Morecambe Offshore Windfarm: Generation Assets

Development Consent Order Documents

Volume 4

Sediment Disposal Site Characterisation Report (Tracked)

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Rev 02~~1~~

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Glossary of Acronyms

AEZ	Archaeological Exclusion Zone
AfL	Agreement for Lease
AL	Action Level
AoO	Advice on Operations
As	Arsenic
AtoN	Aids to Navigation
AyM	Awel y Môr
BAC	Background Assessment Concentration
BGS	British Geological Survey
CCSA	Carbon Capture Storage Area
Cd	Cadmium
Cefas	Centre for Environment Fisheries and Aquaculture Science
Cr	Chromium
Cu	Copper
DBT	Dibutyltin
DCO	Development Consent Order
DDC	Drop-Down Camera
DML	Deemed Marine Licence
EATL	East Anglia Three Limited
EIA	Environmental Impact Assessment
ERL	Effects Range Low
ES	Environmental Statement
EUNIS	European Nature Information System
FWPM	Freshwater Pearl Mussel
GBS	Gravity Base Structures
Hg	Mercury
HiDef	HiDef Aerial Surveying Limited
HRA	Habitats Regulations Assessment
ICES	International Council for the Exploration of the Sea
INNS	Invasive Non-Native Species
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
LPS	Local Port Service
MarESA	Marine Evidence-based Sensitivity Assessment

MCAA	Marine and Coastal Access Act
MCZ	Marine Conservation Zone
MMO	Marine Management Organisation
MU	Management Unit
NE	Natural England
Ni	Nickel
NSIP	Nationally Significant Infrastructure Project
OEL	Ocean Ecology Limited
OSP(s)	Offshore substation platform(s)
OWSI	Outline Offshore Written Scheme of Investigation
PAD	Protocol for Archaeological Discoveries
PAH	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PCB	Polychlorinated Biphenyls
PEIR	Preliminary Environmental Information Report
PSA	Particle Size Analysis
PSD	Particle Size Distribution
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SSC	Suspended Sediment Concentrations
TBT	Tributyltin
TEZ	Temporary Exclusion Zone
THC	Total Hydrocarbons
TOC	Total Organic Carbon
TOM	Total Organic Matter
TSHD	Trailing suction hopper dredger
TSS	Traffic Separation Scheme
UK	United Kingdom
VTS	Vessel Traffic Service
WTG	Wind turbine generators
Zn	Zinc
ZoI	Zone of Influence

Glossary of Unit Terms

µg/kg	micrograms per kilogram
km	kilometre
m	metre
m^2	~~metre~~ square metre~~d~~
m^3	~~metre~~ cub~~ed~~ic metre
mg/kg	milligram per kilogram
mg/l	milligram per litre

Glossary of Terminology

Advice on Operations (AoO)	Provides information on the activities capable of affecting site integrity and therefore achievement of the site's conservation objectives.
Applicant	Morecambe Offshore Windfarm Ltd
Application	This refers to the Applicant's application for a Development Consent Order (DCO). An application consists of a series of documents and plans which are published on the Planning Inspectorate's (PINS) website.
Agreement for Lease (AfL)	Agreements under which seabed rights are awarded following the completion of The Crown Estate process.
Disposal	The deposit of dredged sediment at the sea surface or at the seabed using a fall pipe; or the deposit of subsurface sediment at the seabed released during any construction or maintenance activity required for the Project.
Far-field	The wider area that might also be affected indirectly by the Project.
Generation Assets (the Project)	Generation assets associated with the Morecambe Offshore Windfarm. This is infrastructure in connection with electricity production, namely the fixed foundation wind turbine generators (WTGs), inter-array cables, offshore substation platform(s) (OSP(s)) and possible platform link cables to connect OSP(s).
Inter-array cables	Cables which link the WTGs to each other and the OSP(s).
Morgan and Morecambe Offshore Wind Farms: Transmission Assets	The transmission assets for the Morgan Offshore Wind Project and the Morecambe Offshore Windfarm. This includes the OSP(s)[1], interconnector cables, Morgan offshore booster station, offshore export cables, landfall site, onshore export cables, onshore substations, 400kV cables and associated grid connection infrastructure such as circuit breaker infrastructure. Also referred to in this report as the Transmission Assets, for ease of reading.
Near-field	The area within the immediate vicinity (tens or hundreds of metres) from the point of disturbance.
Offshore export cables	The cables which would bring electricity from the OSP(s) to the landfall.
Offshore substation platform(s)	A fixed structure located within the windfarm site, containing electrical equipment to aggregate the power from the WTGs and convert it into a more suitable form for export to shore.

[1] At the time of writing the Environmental Statement (ES), a decision had been taken that the offshore substation platforms (OSPs) would remain solely within the Generation Assets application and would not be included within the Development Consent Order (DCO) application for the Transmission Assets. This decision post-dated the Preliminary Environmental Information Report (PEIR) that was prepared for the Transmission Assets. The OSPs are still included in the description of the Transmission Assets for the purposes of this ES as the Cumulative Effects Assessment (CEA) carried out in respect of the Generation/Transmission Assets is based on the information available from the Transmission Assets PEIR.

Platform link cable	An electrical cable which links one or more OSP(s).
Scour protection	Protective materials to avoid sediment being eroded away from the base of the foundations due to the flow of water.
Study area	This is an area which is defined for each Environmental Impact Assessment (EIA) topic which includes the windfarm site as well as potential spatial and temporal considerations of the impacts on relevant receptors. The study area for each EIA topic is intended to cover the area within which an effect can be reasonably expected. For the purpose of this report, this is the area which includes the sediment disposal site (the Project windfarm site).
Technical stakeholders	Technical consultees are considered to be organisations with detailed knowledge or experience of the area within which the Project is located and/or receptors which are considered in the EIA and Habitats Regulations Assessment (HRA). Examples of technical stakeholders include Marine Management Organisation (MMO), local authorities, Natural England (NE) and Royal Society for the Protection of Birds (RSPB).
Tidal excursion ellipse	The path followed by a water particle in one complete tidal cycle.
Windfarm site	The area within which the WTGs, inter-array cables, OSP(s) and platform link cables will be present.
Zone of Influence (ZoI)	This is a refined area within the wider study area covering the maximum anticipated spatial extent of a given potential impact. As such, the ZoI for this topic is intended to cover the area within which an effect can be reasonably expected.

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1 Introduction

1. This Sediment Disposal Site Characterisation Report forms part of a set of documents that supports the Development Consent Order (DCO) application submitted by Morecambe Offshore Windfarm Ltd (the Applicant) for the Morecambe Offshore Windfarm Generation Assets (the Project).

2. The Project relates only to the generation assets of the Morecambe Offshore Windfarm (including wind turbine generators (WTGs), inter-array cables, offshore substation platform(s) (OSP(s)), and possible platform link cables to connect OSP(s)). A separate DCO application for the transmission assets associated with the Morecambe Offshore Windfarm and the Morgan Offshore Wind Project (another proposed windfarm to be located in the Irish Sea) would be sought.

3. Activities carried out under this DCO require dredging and subsequent disposal of the dredged material.

4. The Marine and Coastal Access Act (MCAA) Section 66 states that it is a licensable marine activity to carry out any form of dredging and disposal of dredged material on the seabed within the United Kingdom (UK). For the purposes of this document, ‘disposal’ means the deposit of dredged sediment at the sea surface, or on the seabed, using a fall pipe; or the deposit of subsurface sediment on the seabed released during any construction activity required for the Project.

1.1 Purpose of this document

5. The Applicant is applying to designate the Project windfarm site (as defined by the Order Limits in **Figure 1.1**) as a disposal site for material arising due to construction activities (i.e. seabed preparation/sandwave levelling (dredging) for foundations and cable installation and/or drilling for foundations).

6. This document provides the necessary information to characterise the disposal site application requirements for the Project. The location of the proposed Project disposal site is shown in **Figure 1.1**.

7. To streamline the disposal site characterisation and licensing process, this document provides the necessary information for the windfarm site area to be licensed as a disposal site. It is proposed that these areas are included within the Morecambe Offshore Windfarm Deemed Marine Licence (DML).

8. The purpose of this document is to provide the information required to support the application to dispose of material within the Order Limits. Accordingly, this document sets out:

   - Characteristics of the Project disposal site (**Section 2**)

- The type of material to be disposed (**Section 3**)
- The quantity of the material to be disposed (**Section 4**)
- Alternatives considered (**Section 5**)
- Potential impacts of sediment disposal (**Section 6**)
- A summary (**Section 7**)
- References (**Section 8**)

1.2 Project overview

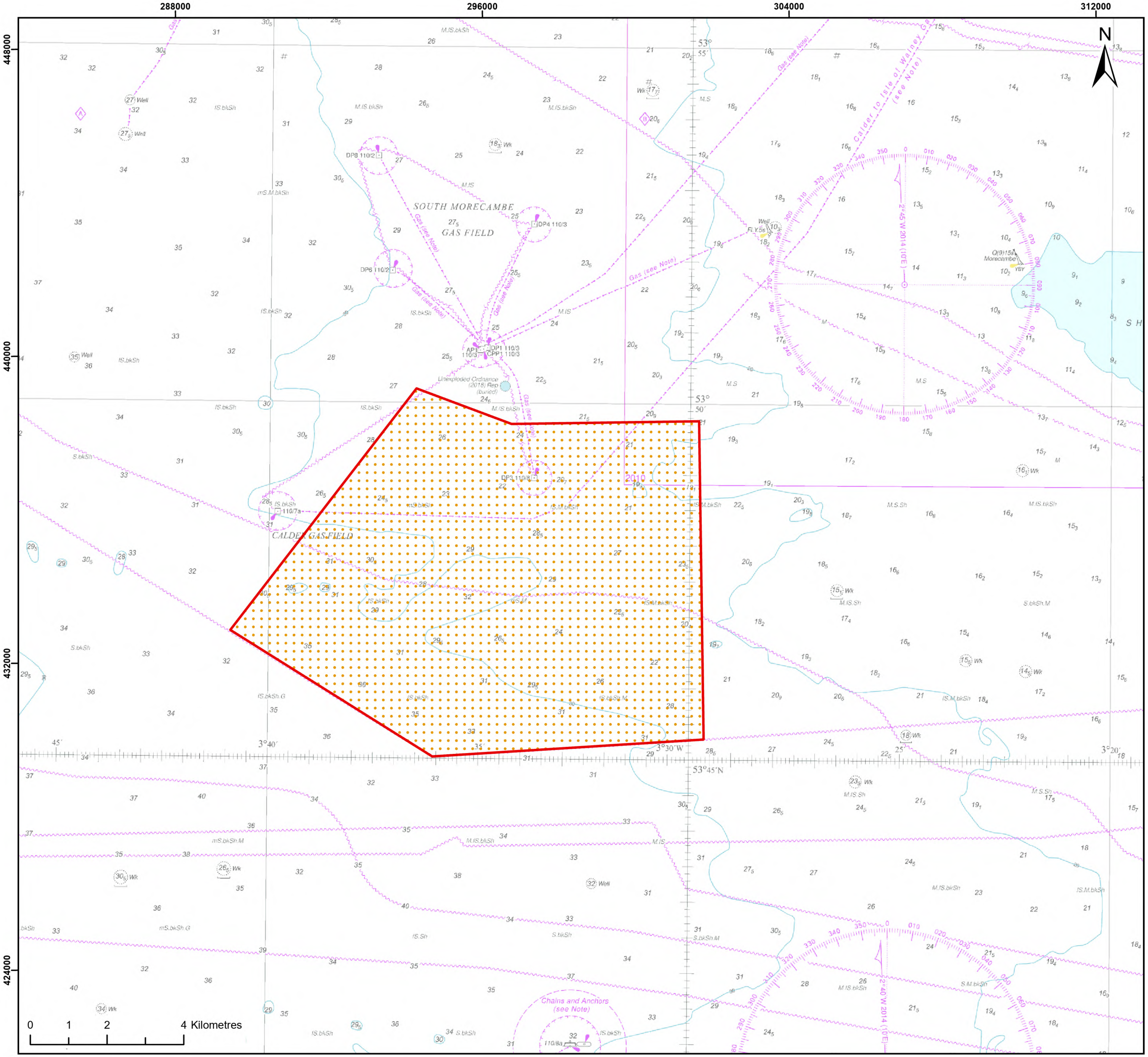
9. Morecambe Offshore Windfarm is a proposed offshore windfarm located in the Irish Sea, approximately 30km off the Lancashire coast (**Figure 1.1**), with an expected nominal capacity of 480 megawatts (MW).

10. The Crown Estate awarded an Agreement for Lease (AfL) to the Applicant in early 2021, as part of The Crown Estate's Offshore Wind Round 4 Leasing, comprising an area of up to 125km^2. Following design development, surveys, assessments and consultation on the Preliminary Environmental Information Report (PEIR), the proposed windfarm site (development area) has been reduced to approximately 87km^2. The site selection process and refinement of the windfarm site is described in **Chapter 4 Site Selection and Assessment of Alternatives** of the Environmental Statement (ES) (Document Reference 5.1.4).

11. As the Morecambe Offshore Windfarm is an offshore generating station of over 100 MW, it is defined under the Planning Act 2008 as a Nationally Significant Infrastructure Project (NSIP) and, as such, it requires a DCO.

12. A Government-initiated review of offshore windfarm transmission connections has concluded that the Morecambe Offshore Windfarm would share a grid connection location at Penwortham in Lancashire with the Round 4 Morgan Offshore Wind Project, also located in the east Irish Sea. Given this, the Applicant is delivering a coordinated, but electrically separate, grid connection with the Morgan Offshore Wind Project. Accordingly, the Applicant, together with the Morgan Offshore Wind Project, are jointly applying for a separate DCO for the Transmission assets for both projects.

13. As illustrated indicatively in **Plate 1.1**, the Project includes the Generation Assets to be located within the windfarm site WTGs, inter-array cables, OSP(s) and possible platform link cables to connect OSP(s)). The Environmental Impact Assessment (EIA) of the Transmission Assets, including offshore export cables to landfall and onshore infrastructure, is part of a separate DCO application, as outlined in **Chapter 1 Introduction** (Document Reference 5.1.1) of the ES. This report considers disposal for the Project (Generation Assets) only, but the Transmission Assets are contained within the cumulative assessment sections presented in **Section 6**.



Legend:

- Morecambe Offshore Windfarm Site
- Location of project sediment disposal site

Report: Morecambe Offshore Windfarm: Generation Assets Sediment Disposal Site Characterisation Report

Title: Location of project sediment disposal site

Figure: 1.1 Drawing No: PC1165-RHD-ES-OF-DG-Z-0075

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
P01	17/10/2023	SB	GC	A3	1:100,000

Co-ordinate system: WGS 1984 UTM Zone 30N

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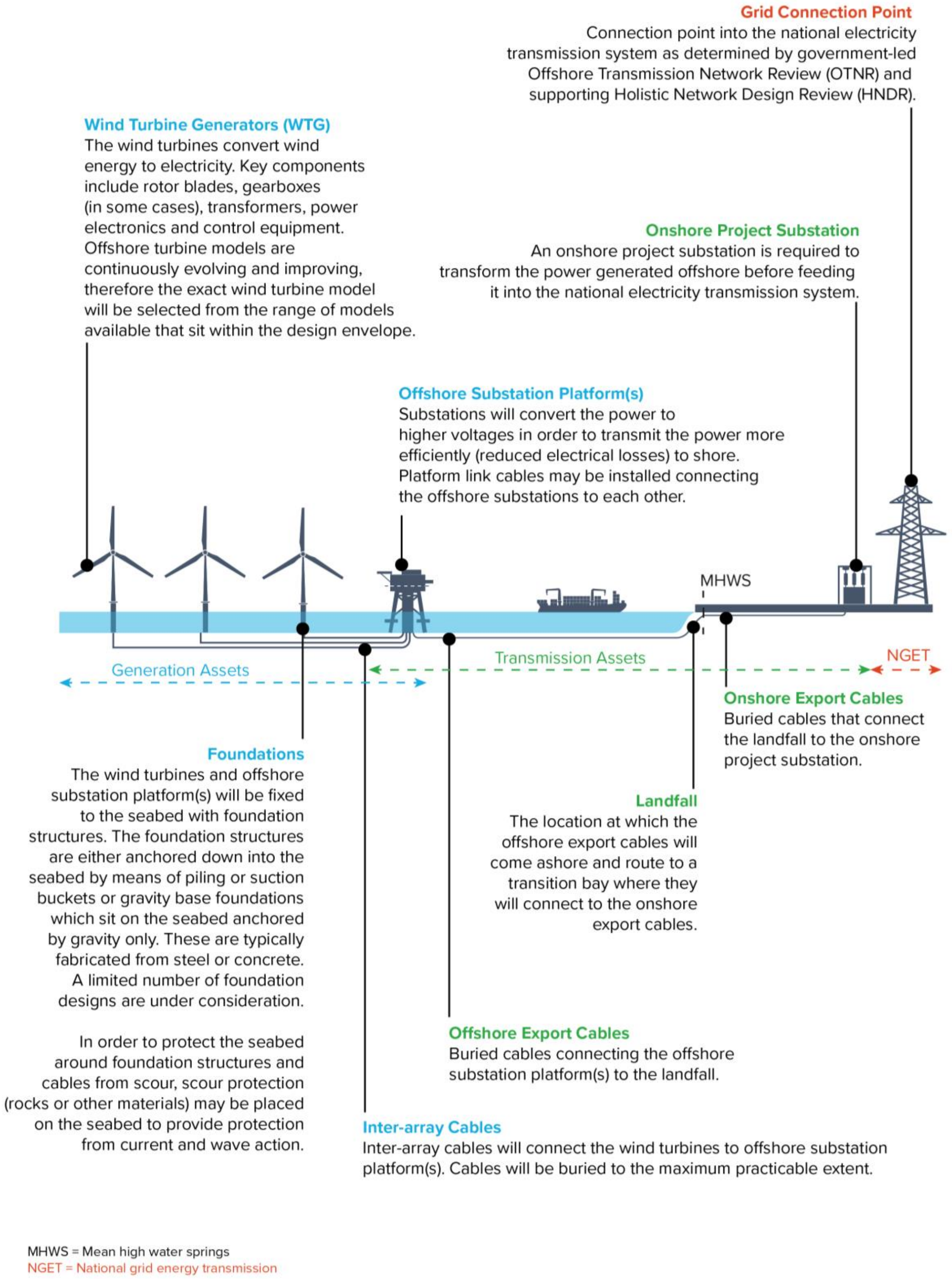


Plate 1.1 Components of Morecambe Offshore Windfarm (note: the components in blue are Generation Assets (included in this Report)) and Transmission Assets are in green. The Transmission Assets would be subject to a separate DCO (known as the Morgan and Morecambe Offshore Wind Farms: Transmission Assets)

14. A summary of the key project characteristics is presented in **Table 1.1** and a full Project description is available as part of the ES in **Chapter 5 Project Description** (Document Reference 5.1.5).

Table 1.1 Key Project characteristics

Parameter	Details
Approximate construction duration	2.5 years
Array area	87km^2
Wind farm site water depth range (m below Lowest Astronomical Tide (LAT))	18-40
Maximum number of WTGs	35
Maximum number of OSP(s)	2
Maximum inter-array cable length (km)	70
Maximum platform link cable length (km)	10
WTG/OSP foundation type options	Gravity Base Structures (GBS), Multi-legged pin-piled jacket (four-legged or three-legged), Monopile, Multi-legged suction bucket jacket (three-legged)

2 Characteristics of the Project disposal site

2.1 Physical characteristics

15. **Sections 2.1.1 – 2.1.4** provide a summary of the physical characteristics of the Project disposal site. Further information is set out in **Chapter 7 Marine Geology, Oceanography and Physical Processes** of the ES (Document Reference 5.1.7).

2.1.1 Tide and wave regime

16. Tidal current flows across the Project windfarm site are directed approximately to the east or north-east on a flood tide, and to the west or south-west on an ebb tide. Peak depth-averaged flood tidal current speeds are approximately 0.75-1.0m/s on spring tides (Figure 3.4 in Halcrow, 2010). Peak depth-averaged ebb tidal current speeds are approximately 0.5-0.75m/s on spring tides (Figure 3.5 in Halcrow, 2010).

17. The mean annual wave height ranges from 1.1m to 1.2m, with the most frequent waves arriving from the west sector (ABPmer, 2018). The largest significant wave heights (greater than 2m) arrive from the west.

2.1.2 Subsurface sediments and underlying geology

18. The underlying geology of the Project windfarm site is complex, given the many periods of glaciation experienced in the Irish Sea during the Pleistocene. The windfarm site is underlain by five geological units, Triassic bedrock (Unit 5) with an undulating top, overlain by Unit 4 (Cardigan Bay Formation), Unit 3 (Western Irish Sea Formation B) and Unit 2 (Western Irish Sea Formation A), all from the Pleistocene (MMT, 2022). These units vary greatly in thickness and are not present across the whole windfarm site. The uppermost Unit 1 (Surface Sands Formation) is the most recent sedimentary deposit. A thin veneer of unconsolidated mobile sand lies at the top of this unit, directly below the seabed (MMT, 2022).

2.1.3 Seabed and shallow near-bed surface sediments

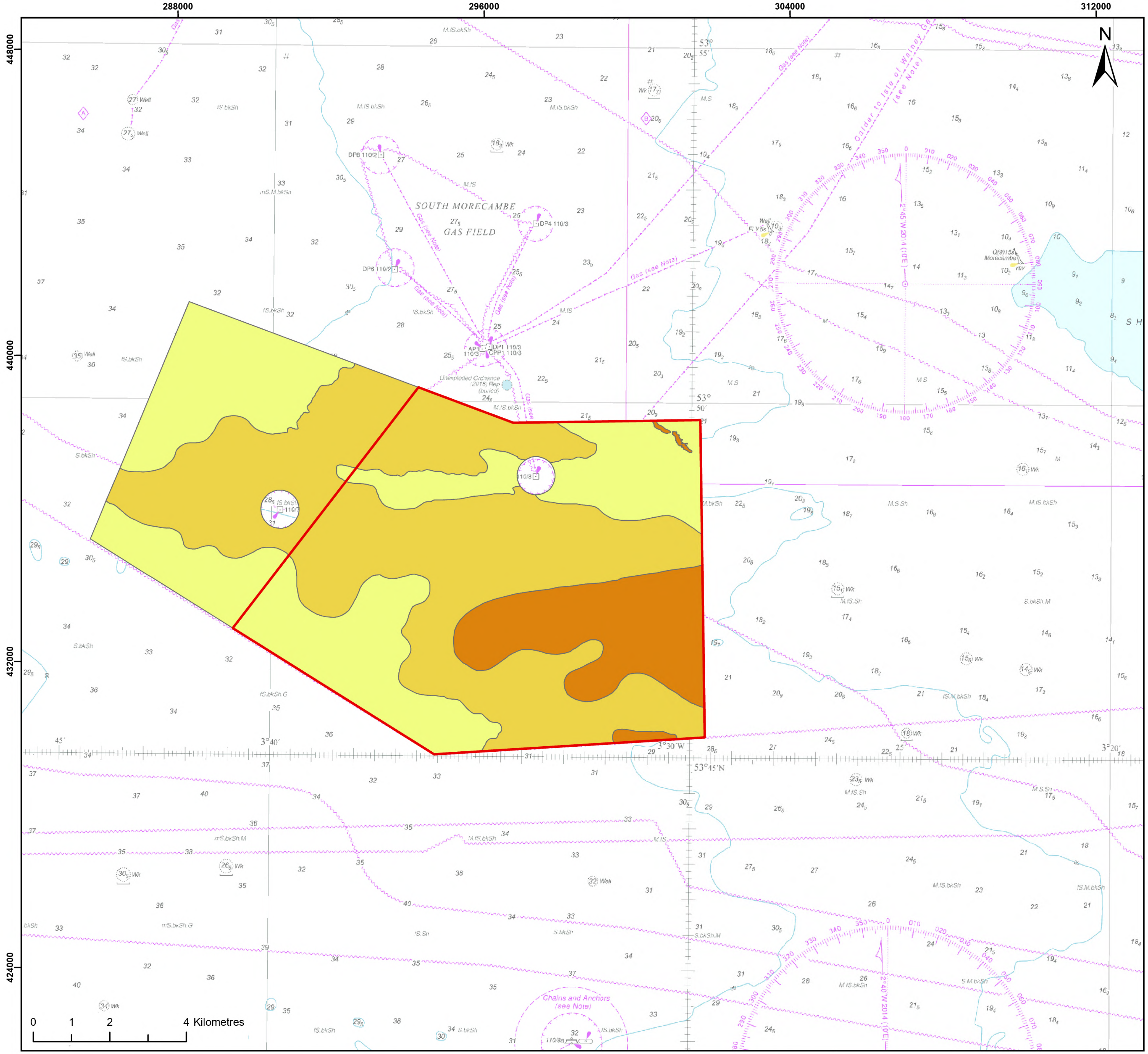
19. The Project windfarm site falls within the Eastern Irish Sea Mud Belt, which is characterised by a smooth and relatively featureless seabed (British Geological Survey (BGS), 2005). The seabed gradient across the windfarm site is described as 'very gentle', with slopes of less than 1° across most of it (MMT, 2022; Plate 7.2 in **Chapter 7 Marine Geology, Oceanography and Physical Processes**). Maximum seabed gradients are observed in isolated areas on the flanks of megaripples (defined as features with wavelengths of 0.5 – 25m and heights of up to 0.5m) (MMT, 2022; **Appendix 7.1 Offshore Geophysical Survey Report** of **Chapter 7 Marine Geology, Oceanography and Physical Processes** (Document Reference 5.2.7.1)).

20. An overview of sediment classification across the windfarm site, based on geophysical survey data, is provided in the Offshore Geophysical Survey Report (MMT, 2022; **Appendix 7.1** of **Chapter 7 Marine Geology, Oceanography and Physical Processes**) and **Figure 2.1**. This shows the site is broadly characterised[2] by sand in the north-east and south-west of the site, clayey sand in the centre of the site and gravelly sand to the east of the site. The survey report notes that '*all of the depositional units mapped at the seabed have similar lithology of predominately sand with laterally variable minor fractions of lithic or shell gravel, clay or silt*'.

21. A site-specific grab sampling campaign, with particle size analysis (PSA) and macrofaunal sampling, was completed at 36 locations across the windfarm site by Ocean Ecology Limited (OEL) from 16th May to 8th June 2022 (OEL, 2022) (**Figure 2.2**). A further 14 locations were also sampled outside and to the west of the windfarm site.

[2] Soil classification is in ISO 14688-1 which establishes the basic principles for the identification and classification of soils on the basis of those material and mass characteristics most commonly used for soils for engineering purposes.

22. The average sediment type across the windfarm site is fine sand (Folk and Ward description). Median particle sizes (d_{50}) range between 0.044mm (coarse silt) and 0.35mm (medium sand). Average gravel content is 0.1% across 35 samples, with only one station (ST 01) comprising a higher gravel content (20.6%). Average mud content across all samples within the windfarm site is 22.5%, ranging from 0% at ST 08 and ST 10 to 55.6% at ST 45. Mud content is less than 30% in 67% of samples and less than 10% in 19% of samples within the windfarm site. The stations with the highest silt content are found in the eastern half of the windfarm site. The average sand content of all 36 samples is 76.9%.



Legend:

Morecambe Offshore Windfarm Site

Sediment classification across the geophysical survey area (MMT, 2022)

- Sand
- Clayey Sand
- Gravelly Sand

Report:
Morecambe Offshore Windfarm: Generation Assets Sediment Disposal Site Characterisation Report

Title:
Sediment classification across the geophysical survey area (MMT, 2022)

Figure: 2.1 | Drawing No: PC1165-RHD-ES-OF-DG-Z-0072

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
P01	17/10/2023	JT	GC	A3	1:100,000
P02	09/04/2024	JH	SB	A3	1:100,000

Co-ordinate system: WGS 1984 UTM Zone 30N

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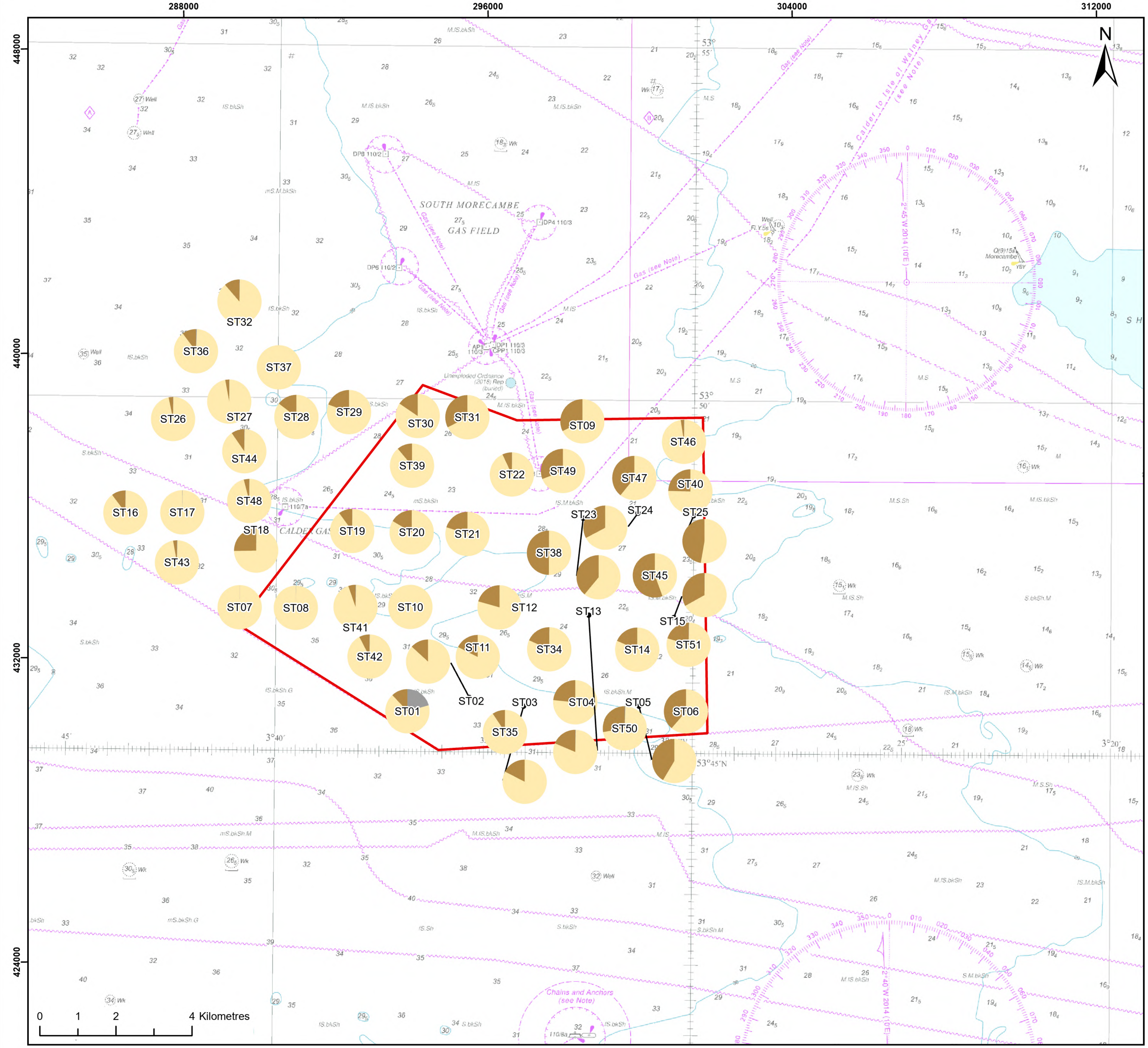

Legend:

Morecambe Offshore Windfarm Site

Seabed Sediment Sample Locations - Major Sediment Fractions

% Gravel

% Sand

% Mud

Report:
Morecambe Offshore Windfarm: Generation Assets Sediment Disposal Site Characterisation Report

Title:
Sediment sampling locations (Ocean Ecology Limited, 2022)

Figure: 2.2 | Drawing No: PC1165-RHD-ES-OF-DG-Z-0073

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
P01	17/10/2023	JT	GC	A3	1:100,000
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Co-ordinate system: WGS 1984 UTM Zone 30N

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2.1.4 Suspended sediment concentrations

23. Centre for Environment Fisheries and Aquaculture Science (Cefas, 2016) published the spatial distribution of average suspended sediment concentrations (SSCs) between 1998 and 2015 for the seas around the UK. Average SSC in the west of the Project windfarm site were approximately 3-5mg/l, gradually increasing to approximately 5-7mg/l in the east of the windfarm site (Cefas, 2016). SSCs can be locally elevated due to tidal currents, particularly when strong tidal currents (e.g., spring tides) coincide with storms, when concentrations may increase up to several hundred mg/l. For example, near bed SSCs data available from the Gwynt y Môr Offshore Windfarm array area indicated that during storm conditions, near bed SSC can reach more than 300mg/l (Gwynt y Môr Offshore Wind Farm Limited, 2005). SSCs would gradually decrease to baseline levels following the end of the storm.

2.2 Chemical characteristics

24. This section provides a summary of the chemical characteristics of the Project disposal site. Further information can be found in **Appendix 1** and **Chapter 8 Marine Sediment and Water Quality** (Document Reference 5.1.8) of the ES.

25. A total of 20 sediment samples (14 within the windfarm site) were collected in 2022, as part of the Project site specific grab sampling campaign (OEL, 2022; **Figure 2.3**) and sent for chemical analysis. Sample sites were selected to cover all sediment types, including fine material, as well as in proximity to existing oil and gas infrastructure. **Chapter 9 Benthic Ecology** of the ES (Document Reference 5.1.9) summarises the analysis results for the following parameters:

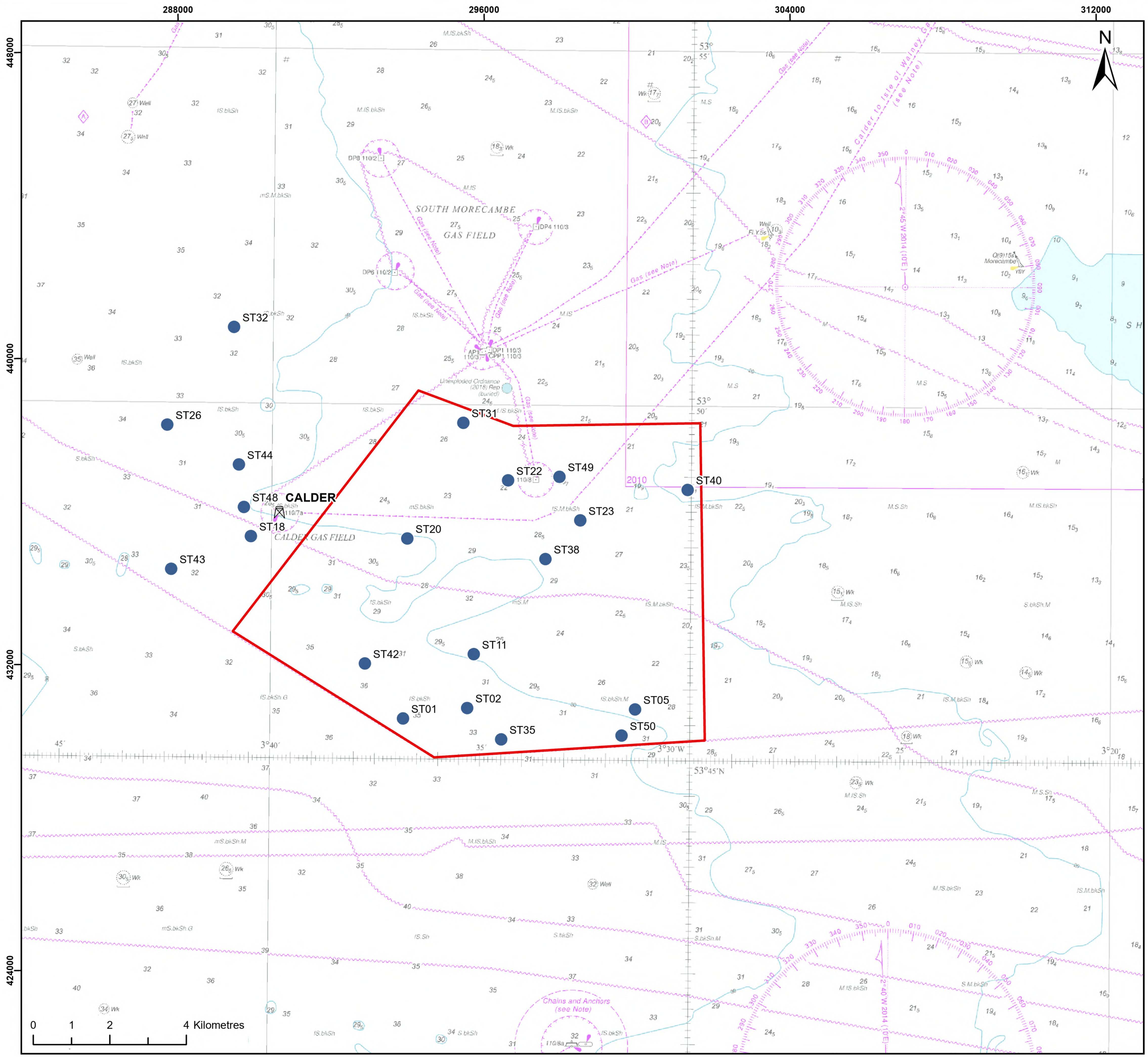
- Total Organic Carbon (TOC)
- Total Organic Matter (TOM)
- Heavy and Trace metals (arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni) and zinc (Zn))
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Total hydrocarbons (THC)
- Organotins (Dibutyltin (DBT) and Tributyltin (TBT))
- Polychlorinated Biphenyls (PCBs)

26. Values for contaminants in samples collected for the Project were assessed against OSPAR's Background Assessment Concentration (BAC) and Effects Range-Low (ERL), and Cefas' action levels (ALs).

27. With respect to metals, concentrations indicated very low levels of contamination. The only parameter exceeding either of the sediment guideline values was mercury for OSPAR BAC (five samples) and only one sample recorded levels at the ERL (i.e., sample concentration equalled the ERL). These findings are broadly in line with the findings of the OSPAR interim assessment (2017) for the region. All other parameters were below all guideline values applied and, therefore, below findings in the OSPAR interim assessment (2017). No samples exceeded the Cefas ALs.

28. With respect to PAHs, several samples exceeded the BAC. Where exceedances occurred, concentrations were only marginally above the BAC value. Concentrations of PAHs are, therefore, very low across the windfarm site and in line with the findings of the OSPAR interim assessment (2017). No samples exceeded the Cefas AL1 value. THC in sediment samples ranged from 1.00mg/kg to 33.70mg/kg, again indicating relatively low levels of contamination.

29. Given the low concentrations of contaminants, it was agreed with the Marine Management organisation (MMO) and Natural England (NE) that indirect effects to ecological receptors from resuspension of contaminants could be scoped out of the ES.



Legend:

- Morecambe Offshore Windfarm Site
- Survey sampling locations for contaminants

Oil & Gas Infrastructure

- Offshore platform

Report:
Morecambe Offshore Windfarm: Generation Assets Sediment Disposal Site Characterisation Report

Title:
Site specific survey sampling locations for contaminants. (Ocean Ecology Limited, 2022)

Figure: 2.3 Drawing No: PC1165-RHD-ES-OF-DG-Z-0074

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
P01	17/10/2023	SB	GC	A3	1:100,000
P02	09/04/2024	JH	SB	A3	1:100,000

Co-ordinate system: WGS 1984 UTM Zone 30N

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2.3 Biological characteristics

30. **Sections 2.3.1** – **2.3.3** provide a summary of the biological characteristics of the Project disposal site. Further information is set out in **Chapter 9 Benthic Ecology**, **Chapter 10 Fish and Shellfish Ecology** (Document Reference 5.1.10) and **Chapter 11 Marine Mammals** (Document Reference 5.1.11) of the ES.

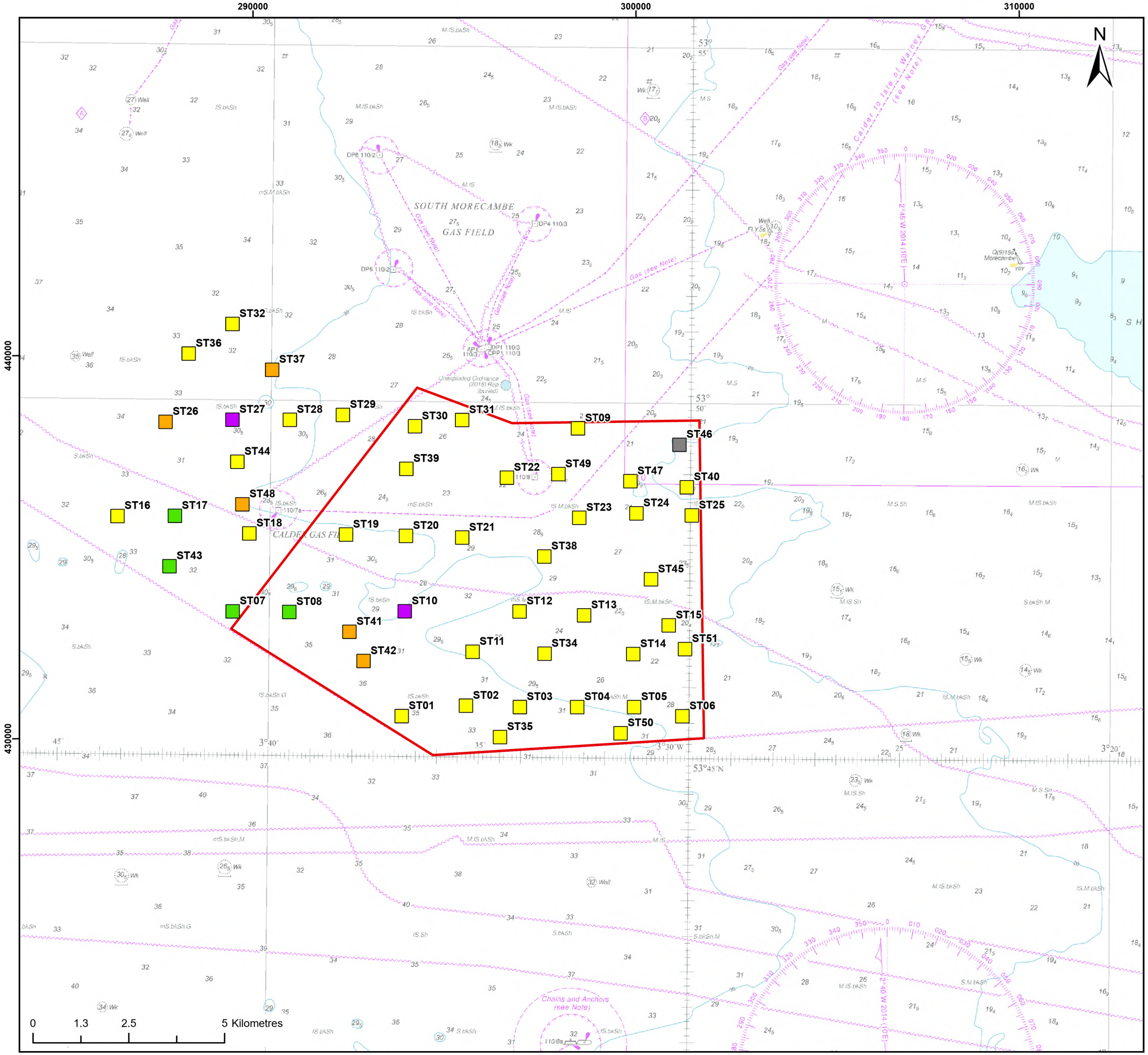
2.3.1 Benthic Ecology

31. A site-specific benthic characterisation survey was undertaken by OEL in May/June 2022. This survey was used to identify the presence and distribution of macrobenthic fauna across the windfarm site, comprising infauna (i.e. living within the sediment) and epifauna (i.e. living on the surface of the seabed). Epifauna comprised sessile, solitary species, such as sea urchins and brittlestars; colonial organisms such as bryozoans were largely absent, given the lack of hard substrate for colonisation. Full detail on the macrofaunal communities recorded during the benthic characterisation survey is provided in the Morecambe Offshore Windfarm Benthic Characterisation Survey Report (OEL, 2022; **Appendix 9.1 Benthic Characterisation Survey** (Document Reference 5.2.9.1) of **Chapter 9 Benthic Ecology** of the ES).

32. Of the 154 taxa identified, Annelida (segmented worms) was the most diverse phylum present, representing approximately 40% of the taxa recorded. This was followed by Crustacea, Mollusca, miscellaneous other phyla (namely Bryozoans, Cnidarians, Entoprocta and Tunicates) and Echinodermata. No Invasive Non-Native Species (INNS) or commercial species were recorded.

33. By contrast, Mollusca taxa contributed most to the overall abundance recorded in the survey, accounting for approximately 40% of all individuals recorded, followed by Echinodermata (33%). Echinodermata represented 67% of the total biomass across the survey area.

34. The two-toothed Montagu shell *Kurtiella bidentata* was the most abundant and frequently occurring taxon recorded from the survey, with 2,706 individuals (accounting for 33.0% of all individuals recorded) and present in 44 samples (i.e. 88% of stations). Other abundant and/or frequently-occurring taxa included the brittlestar *Amphiura filiformis* (accounting for 29.2% of all individuals and present in 78% of samples) and the polychaete *Sthenelais limicola* (accounting for only 2.0% of all individuals but present in 78% of samples).



Legend:

Morecambe Offshore Windfarm Site

2022 Benthic Survey macrobenthic groupings (similarity slice 31%)

- A (average similarity 41.79)
- B (average similarity 37.80)
- C (average similarity 45.33)
- D (average similarity 34.11)
- Outlier

Report:
Morecambe Offshore Windfarm: Generation Assets Sediment Disposal Site Characterisation Report

Title:
2022 Benthic Survey Macrobenthic Groupings (similarity slice 31%) (Ocean Ecology Limited, 2022)

Figure: 2.4 Drawing No: PC1165-RHD-ES-OF-DG-Z-0092

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Co-ordinate system: WGS 1984 UTM Zone 30N

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35. Seabed video footage at grab sample stations and 4 transects (all within the windfarm site) across the surveyed area, plus associated still imagery (a total of 404 still images), were used in conjunction with the particle size data and macrofaunal data, to classify stations in terms of broadscale/main habitats and biotopes, in line with the European Nature Information System (EUNIS) habitat classification. Four EUNIS level 4 habitat types were encountered during review of the imagery from the benthic surveys, summarised in **Table 2.1**. A5.26 'circalittoral muddy sand' was the most frequently encountered, having been assigned to 69% of the images analysed from the site. A5.25 'circalittoral fine sand' was encountered in 16% of the images, A5.44 'circalittoral mixed sediments' were encountered in 12% of the images and A5.35 'circalittoral sandy mud' was encountered in 3% of the images.

Table 2.1 EUNIS habitat type classifications identified during benthic surveys at the windfarm survey area

Level 3 Broadscale habitat (EUNIS 2012)	Level 4 habitat type (EUNIS 2012)	EUNIS 2022 equivalent
A5.2 Sublittoral sand	A5.25 Circalittoral fine sand	MC52 Atlantic circalittoral sand
	A5.26 Circalittoral muddy sand	
A5.3 Sublittoral mud	A5.35 Circalittoral sandy mud	MC62 Atlantic circalittoral mud
A5.4 Sublittoral mixed sediment	A5.44 Circalittoral mixed sediments	MC42 Atlantic circalittoral mixed sediment

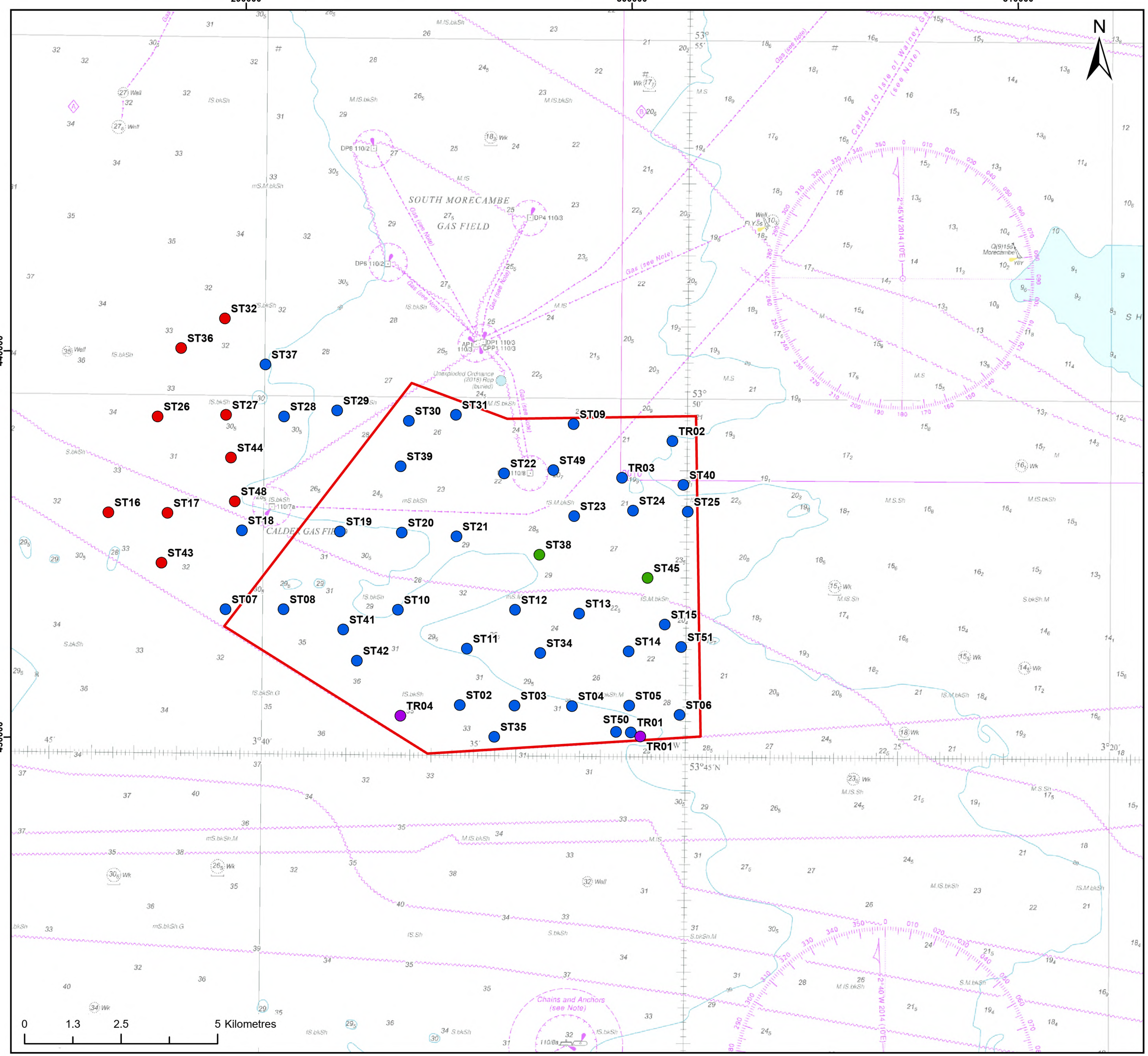
36. Spatial distribution of the Level 4 EUNIS habitat types recorded across the surveyed area during the drop-down camera (DDC) survey are presented in **Figure 2.5**. The windfarm site itself was dominated by A5.26 circalittoral muddy sand, whilst areas surveyed outside the western boundary were dominated by A5.25 circalittoral fine sands. Circalittoral mixed sediments were generally only recorded at the southern edge of the windfarm site.

37. Benthic biotope mapping has been undertaken using geophysical data sets, along with the benthic sample particle size distribution (PSD) and macrofaunal data, to interpret the distribution of habitats and biotopes across the windfarm site. The biotope mapping process is described in **Appendix 9.1** of **Chapter 9 Benthic Ecology** of the ES.

38. For each of the four macrobenthic groups presented in **Figure 2.4**, biotopes were assigned according to the Joint Nature Conservation Committee (JNCC) classification tool (JNCC, 2015) and were based upon their faunal and sedimentary characteristics. In total, two biotopes were described, the spatial distribution of which is presented in **Figure 2.6**.

39. The biotope most closely aligned with the community observed in macrobenthic group A is EUNIS (2012 classification) biotope A5.351 '*Amphiura filiformis, Mysella bidentata* and *Abra nitida* in circalittoral sandy mud'. The equivalent EUNIS biotope under the 2022 classification is MC6211 '*Amphiura filiformis, Mysella bidentata* and *Abra nitida* in Atlantic circalittoral sandy mud'. This biotope is consistent with the presence of fines in the sediment composition at the associated stations and is dominant across most of the windfarm site.

40. The biotope most closely aligned with the communities observed in macrobenthic groups B, C and D is EUNIS biotope A5.252/MC5212 '*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand'. This biotope is consistent with sediments at the associated stations being sandier, with marginally higher gravel content, and is prevalent in the southwest part of the windfarm site and areas outside the western boundary.



Legend:

- Morecambe Offshore Windfarm Site
- A5.44 - Circalittoral mixed sediments
- A5.25 - Circalittoral fine sand
- A5.26 - Circalittoral muddy sand
- A5.35 - Circalittoral sandy mud

Report: Morecambe Offshore Windfarm: Generation Assets Sediment Disposal Site Characterisation Report

Title: 2022 Benthic Survey Habitat Assignment (EUNIS level 4)

Figure: 2.5 | Drawing No: PC1165-RHD-ES-OF-DG-Z-0093

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
P01	17/10/2023	JT	GC	A3	1:100,000
P02	09/04/2024	JH	SB	A3	1:100,000

Co-ordinate system: WGS 1984 UTM Zone 30N

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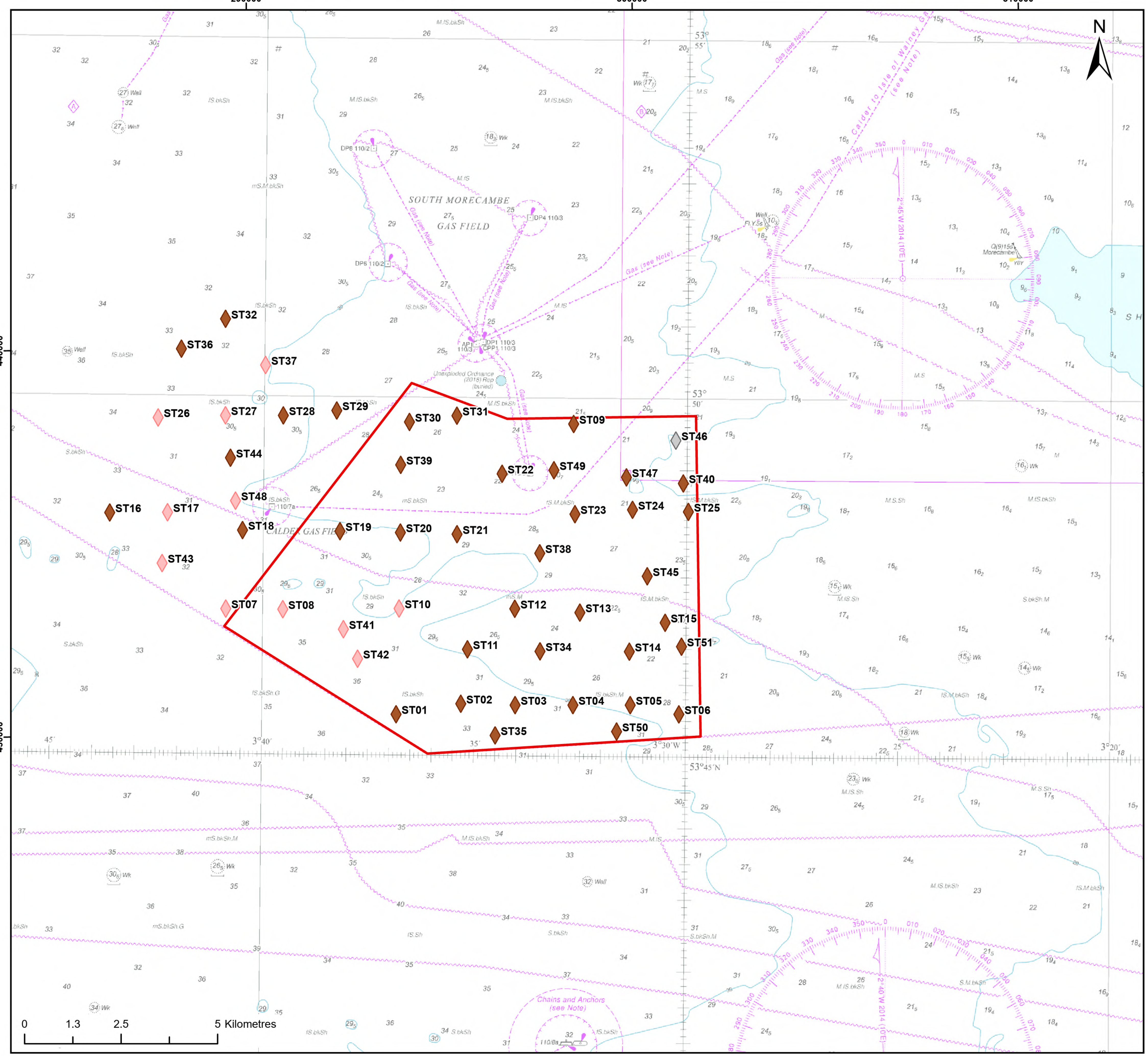

Legend:

Morecambe Offshore Windfarm Site

2022 Benthic Survey biotope assignment (EUNIS level 5)

- A5.252 Abra prismatica, Bathyporeia elegans and polychaetes in circalittoral fine sand
- A5.351 Amphiura filiformis, Mysella bidentata and Abra nitida in circalittoral sandy mud
- Not assigned

Report: Morecambe Offshore Windfarm: Generation Assets Sediment Disposal Site Characterisation Report

Title: 2022 Benthic Survey Biotope Assignment (EUNIS level 5)

Figure: 2.6 | Drawing No: PC1165-RHD-ES-OF-DG-Z-0094

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
P01	17/10/2023	JT	GC	A3	1:100,000
P02	09/04/2024	JH	SB	A3	1:100,000

Co-ordinate system: WGS 1984 UTM Zone 30N

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2.3.2 Fish and Shellfish Ecology

41. The windfarm site overlaps, or is in close proximity to, a number of fish spawning and nursery grounds, including sand eel, common sole, plaice, cod, whiting and mackerel. It is also noted that herring spawning grounds, whilst not overlapping the windfarm site, are found over 40km to the northwest of the windfarm site (Coull *et al*. 1998).

42. Based on landings data, the key (>1% of total landings from International Council for the Exploration of the Sea (ICES) rectangle 36E6) demersal species found in the vicinity of the study area are plaice, common sole, European bass and flounder (National Statistics, 2023).

43. Pelagic species likely to occur in the study area include Atlantic herring, Atlantic mackerel and European sprat (National Statistics, 2021; Coull *et al.*, 1998; Ellis *et al.*, 2012).

2.3.3 Marine Mammals

44. The key marine mammal species relevant to the Project study area are Harbour porpoise, Bottlenose dolphin, Common dolphin, Risso's dolphin, White-beaked dolphin, Minke whale, Grey seal and Harbour seal.

45. Site-specific aerial surveys were conducted for both marine mammals and seabirds. HiDef Aerial Surveying Limited ('HiDef') collected high resolution aerial digital still imagery for marine megafauna (combined with ornithology surveys). The aerial surveys commenced in March 2021 and concluded in February 2023.

46. Harbour porpoise was the most commonly sighted marine mammal species during the site-specific surveys, consistently present throughout each month and were widespread across the survey area. Overall, 925 individuals were recorded in the 24-month survey period.

47. The Project is located in the NW England Management Unit (MU). The two largest, and effectively the only large haul-out sites in the NW England MU, are at West Hoyle Bank (often referred to as Hilbre Island) in the Dee estuary, in Cheshire (approximately 45km from the Project) and at South Walney, in Cumbria (approximately 35km from the Project), which is the only known grey seal breeding site on the mainland in the NW England MU (SCOS, 2021).

2.4 Human characteristics

48. **Sections 2.4.1– 2.4.4** provide a summary of the human characteristics of the Project disposal site. Further information is set out in **Chapter 13 Commercial Fisheries** (Document Reference 5.1.13), **Chapter 14 Shipping and Navigation** (Document Reference 5.1.14), **Chapter 15 Marine Archaeology**

and Cultural Heritage (Document Reference 5.1.15) and **Chapter 17 Infrastructure and Other Users** (Document Reference 5.1.17) of the ES.

2.4.1 Commercial Fisheries

49. Mean annual fisheries landings data for ICES rectangle 36E6 between 2018 and 2022, by species (over 0.5 tonne), shows that catches within this rectangle were dominated by shellfish, with queen scallops representing 37.9% of all landings, whelks 37.5% and king scallops 19.2%. The top two fish species by landed weight were thornback ray, representing 1.7% of all landings, and common sole representing 1.2% (National Statistics, 2023).

2.4.2 Shipping and Navigation

50. The Liverpool Bay Traffic Separation Scheme (TSS) is the closest shipping routeing measure, located approximately 12.4nm south of the Project windfarm site. This TSS deconflicts vessel traffic on passage to/from the Mersey ports and maintains a safe distance between vessels, the oil and gas infrastructure to the north and the Gwynt y Môr offshore windfarm to the south. The area surrounding the Douglas Oil Field infrastructure is charted as an Area to be Avoided with the accompanying note: ‘The IMO-adopted Area to be Avoided should only be entered by authorised vessels to access the Douglas Oil Field’.

51. Aids to Navigation (AtoN) marking oil and gas infrastructure are located within the study area, including the Calder 110/7a platform.

52. The windfarm site and study area are outside of any Vessel Traffic Service (VTS) or Local Port Service (LPS) areas. A number of ferries operate in the study area, including routes from Liverpool and Heysham to the Isle of Man and Belfast.

2.4.3 Marine Archaeology and Cultural Heritage

53. There are no known seabed prehistory sites within the Project windfarm site.

54. An archaeological review of the geophysical survey assessments and ground model covering the Project AfL area (including the windfarm site) was conducted by MSDS Marine. Based on the characterisation of the existing environment and the identification of known and potential heritage assets a total of four Archaeological Exclusion Zones (AEZs) and one Temporary Exclusion Zone (TEZ) have been established within the windfarm site. A total of 21 anomalies of potential archaeological interest were identified within the windfarm site, however, none of these were determined to be of high archaeological potential. A total of 17 of the anomalies in the windfarm site have been interpreted as low archaeological potential, whilst four anomalies were interpreted as of medium archaeological potential.

55. There are no known sites within the windfarm site that are subject to statutory protection from the Protection of Wrecks Act 1973, the Protection of Military Remains Act 1986 or the Ancient Monuments and Archaeological Areas Act 1979.

2.4.4 Infrastructure and Other Users

56. The closest operational windfarm to the Project is West of Duddon Sands (12.9km). Other proposed projects in proximity to the Project are Morgan Offshore Wind Project (16.7km northwest of the windfarm site) and Mona Offshore Wind Project (10.0km west of the Project windfarm site)

57. The Project windfarm site overlaps with the Morecambe South gas fields (owned and operated by Spirit Energy Production UK Limited) and the Calder gas field (owned by Harbour Energy PLC and operated by Spirit Energy Production UK Limited on their behalf). These fields are supported by offshore infrastructure (platforms, pipelines, cables and wells) and onshore facilities for extracting, transporting and processing reserves.

58. There are several active and closed disposal sites within 50km of the Project windfarm site. The nearest closed site is IS195, associated with the Gateway Gas Storage Project, which is 4.1km to the east of the windfarm site. The nearest active disposal site is IS150, which lies 16.8km to the south of the windfarm site. There are also several aggregate sites within 50km of the Project, with the nearest being Area 457 Liverpool Bay Aggregate Production Area, which lies 9.5km south of the windfarm site and is operated by Westminster Gravels for the extraction of sand and gravel.

3 Type of material to be disposed

59. As discussed in **Section 2.1** and **2.2**, sediment to be disposed of from activities associated with the project would be composed of largely fine sand and have low levels of contamination.

4 Quantity of material to be disposed

60. **Table 4.1** shows the worst-case volume of sediment associated with seabed preparation for WTGs/OSP(s) and inter-array and platform link cables, pile drilling and cable installation, as well as sediment associated with operation and maintenance activities over the lifetime of the Project.

Table 4.1 Maximum quantities of sediment for each activity

Activity	Volume	Assumptions
Construction phase		
Seabed preparation for WTG/OSP(s)	481,463m^3	The worst-case sediment volume assumes up to 37 GBS foundations (35 WTGs and 2 OSPs) structures, each with a 65m base diameter, plus 10m either side and an area for two jack-up visits per WTG/OSP(s) foundation in different positions over the construction period (each jack-up has 6 legs and a 250m^2 footprint). The worst-case volume assumes that the seabed would be dredged to a depth of up to 1.5m.
Drill arisings for WTG/OSP(s) foundation installation	55,865m^3	The worst-case assumes up to 30 'large' monopile foundations. The drill diameter is 12.6m and maximum installation depth is 56m. This assumes a drive-drill-drive methodology (50% drill arisings per foundation) at 50% of WTG locations.
Seabed preparation for inter-array and platform link cables	80,000m^3	The worst-case assumes that 10% of the length of inter-array and platform link cables with a 10m corridor width would require sandwave clearance/levelling. The average sandwave height is assumed to be 1m.
Inter-array and platform link cable installation	540,000m^3	The worst-case assumes that up to 70km of inter-array cables plus 10km of platform link cables are installed with a 3m trench width. Assumes that 50% of the length of inter-array and platform link cables are buried at 3m and that 50% of the length is buried at 1.5m. In consideration of the Marine (Scotland) Act 2010 definition of dredging "*using any device to move any material (whether or not suspended in water) from one part of the sea or seabed to another part*" cable trenching has also been assessed, however it is noted that jetting and back filling techniques means sediment would remain in situ or within the immediate proximity of the trench.
Operation and maintenance phase		
Cable repair/replacement and reburial	315,000m^3	The worst-case for cable repair/replacement over the operational period assumes an average of up to 200m of cable repaired/replaced every year with a 10m disturbance width. Cable reburial assumes an

Activity	Volume	Assumptions
		average of up to 100m of cable reburied every year with a 10m disturbance width. The worst-case for sediment volume disturbed assumes both cable repair/replacements and reburial would have a 3m maximum depth for a box-shaped trench. As above, cable reburial (trenching) is also considered.
Decommissioning phase		
Decommissioning activities	N/A	Sediment disturbance would be expected during decommissioning, but dredging and disposal, as per construction would not be expected and not considered within this report, noting that further environmental assessments would be undertaken at the time of decommissioning. It is noted however that in the ES assessment, decommissioning is assessed as per construction at worst-case, but not included in this report.

5 Alternatives considered

61. The Waste (England and Wales) Regulations 2011 (as amended) sets out the Waste Hierarchy, a legal requirement for waste prevention and management in legislation and policy. The waste hierarchy requires the producer/holder of a waste to demonstrate that the priorities identified in **Table 5.1** have been considered in a priority order, to determine the most suitable waste management option for all wastes prior to removal from site.

Table 5.1 The Waste Hierarchy, definitions and relevant applications for dredged material

Waste Hierarchy	Definition*	Application for dredge material**
Prevention	Most favoured option. Using less material in design and manufacture. Keeping products for longer; re-use. Using less hazardous materials.	Not undertaking dredging activities unless necessary.
Preparing for re-use	Checking, cleaning, repairing, refurbishing, whole items or spare parts.	The re-use of dredged material refers to the potential to re-use dredged sediments as a sediment in a manner that would benefit society and the natural environment. Options include mid-river disposal, mudflat or beach re-charge schemes and habitat creation schemes.
Recycling	Turning waste into a new substance or product. Includes composting if it meets quality protocols.	The recycling of dredged material is the use of dredged sediments in the creation of a new substance or product (such as construction material).
Other recovery	Includes anaerobic digestion, incineration with energy recovery, gasification and pyrolysis which produce energy (fuels, heat and power) and materials from waste; some backfilling.	The treatment of sediment to be used for another purpose (i.e., processes to remove contamination). Some of these options are not considered viable for dredged material.
Disposal	Least favoured option. Landfill and incinerations without energy recovery.	Disposal to sea or landfill.

* Definitions taken from Defra (2011). Guidance on applying the Waste Hierarchy.

** Adapted from MMO (2020) and Manning *et al.* (2021).

5.1 Prevention

62. The Waste Hierarchy, as outlined guidance produced by Defra (2011), ranks ‘Prevention’ as the top priority. The type of foundations and installation methods required for WTG/OSP(s) associated with the Project are yet to be determined. Foundation types currently under consideration include GBS, multi-legged pin-piled jackets (four or three-legged), monopiles or multi-legged suction bucket jackets (three-legged). All foundation types would involve either seabed preparation (including sandwave clearance/levelling) prior to foundation installation, or drilling, both of which would result in the production of material.

63. Furthermore, sandwave levelling may need to be undertaken to enable the cables to be buried into stable sediment beneath the sandwaves to reduce the potential that cables become unburied over the lifetime of the project. As noted in **Table 4.1**, sediment would also be moved via cable trenching, however, it is noted that jetting and back filling techniques means sediment would remain in-situ or within the immediate proximity of the trench.

64. Sediment may also be excavated for cable repair/replacement and/or reburial during the operation and maintenance phase.

65. Therefore, sediment disposal is likely to be required for the construction of the Project.

66. The presence of contaminants is typically one of the primary reasons why dredged material cannot be used beneficially for habitat restoration (Manning *et al.,* 2021). It is also recognised that there are currently very few examples of recovery from dredged material (such as biomass or energy recovery).

67. Seabed preparation prior to foundation and cable installation is essential to create a flat and stable surface. However, it would be ensured that the amount of material to be dredged would be kept as low as possible. As noted in Section 7.6.2 of **Chapter 7 Marine Geology, Oceanography and Physical Processes**, given the absence of sandwaves within the windfarm site at the time of the site survey, the volume of sediment disturbed due to sandwave clearance/levelling is considered precautionary.

5.2 Reusing/recycling and other recovery

68. If prevention of the creation of waste is not an option, the next best options environmentally are to aim for the re-use or recycling of the material. The re-use of dredged material refers to the potential to re-use dredged sediments as a sediment, whilst the recycling of dredged material is the use of dredged sediments for another purpose.

69. Re-using dredged material as a sediment (re-use) can include mid-river disposal as well as mudflat or beach re-charge schemes, where sediment is fed back into the local sediment system. The re-use of sediments can also extend to the use of material as a sediment within habitat creation schemes, although often this can be interpreted as the recycling of sediments, as the purpose of the sediment is more in line with using the sediment as construction materials as part of a wider scheme (i.e. flood defence, climate change adaptation projects, creation of new habitats). Recycling additionally includes the use of sediments in the construction of coastal defences, land reclamation and use within construction projects.

70. Where extensive excavation works are required, it is possible that material could be retained and used for infill works, or ballast material, if technically

suitable for purpose. Ballast material is heavy material which is loaded into designated void spaces within the lower part of the foundation adding weight to enhance its stability and is likely to be composed of locally dredged sand.

71. The use of excavated material as ballast would depend on a relevant foundation type being selected, based on a range of factors, including technical feasibility and installation programme, and the results of detailed post-consent geotechnical investigations. It would also depend on the quality of excavated material.

72. Therefore, no potential alternative uses have been identified at this time.

5.3 Disposal

73. The largest open disposal sites in the vicinity of the Project are Site Y (16.8km from the Project) and IS205 Barrow D Disposal Area (22.7km from the Project), however, these disposal sites are typically licenced for a specific volume of sediment and would not permit additional sediment disposal beyond their designated use.

74. Furthermore, the transport of large quantities of sediment from the Project to these disposal sites would involve a large number of return vessel trips and it is unknown whether the sediment characteristics are suitable for disposal in these locations. Retaining the sediment from Project activities within the Order Limits would ensure a similar sediment type is placed on the seabed and is subject to the same hydrodynamic and sediment transport regimes.

75. It is therefore concluded that disposal at an existing disposal site is not a suitable option.

5.4 Summary

76. As seabed preparation activities would not be taking place until Q2 2027 at the earliest, liaison with external organisations to identify potential suitable beneficial use schemes has not yet been undertaken. Prior to the commencement of the seabed preparation activities, engagement with local organisations to determine suitable alternative uses for the dredge material would be undertaken. Should a suitable alternative use be identified for acceptance of some, or all, of the material in Q2 2027, this would be prioritised prior to disposal at sea.

6 Potential impacts of sediment disposal

77. As far as possible, the Applicant intends to dispose of sediment in the vicinity from which it was extracted, such that the disposed sediment is a similar type to the seabed it is disposed upon and is subject to the same sedimentary and hydrodynamic processes. The impact of sediment excavation and disposal on physical and human characteristics of the site has been assessed in line with the overarching method outlined in **Chapter 6 EIA Methodology** (Document Reference 5.1.6) of the ES and is also presented within **Chapter 7 Marine Geology**, **Oceanography and Physical Processes**, **Chapter 8 Marine Sediment and Water Quality**, **Chapter 9 Benthic Ecology, Chapter 10 Fish and Shellfish Ecology**, **Chapter 11 Marine Mammals**, **Chapter 13 Commercial Fisheries** and **Chapter 15 Marine Archaeology and Cultural Heritage** of the ES.

78. It should be noted that the ES assesses the impacts of the Project as a whole. Therefore, **Table 6.1** draws out the impacts of the relevant chapter that are specifically associated with dredge/excavation and disposal. These impacts are subsequently described in **Sections 6.1**, **Section 6.2** and summarised in **Table 7.1**.

Table 6.1 ES chapters and impacts relevant to this assessment

ES chapter	Phase	Impacts which contain relevant information for this assessment and relevant ES reference	Relevant section assessed in this report
Chapter 7 Marine Geology, Oceanography and Physical Processes	Construction	Changes in SSCs due to seabed preparation for foundation installation (Section 7.6.2.1)	**Section 6.1.1.1**
		Changes in seabed level due to seabed preparation for foundation installation (Section 7.6.2.3)	
		Changes in SSCs due to drill arisings for installation of piled foundations (Section 7.6.2.2)	
		Changes in seabed level due to drill arisings for installation of piled foundations (Section 7.6.2.4)	
		Changes in SSCs due to seabed preparation and installation of inter-array and platform link cables (Section 7.6.2.5)	
		Changes in seabed level due to seabed preparation and installation of inter-array and platform link cables (Section 7.6.2.6)	
		Interruptions to bedload sediment transport due to sandwave levelling for cable installation (Section 7.6.2.7)	
	Operation and maintenance	Cable and WTG/OSP(s) maintenance (Section 7.6.3.6)	**Section 6.1.1.2**

ES chapter	Phase	Impacts which contain relevant information for this assessment and relevant ES reference	Relevant section assessed in this report
Chapter 8 Marine Sediment and Water Quality	Construction	Increase in SSCs due to seabed preparation for foundation installation (Section 8.6.1.1)	**Section 6.1.2.1**
		Increase in SSCs due to drill arisings for foundation installation (Section 8.6.1.2)	
		Increase in SSCs due to seabed preparation for inter-array and platform link cables (Section 8.6.1.3)	
		Deterioration in water quality associated with release of sediment bound contamination (Section 8.6.1.4)	
	Operation and maintenance	Increase in SSCs associated with cable repairs and reburial activities (Section 8.6.2.1)	**Section 6.1.2.2**
		Deterioration in water quality due to resuspension of sediment bound contamination (Section 8.6.2.2)	
Chapter 9 Benthic Ecology	Construction	Increases in SSCs and subsequent deposition (Section 9.6.3.2)	**Section 6.1.3.1**
	Operation and maintenance	Temporary increases in SSCs/sedimentation during operation and maintenance activities (Section 9.6.4.6)	**Section 6.1.3.2**
Chapter 10 Fish and Shellfish Ecology	Construction	Increased suspended sediments and sediment re-deposition (Section 10.6.2.2)	**Section 6.1.4.1**
	Operation and maintenance	Temporary habitat loss/disturbance and increased suspended sediments (and subsequent deposition) (Section 10.6.3.2)	**Section 6.1.4.2**
Chapter 11 Marine Mammals	Construction	Changes to prey resources (Section 11.6.3.7)	**Section 6.1.5.1**
		Changes to water quality (Section 11.6.3.8)	
	Operation and maintenance	Changes to prey resources (Section 11.6.4.7)	**Section 6.1.5.2**
		Changes to water quality (Section 11.6.4.8)	

ES chapter	Phase	Impacts which contain relevant information for this assessment and relevant ES reference	Relevant section assessed in this report
Chapter 13 Commercial Fisheries	Construction	Displacement or disruption of commercially important fish and shellfish resources (Section 13.6.2.3)	**Section 6.2.1.1**
	Operation and maintenance	Displacement or disruption of commercially important fish and shellfish resources (Section 13.6.3.3)	**Section 6.2.1.2**
Chapter 15 Marine Archaeology and Cultural Heritage	Construction	Direct impact to potential heritage assets (Section 15.6.1.1)	**Section 6.2.2.1**
	Operation and maintenance	Direct impact to potential heritage assets (Section 15.6.1.1)	**Section 6.2.2.2**

6.1 Physical characteristics

6.1.1 Marine Geology, Oceanography and Physical Processes

79. The assessment provided in **Chapter 7 Marine Geology, Oceanography and Physical Processes** of the ES is supported by an evidence-base obtained from research into the physical impacts of marine aggregate dredging on sediment plumes and seabed deposits (Whiteside *et al*., 1995; John *et al*., 2000; Hiscock and Bell, 2004; Newell *et al*., 2004; Tillin *et al*., 2011; Cooper and Brew, 2013), as well as numerical physical processes modelling for nearby projects (undertaken for Awel y Môr (AyM) Offshore Windfarm, 2022), Morgan Offshore Wind Project Generation Assets (Morgan Offshore Wind Limited, 2023a) and Mona Offshore Wind Project (Mona Offshore Wind Limited, 2023a). The various modelled scenarios for each of these proposed Irish Sea projects, and a justification of this approach, is presented in detail in Section 7.4.3.3, Section 7.6.2 and Section 7.6.3 of **Chapter 7 Marine Geology, Oceanography and Physical Processes** of the ES.

80. **Chapter 7 Marine Geology, Oceanography and Physical Processes** of the ES assessed potential effects of sediment excavation and disposal on receptors with an inherent geological or geomorphological value or function within 30km of the Project.

81. Based on the tidal excursion ellipse, the only physical processes receptors with the potential to be impacted by the Project are:

- Fylde Marine Conservation Zone (MCZ) (located 8km from the Project)
- Shell Flat and Lune Deep Special Area of Conservation (SAC) (located 10km from the Project)
- Annex I sandbanks (located 8km from the Project)

82. The receptors outlined above are described in detail in Section 7.6.1 of **Chapter 7 Marine Geology, Oceanography and Physical Processes** of the ES.

83. **Section 6.1.1.1** to **Section 6.1.1.3** below focusses on the potential impacts of sediment excavation and disposal on the receptors identified above. A summary of the assessment sections below is provided in **Table 7.1**.

6.1.1.1 Construction phase

Changes in SSCs due to seabed preparation for foundation installation

84. Seabed preparation (including sandwave clearance/levelling) for the installation of WTGs/OSP(s) foundations has the potential to disturb sediments from the seabed (near-surface sediments), which may result in increased SSCs. The worst-case scenario adopted to inform the ES

assessments assumes that up to 481,463m^3 (see **Table 4.1**) of sediment would be removed and returned to the water column at the sea surface as overflow from a dredge vessel.

85. Conceptual evidence-based assessment suggests that any medium and coarse-grained sediment disturbed by the drag head of the dredger at the seabed would remain close to the seabed and settle back to the bed rapidly. Most of the sediment released at the water surface from the dredge vessel 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 (east or north-east on a flood tide, and to the west or south-west on an ebb tide).

86. The finer sand fraction from this release would 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 modest concentration plume (tens of mg/l) for around half a tidal cycle (around 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 amounts of suspended sediment would extend further from the dredged area, along the axis of predominant tidal flows, the magnitudes would be indistinguishable from background levels.

87. This assessment was supported by numerical physical processes modelling undertaken for AyM Offshore Windfarm, Morgan Offshore Wind Project and Mona Offshore Wind Project (see Section 7.6.2.1 of **Chapter 7 Marine Geology, Oceanography and Physical Processes**) of the ES.

88. The receptors outlined in **Section 6.1.1** are not sensitive to increases in SSCs, because they are characterised by processes that are active along the seabed and not affected by increases in SSCs in the water column.

89. The magnitude of effect would be medium in the near-field (within a few hundred metres, up to a kilometre) and low in the far-field (beyond a kilometre). Although there would be a modest increase in SSCs within the disposal site, close to the point of excavation and in the location of disposal, it would be relatively short-lived (hours to days), and would reduce to background levels, due to tidal currents.

90. Therefore, the assessment concluded that there is no change on the identified receptor groups associated with increases in SSCs, due to seabed preparation, and no significant effect in EIA terms would occur.

Changes in seabed level due to seabed preparation for foundation installation

91. The increase in SSCs associated with **Section 6.1.1.1** has the potential to raise the seabed elevation slightly through deposition. The conceptual

evidence-based assessment suggests that coarser sediment disturbed during seabed preparation would fall rapidly to the seabed (minutes or tens of minutes), as a highly turbid dynamic plume, immediately after it is discharged. Deposition of this sediment would form a 'mound' local to the point of release.

92. The resulting mound would be a measurable protrusion above the existing seabed, but would remain local to the release point. The geometry of each of these produced mounds would vary across the windfarm site, depending on the prevailing physical conditions, but in all cases, the sediment within the mound would be similar to (but not exactly the same as) both the seabed that it has replaced and the surrounding seabed. The baseline particle size distribution data for the windfarm site shows that the seabed is dominated by fine sand, with overall compositional variations related to the volumes of medium sand and very fine sand. Average mud content is less than 30% in 76% of samples and less than 10% in 30% of samples. This would mean that there would be a small, but insignificant, change in seabed sediment type, likely to be caused by differences in the volume of the coarser fraction in the mound, compared to the natural seabed.

93. Also, the overall change in elevation of the seabed would be small, compared to the absolute depth of water (up to 40m below LAT in the south-southwest of the windfarm site and up to 18m below LAT in the eastern part of the site). The change in seabed elevation is within the ranges of natural change to the seabed caused by sandwaves and sand ridges and, hence, the blockage effect on physical processes would be negligible.

94. The mound would be mobile and be driven by the physical processes, rather than the physical processes being driven by it. This means that, over time, the sediment comprising the mound would gradually be re-distributed by the prevailing waves and tidal currents.

95. In addition to localised mounds, finer grained sediment within the windfarm site would form a passive plume and become more widely dispersed before settling on the seabed.

96. Given the lack of coarser sediment at the Project windfarm site, it is considered that most of the sediment disturbed during seabed preparation would form a passive plume and deposit farther afield within one spring tidal excursion ellipse (approximately 10km). As shown by the numerical modelling undertaken for the Morgan and Mona Offshore Wind Projects and AyM Offshore Wind Farm (see Section 7.6.2.3 of **Chapter 7 Marine Geology, Oceanography and Physical Processes**), changes in seabed level, due to seabed preparation for foundation installation, would be in the order of millimetres over the affected area (within approximately 10km of the disturbance, in line with one spring tidal excursion ellipse) and would be indistinguishable from background levels.

97. While the value of Fylde MCZ, Shell Flat and Lune Deep SAC and Annex I sandbanks is high, sensitivity is negligible, because the receptors are naturally exposed and tolerant to sediment redistribution.

98. Given the deposition is effectively a veneer, the magnitude is low in the near-field and negligible in the far-field. The tidal excursion ellipse overlaps only a small proportion of the Fylde MCZ, Shell Flat and Lune Deep SAC and Annex I sandbanks. Deposition thicknesses would be indistinguishable, as these features are 8km from the Project windfarm site.

99. Receptors are remote from the Project windfarm site and, as such, based on a negligible sensitivity of the identified receptors, and negligible magnitude (far-field), changes in seabed level, due to seabed preparation for foundation installation, would have a negligible adverse effect, which is not significant in EIA terms.

Changes in SSCs due to drill arisings for installation of piled foundations

100. Drilling of WTG/OSP(s) foundation has the potential to disturb up to 55,865m^3 (see **Table 4.1**) of deeper sub-surface sediments, which may result in increased SSCs.

101. Conceptual evidence-based assessment suggests that the drilling process would cause localised and short-term increases in SSCs at the point of discharge of the drill arisings. Away from the immediate release locations, elevations in suspended sediment above background levels would be very low (less than 10mg/l) and within the range of natural variability. Net movement of fine-grained sediment retained within a plume would be to the east or west, depending on the state of the tide at the time of release. The disturbance at each WTG/OSP(s) location are only likely to last for a few days for each drilling activity (noting only one foundation would be piled/drilled at any one time) within the overall foundation installation programme, lasting up to approximately 9-12 months in total. Increases in SSCs arising from one foundation installation are unlikely to persist for sufficiently long enough for them to interact with subsequent operations, and therefore, no additive effect is anticipated from multiple installations.

102. This assessment was supported by numerical physical processes modelling undertaken for AyM Offshore Windfarm, Morgan Offshore Wind Project and Mona Offshore Wind Project (see Section 7.6.2.2 of **Chapter 7 Marine Geology, Oceanography and Physical Processes** of the ES).

103. The receptors outlined in **Section 6.1** are not sensitive to increases in SSCs, because they are characterised by processes that are active along the seabed and not affected by increases in SSCs in the water column.

104. The magnitude of effect would be negligible in the near-field (confined to a small area, likely to be up to kilometre from each foundation location) and

negligible in the far-field (beyond one kilometre). Although there would be a modest increase in SSCs at the point of discharge up to a kilometre from each foundation location, this would decrease with distance away from the point of drilling to background levels.

105. Therefore, the assessment concluded that there is no change on the identified receptor groups associated with increases in SSCs generated by drill arisings and no significant effect in EIA terms would occur.

Changes in seabed level due to drill arisings for installation of piled foundations

106. The increase in SSCs and the creation of aggregated clasts of sediment associated with drill arisings outlined above has the potential to deposit and raise the seabed elevation.

107. Drilling of piled foundations could potentially occur through five different geological units; Holocene deposits potentially overlying a series of four Pleistocene units comprised of silt with sand, and diamict resting on Triassic mudstone and halite. If the drilling penetrates the diamict, then a worst-case scenario is considered, whereby the sediment released from the drilling is assumed to be wholly in the form of larger aggregated 'clasts', which would settle rapidly. These clasts would remain on the seabed (at least initially), rather than being disaggregated into individual fine-grained sediment components immediately upon release. Under this scenario, the worst-case scenario assumes that a 'mound' would reside on the seabed near the site of its release. The mounds would be composed of sediment with a different particle size and would behave differently (they would be cohesive) to the surrounding sandy seabed, and therefore represent the worst-case scenario for mound formation during construction.

108. The method for calculating the footprint of each mound follows that which was developed and agreed with NE for previous major offshore wind projects at Dogger Bank Creyke Beck (Forewind, 2013), Dogger Bank Teesside (Forewind, 2014), East Anglia THREE (East Anglia Three Limited (EATL), 2015), Norfolk Vanguard (Vattenfall, 2017) and Norfolk Boreas (Royal HaskoningDHV, 2018) and is provided in detail in **Chapter 7 Marine Geology, Oceanography and Physical Processes** of the ES. Based on this approach, the footprint of an individual 0.5m-high mound arising from the installation of an individual monopile WTG/OSP(s) would be 2,081m^2.

109. Because of their potential size, future transport of the aggregated clasts would be limited, and most would remain static within the mound. However, over time the flow of tidal currents over the mound would gradually winnow the topmost clasts (there would be a gradual disaggregation of the clasts into their constituent particle sizes), and, over time, the mound would lower through erosion. No specific calculations have been undertaken to understand how long it would take for the mounds to fully erode. The shallow mounds would

not impact the tidal or wave regime. Sediment would accumulate and form a 'ramp' over the shallow mound, allowing sediment to continue moving east with no significant changes to sediment transport pathways.

110. The mounds within the disposal site would be relatively shallow and would eventually be lowered to the seabed level by erosion over time. The magnitude of the impact is considered to be low in the near-field (local to the WTG/OSP(s) foundation) and negligible in the far-field (beyond the WTG/OSP(s) foundation).

111. Outside the disposal site, changes in seabed level due to drilling for foundation installation would have a negligible adverse effect on the identified receptors and is not significant in EIA terms.

Changes in SSCs associated with seabed preparation and installation of inter-array and platform link cables

112. Seabed preparation (including sandwave clearance/levelling) for the installation of inter-array and platform link cables has the potential to disturb sediments from the seabed (near-surface sediments). The worst-case scenario assumes that up to 80,000m^3 (see **Table 4.1**) of sediment would be excavated and returned to the water column at the sea surface as deposition from a dredge vessel. The sediment released at any one time would depend on the capacity of the dredger.

113. Installation of inter-array and platform link cables has the potential to disturb up to 540,000m^3 of seabed sediments (see **Table 4.1**). The worst-case cable laying technique is considered to be jetting, as this method disperses sediment higher into the water column compared to other methods (e.g. plough), which pushes sediment to the sides. It is important to note that the volume of sediment disturbed during seabed preparation for cable installation would be released prior to the cable installation works and, therefore, would not be additive.

114. Both processes would cause local and short-term increases in suspended sediment. Finer mobilised sediment from both activities may be transported by wave and tidal action in suspension in the water column. The disturbance effects at each location are likely to last for no more than a few days.

115. The conceptual evidence-based assessment indicates that the changes in SSCs due to sandwave clearance/levelling and cable installation would be similar to those that have been assessed in relation to the disturbance of near-surface sediments during seabed preparation activities for WTG/OSP(s) foundation installation (**Section 6.1.1.1**).

116. The receptors outlined in **Section 6.1.1** are not sensitive to increases in SSCs, because they are characterised by processes that are active along the seabed and not affected by increases in SSCs in the water column.

117. The spatial extent of this impact would be local for coarser sediments (due to their immediate settling out) and larger-scale for finer sediments. However, SSCs in the water column are predicted to return to baseline conditions within days, due to dispersion and dilution. Given the lack of coarser sediments at the Project windfarm site, most of the sediment is expected to form a passive plume and deposit farther afield, dispersing to a minimal level above background levels within a spring tidal excursion. As such, the magnitude of the impact was assessed asmedium in the near-field and low in the far-field.

118. Therefore, the assessment concluded that there is no change on the identified receptor groups associated with increases in SSCs generated, due to seabed preparation and installation of inter-array and platform link cables and no significant effect in EIA terms would occur.

Change in seabed level due to deposition from the suspended sediment plume associated with inter-array and platform link cable installation

119. The increases in SSCs associated with seabed preparation (including sandwave clearance/levelling) and cable installation outlined above have the potential to deposit and raise the seabed elevation.

120. Sediment released from seabed preparation would deposit on the seabed and behave in a similar way as outlined above.

121. The evidence-based assessment suggests that coarser sediment disturbed during cable installation would fall rapidly to the seabed (minutes or tens of minutes) as a highly turbid dynamic plume, immediately after it is discharged. Deposition of this sediment would form a linear mound (likely to be tens of centimetres high), parallel to the cable route, as the point of release moves along the excavation.

122. The finer sediment would also be released to form a passive plume and become more widely dispersed across the tidal excursion, before settling on the seabed. The conceptual evidence-based assessment suggests that, due to the dispersion by tidal currents, and subsequent deposition and re-suspension, the deposits across the wider seabed would be very thin (in the order of millimetres).

123. Given the lack of coarse sediment at the Project windfarm site, it is considered that most of the sediment disturbed during inter-array and platform link cable installation, including sandwave clearance/levelling, would form a passive plume and deposit farther afield within a spring tidal excursion. As shown by the numerical modelling undertaken for AyM Offshore Wind Farm and the Mona and Morgan Offshore Wind Projects, changes in seabed level would be mostly in the order of millimetres over the affected area (within approximately 10km of disturbance) and would be indistinguishable from background levels.

The magnitude of effect would be low in the near-field and negligible in the far-field.

124. Outside the disposal site, changes in seabed level due to deposition from the suspended sediment plume, associated with inter-array and platform link cable installation, would have a negligible adverse effect on the identified receptors, which is not significant in EIA terms.

125. Any changes in seabed level arising from SSCs during the operation and maintenance phase (for cable repair/reburial) would be intermittent and several magnitudes lower than during construction and, therefore, would not exceed the magnitude of effect anticipated for the construction phase.

Interruptions to bedload sediment transport due to sandwave levelling for inter-array and platform link cable installation

126. The removal of sandwaves could potentially interfere with sediment transport pathways that supply sediment to the local sandbank systems, or subtidal sediment habitats, including Fylde MCZ, the undesignated sandbanks and those designated under the Shell Flat and Lune Deep SAC.

127. Any excavated sediment due to sandwave clearance/levelling for cables would be disposed of within the windfarm site and, therefore, there would be no net loss of sand from the physical processes system. Tidal currents would, over time, re-distribute the sand back over the levelled area (as re-formed sandwaves). The extent of sandwave levelling required, and the specific disposal locations within the windfarm site, would be determined post-consent, following detailed geophysical surveys. Furthermore, as noted in **Section 2.1.3**, there is an absence of sandwaves within the windfarm site and, therefore, the volume of sediment disturbed due to sandwave clearance/levelling and cable installation, provided in **Table 4.1**, is considered highly precautionary.

128. Whilst the value of Fylde MCZ, Shell Flat and Lune Deep SAC and Annex I sandbanks is high, sensitivity is low. This is because the receptors are naturally exposed and tolerant to sediment redistribution and are supplied with additional sediment from the Irish Sea.

129. The magnitude is low in the near-field and negligible in the far-field, given the scale of impact and distance to local sandbank systems and subtidal sediment habitats.

130. Receptors are remote from the windfarm site (at least 8km) and, based on a low sensitivity and negligible magnitude, interruptions to bedload sediment transport due to sandwave levelling for cable installation would have a negligible adverse effect on the receptors, which is not significant in EIA terms.

6.1.1.2 Operation and maintenance phase

Changes in SSCs associated with cable and WTG/OSP(s) maintenance

131. Cable repair/replacement and/or reburial could be needed over the operational lifetime of the Project. The disturbance areas for these activities would be extremely small in comparison to installation of the cables during the construction phase (**Section 6.1.1.1**). The worst-case scenario adopted to inform the ES assessments assumes that up to 315,000m^3 (see **Table 4.1**) of sediment could be disturbed due to repair/replacements and reburial.

132. As outlined in **Section 6.1.1.1**, the receptors outlined in **Section 6.1.1** are not sensitive to increases in SSCs because they are characterised by processes that are active along the seabed and not affected by increases in SSCs in the water column.

133. SSCs arising during the operation and maintenance phase (for cable repair/reburial) would be intermittent and several magnitudes lower than those anticipated during construction. The magnitude of this impact is negligible in the near-field and negligible in the far-field.

134. Given the low sensitivity and negligible magnitude, the impact on Annex I sandbanks, Shell Flat and Lune Deep SAC and Fylde MCZ is negligible adverse, which is not significant in EIA terms.

6.1.1.3 Cumulative effects

135. **Chapter 7 Marine Geology, Oceanography and Physical Processes** of the ES identifies a list of other plans and projects with the potential for cumulative effects, which includes other construction projects, as well as existing infrastructure and disposal/aggregate grounds. Conservatively, projects within 30km were included in the assessment, including operational projects where there is ongoing sediment disturbance. Assessments consider the Project-alone impacts, as summarised below, alongside the other plans and projects.

136. Project-alone assessments, in **Section 6.1.1.1**, show seabed preparation for GBS foundations (**Table 4.1**) would result in the greatest amount of sediment released into the water column. However, as noted in **Section 6.1.1.1**, the scale of this impact would be relatively local for coarser sediments (due to settling out in the immediate vicinity) and larger-scale (over a spring tidal excursion) for finer sediments. SSCs in the water column are predicted to return to baseline conditions within days, due to dispersion and dilution. Given the lack of coarser sediments at the windfarm site, the majority of sediment is expected to form a sediment plume, which would become advected by tidal currents and deposit farther afield, dispersing to a minimal level above background levels within a spring tidal excursion.

137. Increases in SSCs arising during operation and maintenance activities for the Project would also be minimal, compared to anticipated construction related SSCs.

Cumulative impacts with offshore windfarms in the Eastern Irish Sea

Construction impacts with offshore windfarms and associated infrastructure

138. Offshore windfarms with construction phases, which have the potential to interact with the Project, are Morgan and Morecambe Offshore Wind Farms: Transmission Assets; Morgan Offshore Wind Project; Mona Offshore Wind Project; and AyM Offshore Windfarm.

139. The Morgan Offshore Wind Project is located 16.7km to the north-west of the Project and AyM is located 28.9km to the south of the Project. Given the spring tidal ellipses of approximately 10km in an east-west orientation, any suspended sediment plumes arising from construction phase activities for the Project are not anticipated to coalesce with the suspended sediment plumes arising from Morgan Offshore Wind Project or AyM. Therefore, they have not been assessed further.

140. The Mona Offshore Wind Project is located 10.0km to the west of the Project (however, the export cable route is 25km south from the Project) and the Transmission Assets which encompasses both the offshore export cables for the Morgan Offshore Wind Project and Morecambe Offshore Windfarm is adjacent to the Project. If the construction programmes of the projects overlap, it is possible that their sediment plumes could coalesce. There is potential for a slight overlap in suspended sediment plumes from the Mona Offshore Wind Project and the Transmission Assets with the Project (with no potential for interaction with suspended sediment plumes from the Mona offshore export cable route). Given that suspended sediments would be advected on the same tide, any overlap in suspended sediments would be minimal and the majority of sedimentation would occur in close proximity to each activity. Maximum changes in seabed thickness in the outer extents of the suspended sediment plume would be minimal and would be redistributed to indistinguishable levels on successive tides.

141. All effects are local and minor in comparison with the large processes driving tidal currents, waves and sediment transport. Whilst there is potential for sediment plumes to partially overlap during construction activities, given the limited spatial extent, rate of dispersal and the temporary and transient nature of these impacts, cumulative effects would result in impacts of no greater significance than the Project-alone (negligible adverse and not significant in EIA terms).

Operation and maintenance impacts with other offshore windfarms and associated infrastructure

142. There is potential for cumulative effect, due to multiple operational developments in the study area.

143. The closest existing offshore windfarms to the Project are Walney I, II and Extension IV, West of Duddon Sands, Ormonde and Barrow offshore windfarms (over 12.9km to the north). Gwynt y Môr and Burbo Bank Extension offshore windfarms are located over 28km to the south of the Project. Morgan and Morecambe Offshore Wind Farms: Transmission Assets; Morgan Offshore Wind Project, Mona Offshore Wind Project and AyM would also overlap in their operational phases.

144. The environmental assessments for these offshore windfarms concluded no discernible impact on tidal currents and waves beyond the immediate vicinity of the infrastructure themselves and there would be minimal sediment disturbance for maintenance activities.

145. Increases in SSCs caused by maintenance activities over the operational lifespan of the projects would be minimal and considerably less than those anticipated to occur during construction. Most of the suspended sediment arising from each maintenance activity would fall rapidly to the seabed after the start of works and would not travel further than one spring tidal excursion (approximately 10km). Given the separation of the projects, and that impacts are local in spatial extent during maintenance activities, no cumulative effects (above Project-alone - no change to negligible adverse and not significant in EIA terms) are anticipated with operational projects in the study area.

146. Any additive effects from the presence of the physical infrastructure associated with other offshore windfarms and the Project are localised and minor, in comparison with the large-scale processes driving sediment transport. As such, cumulative effects would result in impacts of no greater significance than those assessed for the Project-alone (negligible adverse and not significant in EIA terms).

Cumulative impacts with maintenance activities for cables and pipelines

147. The Lanis 1 telecom cable, EXA Atlantic cable, Calder CA1 platform (and associated pipelines and cables) and South Morecambe platforms overlap or are in the vicinity of the Project windfarm site. The Isle of Man Interconnector is located 4.6km to the north of the Project windfarm site.

148. Given that the ZoI extends to a maximum distance of 10km from the Project windfarm site (in a west-east orientation), there is a potential cumulative impact with maintenance activities for both cables, as their ZoIs could overlap.

149. Maintenance activities for the cable/pipeline projects could include inspections, upkeep, repairs, adjustments, alterations, removals, reconstruction and replacement. Increases in SSCs during these activities would be minimal and considerably less than those generated during installation of the cable projects. Most of the suspended sediment arising from each maintenance activity would fall rapidly to the seabed after the start of works and would not travel further than one spring tidal excursion (approximately 10km).

150. Cumulative effects would result in impacts of no greater significance than those assessed for the Project-alone for the construction and operation and maintenance phases (no change to negligible adverse and not significant in EIA terms).

Cumulative impacts with marine aggregate dredging

151. The southern boundary of the windfarm site is 9.7km from the Liverpool Bay aggregate production area (Area 457) and 29.0km from the Hilbre Swash aggregate production area.

152. The Hilbre Swash aggregate area has been in operation for over 50 years and is currently licenced to Lafarge Tarmac Marine Ltd and Norwest Sand & Ballast Company Ltd. The target material of the aggregate area is sand, and the area contains relatively few fines (less than 5%). Dredging activities at this area are restricted to anchor or trailing suction hopper dredger (TSHD) methods and the dredge amount is restricted to 0.8 million tonnes per year (NRW, 2013).

153. The Liverpool Bay aggregate extraction area has been active since 1959 (with an active licence until 2025) and is currently licenced to Westminster Gravels Ltd (Marinet, undated). The current licence permits the extraction of 1.2 million tonnes per year. The target material is also sand.

154. Plume modelling undertaken at analogous aggregate extraction sites by HR Wallingford (2011) show that SSCs in excess of tens of mg/l would be restricted to within approximately 2km of the aggregate dredging boundary. Given the distance of Liverpool Bay and Hilbre Swash aggregate dredging sites from the Project windfarm site, and the alignment of the tidal axis in a west-east orientation, it is unlikely that the sediment plumes would coalesce. No cumulative effects above Project-alone (no change to negligible adverse and not significant in EIA terms) are anticipated.

Cumulative impacts with disposal sites

155. Given that all disposal areas are over 15km from the Project (and that one spring tidal excursion is approximately 10km), it is unlikely that sediment plumes from Project construction activities and disposal areas would coalesce. Therefore, cumulative effects would result in impacts of no greater

significance than those assessed for the Project-alone (no change to negligible adverse and not significant in EIA terms).

Cumulative impacts with carbon capture storage sites

7.1 The Carbon Capture Storage Area (CCSA) (EIS Area 1) and Morecambe Net Zero Cluster overlaps with the Project windfarm site, while the CCS Licence (CS004) is 7.5km from the Project windfarm site. There is little information publicly available about what infrastructure would need to be constructed offshore, or when construction would start, but it is anticipated that existing gas infrastructure within and around the Project windfarm site may be utilised (e.g. existing wells/pipelines).

7.2 Given that the CCSA overlaps the Project, there is a potential cumulative effect with construction related activities (should their construction periods overlap). It is not clear what infrastructure would be required for the CCSA, however, this could include well workovers, retrofitting/reconditioning of existing infrastructure or possibly the installation of new infrastructure. In this case, there would be an increase in SSCs where sediment plumes overlap, however, the plumes would be advected in the same tidal axis for approximately 10km from the point of activity. The majority of sediment would deposit with thicknesses in the order of millimetres over the affected area (within approximately 10km of the disturbance, in line with one spring tidal excursion ellipse), which would be redistributed by successive tides to indistinguishable levels.

7.3 It is unlikely that any maintenance activities for the CCSA would be undertaken at the same time as maintenance activities for the Project. However, if this situation does occur, maintenance activities could include inspections, upkeep, repairs, adjustments, alterations, removals, reconstruction and replacement. Any increases in suspended sediment during these activities would be minimal and are anticipated to be considerably less than those generated during the construction phase. Most of the suspended sediment arising from each maintenance activity would fall rapidly to the seabed after the start of works and would not travel further than one spring tidal excursion (approximately 10km). Although there is a potential overlap of sediment plumes between these activities and the sediment plumes created during construction of the Project, the SSCs and sedimentation on the outer edges of the plume (10km) would be minimal.

156. Therefore, cumulative effects would result in impacts of no greater significance than those assessed for Project-alone (no change to negligible adverse and not significant in EIA terms), including the Morecambe Net Zero Cluster.

6.1.2 Marine Sediment and Water Quality

157. The assessment provided in **Chapter 8 Marine Sediment and Water Quality** of the ES was informed by the evidence-based and numerical physical processes modelling, undertaken in **Chapter 7 Marine Geology, Oceanography and Physical Processes**.

158. **Chapter 8 Marine Sediment and Water Quality** of the ES assessed potential effects of sediment excavation and disposal on water quality. Water quality in the study area is described in detail in Section 8.5.1 of **Chapter 8 Marine Sediment and Water Quality**.

159. **Section 6.1.2.1** to **Section 6.1.2.3** below focusses on the potential impacts of sediment excavation and disposal on water quality. A summary of the assessment sections below is provided in **Table 7.1**.

6.1.2.1 Construction phase

Increase in SSCs due to seabed preparation for foundation installation

160. As discussed in **Section 6.1.1.1**, mobilised sediments from seabed preparation for foundation installation, including material removed by means of dredging and returned to the water column at its surface layer, may be transported by wave and tidal action in suspension in the water column, forming a suspended sediment plume. The worst-case scenario adopted to inform the ES assessments assumes that up to 481,463m^3 (see **Table 4.1**) of sediment would be removed and returned to the water column at the sea surface as deposition from a dredge vessel.

161. As outlined in **Section 6.1.1.1**, medium and coarse-grained sediment disturbed by the drag head of the dredger at the seabed would remain close to the seabed and settle back to the bed rapidly. Most of the sediment released at the water surface from the dredge vessel 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 (west-east).

162. The finer sand fraction from this release would 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 modest concentration plume (tens of mg/l) for around half a tidal cycle (around 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 amounts of suspended sediment would extend further from the dredged area, along the axis of predominant tidal flows, the magnitudes would be indistinguishable from background levels.

163. Water quality in the study 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.

164. The scale of this impact would be relatively localised for coarser sediments (due to settling out) and further afield for finer sediments, but SSCs are predicted to return to baseline conditions within days, due to dispersion and dilution. The magnitude of the impact associated with increased SSCs, due to seabed preparation for foundation installation, is therefore predicted to be low.

165. This gives rise to a **minor adverse** effect, which is not significant in EIA terms.

Increase in SSCs due to drill arisings for foundation installation

166. As discussed in **Section 6.1.1.1**, drilling would cause sediments below the seabed to be disturbed and released within the windfarm site close to each foundation. The disposal of any sediment would also occur within the windfarm site close to each foundation.

167. This process would cause localised and short-term increases in SSCs at the point of discharge, which would then be transported by tidal currents in suspension. Most of the sediment released 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 7 Marine Geology, Oceanography and Physical Processes** indicates that SSCs would be very low away from the immediate release locations and within the range of natural variability. Additionally, SSCs arising from one foundation installation are unlikely to persist for sufficiently long for them to interact with subsequent foundation installations.

168. This assessment was supported by the numerical physical processes modelling undertaken for AyM Offshore Windfarm, Morgan Offshore Wind Project and Mona Offshore Wind Project (see Section 7.6.2.2 of **Chapter 7 Marine Geology, Oceanography and Physical Processes**) of the ES.

169. Water quality in the study 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.

170. The scale of this impact would be relatively localised for coarser sediments (due to settling out) and further afield for finer sediments, but SSCs are predicted to return to baseline conditions within days, due to dispersion and dilution. The magnitude of the impact is, therefore, predicted to be low.

171. This gives rise to a minor adverse effect which is not significant in EIA terms.

Increase in SSCs due to seabed preparation for inter-array and platform link cables

172. As discussed in **Section 6.1.1.1**, seabed preparation prior to cable installation and cable installation drilling would cause local and short-term increases in SSCs. Finer mobilised sediment from both activities may be transported by wave and tidal action in suspension in the water column. The disturbance effects at each location are likely to last for no more than a few days.

173. The conceptual evidence-based assessment indicates that the changes in SSCs, due to sandwave clearance/levelling and cable installation, would be similar to those that have been assessed in relation to the disturbance of near-surface sediments during seabed preparation activities for WTG/OSP(s) foundation installation (**Section 6.1.1.1**).

174. This assessment was supported by the numerical physical processes modelling undertaken for AyM Offshore Windfarm, Morgan Offshore Wind Project and Mona Offshore Wind Project (see Section 7.6.2.5 of **Chapter 7 Marine Geology, Oceanography and Physical Processes**) of the ES.

175. Water quality in the study 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.

176. The scale of this impact would be relatively localised for coarser sediments (due to settling out) and further afield for finer sediments, but SSCs are predicted to return to baseline conditions within days, due to dispersion and dilution. The magnitude of the impact is therefore predicted to be low.

177. This gives rise to a minor adverse effect, which is not significant in EIA terms.

Deterioration in water quality due to a release of sediment bound contamination

178. Site-specific data collected for the Project indicates that, for all parameters outlined in **Section 2.2** (presented in full in **Appendix 1**), sediment contaminant concentrations are low. Where exceedances of sediment guidelines occur, these are marginal (i.e. only just above the lower guideline level value) and no samples exceeded the Cefas AL1 thresholds (where available), which indicates that there is minimal risk to water quality.

179. Additionally, as assessed in **Section 6.1.1.1** and **Section 6.1.1.2**, sediments are not predicted to remain in suspension for long periods of time, given that the seabed material is predominantly sand, and the disposal process is returning sediments to a similar location from where they were removed.

180. Water quality in the study 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.

181. Given that sediment samples do not indicate elevated levels of contaminants, and suspended sediment plumes are predicted to return to baseline conditions within days, the magnitude of the impact was assessed as negligible.

182. This gives rise to a negligible adverse effect, which is not significant in EIA terms.

6.1.2.2 Operation and maintenance phase

Increase in SSCs associated with cable repairs and reburial activities

183. Cable repairs and reburial could be needed over the operational lifetime of the Project. As set out in the worst-case scenario **Table 4.1**, 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 the Project. As such, the disturbance areas for reburial and repairs of cables are predicted to be extremely small, in comparison to the construction assessment.

184. Water quality in the study 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.

185. The scale of these impacts would be small, infrequent and of short-term duration, and of a lower magnitude than those anticipated during the construction phase. The magnitude of the impact is, therefore, predicted to be negligible.

186. This gives rise to a negligible adverse effect, which is not significant in EIA terms.

Deterioration in water quality due to resuspension of sediment bound contamination

187. As outlined in **Section 2.2**, site-specific data collected for the Project indicates that, for all parameters outlined in **Section 2.2**, sediment contaminant concentrations are low. Where exceedances of sediment guidelines occur, these are marginal (i.e., only just above the lower guideline level value) and no samples exceeded the Cefas AL1 thresholds (where available), which indicates that there is minimal risk to water quality.

188. Additionally, as assessed in **Section 6.1.1.1** and **Section 6.1.1.2**, sediments are not predicted to remain in suspension for long periods of time, given that the seabed material is predominantly sand and the disposal process is returning sediments to a similar location from where they were removed.

189. Water quality in the study 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.

190. Given that sediment samples do not indicate elevated levels of contaminants, and increases in SSCs are predicted to be small, infrequent and of short-term duration, the magnitude of the impact was assessed as negligible.

191. This gives rise to a negligible adverse effect, which is not significant in EIA terms.

6.1.2.3 Cumulative effects

192. Cumulative increases in SSCs and deposition associated with the Project and other plans and projects is outlined in detail in **Section 6.1.1.3**.

193. Whilst there is a potential for sediment plumes to partially overlap during construction activities, given the limited spatial extent, rate of dispersal and the temporary and transient nature of these impacts, cumulative effects are not considered to be beyond the Project-alone assessment.

194. Suspended sediment plumes arising during the operation and maintenance phase for the Project would be intermittent and on a much smaller scale than those arising during the construction phase. The potential for cumulative effects is, therefore, significantly reduced and not considered to be beyond the Project-alone assessment.

195. With respect to contaminant concentrations, and as outlined in **Section 6.1.2.1**, cumulative effects are not identified, given the low levels of contaminants across the windfarm site.

6.1.3 Benthic Ecology

196. The assessment provided in **Chapter 9 Benthic Ecology** of the ES was informed by the evidence-base and numerical physical processes modelling undertaken in **Chapter 7 Marine Geology, Oceanography and Physical Processes**.

197. **Chapter 9 Benthic Ecology** of the ES assessed potential effects of sediment excavation and disposal on the following receptors:

- Subtidal sands and gravels
- Subtidal mud/mud habitats in deep water
- Designated sites, including:
  - Fylde MCZ (subtidal sand and subtidal mud)
  - Shell Flat and Lune Deep SAC (Annex I sandbank)

- West of Walney MCZ (subtidal mud and seapen and burrowing megafauna communities)

198. The receptors outlined above are described in detail in Section 9.6.1. of **Chapter 9 Benthic Ecology**.

199. **Section 6.1.3.1** to **Section 6.1.3.3** below focusses on the potential impacts of sediment excavation and disposal on the receptors outlined above. A summary of the assessment sections below is provided in **Table 7.1**.

6.1.3.1 Construction phase

Increases in SSCs and subsequent deposition

Effects on habitats and biotopes recorded with the 15km Project ZoI

200. Increases in SSCs and deposition resulting from seabed preparation prior to WTG/OSP(s) foundation installation and cable installation, drilling and cable installation have the potential to increase SSCs within the water column and increase sedimentation depths on the seabed, following deposition. These impacts are outlined in detail in **Section 6.1.1.1** and **Section 6.1.1.2** and **Chapter 7 Marine Geology, Oceanography and Physical Processes** of the ES and are, therefore, not repeated here.

201. Increases in SSCs and deposition has the potential to affect the benthos through blockage to the sensitive filter feeding apparatus of certain species and/or smothering of sessile species, upon deposition of the sediment. Changes in turbidity, associated with increased SSC, also decreases the depth to which natural light can penetrate into the water column and may, therefore, result in a reduction in primary productivity. Additionally, sediment plumes can create barriers to movement of marine ecological parameters.

202. The sensitivity of identified habitats and biotopes to increased SSCs and deposition pressures range from ‘not sensitive’ to ‘medium’ (sensitivities of each receptor is presented in Section 9.6.2 of **Chapter 9 Benthic Ecology** of the ES).

203. The total volume of sediment that would be disturbed, and may potentially be brought into suspension, is outlined in **Section 4.** However, disturbance would be temporary and intermittent over a construction period of up to 2.5 years, and any increases in SSCs around each foundation/location along the cable routes would last a fraction of this time (a matter of hours to days).

204. The area over which ‘heavy’ deposition (i.e. more than 5cm of fine material, as defined by Marine Evidence-based Sensitivity Assessment (MarESA) assessments), may occur, based on the assessment of changing bed levels, as set out in **Section 6.1.1.1**, would be restricted to the immediate vicinity of the point of release.

205. The area over which 'light' material deposition (i.e. less than 5cm of fine material, as defined by MarESA assessments) may occur, again based on the assessment of changing bed levels, as set out in **Section 6.1.1.1**, although larger (and potentially anywhere within the tidal ellipse), but is still considered to be small in the context of the extent of subtidal habitats within the wider Eastern Irish Sea. Regardless, it is likely that fine materials in areas of light deposition would be remobilised and redistributed within a short period of time. As such, effects are predicted be relatively limited spatially, in the context of the habitats present in this area of the East Irish Sea. Consequently, the magnitude of this impact is considered to be low.

206. Based on a negligible (sea pens and burrowing megafauna communities) and medium (subtidal sands/gravels, subtidal mud) sensitivity, and a low magnitude of impact, increases in suspended sediment, and consequent deposition during the construction phase, would have a negligible to minor adverse effect on the biotopes and habitats that are present within the Project ZoI, which is deemed not significant in EIA terms.

Effects on designated sites

207. The sensitivity of features from Fylde MCZ, West of Walney MCZ and Shell Flat and Lune Deep SAC, as set out in the respective Advice on Operations (AoO), is summarised in Section 9.6.2 of **Chapter 9 Benthic Ecology** of the ES.

208. In all instances, the component biotopes of the designated features (as considered in the AoO) have no, or low, sensitivity to the effects of increased SSCs, or subsequent light siltation, during operational and maintenance activities. Conservatively, therefore, the sensitivity of this receptor group is considered to be low.

209. As described in **Section 6.1.1.1**, finer sediment disturbed by Project activities has the potential for deposition within a 10km area. This ZoI overlaps a small proportion of the Fylde MCZ, Annex I sandbanks, and Shell Flat and Lune Deep SAC. However, given the designated sites are a minimum of 8km from the Project, sediment deposition this far from the activity would be minimal and indistinguishable from background levels.

6.1.3.2 Operation and maintenance phase

Temporary increases in SSCs/sedimentation during operational and maintenance activities

210. Increases in SSCs, and subsequent deposition resulting from operation and maintenance phase activities, are outlined in detail in **Section 6.1.1.2** and **Chapter 7 Marine Geology, Oceanography and Physical Processes** of the ES and is therefore not repeated here.

Effects on habitats and biotopes recorded with the 15km Project ZoI

211. Given that effects may extend across the windfarm site and near-field habitats, a discernible, yet temporary, effect would be expected during each maintenance activity. The areas affected would represent a small proportion of the subtidal sand and mud habitats present in the ZoI and wider Eastern Irish Sea study area. Consequently, the magnitude of this impact is considered to be negligible.

212. Based on a negligible (sea pens and burrowing megafauna communities) to medium (subtidal sands/gravels, subtidal mud) sensitivity, and a negligible magnitude of impact, increases in SSCs, and subsequent deposition during operational and maintenance activities in this phase, would have a negligible to minor adverse effect on the biotopes and habitats that are present within the survey area, which is not significant in EIA terms.

Effects on designated sites

213. The magnitude of impact during the operation and maintenance phase would be lower than that assessed for the construction phase. At a distance of approximately 8km from the windfarm site (the shortest distance between the site and any of the designated site receptors), an evidence-based assessment concluded that SSCs increases would be indistinguishable from background levels and well in line with the range of natural variability.

214. As such, it is likely that any effect within the designated sites would be indiscernible and, hence, the impact on benthic features is considered to be of negligible magnitude.

215. Based on a low sensitivity and a negligible magnitude of impact, increases in SSCs, and consequent deposition during operation and maintenance phases, would have a negligible adverse effect on the benthic features of designated sites, which is not significant in EIA terms.

6.1.3.3 Cumulative effects

216. As outlined in **Section 6.1.1.3**, there is the potential for sediment plumes arising from the Project construction phase to overlap with sediment plumes arising from other plans or projects, including the Transmission Assets.

217. Marine habitats/biotopes present within the extent of one excursion of the tidal ellipse around the windfarm site have no, to low, sensitivity to changes in SSCs, hence, would be unaffected by the cumulative effects on SSCs. However, there is low to medium sensitivity to smothering caused by deposition.

218. As discussed in **Section 6.1.1**, increases in seabed level at any stage of the Project would be temporary (i.e. deposited fines would be redistributed within a short period of time by hydrodynamic actions) and very localised. Beyond around 1km from the point of release, deposition impacts would be of negligible magnitude (in the order of millimetres). As such, impacts could only realistically interact in the instance that sediment-disturbing activities are taking place at the Project and other developments simultaneously, and sediment plumes from other developments encroach into the 'near-field' area of the Project's activities.

219. As outlined in **Section 6.1.1.3** and **Section 6.1.1.2**, the overlap is anticipated to be minimal, given that sediment would be transported along the same tidal axis (west-east). The area affected would be small, in terms of the unaffected subtidal sand and mud habitats/biotopes present within the ZoI and the wider Eastern Irish Sea study area. Therefore, while impacts are additive across the study area, due to the lack of interaction of effects and the limited magnitude of effects identified for all projects, cumulative effects are not identified beyond those identified for the Project-alone.

220. As outlined in **Section 6.1.1.2**, suspended sediment plumes arising during the operation and maintenance phases would be intermittent (cable repair/reburial) and on a much smaller scale than those arising during the construction phase. Therefore, any cumulative effects are unlikely to be significantly elevated over that predicted for the Project-alone.

6.1.4 Fish and Shellfish Ecology

221. The assessment provided in **Chapter 10 Fish and Shellfish Ecology** of the ES was informed by the evidence-based and numerical physical processes modelling undertaken in **Chapter 7 Marine Geology, Oceanography and Physical Processes**.

222. The principal receptors, with respect to fish and shellfish ecology, are spawning and nursery grounds, diadromous fish, pelagic fish, demersal fish, elasmobranchs, shellfish (crustaceans and molluscs) and designated sites. The specific features within these receptors that were assessed are outlined in Table 10.17 of **Chapter 10 Fish and Shellfish Ecology** of the ES.

223. **Section 6.1.4.1** to **Section 6.1.4.3** below focus on the potential impacts of sediment excavation and disposal on the receptors outlined above. A summary of the assessment sections below is provided in **Table 7.1**.

6.1.4.1 Construction phase

Increased SSCs and sediment re-deposition

224. During construction activities, there may be a temporary increase in suspended sediments and deposition. Suspended sediment has the potential

to impair respiratory, filter feeding or reproductive functions, including the disruption of migration/spawning activity. Sediment deposition, especially if it changes the characteristics of the existing seabed sediments, could affect the quality of spawning and nursery habitats.

225. Sands and silts released during seabed preparation and foundation construction activities would be temporarily deposited on the seabed, but are more likely to be remobilised and redistributed through natural hydrodynamic processes than gravels and clays, which are likely to remain on the seabed for a longer period of time after settlement. As discussed in **Chapter 7 Marine Geology, Oceanography and Physical Processes**, the windfarm site is predominantly composed of sand and fine sand. Based on the sediment sizes present, finer suspended sediment is expected to exist as a passive plume, extending to a maximum of one spring tidal ellipse (10km), with other sediments settling quickly in proximity to its release, within a few hundred metres and up to around a kilometre away from the construction activity.

Spawning grounds

226. Sediment re-deposition could result in changes to the particle size distribution of the seabed, giving rise to some loss of spawning grounds for substrate specific demersal spawning species, such as herring and sandeel. High levels of suspended sediments could also have the potential to deter spawning adults from entering traditional spawning areas.

227. The following fish species' spawning grounds may be affected by suspended sediments and deposition during construction activities, as they have mapped spawning grounds located within the windfarm site, or up to 10km away from the site: sandeel, common sole, lemon sole, plaice, whiting, cod, mackerel, ling and *Nephrops*. Herring spawning grounds are located 44km away from the Project and, therefore, no impact pathway has been identified.

228. Eggs and early larval stages do not have the same capacity to avoid increased suspended sediments as juvenile or adult fish, as they are either passively drifting in the water column or present on/attached to benthic substrates. The value/sensitivity of sandeel spawning grounds is considered high**,** due to this key life stage and that spawning is demersal. PSA results suggest habitat is not suitable for sandeel, however, this value/sensitivity has been conservatively applied.

229. As detailed in **Chapter 7 Marine Geology, Oceanography and Physical Processes,** suspended sediment and sediment deposition increases would only occur for a limited duration (minutes or tens of minutes for medium and coarse grains and up to six hours for fine grains), at specific locations (e.g. piling location), at any given time. Impacts would be restricted to a passive plume and minimal (1mm) disposal, within the 10km tidal excursion. The highest suspended sediments would cover a much smaller area (around 1km

from release). The identified spawning grounds are part of a much wider area in the Irish Sea. Therefore, the magnitude of the effect of increased suspended sediments, and sediment re-deposition during construction, is assessed as negligible, and an effect of minor adverse significance on sandeel spawning grounds is concluded. This is not significant in EIA terms.

230. All other fish species with pelagic spawning have lower sensitivity to sediment loading for spawning, as these species do not have the same level of spatial dependency on a specific substrate. The value/sensitivity is thus medium and the magnitude negligible. An effect of minor adverse significance would be expected on other fish spawning grounds, from increased suspended sediments and sediment re-deposition associated with the Project construction phase. This is not significant in EIA terms.

Nursery grounds

231. The following fish species' nursery grounds may be affected by suspended sediments and deposition during construction activities, as they are located within the windfarm site, or up to 10km (one spring tidal ellipse) away from the windfarm site: common sole, cod, whiting, herring, spurdog, *Nephrops,* sandeel spp., plaice, mackerel, anglerfish, tope, thornback ray and spotted ray.

232. Juvenile stocks of fish are not thought to be sensitive to increased sediment loading, as they have high levels of adaptability and tolerance to transient stress and disturbance. Their high mobility allows them to avoid any localised suspended sediment increases. The value/sensitivity of nursery grounds to the construction phase of the Project is, therefore, considered medium, considering their key importance in fish life cycles.

233. Whilst the nursery grounds of many species overlap with the windfarm site, or are within the area of one tidal ellipse (where sediments may be distributed), the areas impacted by suspended sediments and deposition during construction activities are very small, relative to the size of the entire main nursery grounds, which extend around much of the Irish, English and Scottish coasts. Furthermore, based on their extensive occurrence within the wider geographic context, any potential disturbance to these areas, due to construction activities, is not predicted to have a significant impact on future local fish populations. As this increase in suspended sediment would be temporary (intermittent over the construction period) and affect a very small proportion of the wider nursery ground, the magnitude of the impact was assessed as negligible.

234. An effect of minor adverse significance would be expected on fish nursery grounds from increased suspended sediments and sediment re-deposition associated with the Project construction phase. This is not significant in EIA terms.

Diadromous fish

235. The value/sensitivity of diadromous fish species to the construction phase of the Project is considered low. This considers their conservation status, yet tolerance to high levels of suspended sediments, given their association with estuarine environments in their life cycle. For example, eels and lamprey tolerate silty, turbid and poor light conditions (Behrmann-Godel and Eckmann, 2003; Hansen *et al*., 2016; Christoffersen *et al*., 2018). As these species are all highly mobile and active in the water column above the seabed, then there is also no risk of smothering or burial.

236. Migrating individuals of these species could feasibly cross the windfarm site (and extended area impacted by increased suspended sediments), during migration to or from freshwater, during the construction phase. During this time, they would be exposed to an increased water column sediment loading for a limited period of time during construction, associated with each disturbance activity. Also, the increased sediment loading would be short-term and localised in nature, occurring sequentially with the location of the installation activity and near the seabed. Impacts would be restricted to a passive plume and minimal (1mm) disposal within the 10km tidal excursion. The highest suspended sediments would cover a much smaller area (around 1km from release). Therefore, the likelihood of migratory, or marine resident, diadromous fish encountering an area of increased water column sediment loading is low. Furthermore, as they are highly mobile species, and should they encounter an area of increased suspended sediments, they are capable of moving to avoid the area. Therefore, the magnitude of these impacts are deemed to be negligible.

237. An effect of negligible adverse significance on diadromous fish species would be expected from increased suspended sediments and sediment re-deposition associated with the Project construction phase. This is not significant in EIA terms.

Demersal fish, pelagic fish and elasmobranchs

238. The value/sensitivity of demersal fish, pelagic fish and elasmobranchs to suspended sediments is considered, as a group, to be low. This considers their value, yet the mobility of these species. As these are highly mobile species, then should they encounter an area of increased sediment loading, they are capable of navigating away and avoiding the area. As these species are all highly mobile, then there is low risk of smothering or burial, even for demersal individuals.

239. As individuals of these species, if present in the windfarm site and surrounding areas, would be foraging, then there is a potential effect upon their feeding success from the increased water column sediment loading (Robertson *et al*., 2006). As the increased sediment loading would be relatively short-term

(occurring intermittently over part of the construction period) and localised in nature, the likelihood of individuals of these receptor groups encountering an area of increased sediment loading is low. Encounters may be more likely for demersal elasmobranchs, such as the lesser spotted dogfish, thornback ray and spotted ray, as well as non-elasmobranch demersal fish, such as plaice and common sole.

240. These species are distributed across the Irish Sea (as well as the North Sea), where storm events, and the associated increases in turbidity, are a regular occurrence. Since the increased suspended sediments associated with construction are unlikely to exceed background levels, other than in very localised areas and for short time periods (**Chapter 7 Marine Geology, Oceanography and Physical Processes**), it can be expected that both adult and juvenile fish species are unlikely to be affected by a low-level increase in suspended sediments from construction activities.

241. Fine silt particles associated with increases in suspended sediments have the potential to adhere to the gills of larvae, which could cause suffocation (De Groot, 1980). However, the extent of the impact is minimal in consideration of the distribution of these species. In addition, larvae may be subject to reduced predation from larger visual planktivores in turbid environments (Bone and Moore, 2008).

242. Therefore, the overall magnitude of impact upon demersal fish, pelagic fish, and elasmobranchs is assessed as negligible.

243. An effect of negligible adverse significance would be expected from increased suspended sediments and sediment re-deposition on demersal fish, pelagic fish and elasmobranchs. This is not significant in EIA terms.

Molluscs

244. Some mollusc species (e.g., bivalves, gastropods) have limited mobility with which to move away from areas of increased water column sediment loading, or to prevent themselves from being smothered. However, these species tend to show tolerance to increased suspended sediments (Mainwaring *et al*., 2014). For example, the MarESA review of ocean quahog identifies that an increase in turbidity (suspended sediments) may not adversely affect the species, especially as it can avoid sudden changes by burrowing for several days.

245. The value/sensitivity of molluscs to the construction phase of the Project is considered medium (given the ocean) and their tolerance to turbidity and sediment remobilisation.

246. As the increased sediment loading would be short-term and localised in nature, whilst there is a risk of some effect upon nearby individuals, the risk to

the wider population is very limited and, therefore, the magnitude of impact upon molluscs is assessed as negligible.

247. There is also potential for indirect effects upon juvenile forms of the Freshwater Pearl Mussel (FWPM), via the Project's effect on Atlantic salmon and sea trout. However, no significant effects on diadromous fish have been identified.

248. An effect of minor adverse significance from increased suspended sediments and sediment re-deposition is identified. This is not significant in EIA terms.

Crustaceans

249. Crustacean species are less mobile than fish, and may not readily move away from areas of increased water column sediment loading, however, some species, including Nephrops, are particularly tolerant to a degree of smothering (Johnson *et al*., 2013). According to the MarESA, shellfish species, such as brown crab, have a low sensitivity to increased suspended sediments. The value/sensitivity of crustaceans to suspended sediment increases and deposition is considered, as a group, to be medium.

250. As the increased sediment loading would be short-term and localised in nature, whilst there is a risk of some effect upon nearby individuals, the risk to the wider population is very limited and, therefore, the magnitude of impact upon crustaceans is assessed as negligible. This means an effect of negligible adverse significance on crustacean species would be expected from increased suspended sediments and sediment re-deposition associated with the Project construction phase. This is not significant in EIA terms.

Designated sites

251. The value/sensitivity of designated sites (relevant for fish and shellfish species) to the construction phase of the Project is considered high. There are two relevant designated sites (for habitats) within 10km (one spring tidal ellipse) of the Project that may be affected by increased suspended sediments and deposition: Fylde MCZ, designated for subtidal sand and subtidal mud (8km) and Shell Flat and Lune Deep SAC, designated for sandbanks (10km). Further, Liverpool Bay SPA (adjacent to the windfarm site), which although is not designated for fish and shellfish or habitats, contains mud and sand habitat that supports fish and shellfish populations, which are prey to the designated ornithological features.

252. These sites are not designated specifically for fish or shellfish receptors (although their habitat would support fish and shellfish), therefore, the impact of increased suspended sediments on these designating features has been concluded to be not significant (see **Chapter 7 Marine Geology, Oceanography and Physical Processes** and **Chapter 8 Marine Sediment and Water Quality**). Suspended sediment increases above background levels would be limited at Fylde MCZ, and Shell Flats and Lune Deep SAC,

given their separation of at least 8km. While Liverpool Bay SPA is adjacent to the eastern edge of the windfarm site, effects would be temporary and the maximum distance that suspended sediments could travel overlaps with only 16% of the total area of the SPA (with <1% of the total area of the SPA overlapping a 1km buffer from the windfarm site, where suspended sediments would be higher). Therefore, the magnitude of increased suspended sediments and sediment re-deposition on designated sites is assessed as negligible. It is noted that no sites specifically designated for fish and shellfish are within the ZoI of impacts.

253. An effect of minor adverse significance on designated sites would be expected from increased suspended sediments and sediment re-deposition associated with the Project construction phase. This is not significant in EIA terms.

6.1.4.2 Operation and maintenance phase

Temporary habitat loss/disturbance and increased suspended sediments (and subsequent deposition)

254. Maintenance activities may disturb the seabed and elevate SSCs. For example, when conducting repairs on the inter-array or platform link cables, the cables may be brought to the surface and then re-laid, which would disturb the seabed. The extent of disturbance anticipated during the operation and maintenance phase, including increases suspended sediments, is outlined in **Table 4.1**. The extent of disturbance would be lower than that for the construction phase, but would occur as intermittent (short-term) events throughout the 35-year operational period of the Project.

255. As discussed in **Section 6.1.1.2** and **Chapter 7 Marine Geology, Oceanography and Physical Processes**, the maximum range of sediment plumes is 10km and, therefore, there is no effect pathway between the Project and herring spawning grounds, which lie 44km away. Furthermore, as demonstrated in the site-specific PSA results summarised in **Chapter 7 Marine Geology, Oceanography and Physical Processes**, the windfarm site itself does not contain any suitable habitat for sandeel or herring spawning, though these species do utilise spawning grounds in the wider area of the Irish Sea, spanning a large area. As per construction, there would be no expected pathway to sites designated for fish and shellfish, and with only localised effects in sites that are designated for supporting habitats (Fylde MCZ, Shell Flat and Lune Deep SAC and Liverpool Bay SPA).

256. The value/sensitivity of receptors is considered to be the same as in the construction phase (due to temporary increases in SSCs) as per **Section 6.1.4**.

257. Due to reduced scope for increased suspended sediments during operation and maintenance, compared to construction, the magnitude of impact is likely

to be lower. However, the magnitude is conservatively scoped to be the same as for construction for all receptor groups (see **Section 6.1.4**). The magnitude of impact upon all receptors is, therefore, assessed as negligible.

258. Considering the variation in receptor sensitivity, the resulting significance of effect is assessed as negligible adverse to minor adverse for all species. The effects are summarised in **Table 7.1** and are not significant in EIA terms.

6.1.4.3 Cumulative effects

259. There is potential for construction and operation, and maintenance works, at other projects, including offshore windfarms, aggregate production areas and disposal areas, to result in suspended sediment plumes in addition to those produced in the Project windfarm site. As discussed in **Sections 6.1.1.3**, any increases in SSCs associated with Project works is temporary and localised in all Project phases. Therefore, for any plume interaction to occur, works in nearby projects would need to occur simultaneously (at the same time) (however, additive effects are also considered for sequential (one after the other) disturbance events).

260. Increases in SSCs caused by maintenance activities of other projects would be minimal and considerably less than those anticipated during construction. For example (and as shown for the Project-alone impacts), existing windfarms would only have minimal activities that would cause seabed disturbance, such as infrequent cable repair. The majority of increased suspended sediment arising from each maintenance activity of existing windfarms, and dredging/aggregate activities, would fall rapidly to the seabed after the initial suspension and would not travel further than one spring tidal excursion, within minimal levels above background. Therefore, no cumulative impact is anticipated with existing windfarms or dredging/aggregate activities in the Irish Sea. This is the same for existing infrastructure, such as the existing cables within and near to the site, and oil and gas infrastructure.

261. The ZoI for increased SSCs for the Project during construction phases (the phase during which the greatest amount of suspended sediment is produced) has been assessed as 10km. The direction of travel of sediment plumes of other projects would be dictated by the directionality of the currents at the time of the works associated with those projects. The regional direction of current flow would cause sediment plumes from nearby projects (if occurring at the same time as e.g., construction of the Project), to travel in largely the same direction as sediment plumes from this Project. The spring tidal excursion at the Project windfarm site is approximately 10km, in an east-west orientation.

262. This means that, for sediment plumes from multiple projects to interact, the projects would likely need to be situated within 10km of the Project windfarm site, with sediment-producing works occurring simultaneously. The Morgan

Offshore Wind Project and Mona Offshore Wind Project and the Transmission Assets have the greatest potential for this, with their construction phases (the phases with the greatest potential for increased suspended sediment) potentially overlapping temporally (and being situated <15km from the Project). Other projects, which have construction phases that overlap with the Project temporally, such as AyM offshore windfarm, are too far away (>15km) to have cumulative suspended sediment effects.

263. In the worst-case scenario, where the Transmission Assets, Morgan Offshore Wind Project and Mona Offshore Wind Project construction coincides with the Project construction, there may be additive effects in respect of increased suspended sediment and sediment deposition. However, these impacts are time-limited and localised, so the scope for temporal and spatial overlap is limited. The overall combined magnitude is considered to be negligible, relative to the scale of the populations of fish and shellfish receptors potentially affected. Given the above, there would be no significant cumulative effect or elevation beyond the Project-alone assessment (minor adverse).

6.1.5 Marine Mammals

264. The assessment provided in **Chapter 11 Marine Mammals** was informed by **Chapter 7 Marine Geology, Oceanography and Physical Processes**, **Chapter 8 Marine Sediment and Water Quality** and **Chapter 10 Fish and Shellfish Ecology**.

265. The marine mammal receptors assessed in **Chapter 11 Marine Mammals** are:

- Harbour porpoise
- Bottlenose dolphin
- Common dolphin
- Risso's dolphin
- White-beaked dolphin
- Minke whale
- Grey seal
- Harbour seal

266. **Section 6.1.5.1** to **Section 6.1.5.3** below focus on the potential impacts of sediment excavation and disposal on the receptors outlined above. A summary of the assessment sections below is provided in **Table 7.1**.

6.1.5.1 Construction phase

Changes to prey resources

267. Construction activities, such as seabed preparation, dredging, WTG/OSP(s) foundation installation and cable installation, may lead to the potential for increased SSCs in the water column and subsequent sediment re-deposition.

268. As outlined in **Section 2.1.3**, the windfarm site is predominantly composed of sand and fine sand. Based on the sediment sizes present, finer suspended sediment is expected to exist as a passive plume, extending to a maximum of one spring tidal ellipse (10km) from the construction activity. Other sediments would settle quickly in proximity to their release, within a few hundred metres and up to around a kilometre away from the construction activity.

269. The total volume of sediment that could be disturbed, and may potentially be brought into suspension, is approximately 1,101,481m^3 (**Table 4.1**). Any disturbance would be temporary and intermittent over the construction period and any increases in suspended sediment would last a matter of hours to days around the point of seabed disturbance.

270. The diet of harbour porpoise consists of a wide variety of prey species and varies geographically and seasonally, reflecting changes in available food resources. Harbour porpoise have relatively high daily energy demands and need to capture enough prey to meet daily energy requirements. It has been estimated that, depending on the environmental conditions, harbour porpoise can rely on stored energy (primarily blubber) for three to five days, depending on body condition (Kastelein *et al*., 1997).

271. Harbour porpoise are, therefore, considered to have low to medium sensitivity to changes in prey resources.

272. Dolphin species, including bottlenose dolphin, common dolphin and white-beaked dolphin have a broad diet, feeding on a wide range of prey species. Risso's dolphin prey mainly upon cephalopods.

273. All dolphin species are considered to have large foraging ranges, and a broad range of prey species, and are, therefore, considered to have low sensitivity to changes in prey resources.

274. Minke whale feed on a variety of prey species, but in some areas, they have been found to prey upon specific species. Therefore, minke whale are considered to have a low to medium sensitivity to changes in prey resource.

275. Grey and harbour seal feed on a variety of prey species, and both are considered to be opportunistic feeders, feeding on a wide range of prey species, and they are also able to forage in other areas and have relatively large foraging ranges.

276. Grey seal and harbour seal are, therefore, considered to have low sensitivity to changes in prey resources.

277. Further information on the diet of marine mammal species is provided in **Appendix 11.2 Marine Mammal Information and Survey Data** (Document Reference 5.2.11.2) of **Chapter 11 Marine Mammals** of the ES.

278. Any increases in SSCs are expected to cause localised and short-term changes at the point of discharge. These temporary impacts would only represent a very small proportion of the subtidal sand and mud habitats present across the wider Eastern Irish Sea. Therefore, the potential magnitude of impact is considered to be low in **Chapter 9 Benthic Ecology**, with a negligible to minor adverse significance of effect.

279. The significance of effects in **Chapter 10 Fish and Shellfish Ecology** is assessed as negligible to minor adverse.

280. Any potential changes to prey resources, as a result of increased SSCs and sediment deposition, is, therefore, assessed as negligible adverse for all marine mammal species.

Changes to water quality

281. As outlined in **Chapter 8 Marine Sediment and Water Quality**, potential changes in water quality could occur during construction as a result of increases in SSCs.

282. As outlined above, the magnitude of impact for increased SSCs, due to foundation installation, is predicted to be low and significance of effect was assessed minor adverse.

283. Therefore, increased SSCs are unlikely to have any direct or indirect impacts on marine mammals. Marine mammals often inhabit turbid environments, and cetaceans utilise sonar to sense the environment around them, and there is little evidence that turbidity affects cetaceans directly (Todd *et al*., 2014). Pinnipeds are not known to produce sonar for prey detection purposes; however, it is likely that other senses are used instead of, or in combination with, vision. Studies have shown that vision is not essential to seal survival or their ability to forage (Todd *et al*., 2014).

284. The sensitivity of marine mammals to any increased SSCs is negligible.

285. The magnitude of impact for any changes in water quality, as a result of increased SSCs, is negligible for marine mammals.

286. The significance of effect for any changes in water quality during construction is negligible adverse (and not significant in EIA terms) for marine mammals (**Table 7.1**).

6.1.5.2 Operation and maintenance

287. During the operation and maintenance phase, there is the potential for maintenance activities to disturb sediment, potentially resulting in increases in SSCs.

288. Cable repairs and reburial could be needed over the operational lifetime of the Project. It is estimated that reburial of an average of 100m of inter-array/ platform link cables could be required every year and up to 200m of inter-array/platform link cables could be repaired/replaced every year (**Table 4.1**). The scale of these impacts would be small, infrequent and of short-term duration and of a lower magnitude than during the construction phase.

289. As assessed in **Chapter 8 Marine Sediment and Water Quality**, any changes to water quality during operation and maintenance would also be of negligible magnitude for marine mammals. Therefore, there is no potential effect for marine mammals, with negligible effect significance.

Changes to prey resources

290. Any changes to prey resources during the operation and maintenance phase would be less than those assessed for construction (**Section 6.1.5.1**).

291. As outlined in **Section 6.1.5.1**, harbour porpoise are considered to have low to medium sensitivity to changes in prey resources. All dolphin species are considered to have low sensitivity to changes in prey resources. Minke whale are considered to have a low to medium sensitivity to changes in prey resource. Grey seal and harbour seal are considered to have low sensitivity to changes in prey resources.

292. The magnitude of increases in SSCs and sediment deposition due to operation and maintenance activities would be less than for construction phase (**Section 6.1.5.1**). Such impacts would arise from cable repair, replacement and reburial activities.

293. The significance of effect on fish species, due to such impacts, is assessed as negligible to minor adverse (**Section 6.1.4.2**).

294. The magnitude of impact for any change to prey resources for marine mammals would be negligible.

Changes to water quality

295. During the operation and maintenance phase, there is the potential for maintenance activities to disturb sediment, potentially resulting in increases in suspended sediment.

296. Cable repairs and reburial could be needed over the operational lifetime of the Project. It is estimated that reburial of an average of 100m of inter-array/ platform link cables could be required every year and up to 200m of inter-

array/platform link cables could be repaired/replaced every year (**Table 4.1**). The scale of these impacts would be small, infrequent and of short-term duration and of a lower magnitude than during the construction phase.

297. As assessed in **Chapter 8 Marine Sediment and Water Quality**, any changes to water quality during operation and maintenance would also be of negligible magnitude for marine mammals. Therefore, there is no potential effect for marine mammals, with negligible effect significance.

6.1.5.3 Cumulative effects

298. Any effects to prey species (such as seabed disturbance and associated suspended sediments) are likely to be intermittent, temporary and highly localised, with potential for recovery following cessation of the disturbance activity. Any permanent loss or changes of prey habitat would typically represent a small percentage of the potential habitat for prey species in the surrounding area.

299. Taking into account the assessment for the Project-alone, and assuming similar effects for other projects and activities, along with the range of prey species taken by marine mammals and the extent of their foraging ranges, there would be no potential for cumulative effect on marine mammal populations as a result of changes to prey resources. Therefore, the cumulative magnitude is considered to be negligible.

300. With the sensitivity of low to medium, and the magnitude level of negligible (at worst), for minke whale and harbour porpoise, the effect significance would be minor adverse (not significant in EIA term), and for all other marine mammals would be negligible (not significant in EIA terms).

301. No mitigation is required for the potential for cumulative effects to prey species.

6.2 Human characteristics

6.2.1 Commercial Fisheries

302. The assessment provided in **Chapter 13 Commercial Fisheries** of the ES was informed by the assessment undertaken in **Chapter 10 Fish and Shellfish Ecology**.

303. **Chapter 13 Commercial Fisheries** of the ES assessed potential effects of sediment excavation and disposal on the following receptors:

- Dredge and demersal otter trawl
- Potting
- Beam trawl

- Fixed nets
- Gear with hooks
- Pelagic trawl

304. Each receptor is described in detail in Section 13.5 of **Chapter 13 Commercial Fisheries** of the ES.

305. **Section 6.2.1.1** to **Section 6.2.1.3** below focusses on the potential impacts of sediment excavation and disposal on the receptors outlined above. A summary of the assessment sections below is provided in **Table 7.1**.

6.2.1.1 Construction

Displacement or disruption of commercially important fish and shellfish resources

306. Temporary seabed disturbances during construction activities may displace commercially important fish and shellfish populations from the area.

307. There is potential for fishing grounds beyond the immediate construction activities to be affected by these impacts. Exposure to the impact is likely and commercial fleets targeting key species would be affected, including those targeting whelk and other shellfish species.

308. Given the reliance on fishing grounds across the local study area, together with relatively low mobile target species, the potting fleet is deemed to be of medium vulnerability, medium recoverability and medium value; the sensitivity is considered to be medium.

309. For all other fleets, due to the range of alternative areas targeted, and the distribution of key commercial species throughout the Irish Sea, fleets are deemed to be of low vulnerability, high recoverability and medium-low value. The sensitivity of the receptor for all other fleets is therefore considered to be low.

310. With respect to the magnitude of this impact on commercial fisheries, the overall significance of the effect on fish and shellfish species is considered (i.e. both the magnitude and sensitivity of fish and shellfish species are considered to assess the magnitude on commercial fishing fleets). This is because the overall effect on the fish and/or shellfish species relates directly to the availability and amount of exploitable resource. For instance, where an effect of negligible significance is assessed for a species, a negligible magnitude is assessed for commercial fishing; where an effect of minor adverse significance is assessed for a species, a low magnitude is assessed for commercial fishing, i.e., the overall significance for fish and shellfish ecology helps to determine the magnitude of the impact for commercial fishing

fleets. The significance of effect on fish as a result of increases in SSCs and deposition is outlined in **Section 6.1.4**.

311. The impact is predicted to be of regional spatial extent, of relevance to national fishing fleets and of short-term duration. It is predicted that the impact would affect the receptor directly through loss of resources. The magnitude is therefore considered to be low adverse.

312. It is predicted that the sensitivity of the receptor is medium for potting and low for all other fleets, and the magnitude is low. Therefore, the effect is minor adverse, which is not significant in EIA terms.

6.2.1.2 Operation and maintenance

Displacement or disruption of commercially important fish and shellfish resources

313. Temporary seabed disturbances during operation and maintenance activities may displace commercially important fish and shellfish populations from the area.

314. As outlined in **Section 6.2.1.1**, fleets are deemed to be of low vulnerability, high recoverability and medium-low value. The sensitivity of the receptor for all fleets is therefore considered to be low. The significance of effect on fish as a result of increases in SSCs and deposition is outlined in **Section 6.1.4**.

315. It is predicted that the sensitivity of the receptor is low and the magnitude is low. The effect is minor adverse, which is not significant in EIA terms.

6.2.1.3 Cumulative effects

316. The cumulative increases in SSCs, as a result of the Project and other plans and projects on the populations of fish and shellfish receptors, were found not to be materially elevated from Project-alone effects in EIA terms, although it is noted that there would be additional effects.

6.2.2 Marine Archaeology and Cultural Heritage

317. The assessment provided in **Chapter 15 Marine Archaeology and Cultural Heritage** was informed by the assessment undertaken in **Chapter 7 Marine Geology, Oceanography and Physical Processes** and **Chapter 9 Benthic Ecology.**

318. **Chapter 15 Marine Archaeology and Cultural Heritage** of the ES assessed potential effects of sediment excavation and disposal on the following receptors:

- Wrecks and anomalies of archaeological interest (seabed features identified as medium archaeological potential)

- Historic wrecks for which remains have yet been to be identified
- In-situ prehistoric, maritime or aviation sites
- Isolated finds
- Known and potential heritage assets

319. Each receptor is described in detail in Section 15.5 of **Chapter 15 Marine Archaeology and Cultural Heritage** of the ES

320. **Section 6.2.1.1** to **Section 6.2.1.3** below focusses on the potential impacts of sediment excavation and disposal on the receptors outlined above. A summary of the assessment sections below is provided in **Table 7.1**.

6.2.2.1 Construction

Direct impact to potential heritage assets

321. It is not possible to avoid heritage assets that have not yet been discovered (potential heritage assets). Therefore, unavoidable direct impacts associated with seabed preparation may occur, if undiscovered archaeological material is present within the windfarm site.

322. Until the final design and layouts are confirmed, there would remain uncertainty of the precise nature and extent of any potential direct impacts. All direct impacts that result in damage to, or disturbance of, in-situ prehistoric, maritime and aviation sites, and potential submerged landscape features and palaeoenvironmental evidence (where associated with palaeolandscape features or archaeological material), would be adverse, permanent and irreversible. The 'fabric' of the asset and, hence, its potential to inform our historical understanding, would be removed.

323. In practice, the magnitude of the impact would not be fully understood until after the potential heritage asset has been encountered and the impact has occurred. The extent of any impact would depend on the presence, nature and depth of any such remains, in association with the depth, location and nature of construction-related groundworks and contact with the seabed. However, as a precautionary approach, it should be assumed that key elements of the asset's fabric could be lost, or fundamentally altered, such that the asset's heritage significance is lost or severely compromised.

324. The precise nature of the impact, and the heritage significance of any material impacted, cannot be fully understood until the impact has occurred. However, it is anticipated that the appropriate application of these additional mitigation measures (outlined in Section 15.6.1.2 of **Chapter 15 Marine Archaeology and Cultural Heritage**), specifically tailored to the significance of a discovery, would result in residual effects no higher than minor adverse significance (not significant in EIA terms).

6.2.2.2 Operation and maintenance

Direct impact to potential heritage assets

325. Direct impacts to potential heritage assets are unlikely to occur resulting from intrusive maintenance activities (as described in **Chapter 5 Project Description**), as any impacts would already have occurred during the construction phase of the Project. These would already have been subject to appropriate and proportionate additional mitigation measures, as and where necessary.

326. In practice, the nature and extent of individual impacts cannot be fully understood until after any impact has occurred. Therefore, as for construction activities, and as a worst-case, there is potential for direct impacts of high adverse magnitude upon potential in-situ heritage assets and low adverse magnitude upon potential isolated finds.

327. Although the precise nature of the impact, and the heritage significance of any material impacted, cannot be fully understood until any impact has occurred, it is anticipated that the implementation of a formal Protocol for Archaeological Discoveries (PAD), and the appropriate application of additional mitigation measures (outlined in Section 15.6.2.2 of **Chapter 15 Marine Archaeology and Cultural Heritage**), if required, which would be specifically tailored to the significance of a discovery, would mean that the residual effects would be no higher than minor adverse**,** which is not significant in EIA terms.

6.2.2.3 Cumulative effects

328. On a regional level, the cumulative impacts from the Project with other projects can be offset through the mapping of accessible data and the provision of publicly accessible data, post-consent, with results from the Project and results from other offshore wind developments within the Irish Sea, if available. In this way, contribution could be made to regional research initiatives and provide 'joined-up' objectives for post-consent investigation and mitigation. This approach is set out in the Outline Offshore Written Scheme of Investigation (OWSI) (Document Reference 6.10).

7 Summary

329. As part of the DCO Application for the Project, the Applicant is applying for a disposal licence for the area identified in **Figure 1.1**, the Project windfarm site. In order to streamline the disposal site characterisation and licensing process within the DCO, this report provides the necessary information for the windfarm site to be licensed as a disposal site (and included in the DML).

330. Licensing of the proposed disposal site would allow the Applicant to dispose of material arising from construction activities (including drilling and seabed preparation, such as sandwave clearance/levelling for WTGs/OSP(s) and cables), as well as cable repair/replacement and reburial activities during the operation and maintenance phase. Licensing of the windfarm site as a disposal site would also allow the Applicant, as far as possible, to dispose of sediment in the vicinity of the locations from which it was extracted, such that sediment is disposed of within areas of similar sediment type and subject to the same sedimentary processes. Therefore, there would be no net loss of sand from the physical processes system.

331. Maximum quantities of material which would need to be excavated for seabed preparation for WTG/OSP(s) foundations and cables, drilling and cable installation are provided in **Section 2**.

332. Results of the assessment of dredging/sediment excavation and disposal on physical and human receptors are outlined in **Sections 6.1 – 6.2**. The assessment concludes that no impacts greater than minor adverse (not significant in EIA terms) are anticipated. Cumulative effects are also not considered to be above Project-alone effects, given interactions with the windfarm site would be limited. A summary of the assessments is presented in **Table 7.1.**

Table 7.1 Summary of impacts from disposal of material within the Project Order Limits

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Cumulative effect
Marine Geology, Oceanography and Physical Processes					
Construction phase Changes in SSCs due to seabed preparation for foundation installation	**ES Volume 5, Chapter 7 Marine Geology, Oceanography and Physical Processes**	**All receptors** Low	**All receptors** Not sensitive (Pathway)	**All receptors** No change (Pathway)	**All receptors** As per Project-alone
Construction phase Changes in SSCs due to drill arisings for installation of piled foundations		**All receptors** Negligible	**All receptors** Not sensitive (Pathway)	**All receptors** No change (Pathway)	
Construction phase Changes in seabed level due to seabed preparation for foundation installation		**All receptors** Negligible	**All receptors** Negligible	**All receptors** Not significant (Negligible adverse)	
Construction phase Changes in seabed level due to drill arisings for installation of piled foundations		**All receptors** Negligible	**All receptors** Negligible	**All receptors** Not significant (Negligible adverse)	
Construction phase Change in SSCs due to cable installation		**All receptors** Low	**All receptors** Not sensitive (Pathway)	**All receptors** No change (Pathway)	
Construction phase Change in seabed level due to deposition from the suspended sediment plume during cable installation		**All receptors** Negligible	**All receptors** Negligible	**All receptors** Not significant (Negligible adverse)	

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Cumulative effect
Construction phase Interruptions to bedload sediment transport due to sandwave levelling for cable installation		**All receptors** Negligible	**All receptors** Low	**All receptors** Not significant (Negligible adverse)	
Operation and maintenance Cable and WTG/OSP(s) maintenance		**All receptors** Negligible	**All receptors** Negligible	**All receptors** Not significant (Negligible adverse)	
Marine Sediment and Water Quality					
Construction phase Increase in SSCs due to seabed preparation for foundation installation	**ES Volume 5, Chapter 8 Marine Sediment and Water Quality**	**Water quality** Low	**Water quality** Low	**Water quality** Not Significant (Minor adverse)	As per Project-alone impact
Construction phase Increase in SSCs due to drill arisings for foundation installation		**Water quality** Low	**Water quality** Low	**Water quality** Not Significant (Minor adverse)	
Construction phase Increase in SSCs due to seabed preparation for inter-array and platform link cables		**Water quality** Low	**Water quality** Low	**Water quality** Not Significant (Minor adverse)	
Construction phase Deterioration in water quality due to a release of sediment bound contamination		**Water quality** Negligible	**Water quality** Low	**Water quality** Not Significant (Negligible adverse)	

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Cumulative effect
Operation and maintenance Increase in SSCs associated with cable repairs and reburial activities		**Water quality** Negligible	**Water quality** Low	**Water quality** Not Significant (Negligible adverse)	
Operation and maintenance Deterioration in water quality due to resuspension of sediment bound contamination		**Water quality** Negligible	**Water quality** Low	**Water quality** Not Significant (Negligible adverse)	

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Cumulative effect
Benthic Ecology					
Construction Increased suspended sediments and subsequent deposition	**ES Volume 5, Chapter 9 Benthic Ecology**	**Subtidal sands and gravels** Low **Subtidal mud** Low **Sea-pens and burrowing megafauna communities** Low **Designated sites with benthic features** Negligible	**Subtidal sands and gravels** Medium **Subtidal mud** Medium **Sea-pens and burrowing megafauna communities** Negligible **Designated sites with benthic features** Low	**Subtidal sands and gravels** Not Significant (Minor adverse) **Subtidal mud** Not Significant (Minor adverse) **Sea-pens and burrowing megafauna communities** Not Significant (Negligible adverse) **Designated sites with benthic features** Not Significant (Negligible adverse)	As per Project-alone impact

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Cumulative effect
Operation and maintenance Temporary increases in SSCs/sedimentation during operation and maintenance activities		**Subtidal sands and gravels** Negligible **Subtidal mud** Negligible **Sea-pens and burrowing megafauna communities** Negligible **Designated sites with benthic features** Negligible	**Subtidal sands and gravels** Medium **Subtidal mud** Medium **Sea-pens and burrowing megafauna communities** Negligible **Designated sites with benthic features** Low	**Subtidal sands and gravels** Not Significant (Minor adverse) **Subtidal mud** Not Significant (Minor adverse) **Sea-pens and burrowing megafauna communities** Not Significant (Negligible adverse) **Designated sites with benthic features** Not Significant (Negligible adverse)	

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Cumulative effect
Fish and Shellfish Ecology					
Construction Increased suspended sediments and sediment deposition	**ES Volume 5, Chapter 10 Fish and Shellfish Ecology**	**Spawning grounds** Negligible **Nursery Grounds** Negligible **Diadromous fish** Negligible **Demersal fish** Negligible **Pelagic fish** Negligible **Elasmobranchs** Negligible **Molluscs** Negligible **Crustaceans** Negligible **Designated sites** Negligible	**Spawning grounds** High/Medium **Nursery Grounds** Medium **Diadromous fish** Low **Demersal fish** Low **Pelagic fish** Low **Elasmobranchs** Low **Molluscs** Medium **Crustaceans** Medium **Designated sites** High	**Spawning grounds** Not Significant (Minor adverse) **Nursery Grounds** Not Significant (Minor adverse) **Diadromous fish** Not Significant (Negligible adverse) **Demersal fish** Not Significant (Negligible adverse) **Pelagic fish** Not Significant (Negligible adverse) **Elasmobranchs** Not Significant (Negligible adverse) **Molluscs** Not Significant (Minor adverse) **Crustaceans** Not Significant (Minor adverse) **Designated sites** Not Significant (Minor adverse)	As per Project-alone impact

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Cumulative effect
Operation and maintenance Temporary habitat loss/disturbance and increased suspended sediments (and subsequent deposition)		**Spawning grounds** Negligible **Nursery Grounds** Negligible **Diadromous fish** Negligible **Demersal fish** Negligible **Pelagic fish** Negligible **Elasmobranchs** Negligible **Molluscs** Negligible **Crustaceans** Negligible **Designated sites** Negligible	**Spawning grounds** High/Medium **Nursery Grounds** Medium **Diadromous fish** Low **Demersal fish** Low **Pelagic fish** Low **Elasmobranchs** Low **Molluscs** Medium **Crustaceans** Medium **Designated sites** High	**Spawning grounds** Not Significant (Minor adverse) **Nursery Grounds** Not Significant (Minor adverse) **Diadromous fish** Not Significant (Negligible adverse) **Demersal fish** Not Significant (Negligible adverse) **Pelagic fish** Not Significant (Negligible adverse) **Elasmobranchs** Not Significant (Negligible adverse) **Molluscs** Not Significant (Minor adverse) **Crustaceans** Not Significant (Minor adverse) **Designated sites** Not Significant (Minor adverse)	

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Cumulative effect
Marine Mammals					
Construction Changes to prey resources	**ES Volume 5, Chapter 11 Marine Mammals**	**Harbour porpoise, minke whale** Magnitude **Dolphins, seals** Magnitude **Grey seal** Low	**Harbour porpoise, minke whale** Low to medium **Dolphins, seals** Low **Grey seal** Low	**Harbour porpoise, minke whale** Not Significant (Negligible - Minor adverse) **Dolphins, seals** Not Significant (Negligible adverse) **Grey seal** Not Significant (Minor adverse)	As per Project-alone impact
Construction Changes to water quality		**All marine mammal species** Negligible	**All marine mammal species** Negligible	**All marine mammal species** Not Significant (Negligible adverse)	
Operation and maintenance Changes to prey resources		**Harbour porpoise, minke whale** Negligible **Dolphins, seals** Negligible	**Harbour porpoise, minke whale** Low to medium **Dolphins, seals** Low	**Harbour porpoise, minke whale** Not Significant (Minor adverse) **Dolphins, seals** Not Significant (Negligible adverse)	
Operation and maintenance Changes to water quality		**All marine mammal species** Negligible	**All marine mammal species** Negligible	**All marine mammal species** Not Significant (Negligible adverse)	

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Cumulative effect
Commercial Fisheries					
Construction Displacement or disruption of commercially important fish and shellfish resources	**ES Volume 5, Chapter 13 Commercial Fisheries**	**All fleets** Low	**Potting** Medium **All other fleets** Low	**All fleets** Not significant (Minor adverse)	**UK and Isle of Man dredge and demersal otter trawl (scallop) fishery** Significant (Moderate adverse) Noting commitment to monitoring and establishment of a fisheries working group **All other fleets** Not Significant (Minor adverse)
Operation and maintenance Displacement or disruption of commercially important fish and shellfish resources		**All fleets** Low	**All fleets** Low	**All fleets** Not significant (Minor adverse)	**All fleets** Not Significant (Minor adverse)

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Cumulative effect
Marine Archaeology and Cultural Heritage					
Construction Direct impact to potential heritage assets	**ES Volume 5, Chapter 15 Marine Archaeology and Cultural Heritage**	**In-situ prehistoric, maritime or aviation sites** High **Isolated finds** Low	**In-situ prehistoric, maritime or aviation sites** High* **Isolated finds** Medium*	**In-situ prehistoric, maritime or aviation sites** Not significant (Minor adverse)** **Isolated finds** Not significant (Minor adverse)**	Potential beneficial effect through regional mapping of accessible data and provision of publicly accessible data post-consent (described but currently not quantifiable)
Operation and maintenance Direct impact to potential heritage assets		**In-situ prehistoric, maritime or aviation sites** High **Isolated finds** Low	**In-situ prehistoric, maritime or aviation sites** High* **Isolated finds** Medium*	**In-situ prehistoric, maritime or aviation sites** Not significant (Minor adverse)** **Isolated finds** Not significant (Minor adverse)**	

*Cultural heritage significance

**Residual significance of effect following additional mitigation

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9 Appendix 1

333. The locations of sediment sample sites analysed for contaminants are shown in **Table 9.1**. Of the 20 sample sites, 14 are located within the windfarm site, with the remaining six samples located outside of the windfarm site (within 5km of the western site boundary). **Table 9.1** presents the survey data for metals, and **Table 9.2** and **Table 9.3** presents the data for PAHs compared to the sediment quality guidelines outlined in Section 8.4.1.2 of **Chapter 8 Marine Sediment and Water Quality**. Sampling sites located within the windfarm site are marked in red text in all tables. All other data was below the limits of detection and is available in **Appendix 9.1** of **Chapter 9 Benthic Ecology** of the ES.

334. With respect to metals, concentrations indicate very low levels of contamination across the sampled sites. The only parameter exceeding either of the sediment guideline values was mercury for OSPAR BAC (five samples) and only one sample recorded levels at the ERL (i.e., sample concentration equalled the ERL). These findings are broadly in line with the findings of the OSPAR interim assessment (2017) for the region. All other parameters were below all guideline values applied and therefore below findings in the OSPAR interim assessment (2017). No samples exceeded the Cefas ALs.

335. With respect to PAHs, several samples exceeded the BAC, but there were no exceedances of the Cefas AL1. Where exceedances occurred, concentrations were only marginally above the BAC value. Concentrations of PAHs are therefore very low across the sampled sites and in line with the findings of the OSPAR interim assessment (2017). No samples exceeded the Cefas AL1 value. THC in sediment samples ranged from 1.00mg/kg to 33.70mg/kg, again indicating relatively low levels of contamination.

Table 9.1 Site specific data collected in 2022 for metals (Ocean Ecology Limited, 2022) (coloured dots against each sediment quality guideline are used to indicate where there is an exceedance). All data in mg/kg. Stations within the windfarm site are in red text

Site reference	Arsenic	Cadmium	Chromium	Copper	Nickel	Lead	Mercury	Zinc
AL1 ●	20	0.4	40	40	20	50	0.3	130
AL2 ●	100	5	400	400	200	500	3	800
BAC ●	25	0.31	81	27	36	38	0.07	122
ERL ●	-	1.2	81	34	-	47	0.15	150
ST01	8.7	<0.04	12.2	12.2	10.4	12.2	0.06	32.3
ST02	5.0	<0.04	8.4	8.4	6.5	8.8	0.05	28.6
ST05	5.9	0.08	14.7	14.7	11.2	15.4	0.11 ●	47.8
ST11	4.6	<0.04	8.7	8.7	6.3	9.3	0.06	28.8
ST18	5.7	<0.04	8.1	8.1	6.0	8.0	0.05	24.3
ST20	5.0	0.06	9.2	9.2	7.3	10.0	0.06	29.8
ST22	5.8	0.08	13.5	13.5	10.8	15.4	0.15 ●●	47.1
ST23	4.9	0.05	7.8	7.8	5.8	7.9	0.06	22.4
ST26	8.3	0.05	6.6	6.6	5.3	8.6	0.04	27.2
ST31	6.7	<0.04	14.7	14.7	10.8	16.5	0.12 ●	47.4
ST32	7.1	<0.04	7.1	7.1	5.1	8.1	0.03	26.0
ST35	5.8	<0.04	9.8	9.8	7.2	11.5	0.05	32.8
ST38	6.0	0.07	16.8	16.8	12.7	18.2	0.12 ●	52.2
ST40	6.4	<0.04	15.9	15.9	11.5	16.1	0.12 ●	46.5
ST42	4.6	0.08	7.2	7.2	5.6	7.3	0.02	22.1
ST43	9.2	<0.04	6.2	6.2	5.3	6.4	0.01	21.3

Site reference	Arsenic	Cadmium	Chromium	Copper	Nickel	Lead	Mercury	Zinc
ST44	6.5	<0.04	6.4	6.4	5.0	8.5	0.03	25.0
ST48	6.0	<0.04	6.8	6.8	4.8	7.6	0.05	21.0
ST49	4.6	0.05	7.5	7.5	5.4	8.3	0.05	23.8
ST50	6.1	0.07	14.8	14.8	10.3	15.7	0.10	44.1

Table 9.2 Site specific data for PAHs collected in 2022 (Ocean Ecology Limited, 2022) (coloured dots against each sediment quality guideline are used to indicate where there is an exceedance). All data in µg/kg. Stations within the windfarm site are in red text.

Site reference	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(ghi)perylene	Benzo(e)pyrene	Benzo(k)fluoranthene	C1-Naphthalene	C1 -Phenanthrene	C2-Napthalene	C3-Napthalene	Chrysene	Dibenzo(ah)anthracene
AL1 ●	100	100	100	100	100	100	100	100	100	100	100	100	100	100	10
AL2 ●	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BAC ●	-	-	5	16	30	-	80	-	-	-	-	-	-	-	-
ERL ●	-	-	85	261	430	-	-	-	-	-	-	-	-	-	-
ST01	<1	<1	1.40	4.34	5.97	8.61	7.38	8.05	3.93	9.20	12.3	17.5	11.1	5.44	1.24
ST02	<1	<1	<1	2.48	3.45	5.37	4.89	5.03	2.63	5.82	5.22	11.8	6.27	3.07	<1
ST05	1.94	2.62	6.05 ●	16.9 ●	24.3	31.6	28.6	29.1	15.4	25.6	34.0	31.6	25.2	19.5	4.60
ST11	<1	<1	1.68	4.69	6.63	9.43	8.42	9.38	4.47	9.58	12.7	13.7	11.2	6.35	1.43
ST18	<1	<1	<1	2.07	3.16	4.07	4.98	4.56	2.05	4.18	5.04	7.54	5.22	2.68	<1
ST20	<1	<1	1.73	4.86	6.62	9.66	8.27	9.58	5.00	9.28	18.3	17.1	16.3	6.60	1.36
ST22	2.24	2.20	5.54 ●	17.1 ●	25.1	33.3	29.3	31.1	19.7	25.6	35.9	35.5	30.0	21.4	4.89
ST23	<1	<1	<1	2.85	4.23	5.69	4.82	5.79	3.74	5.14	5.40	11.1	5.57	3.53	<1
ST26	<1	<1	<1	<1	<1	1.78	1.45	1.85	<1	2.05	2.49	6.05	2.10	1.15	<1
ST31	2.43	2.96	5.37 ●	18.3 ●	26.8	34.7	30.2	32.3	20.0	29.9	32.9	44.0	28.9	22.2	5.21

Site reference	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(ghi)perylene	Benzo(e)pyrene	Benzo(k)fluoranthene	C1-Naphthalene	C1 -Phenanthrene	C2-Napthalene	C3-Napthalene	Chrysene	Dibenzo(ah)anthracene
ST32	<1	<1	<1	1.08	1.49	2.21	1.71	2.40	1.29	2.43	3.65	5.06	3.62	1.52	<1
ST35	1.23	1.09	2.42	7.71	10.6	13.5	10.9	12.9	5.79	10.5	12.9	14.0	10.9	8.86	1.99
ST38	2.74	3.26	6.64 ●	20.8 ●	30.5 ●	40.0	35.0	38.3	22.4	33.9	40.1	47.8	37.4	24.4	5.98
ST40	2.45	2.89	5.23 ●	17.3 ●	25.7	33.6	29.4	31.8	18.0	29.7	29.7	42.5	26.7	18.8	5.30
ST42	<1	<1	1.01	3.03	4.39	5.93	4.80	5.93	3.36	5.29	6.63	13.9	5.30	4.77	1.14
ST43	<1	<1	<1	<1	<1	1.11	<1	1.11	<1	1.62	1.34	2.81	1.26	<1	<1
ST44	<1	<1	<1	1.05	1.70	2.66	2.05	2.53	1.10	2.80	2.93	8.50	2.81	1.45	<1
ST48	<1	<1	1.09	2.84	4.34	6.26	5.00	5.93	3.13	5.06	5.95	11.3	4.79	3.88	<1
ST49	<1	<1	1.21	3.33	4.81	6.30	5.03	6.29	3.01	5.41	6.29	8.05	4.82	4.06	<1
ST50	2.10	2.08	4.69	14.1	20.3	25.3	22.0	24.3	15.0	22.4	23.0	30.3	20.6	17.6	3.73

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Table 9.3 Site specific data for PAHs collected in 2022 (Ocean Ecology Limited, 2022) (coloured dots against each sediment quality guideline are used to indicate where there is an exceedance). All data in µg/kg apart from THC which is in mg/kg. Stations within the windfarm site are in red text.

Site reference	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Perylene	Phenanthrene	Pyrene	THC (mg/kg)
AL1 ●	100	100	100	100	100	100	100	100mg/kg
AL2 ●	-	-	-	-	-	-	-	-
BAC ●	39	-	103	8	-	-	24	-
ERL ●	600	-	-	160	-	-	665	-
ST01	8.10	1.58	6.75	4.11	1.91	8.32	8.14	9.07
ST02	4.86	1.11	3.34	2.46	1.12	4.10	5.10	3.41
ST05	32.7	4.79	26.3	8.98 ●	9.06	30.0	32.7 ●	18.3
ST11	8.67	1.57	7.50	3.68	2.23	8.80	9.09	6.52
ST18	4.43	<1	2.58	2.08	1.06	3.89	4.35	3.33
ST20	8.96	1.71	7.57	3.91	2.47	10.8	10.1	4.50
ST22	31.1	4.40	27.6	10.2 ●	8.98	26.4	32.3 ●	33.7
ST23	5.22	<1	4.93	2.36	1.58	4.50	5.46	7.22
ST26	1.77	<1	1.24	1.06	<1	1.76	1.86	1.35
ST31	33.8	5.63	28.0	12.5 ●	9.33	28.3	34.7 ●	23.8
ST32	2.29	<1	1.54	1.27	<1	2.29	2.44	1.45
ST35	15.7	1.92	9.89	4.84	2.81	11.4	15.6	7.18

Site reference	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Perylene	Phenanthrene	Pyrene	THC (mg/kg)
ST38	40.1 ●	6.29	31.8	15.2 ●	11.1	33.6	40.0 ●	27.3
ST40	32.1	5.43	27.6	16.6 ●	8.87	25.8	32.8 ●	18.3
ST42	6.24	<1	4.01	2.67	1.34	5.57	6.33	3.99
ST43	1.02	<1	<1	1.11	<1	1.01	1.23	1.00
ST44	2.25	<1	1.92	2.90	<1	2.13	2.38	1.42
ST48	5.85	1.08	4.02	2.57	1.37	4.86	5.88	4.76
ST49	6.40	<1	4.42	2.36	1.94	5.04	6.56	3.62
ST50	27.3	4.37	20.2	10.3 ●	6.94	20.8	28.3 ●	16.6