such as silt are more readily remobilised if disturbed and stay suspended over longer periods, allowing greater geographical dispersal. Heavier sediment types like sand require greater kinetic energy to be resuspended and, due to their greater mass, fall back to the seabed, hence geographic spread is more limited (Jones *et al.,* 2016).

38. Additionally, sediment grain size is important to inform assessment of the risk of contamination because finer grained materials (silts and clays) function as a sink for contaminants and therefore have a greater potential to retain contaminants than larger grained materials (Cefas, 2021).

39. As outlined in Section 9.4.2.1, a benthic survey was undertaken between May and August 2021 covering both array areas, the interconnector cable corridor and the export cable corridor. The sites sampled for particle size analysis (PSA) are shown in (Figure 8.3, Volume II) and a summary of the findings in each area is presented in Table 9.11.

40. Overall, sediments across the North Falls survey area comprised a mix of gravel, sand and mud with percentages of fines being highest at stations along the nearshore section of the export cable corridor. Sand was the predominant sediment type in the array areas.

Table 9.11 Summary of PSA analysis

Area	Summary description
North Falls north array	The dominant sediment type in the North Falls north array is coarse sand (with a range of 6.5-65.7% content in each sample, recorded). Gravel was present in high proportions in the ST28 located close to the interconnector cable corridor.
North Falls south array	The dominant sediment type in the North Falls south array is medium sand (16-74% content in all samples). The mud content is less than 18% in 100% of the samples. Samples in the north and north-west of the array had a high proportion of gravel (1.84-41.8%).
Interconnector cable corridor	The dominant sediment type in the interconnector cable corridor is medium sand (25% content in the sample). The mud content is less than 15% in the sample and gravel accounts for less than 30%.
Export cable corridor	The dominant sediment type in the export cable corridor is medium sand (2-51% content in all samples). The mud content is less than 5% in 26% of the samples and less than 78% in 100% of the samples. The samples with the highest mud content were located in the nearshore section of the offshore cable corridor (average mud content of 59.4%).

9.5.1.2 Chemical characteristics

Sediment samples were also sent for chemical analysis, the locations are shown in Figure 9.1 (Volume II). Results were compared to sediment guidelines as outlined in Section 9.4.1 and the output is presented in Table 9.12 and Table 9.13 for metals and Table 9.14 and

41. Table 9.15 for PAHs. PCB data indicated that the samples were at or below the detection limits and therefore are not presented in the tables. All data is available in Appendix 10.1, Volume III.

Table 9.12 Sediment sample results for metals within the export cable corridor. Yellow indicates exceedance of AL1 or BAC. Orange indicates exceedance of both BAC and AL1. There are no exceedances of AL2 or ERL

	Sample reference									Cefas		OSPAR	
Metals (units mg/kg)	ST01	ST03	ST05	ST07	ST11	ST15	ST17	ST19	ST21	AL1	AL2	BAC	ERL
Arsenic	30.2	9.7	19.6	16.1	23.5	17.5	33.0	10.5	33.1	20	100	25	-
Cadmium	0.13	0.08	0.23	<0.04	<0.04	<0.04	0.16	0.07	0.10	0.4	5	0.31	1.2
Chromium	17.4	14.2	26.5	8.6	6.8	4.9	9.6	15.3	13.8	40	400	81	81
Copper	12.9	6.9	18.0	5.0	0.01	6.1	8.4	<0.5	33.6	40	400	27	34
Mercury	0.07	0.03	0.07	0.01	<0.01	0.04	<0.01	0.01	<0.01	0.3	3	0.07	0.15
Nickel	16.1	9.1	25.9	6.1	4.6	4.2	11.9	8.9	13.8	20	200	36	-
Lead	17.1	10.3	18.0	8.4	9.6	4.1	6.2	8.9	8.7	50	500	38	47
Zinc	62.0	35.5	89.1	33.6	31.9	18.6	26.6	35.8	32.9	130	800	122	150

Table 9.13 Sediment sample results for metals within the arrays and interconnector cable corridor (ST28 North array, ST31 interconnector cable corridor and ST32-ST49 in the South array). Yellow indicates exceedance of AL1. Orange indicates exceedance of both BAC and AL1. There are no exceedances of AL2 or ERL

	Sample reference										Cefas		OSPAR	
Metals (units mg/kg)	ST28	ST31 (ALT)	ST32	ST34	ST36	ST41	ST43	ST44	ST46	ST49	AL1	AL2	BAC	ERL
Arsenic	73.6	58.1	23.2	21.0	26.3	14.9	8.8	10.5	12.0	4.7	20	100	25	-
Cadmium	0.16	0.24	0.06	0.09	0.16	<0.04	<0.04	0.06	<0.04	<0.04	0.4	5	0.31	1.2
Chromium	15.8	22.6	5.6	4.9	14.0	4.4	4.2	3.5	3.7	5.9	40	400	81	81
Copper	11.7	9.5	3.7	3.4	5.6	2.4	2.5	2.7	2.4	4.5	40	400	27	34
Mercury	<0.01	0.03	<0.01	0.02	0.01	<0.01	<0.01	0.04	0.02	0.01	0.3	3	0.07	0.15
Nickel	27.8	23.3	4.2	6.3	10.8	3.5	3.5	3.1	3.4	4.2	20	200	36	-

	Sample reference										Cefas		OSPAR	
Metals (units mg/kg)	ST28	ST31 (ALT)	ST32	ST34	ST36	ST41	ST43	ST44	ST46	ST49	AL1	AL2	BAC	ERL
Lead	7.7	8.3	2.7	5.6	5.3	2.6	2.4	3.5	2.9	2.5	50	500	38	47
Zinc	38.0	47.1	29.3	29.8	26.6	13.0	11.9	15.4	20.5	18.1	130	800	122	150

Table 9.14 Sediment sample results for PAHs within the export cable corridor. Cefas Action Level 1 is 100µg/kg for all PAHs with the exception of Dibenzo(ah)anthracene which is 10µg/kg. There are no exceedances of Cefas AL1. Yellow indicates exceedance of the OSPAR BAC

									Cefas	OSPAR	
PAH (units µg/kg)	ST01	ST03	ST05	ST07	ST11	ST15	ST17	ST19	ST21	AL1	BAC	ERL
Acenaphthene	2.33	4.77	1.41	<1	<1	<1	<1	1.54	<1	100	-	-
Acenaphthylene	2.94	4.17	1.28	<1	<1	<1	<1	1.21	<1	100	-	-
Anthracene	5.01	10.1	2.58	<1	<1	<1	<1	2.97	1.93	100	5	85
Benzo(a)anthracene	16.9	26.5	8.19	2.03	1.66	<1	<1	8.43	5.32	100	16	261
Benzo(a)pyrene	21.2	33.8	10.7	2.72	1.65	<1	1.01	11.1	6.8	100	30	430
Benzo(b)fluoranthene	30.5	45.8	16.5	3.16	1.38	<1	1.30	14.2	9.25	100	-	-
Benzo(e)pyrene	27.7	43.9	15.4	4.28	1.29	<1	1.76	13.4	9.03	100	-	-
Benzo(ghi)perylene	26.4	42.4	15.2	3.93	1.54	<1	1.50	13.3	8.69	100	80	-
Benzo(k)fluoranthene	13.8	22.4	7.41	2.19	<1	<1	<1	6.29	5.18	100	-	-
C1-Naphthalene	56.3	96.9	35.4	9.25	2.07	1.01	2.78	25.7	11.3	100	-	-
C2-Phenanthrene	40.0	66.7	23.7	5.81	3.70	<1	1.99	17.6	9.33	100	-	-
C2-Napthalene	53.9	94.6	34.3	8.25	1.73	<1	2.92	26.3	11.7	100	-	-
C3-Napthalene	47.2	83.7	32.1	6.43	1.78	<1	2.56	21.2	9.84	100	-	-

										Cefas	OSPAR	
PAH (units µg/kg)	ST01	ST03	ST05	ST07	ST11	ST15	ST17	ST19	ST21	AL1	BAC	ERL
Chrysene	22.0	33.6	10.5	2.53	1.65	<1	<1	10.5	6.00	100	20	-
Dibenzo(ah)anthracene	4.76	7.92	2.29	<1	<1	<1	<1	2.35	1.56	10	-	-
Fluoranthene	33.2	58.8	15.8	4.38	2.13	<1	1.57	18.4	12.4	100	39	600
Fluorene	4.62	9.47	2.92	<1	<1	<1	<1	2.50	1.22	100	-	-
Indeno(1,2,3-cd)pyrene	24.1	39.1	13.5	3.85	1.29	<1	1.55	12.6	8.33	100	103	-
Naphthalene	19.0	31.4	11.6	3.37	1.28	1.01	1.39	9.13	4.99	100	8	160
Perylene	13.9	24.5	8.26	1.68	<1	<1	<1	6.75	4.16	100	-	-
Phenanthrene	30.7	60.0	18.2	4.45	1.10	<1	1.56	15.8	8.76	100	-	-
Pyrene	31.4	53.8	16.0	4.17	3.24	<1	1.67	16.8	11.7	100	24	665

Table 9.15 Sediment sample results for PAHs within the arrays and interconnector cable corridor (ST28 North array, ST31 interconnector cable corridor and ST32-ST49 in the South array)

		ST31 ALT									Cefas	OSPAR	
PAH (units µg/kg)	ST28		ST32	ST34	ST36	ST41	ST43	ST44	ST46	ST49	AL1	BAC	ERL
Acenaphthene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	100	-	-
Acenaphthylene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	100	-	-
Anthracene	<1	<1	<1	<1	27.3	<1	<1	<1	<1	<1	100	5	85
Benzo(a)anthracene	1.85	<1	<1	<1	3.89	<1	<1	<1	<1	<1	100	16	261
Benzo(a)pyrene	2.78	1.88	<1	<1	2.54	<1	<1	<1	<1	<1	100	30	430
Benzo(b)fluoranthene	4.14	1.94	<1	<1	3.54	<1	<1	<1	<1	<1	100	-	-
Benzo(e)pyrene	4.02	2.50	<1	1.08	2.54	<1	<1	<1	<1	<1	100	-	-

PAH (units µg/kg)	ST28	ST31 ALT	ST32	ST34	ST36	ST41	ST43	ST44	ST46	ST49	Cefas	OSPAR	
											AL1	BAC	ERL
Benzo(ghi)perylene	3.53	2.21	<1	<1	2.90	<1	<1	<1	<1	<1	100	80	-
Benzo(k)fluoranthene	2.17	1.58	<1	<1	1.90	<1	<1	<1	<1	<1	100	-	-
C1-Naphthalene	6.2	3.08	<1	1.33	4.53	<1	<1	<1	<1	<1	100	-	-
C2-Phenanthrene	4.38	2.06	<1	<1	5.03	<1	<1	<1	<1	<1	100	-	-
C2-Napthalene	6.84	2.72	<1	1.47	3.16	<1	<1	<1	<1	<1	100	-	-
C3-Napthalene	5.33	2.48	<1	1.01	2.42	<1	<1	<1	<1	<1	100	-	-
Chrysene	2.20	1.66	<1	<1	5.22	<1	<1	<1	<1	<1	100	20	-
Dibenzo(ah)anthracene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	10	-	-
Fluoranthene	3.89	2.31	<1	<1	6.83	<1	<1	<1	<1	<1	100	39	600
Fluorene	<1	<1	<1	<1	6.79	<1	<1	<1	<1	<1	100	-	-
Indeno(1,2,3-cd)pyrene	3.85	2.31	<1	<1	2.61	<1	<1	<1	<1	<1	100	103	-
Naphthalene	2.52	1.41	<1	<1	2.18	<1	<1	<1	<1	<1	100	8	160
Perylene	1.73	<1	<1	<1	1.21	<1	<1	<1	<1	<1	100	-	-
Phenanthrene	3.58	1.84	<1	<1	12.0	<1	<1	<1	<1	<1	100	-	-
Pyrene	3.78	2.33	<1	1.03	5.86	<1	<1	<1	<1	<1	100	24	665

42. Of the metals analysed, arsenic was above Cefas AL1 at nine stations, including four along the export cable corridor, one in the north array, one along the interconnector and three in the south array. The arsenic concentrations at three stations were also above OSPAR BAC. Given the exceedances of the sediment quality guidelines results have been considered against regional information available for arsenic to provide context.

43. 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.

44. 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.

45. The arsenic concentrations within sediments in North Falls study area (range between 4.7 and 73.6mg/kg) are similar to the range reported by Whalley *et* al. (1999) and therefore do not represent excessive levels for the region. This is supported by studies undertaken as part of the GGOW investigations which also revealed elevated levels of arsenic in some samples across the GGOW site (GGOW, 2005) along with Norfolk Vanguard, East Anglia TWO and East Anglia THREE, all in the southern North Sea, had similar findings in their surveys (Norfolk Vanguard, 2012, East Anglia THREE, 2016, East Anglia TWO, 2019).

46. Concentrations of nickel were above Cefas AL1 at three stations, including one along the nearshore section of the export cable corridor, one in the north array and one along the interconnector cable corridor. The remaining metals had concentrations below their respective sediment quality guidelines.

47. With respect to PAHs, the majority of the samples did not exceed sediment quality guidelines. The exception were the three sample locations near the coast (ST01, ST03 and ST05), and two in offshore locations within the export cable route (ST19) and south array (ST36) which exceeded OSPAR BAC for a number of individual PAHs, but all were marginal. No samples exceeded Cefas AL1.

9.5.2 Water quality

9.5.2.1 Suspended solids concentrations (SSC)

48. SSCs were measured at four locations as part of the metocean data collection at GGOW in 2011. The maximum concentration was recorded as 85mg/l with a mean concentration of 20mg/l (ABPmer, 2011a).

49. Cefas (2016) published average SSCs between 1998 and 2015 for the seas around the UK (Figure 8.7, Volume II). The average SSC in the vicinity of the array areas for the period 1998-2015 was approximately 7-15mg/l at the south array and 20-27mg/l for the north array (Figure 8.7, Volume II). The average SSC in the vicinity of the interconnector cable corridor is approximately 14-21mg/l, and the export cable corridor is 15mg/l offshore, ranging to 100mg/l close to the landfall location (Figure 8.7, Volume II).

9.5.2.2 Designated sites

50. The offshore cable corridor runs through the WFD Essex coastal water body (GB650503520001) (see Figure 9.2, Volume II). The Essex coastal waterbody is a 'heavily modified' water body due to flood and coastal protection management and is currently classified to have an overall status of 'moderate'. Classification for physico-chemical parameters is considered moderate due to dissolved inorganic nitrogen concentrations in the water. In the River Basin Management Plan, reasons for the elevated inorganic nitrogen concentrations are listed as diffuse pollution (arable land and therefore field runoff), and point sources associated with sewage discharges. In terms of chemical contaminants, the waterbody is at 'fail' status and is associated with concentrations of mercury and its compounds and Polybrominated diphenyl ethers (PBDE). The WFD assessment of potential impacts of North Falls on this water body is included in Appendix 21.2, Volume III.

51. There are eight designated bathing waters within the Essex coastal WFD water body (see Figure 9.2, Volume II). Holland is located within the export cable corridor/landfall area and Frinton is located approximately 0.75km to the north. Holland is classified as having excellent bathing water quality and Frinton is classified as having good bathing water quality (both latest classifications from Environment Agency, 2022).

9.5.3 Future trends in baseline conditions

52. 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 8 Marine Geology Oceanography and Physical Processes, Volume I) 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.

9.6 Assessment of significance

9.6.1 Potential effects during construction

53. During the construction phase of North Falls, there is the potential for foundations and cable installation activities to disturb sediment, potentially resulting in increases in SSCs. These potential effects are considered in construction impacts 1 to 4. The worst-case scenario is discussed in Section 9.3.2.

54. Previous numerical modelling and theoretical work was undertaken for the GGOW and GWF located adjacent to North Falls to the east and southeast. The results of this modelling are used in Chapter 8 Marine Geology Oceanography and Physical Processes (Volume I) as part of the expert-based assessment to assess the potential construction and operational effects of North Falls on marine geology, oceanography and physical processes receptors. This modelling is also relevant here to assess the potential effects associated with increases in SSCs. The justification for the use of this modelling as an analogue is provided in Section 8.4.6 of Chapter 8 Marine Geology Oceanography and Physical Processes (Volume I).

9.6.1.1 Impact 1: Increases in suspended sediment associated with seabed preparation for the installation of foundations, array and interconnector cables

55. Potential increases in SSCs could occur as a result of dredging to prepare the seabed for turbine installation and subsequent release of sediment at the sea surface as overflow from the dredger. Increases in SSC could also occur as a result of array cables and interconnector cable installation. It is anticipated that the offshore cables could be installed via ploughing, jetting, trenching, or a combination of these techniques, depending on ground conditions along the specific cable route. Other installation methods could also be considered.

9.6.1.1.1 Magnitude of impact

56. As discussed in Chapter 8 Marine Geology, Oceanography and Physical Processes (Volume I), conceptual evidence-based assessment suggests that, due to the predominance of medium and coarse-grained sand across the North Falls offshore project area, the sediment disturbed by the drag head of the dredger at the seabed would remain close to the bed and settle rapidly. With respect to sediment released at the water surface, it is predicted that sediments would fall rapidly (minutes or tens of minutes) to the seabed as a highly turbid dynamic plume immediately upon its discharge within a few tens of metres along the axis of tidal flow.

57. Some of the finer sand fraction from this release and the very small proportion of mud present is 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 (up to six hours). Sediment would eventually settle to the seabed in proximity to its release (within a few hundred metres up to around a kilometre along the axis of tidal flow) within a short period of time (hours to days). Whilst lower SSCs would extend further,

along the axis of predominant tidal flows, the magnitudes would be indistinguishable from background levels. The magnitude of the impact is therefore predicted to be low.

9.6.1.1.2 Sensitivity of receptor

58. Water quality in the offshore area 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.

9.6.1.1.3 Significance of effect

59. Due to the low magnitude of the impact and low sensitivity of the receptor, the effect is assessed as minor adverse significance.

9.6.1.2 Impact 2: Increases in suspended sediment due to drill arisings for installation of piled foundations for wind turbines and OSP

60. During drilling (if required), sediments below the seabed would be disturbed and released within the North Falls array areas close to each foundation. The disposal of any sediment would occur within the North Falls array areas close to each foundation.

61. This process would cause localised and short term increases in SSC at the point of discharge which would then be transported by tidal currents in suspension.

9.6.1.2.1 Magnitude of impact

62. Most of the sediment released during drilling would be sand or aggregated clasts and therefore would fall immediately to the seabed in close proximity to the foundation. Where fines are released, the conceptual evidence-based assessment presented in Chapter 8 Marine Geology, Oceanography and Physical Processes (Volume I) indicates that concentrations would be very low (less than 10mg/l) away from the immediate release locations and therefore within the range of natural variability. Additionally, sediment concentrations arising from one foundation installation are unlikely to persist for sufficiently long for them to interact with subsequent foundation installations. The magnitude of the impact is therefore predicted to be low.

9.6.1.2.2 Sensitivity of receptor

63. Water quality in the offshore area 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.

9.6.1.2.3 Significance of effect

64. Due to the low magnitude of the impact and low sensitivity of the receptor, the effect is assessed as minor adverse significance.

9.6.1.3 Impact 3: Increases in suspended sediment associated with installation of the export cable

65. The detail of the export cabling is dependent upon the final project design and installation methods may include ploughing, jetting, trenching, or a combination of these techniques, depending on ground conditions along the specific cable route. Other installation methods could also be considered.

66. The installation of the export cable therefore has the potential to disturb the shallow sub-seabed (to an average depth of 1.2m) and a width of up to 24m. A trench will also be required at the Horizontal Directional Drilling (HDD) exit location, which will be located on the seabed at approximately 1 to 8m depth. Table 9.2 summarises the worst case scenario sediment releases.

9.6.1.3.1 Magnitude of impact

67. Using the conceptual evidence-based assessment presented in Chapter 8 Marine Geology, Oceanography and Physical Processes (Volume I), it is likely that the increase in concentrations would be greatest in the shallowest sections of the export cable corridor, but in these locations the background concentrations are also greater than in deeper waters, with values in excess of 256mg/l recorded in the vicinity of the coast at Orfordness (HR Wallingford et al., 2002).

68. The HDD exit point will be in the subtidal zone, seaward of the low water mark at 1-8m below lowest astronomical tide (LAT). The cable exit point would require excavation of a trench to bury the nearshore portion of the offshore cable on the seaward side of the landfall HDD. This excavation has the potential to increase SSCs close to shore.

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

9.6.1.3.2 Sensitivity of receptor

70. The landfall search area overlaps a designated bathing water, however as for the offshore area, the inshore project area (the offshore export cable corridor) has a high capacity to accommodate change through dilution of any water quality effects. The sensitivity is therefore considered to be medium.

9.6.1.3.3 Significance of effect

71. Due to the low magnitude of the impact and medium sensitivity of the receptor, the effect is assessed as minor adverse significance.

9.6.1.4 Impact 4: Deterioration in water quality associated with release of sediment bound contaminants

72. Site specific data collected to inform the EIA indicates that, with the exception of arsenic, sediment contaminant concentrations are low (Section 9.5.1.2). Where exceedances of sediment guidelines occur, these are generally marginal (i.e., only just above the lower guideline level value). With respect to arsenic, contextual information available indicates that these levels are close to the range identified as being typical for the area.

73. Additionally, sediments are not predicted to remain in suspension for long periods of time given that the seabed material is predominantly sand/gravel and as such the risk of exposure to the water column for partitioning to occur is also reduced.

9.6.1.4.1 Magnitude of impact

74. Given the low levels of contamination described above, the magnitude of impact is predicted to be negligible.

9.6.1.4.2 Sensitivity of receptor

75. Water quality in the offshore area 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.

9.6.1.4.3 Significance of effect

76. Due to the negligible magnitude of the impact and low sensitivity of the receptor, the effect is assessed as negligible adverse significance.

9.6.2 Potential effects during operation

9.6.2.1 Impact 1: Increase in suspended sediment resulting from cable repairs/reburial

77. Disturbance of sediments by maintenance activities that impact the seabed (e.g., cable repair, reburial or replacement) has the potential to re-suspend sediment and increase SSC.

78. Cable repairs and reburial could be needed over the operational lifetime of North Falls. It is estimated that reburial of 5km of array/interconnector cables and 5km of export cables could be required over the life of the Project. In addition, five array/interconnector cable repairs and four export cable repairs could be required over the life of the Project.

9.6.2.1.1 Magnitude of impact

79. As set out in the worst case scenario in Table 9.2, the anticipated length of cables required to be repaired or reburied at any one time represents a small proportion of the length of cabling associated with North Falls. As such, the disturbance areas for reburial and repairs of cables is predicted to be extremely small in comparison to the construction assessment. As with construction, coarse sediment would settle rapidly to the seabed and fine sediment would remain in suspension for longer periods but be indistinguishable from background levels.

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

9.6.2.1.2 Sensitivity of receptor

81. Water quality in the offshore area 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.

9.6.2.1.3 Significance of effect

82. Due to the negligible magnitude of the impact and low sensitivity of the receptor, the effect is assessed as negligible adverse significance

9.6.2.2 *Impact 2: Deterioration in water quality resulting from the resuspension of contaminated sediment due to maintenance activities*

83. Sample data collected to inform this PEIR indicates some elevated levels of contaminants within the sediments, however these are within the range identified as being typical for the area (Section 9.5.1.2).

9.6.2.2.1 Magnitude of impact

84. Given the low levels of contaminants present, coupled with the low volumes of sediments expected to be disturbed during the maintenance activities, the magnitude of effect is predicted to be negligible.

9.6.2.2.2 Sensitivity of receptor

85. Water quality in the offshore area 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.

9.6.2.2.3 Significance of effect

86. Due to the negligible magnitude of the impact and low sensitivity of the receptor, the effect is assessed as negligible adverse significance.

9.6.3 Potential effects during decommissioning

87. A decision regarding the final decommissioning policy is yet to be decided as it is recognised that rules and legislation change over time in line with best industry practice. The decommissioning methodology and programme would need to be finalised nearer to the end of the lifetime of the proposed North Falls to ensure it is in line with the most recent guidance, policy and legislation.

88. The scope of the decommissioning works would most likely involve removal of the accessible installed components. This is outlined in Chapter 5 Project Description (Volume I) and the detail would be agreed with the relevant authorities at the time of decommissioning. Offshore, this is likely to include removal of all of the wind turbine components and part of the foundations (those above seabed level), removal of some or all of the array, interconnector and export cables. Scour and cable protection would likely be left in situ.

89. The worst case scenario arising from the decommissioning of the Project is listed in Table 9.2**.**

90. During the decommissioning phase, there is potential for:

- Increases in suspended sediment associated with removal of foundations, array and interconnector cables
- Increases in suspended sediment associated with removal of parts of the export cable
- Deterioration in water quality associated with release of sediment bound contaminants

9.6.3.1.1 Magnitude of impact

91. The magnitude of impact from decommissioning activities would be less than those identified for the construction phase as seabed preparation is not required, which is the main source of suspended sediment, and the

decommissioning works would otherwise be a reverse of the installation process.

92. As with construction, coarse sediment would settle rapidly to the seabed and fine sediment would remain in suspension for longer periods but be indistinguishable from background levels. The scale of these effects will therefore be small, infrequent and of short-term duration. The magnitude of impact is therefore predicted to be negligible.

9.6.3.1.2 Sensitivity of receptor

93. Water quality in the offshore area 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.

9.6.3.1.3 Significance of effect

94. Due to the negligible magnitude of the impact and low sensitivity of the receptor, the effect is assessed as negligible adverse significance.

9.7 Potential monitoring requirements

95. No monitoring is proposed in relation to marine water and sediment quality given that all of the potential impacts considered will result in either no or, at worse, minor adverse effects on marine water quality.

9.8 Cumulative effects

9.8.1 Identification of potential cumulative effects

96. The first step in the CEA process is the identification of which residual effects assessed for North Falls on their own have the potential for a cumulative effect with other plans, projects and activities. This information is set out in Table 9.16.

Table 9.16 Potential cumulative effects

Impact	Potential for cumulative effect	Rationale
Construction		
Impact 1: Increases in suspended sediment associated with seabed preparation for the installation of foundations, array and interconnector cables	Yes	Effects will occur at isolated locations for a time-limited duration and are local in nature, however, due to nearby projects (see Table 9.17), cumulative effects must be assessed.
Impact 2: Increases in suspended sediment due to drill arisings for installation of piled foundations for wind turbines and OSP	Yes	
Impact 3: Increases in suspended sediment associated with installation of the export cable	Yes	
Impact 4: Deterioration in water quality associated with release of sediment bound contaminants	No	Given the absence of significant contamination present, there is no potential for cumulative effects.

Impact	Potential for cumulative effect	Rationale
Operation		
Impact 1: Increase in suspended sediment resulting from cable repairs/reburial	No	Impacts will be highly localised around the array, interconnector and export cables, short-term and intermittent, therefore there will be no cumulative effect.
Impact 2: Deterioration in water quality resulting from the resuspension of contaminated sediment due to maintenance activities	No	
Decommissioning		
Impact 1: Increases in suspended sediment associated with removal of foundations, array and interconnector cables	No	Effects would occur at discrete locations for a time-limited duration, therefore there will be no cumulative effects from decommissioning.
Impact 2: Increases in suspended sediment associated with removal of parts of the export cable	No	
Impact 3: Deterioration in water quality associated with release of sediment bound contaminants	No	

9.8.2 Other plans, projects and activities

97. The second step in the cumulative assessment is the identification of the other plans, projects and activities that may result in cumulative effects for inclusion in the CEA (described as 'project screening'). This information is set out in Table 9.17 below, together with a consideration of the relevant details of each, including current status (e.g. under construction), planned construction period, closest distance to North Falls, status of available data and rationale for including or excluding from the assessment.

98. The project screening has been informed by the development of a CEA project list which forms an exhaustive list of plans, projects and activities within the study area relevant to North Falls. 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 9.17 Summary of projects considered for the CEA in relation to Marine Water and Sediment Quality (project screening)

Project	Status	Construction Period	Closest Distance from the Project (km)	Distance from the Export Cable corridor (km)	Confidence in Data	Included in the CEA (Y/N)	Rationale
NeuConnect Interconnector	Consent granted	Unknown	0 km	0 km	High	Yes, subject to available information	The NeuConnect Interconnector bisects the North Falls export cable corridor and interconnector cable corridor and there is potential for temporal overlap of cable installation activities.
BritNed Interconnector	Operational since 2009	N/A	0 km	10.86 km	High	No	The BritNed Interconnector passes through the south of the south array but has been operational since 2009. There is therefore no potential for cumulative impact on the identified receptors.
Nautilus Interconnector	Pre-application	2025-2028	Cable route unknown	Cable route unknown	Low	Yes (Subject to available information)	The offshore study area for Nautilus intersects with the North Falls offshore project area, Therefore, there is potential for cumulative effects, subject to the final location and programme for the interconnector.
Sea Link	Pre-application	2026-2030	Cable route unknown	Cable route unknown	Low	Yes, for offshore construction effects only (Subject to available information)	The emerging preferred and alternative routes for Sea Link intersect with the North Falls offshore cable corridor. Therefore, there is potential for cumulative effects, subject to the final location and programme for the interconnector.
Tarchon Energy Interconnector	Pre-planning	N/A	Cable route unknown	Cable route unknown	N/A	Yes (Subject to available information)	Interconnector between UK and Germany with potential to be in proximity to the North Falls offshore project area.
Commercial fisheries	Ongoing	N/A			Medium	No	No potential cumulative effects on water quality are likely due to the highly localised and intermittent nature, and subsequent extent of
Greater Gabbard offshore wind farm	Operational since 2012	N/A	0 km	5.6 km	High	No	

Project	Status	Construction Period	Closest Distance from the Project (km)	Distance from the Export Cable corridor (km)	Confidence in Data	Included in the CEA (Y/N)	Rationale
Galloper offshore wind farm	Operational since 2018	N/A	0 km	8.5 km	High	No	suspended sediment plumes, of any operational maintenance activities.
Five Estuaries offshore wind farm	In planning	Unknown	0 km (0.04m)	14.8 km	High	Yes	Potential for some interaction between the dredging plumes from the cable/foundation installation from Five Estuaries with North Falls. Following construction, cumulative effects on water quality are unlikely due to the highly localised and intermittent nature, and subsequent suspended sediment plumes, of any operational maintenance activities.
East Anglia TWO offshore wind farm	Consent granted	Construction planned mid 2020s	14.8 km	37.2 km	High	No	Construction periods unlikely to overlap and therefore interaction of plumes unlikely. Following construction, cumulative effects on water quality are unlikely due to the highly localised and intermittent nature, and subsequent suspended sediment plumes, of any operational maintenance activities.
Thanet offshore wind farm	Operational since 2010	N/A	24.4 km	36.2 km	High	No	Any ongoing effects of maintenance activity from these offshore wind farms will be highly localised and therefore, given the distance from the North Falls offshore project area, there is no pathway for significant cumulative effects. This approach is in keeping with the GWF EIA, where it was agreed with Cefas and Defra that no assessment of cumulative effects was required with other Round 2 sites in the Thames strategic area (except GGOW).
London Array offshore wind farm	Operational since 2013	N/A	19.4 km	15.5 km	High	No	
Gunfleet Sands offshore wind farm	Operational since 2010	N/A	43.3	10.3 km	High	No	
Outer OTE aggregate exploration and option area 528/2	Unknown	N/A	8.4 km	14 km	Low	No	Suspended sediment from North Falls construction would settle to the seabed in proximity to its release (within a few hundred metres up to around a kilometre along the axis of

Project	Status	Construction Period	Closest Distance from the Project (km)	Distance from the Export Cable corridor (km)	Confidence in Data	Included in the CEA (Y/N)	Rationale
East Orford Ness aggregate exploration and option area 1809	Unknown	N/A	2 km	24.8 km	Low	No	tidal flow), therefore there is no pathway for significant cumulative effects with these aggregate sites.
Thames D aggregates production agreement area 524	Unknown	2022-2036	0 km	12.5 km	Low	Yes, subject to available information	There is potential for some interaction between the dredging plumes from the aggregate exploration and option areas and plumes from cable/foundation installation. Following construction, cumulative effects on water quality are unlikely due to the highly localised and intermittent nature, and subsequent suspended sediment plumes, of any operational maintenance and decommissioning activities.
Shipwash aggregate production agreement area 507	Operational since 2016	N/A	0.2 km	9.8 km	High	No	Sites which were operational at the time of the North Falls characterisation surveys are a component of the baseline environment.
Southwold East aggregates production agreement area 430	Operational since 2012	N/A	27.3 km	48.4 km	High	No	
North Inner Gabbard aggregate production agreement area 498	Operational since 2015	N/A	1.7 km	24 km	High	No	
Longsand aggregate production agreement area 508	Operational since 2014	N/A	11.7 km	5.8 km	High	No	

Project	Status	Construction Period	Closest Distance from the Project (km)	Distance from the Export Cable corridor (km)	Confidence in Data	Included in the CEA (Y/N)	Rationale
Longsand aggregate production agreement area 509	Operational since 2015	N/A	11.7 km	2.1 km	High	No	
Longsand aggregate production agreement area 510	Operational since 2015	N/A	7.3 km	3.5 km	High	No	
North Falls East aggregate production agreement area 501	Operational since 2017	N/A	13.2 km	27.5 km	High	No	

9.8.3 Assessment of cumulative effects

99. As outlined above, there is potential for cumulative effects on water quality due to increases in suspended sediment during construction of the Project with other nearby plans and projects.

100. The NeuConnect Interconnector bisects the North Falls offshore cable corridor and interconnector cable corridor and there is potential for temporal overlap of cable installation activities. Also, the Five Estuaries export cable corridor follows a similar route to North Falls' and may overlap with North Falls construction programme. The cable routes of the Nautilus, Tarchon Energy and Sea Link Interconnectors are not yet known and therefore these will be considered further in the Environmental Statement, if sufficient information is available.

101. At the time of writing, no detailed assessment information is available for these projects and so it is assumed that the effects would be similar to North Falls.

102. The worst case scenario from a marine water and sediment quality perspective would be for all projects to be constructed at the same time. This would provide the greatest opportunity for interaction of sediment plumes during their construction.

103. In addition, the southern array area is adjacent to production agreement area 524. The worst case scenario would therefore also include aggregate extraction during the construction of North Falls, Five Estuaries and the interconnector cables. It is, however, unlikely that all of these activities would occur simultaneously.

104. Results from monitoring of plume dispersal from dredging activities undertaken by Oakwood Environmental (1999) and numerical modelling studies undertaken for the Outer Thames MAREA, concluded that SSCs outside the licenced dredging areas were less than 20mg/l above background levels (except at the boundary, where they were within the range of natural variability) (HR Wallingford, 2010).

105. The sediment recorded in the North Falls offshore project area is typical of the wider study area and therefore, as for North Falls alone, the majority of suspended sediment arising from each project would fall rapidly to the seabed once the activity is complete and sediment plumes would be rapidly dispersed to within background levels.

106. Considering the short-term nature of discernible sediment plumes the potential cumulative impact would be of low magnitude.

107. Water quality in the offshore area 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.

108. It is therefore considered that the cumulative effect on water quality of all projects constructing in this area at the same time would be of minor adverse significance.

9.9 Transboundary effects

109. Due to the distance of North Falls from the EEZ and given that there will not be a significant effect on water quality, transboundary impacts are unlikely to occur and therefore transboundary impacts are scoped out of further assessment in accordance with the scoping opinion (Planning Inspectorate, 2021).

9.10 Interactions

110. Interactions exist between the marine water and sediment quality topic and several other topics that have been considered within this PEIR. Table 9.18 provides a summary of the principal interactions, related chapters and signposts to where those issues have been addressed in this chapter.

Table 9.18 Marine Water and Sediment Quality interactions

Topic and description	Related chapter (Volume I)	Where addressed in this chapter	Rationale
Construction			
Effects on the water column (increases in suspended sediment and presence of sediment bound contaminants)	Chapter 13 Fish and Shellfish Ecology Chapter 16 Commercial Fisheries Chapter 12 Benthic and Intertidal Ecology	Sections 9.6.1.1, 9.6.1.2 and 9.6.1.3 (installation of foundations, array and interconnector cables and export cable) Section 9.6.1.4 (presence of sediment bound contaminants)	Sediment could be contaminated and could cause disturbance to fish and benthic species through smothering.
Operation			
Effects on the water column (increases in suspended sediment and presence of sediment bound contaminants)	Chapter 13 Fish and Shellfish Ecology Chapter 16 Commercial Fisheries Chapter 12 Benthic and Intertidal Ecology	Section 9.6.2.1 (cable repairs/reburial) Section 9.6.2.2 (presence of sediment bound contaminants)	Sediment could be contaminated and could cause disturbance to fish and benthic species through smothering.
Decommissioning			
Interactions for impacts during the decommissioning phase will be the same as those outlined above for the construction phase.			

9.11 Inter-relationships

111. The impacts identified and assessed in this chapter have the potential to interrelate with each other. The areas of potential inter-relationships between impacts are presented in Table 9.19. This provides a screening tool for which impacts have the potential to interrelate. Table 9.20 provides an assessment for each receptor (or receptor group) as related to these impacts.

112. Within Table 9.20 the impacts are assessed relative to each development phase (i.e., construction, operation or decommissioning) to see if (for example) multiple construction impacts affecting the same receptor could increase the significance of effect upon that receptor. Following this, a lifetime assessment is undertaken which considers the potential for impacts to affect receptors across all development phases.

Table 9.19 Inter-relationships between impacts - screening

Potential interrelationships between impacts				
Construction				
	Impact 1: Increases in suspended sediment associated with seabed preparation for the installation of foundations, array and interconnector cables	Impact 2: Increases in suspended sediment due to drill arisings for installation of piled foundations for wind turbines and OSP	Impact 3: Increases in suspended sediment associated with installation of the export cable	Impact 4: Deterioration in water quality associated with release of sediment bound contaminants
Impact 1: Increases in suspended sediment associated with seabed preparation for the installation of foundations, array and interconnector cables		Yes	Yes	Yes
Impact 2: Increases in suspended sediment due to drill arisings for installation of piled foundations for wind turbines and OSP	Yes		Yes	Yes
Impact 3: Increases in suspended sediment associated with installation of the export cable	Yes	Yes		Yes
Impact 4: Deterioration in water quality associated with release of sediment bound contaminants	Yes	Yes	Yes	
Operation				
	Impact 1: Increase in suspended sediment resulting from cable repairs/reburial	Impact 2: Deterioration in water quality resulting from the resuspension of contaminated sediment due to maintenance activities		
Impact 1: Increase in suspended sediment resulting from cable repairs/reburial		Yes		

Potential interrelationships between impacts				
Impact 2: Deterioration in water quality resulting from the resuspension of contaminated sediment due to maintenance activities	Yes			
Decommissioning				
	Impact 1: Increases in suspended sediment associated with removal of foundations, array and interconnector cables	Impact 2: Increases in suspended sediment associated with removal of parts of the export cable	Impact 3: Deterioration in water quality associated with release of sediment bound contaminants	
Impact 1: Increases in suspended sediment associated with removal of foundations, array and interconnector cables		Yes	Yes	
Impact 2: Increases in suspended sediment associated with removal of parts of the export cable	Yes		Yes	
Impact 3: Deterioration in water quality associated with release of sediment bound contaminants	Yes	Yes		

Table 9.20 Inter-relationships between impacts – phase and lifetime assessment

Receptor	Highest significance level				
	Construction	Operation	Decommissioning	Phase assessment	Lifetime assessment
Marine water quality	Negligible	Negligible	Negligible	No greater impact than individually assessed impact. The impacts are considered to have minor adverse magnitude of effect on the receptor. Given that that each impact will be managed with standard and best practice methodologies it is considered that there would either be no interactions or that these would not result in greater impact than assessed individually.	No greater impact than individually assessed impact.

9.12 Summary

113. 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 effects on water quality during the construction, operation and decommissioning phases of North Falls are considered either 'minor adverse' or 'negligible'.

Table 9.21 Summary of potential impacts on Marine Water and Sediment Quality

Potential impact	Receptor	Sensitivity	Magnitude of impacts	Pre-mitigation effect	Additional mitigation measures proposed	Residual effect
Construction						
Impact 1: Increases in suspended sediment associated with seabed preparation for the installation of foundations, array and interconnector cables	Water quality	Low	Low	Minor	N/A	Minor
Impact 2: Increases in suspended sediment due to drill arisings for installation of piled foundations for wind turbines and OSP	Water quality	Low	Low	Minor	N/A	Minor
Impact 3: Increases in suspended sediment associated with installation of the export cable	Water quality	Medium	Low	Minor	N/A	Minor
Impact 4: Deterioration in water quality associated with release of sediment bound contaminants	Water quality	Low	Negligible	Negligible	N/A	Negligible
Operation						
Impact 1: Increase in suspended sediment resulting from cable repairs/reburial	Water quality	Low	Negligible	Negligible	N/A	Negligible
Impact 2: Deterioration in water quality resulting from the resuspension of contaminated sediment due to maintenance activities	Water quality	Low	Negligible	Negligible	N/A	Negligible
Decommissioning						
Impact 1: Increases in suspended sediment associated with removal of foundations, array and interconnector cables	Water quality	Low	Negligible	Negligible	N/A	Negligible
Impact 2: Increases in suspended sediment associated with removal of parts of the export cable	Water quality	Low	Negligible	Negligible	N/A	Negligible
Impact 3: Deterioration in water quality associated with release of sediment bound contaminants	Water quality	Low	Negligible	Negligible	N/A	Negligible

9.13 References

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