FIVE ESTUARIES OFFSHORE WIND FARM

VOLUME 9, REPORT 8: DREDGE DISPOSAL SITE CHARACTERISATION REPORT (~~CLEAN~~TRACKED)

Application Reference	EN010115
Application Document Number	9.8
Revision	C~~B~~
Pursuant to:	Deadline 7~~4~~
EcoDoc Number:	005023924-04~~3~~
Date	~~December 2024~~March 2025

In preparation of this document Five Estuaries Wind Farm Ltd has made reasonable efforts to ensure that the content is accurate, up to date and complete for purpose.

Revision	Date	Status/Reason for Issue	Originator	Checked	Approved
B	Dec-24	Deadline 4	GoBe	GoBe	VE OWFL
C	Mar-25	Deadline 7	GoBe	GoBe	VE OWFL

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DEFINITION OF ACRONYMS

Term	Definition
CAL1	Cefas Guideline Action Level 1
CFE	Controlled Flow Excavation
DBT	Dibutyltin
DCO	Development Consent Order
DML	Deemed Marine Licences
ECC	Export Cable Corridor
EIA	Environmental Impact Assessment
ES	Environmental Statement
HDD	Horizontal Directional Drilling
HVDC	High-Voltage Direct-Current
ICES	International Council for the Exploration of the Sea
INNS	Invasive Non-Native Species
LAT	Lowest Astronomical Tide
LoD	Level of Detection
MBES	Multi-Beam Echo Sounder
MCZ	Marine Conservation Zones
MDS	Maximum Design Scenario
MHWS	Mean High Water Springs
MFE	Mass Flow Excavator
MMO	Marine Management Organisation
MW	Megawatt
NRHE	National Record of the Historic Environment
NSIBTS	North Sea International Bottom Trawl Surveys
NSIP	Nationally Significant Infrastructure Project
OCP	Organochlorine Pesticides
OSP	Offshore Substation Platform
OWF	Offshore Wind Farm
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated biphenyl
PEL	Probable Effect level

Term	Definition
PEXA	Practice and Exercise Areas
PTS	Permanent Threshold Shift
SAC	Special Area of Conservation
SoS	Secretary of State
SPA	Special Protection Area
SQGs	Sediment Quality Guidelines
SSC	Suspended Sediment Concentration
SSS	Side Scan Sonar
SSSI	Sites of Special Scientific Interest
TBT	Tributyltin
TEL	Threshold Effect level
THC	Total Hydrocarbon Content
TTS	Temporary Threshold Shift
UKHO	United Kingdom Hydrographic Office
UXO	Unexploded Ordnance
VE	Five Estuaries
WTG	Wind Turbine Generator

1 INTRODUCTION

1.1 PROJECT BACKGROUND

1.1.1 The Five Estuaries Offshore Wind Farm (hereafter VE) is a proposed extension to the operational Galloper Offshore Wind Farm, which is located off the coast of Suffolk (England, UK) in the Southern North Sea. At its closest point, VE is located 37 km off the Suffolk coast.

1.1.2 VE comprises an offshore generating station with a capacity of greater than 100 Megawatt (MW) and therefore constitutes a Nationally Significant Infrastructure Project (NSIP), as defined by Section 15(3) of the Planning Act 2008. As such, there is a requirement to submit an Application for a Development Consent Order (DCO) to the Secretary of State (SoS). Further information regarding the DCO application process can be found in Volume 6, Part 1, Chapter 2: Policy and Legislation. A Marine Licence is also required under the Marine and Coastal Access Act 2009 before carrying out any licensable marine activity, which includes the works required to construct VE. This will be included within the DCO (if granted).

1.1.3 VE will include both offshore and onshore infrastructure, including an offshore generating station in an area of 128 km^2 (divided in two areas of 67 km^2 and 61 km^2 for the northern array area and southern array area respectively), export cables to landfall (maximum length of 196 km), and connection to electricity transmission network (please see Volume 6, Part 2, Chapter 1: Offshore Project Description for full details of the Project Design).

1.1.4 The key components of VE project are listed below (please see Table 3.1 in Volume 6, Part 2, Chapter 1: Offshore Project Description for full details):

- Up to 79 Wind Turbine Generators (WTG) across two separate seabed areas;
- Up to 2 Offshore Substation Platforms (OSP);
- Offshore cabling (comprising inter-array up to 200 km and export cables up to 196 km);
- Scour and cable protection;
- Onshore substation;
- Onshore cabling; and
- Grid connection.

1.1.5 For the purposes of the Environmental Impact Assessment (EIA) the following turbine and offshore platform foundations have been considered in the assessment (for further details on the various foundation options please see Volume 6, Part 2, Chapter 2: Offshore Project Description):

- Monopile foundation;
- Suction bucket monopile foundation;
- Pin-piled jacket foundation; and
- Suction bucket jacket foundation

1.1.6 The final foundations for VE will be chosen following detailed design, which will consider factors such as the selected wind turbine type or offshore platform size, ground conditions, water depth, metocean conditions (wind, wave, current and tidal regime), economic factors at the time of design and construction, as well as the results of the EIA.

1.2 SCOPE AND PURPOSE OF THIS DOCUMENT

1.2.1 This document comprises the site characterisation for VE as required to permit the disposal of seabed and sub-bottom geological material that may arise during the construction of the offshore elements of VE.

1.2.2 There is a requirement that a site characterisation report be submitted to the Marine Management Organisation (MMO), and their scientific advisor, Cefas (the Centre for Environment, Fisheries and Aquaculture Science), to inform the decision-making process and to allow the licensing of the disposal site/s. In addition, the preparation of a site characterisation report facilitates consideration of the potential need for any relevant conditions in relation to the disposal activity within the Deemed Marine Licences (dMLs) for VE.

1.2.3 Site characterisation is the process whereby a proposed marine disposal site for spoil material and drill arisings generated by construction activities is described in terms of the existing environment, using all available data sources. The following information is provided:

- need for the new disposal site;
- dredged and/or drilled material characteristics;
- disposal site characteristics;
- assessment of potential effects; and
- reasons for the site selection.

1.2.4 This document outlines the site characterisation for the following proposed VE disposal sites that are illustrated in Figure 1.

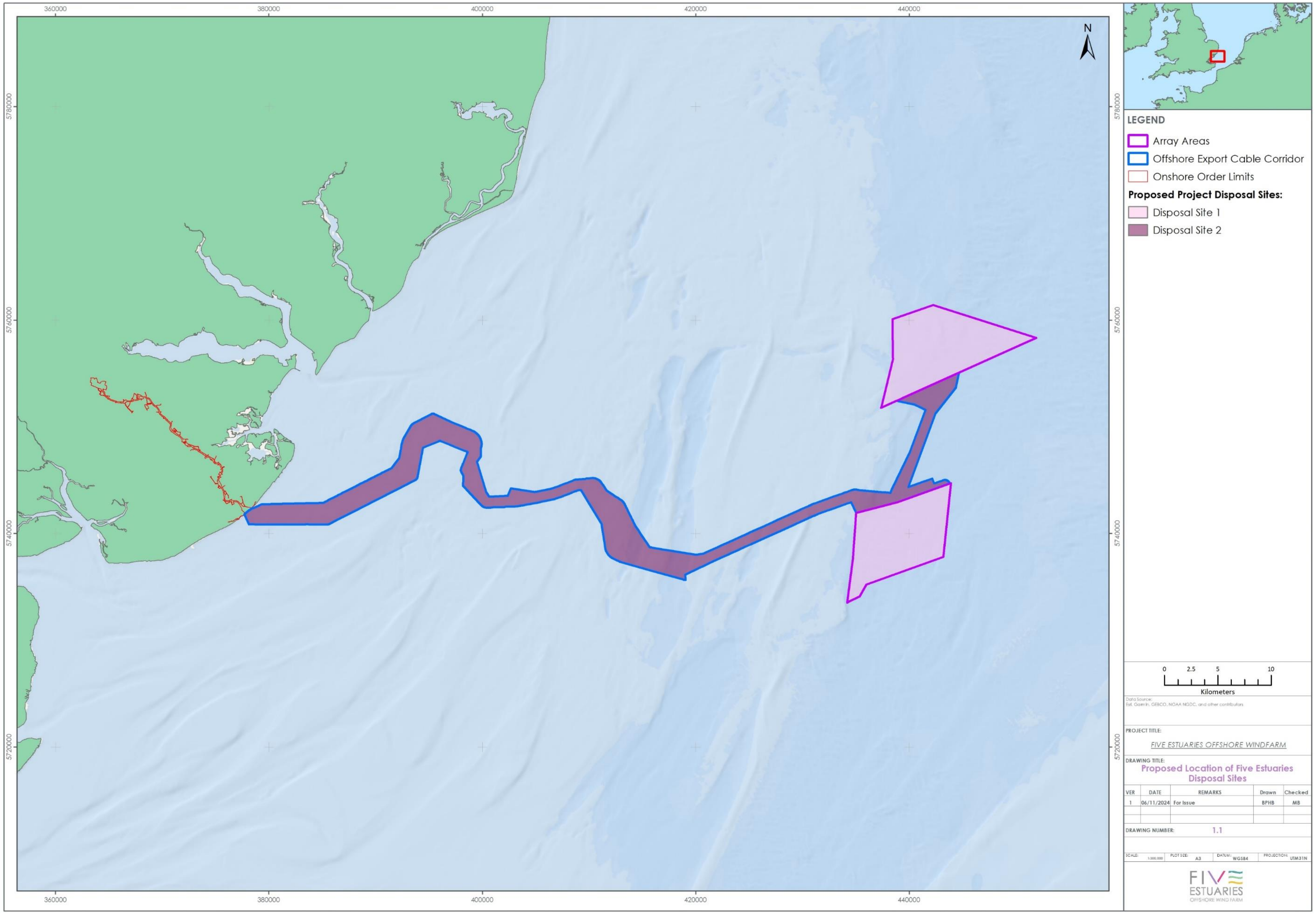
- Array Area Disposal Sites: the full extent of the VE Array Areas (as defined in Figure 1.11 in Volume 6, Part 2, Chapter 1: Offshore Project Description); and
- Export Cable Corridor Disposal Site: the full extent of the offshore export cable corridor (unless otherwise stated within 10.30 Outline Sediment Disposal Management Plan and highlighted within Figure 3.1 of that document) (ECC) including the temporary works area (as defined in Figure 1.11 in Volume 6, Part 2, Chapter 1: Offshore Project Description).

1.2.5 For specific commitments associated with sediment disposal within the two disposal sites i.e. Array Areas (Disposal Site 1) and Offshore ECC (Disposal Site 2), please refer 10.30 Outline Sediment Disposal Management Plan where further detail is provided.

The disposal activity will involve the deposit of inert, native sedimentary material originating from the following activities associated with the construction of VE:

- Construction drilling;
- Seabed preparation for foundation works;
- Cable installation preparation; and

- Excavation of horizontal directional drilling (HDD) exit pits.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380000
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420000
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N
LEGEND
Array Areas
Offshore Export Cable Corridor
Onshore Order Limits
Proposed Project Disposal Sites:
Disposal Site 1
Disposal Site 2
0 2.5 5 10
Kilometers
Data Source:
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
PROJECT TITLE:
FIVE ESTUARIES OFFSHORE WINDFARM
DRAWING TITLE:
Proposed Location of Five Estuaries Disposal Sites
VER DATE REMARKS Drawn Checked
1 06/11/2024 For Issue BPHB MB
DRAWING NUMBER: 1.1
SCALE: 1:300,000 PLOT SIZE: A3 DATUM: WGS84 PROJECTION: UTM31N
FIVE ESTUARIES
OFFSHORE WIND FARM

2 PREDICTED SOURCE OF SPOIL AND ESTIMATED QUANTITIES FOR DISPOSAL

2.1 SOURCES OF SPOIL

FOUNDATION INSTALLATION – SEABED PREPARATION AND DRILLING

2.1.1 Spoil will be generated from the installation of each of the WTG and OSP foundation types that are included in the project design (either through seabed preparatory works and/or from drilling).

2.1.2 For those foundation types that may require seabed preparation (i.e., all foundation types excluding monopiles), any soft mobile or unlevel sediment in the area of installation may need to be removed to create a firm, stable and level seabed prior to foundation installation. Initial investigations (please see Volume 6, Part 2, Chapter 2: Marine Geology, Oceanography and Physical Processes) have shown some variability in seabed sediments across the VE Array Areas, which are dominated by coarse sands, with varying contributions of gravel. Typically, surface sediments (sands and gravels) will be removed by a suction hopper dredger which will subsequently release the dredged sediment from its hopper either at the water surface or via discharge pipes (or downpipe), usually adjacent to the foundation locations.

2.1.3 Seabed preparation may also involve installing a gravel bed (depending on the existing conditions), which may, therefore, require importation of suitable gravel material.

2.1.4 Depending on the local ground conditions within the VE Array Area, drilling may be required to facilitate the installation of monopiles and/or pin-piles for jacket foundations to target depth, with the subsequent drill arisings disposed of at sea adjacent to the foundation location.

2.1.5 Disposal of drill arisings adjacent to installed foundations has been used on existing UK offshore wind farms, including Lynn, Inner Dowsing and Lincs, with preliminary post-disposal monitoring indicating no long-term adverse effects on the overall benthic ecology of the study area (CREL 2013).

CABLE INSTALLATION PREPARATION – SANDWAVE CLEARANCE AND PRE-TRENCHING

2.1.6 Prior to the installation of cables (array, export, and interconnector cables), seabed preparation in the form of sandwave clearance and pre-trenching may be required to facilitate the use of cable installation equipment within its operational tolerances and to reduce stress on the cable by maximising the bending radius. These activities also reduce the chance of unsuccessful cable installation and increases the likelihood of installation to the maximum target burial depth.

2.1.7 As with seabed preparation described above, sandwave clearance may be undertaken by suction hopper dredger, which will subsequently release material at the sea surface or via discharge pipes and will be composed of surficial sediments. Alternatively, the seabed may be levelled by the use of Controlled Flow Excavation (CFE) or Mass Flow Excavation (MFE).

2.2 VOLUME OF SPOIL FOR DISPOSAL

FIVE ESTUARIES OFFSHORE WIND FARM ARRAY DISPOSAL SITE

2.2.1 The Maximum Design Scenario (MDS) volumes of material to be disposed in the Array Area from seabed preparation for foundation works, pile drilling and cable installation preparation are summarised in Table 2.1.

2.2.2 Of note is that it is possible that piled jacket foundations may require seabed preparation as well as drilling. In this case, the total disposal volume for this foundation type will not exceed the total volume for the MDS of seabed preparation for non-piled foundations.

FIVE ESTUARIES OFFSHORE WIND FARM ECC DISPOSAL SITE

2.2.3 The MDS for the offshore ECC includes sandwave clearance and export cable installation are shown in Table 2.1.

2.2.4 For specific commitments associated with disposal within the offshore ECC, please refer to 10.30 Outline Sediment Disposal Management Plan, submitted at Deadline 4.

TOTAL

2.2.5 As the worst-case scenario, the total volume of material that may require disposal would be up to 31,588,757 m^3, of which up to 22,374,37124,556,610 m^3 may be disposed of within the Array Area disposal sites (northern array and southern array sites) and up to 9,214,386 m^3 in the export cable corridor disposal site.

2.2.6 It should be noted that this assessment has been prepared on the basis that the maximum volume of material requiring disposal from activities in the southern and northern arrays may be disposed of anywhere in the Array Area disposal site (e.g. the entire volume disposed of in the northern array). However, as stated in Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology, material from the southern array will either be disposed of in the southern array or the northern array; but material from the northern array will not be disposed of in the southern array. However, the maximum volume, up to 22,374,37124,556,610 m^3, for disposal will not be exceeded under any distribution scenario.

2.2.7 Similarly, the maximum volume of material cleared from sandwaves requiring disposal from the array cables between the array areas may either be disposed of in the northern array (disposal site 1) or in the Offshore ECC (disposal site 2). However, the maximum volume of material requiring disposal (31,588,757 m^3) will not be exceeded regardless of the distribution scenario.

Table 2.1: MDS for dredged material disposal

Parameter	Disposal site 1	Disposal site 2	Total
Project location	Array Areas	Offshore ECC	N/A
Drill arisings (m^3)	567,430	N/A	567,430
Seabed preparation spoil volume for all foundations (m^3)	1,193,600	N/A	1,193,600
Volume from HDD exit pits and vessel laydown areas	N/A	63,225	63,225
Expected maximum volume of material cleared from sandwaves requiring disposal (m^3)	20,613,341 (associated with Array Cables)	6,968,922 (associated with export cables)	29,764,502
	2,182,239 (associated with potential array cables between north and south array areas)		
Total (m^3) – maximum in individual disposal site	22,374,371~~24,556,610~~	9,214,386	31,588,757
Total (km^3) - maximum in individual disposal site	0.025	0.009	0.032

3 ALTERNATIVE OPTIONS FOR DISPOSAL

3.1.1 The following section of this site characterisation document presents information on potential alternative options for the disposal of dredged and/or drilled material derived from VE. The consideration of alternatives to disposal of dredged and/or drilled material within VE is an important part of the site characterisation process and is required in order to inform the decision-making process led by the MMO and its advisers.

3.1.2 Once drilled or dredged material has been produced, it is classified as a waste material. Once a material has entered the waste stream it is strictly controlled.

3.1.3 Disposal of dredged and drilled material is controlled under the London Convention 1972, the Oslo-Paris Commission (OSPAR) Convention 1992, and the European Union (EU) Waste Framework Directive 2008/98/EC. At the core of the Waste Framework Directive is the Waste Hierarchy (Department for Environment, Food & Rural Affairs (Defra) 2011) which comprises:

- Prevention;
- Re-use;
- Recycle;
- Other recovery; and
- Disposal.

3.1.4 Where prevention or minimisation is not possible, management options for dealing with waste material must consider the alternative options in the order of priority indicated above (i.e. re-use, recycle, other recovery and then disposal).

3.2 PREVENTION

3.2.1 The Waste Hierarchy places a strong emphasis on waste prevention or the minimisation of waste. However, consent is being sought for VE for the use of a range of foundation options and cable installation methodologies. Further information is required before the design of VE can be finalised.

3.2.2 In the case of piled foundations selected, if percussive piling alone does not achieve full pile penetration due to the presence of hard ground conditions, the material inside the monopile/pin piles may need to be drilled out before the pile can be driven to the required depth. If drilling is required, the generation of spoil arising from the drilling will be unavoidable.

3.2.3 In the case of non-piled foundations selected, seabed preparation works including dredging and disposal will be unavoidable to achieve the flat and stable seabed that is required to seat these particular foundation types. Furthermore, the volumes of spoil generated will depend on the size of foundations needed and the seabed conditions at each installation location.

3.2.4 Sandwave and megaripple clearance is expected to be required in areas where associated gradients are in excess of the working limits for standard cable and foundation installation, to avoid unnecessary strain on the cables through bending, and to maximise ploughing efficiency and reduce the chances of burial failure. Additionally, the cable must be buried to a depth where it can be expected to stay buried for the duration of the project lifetime. Sandwaves and megaripples are generally mobile in nature, therefore the cable must be buried beneath the level where natural sandwaves movement would uncover it. Sometimes this can only be done by removing the mobile sediments before installation takes place. Therefore, to install the cables and foundations for VE, sandwaves and megaripples clearance and the associated dredging and disposal works will, in some cases, be unavoidable.

3.2.5 As a result, the safe and effective installation of the VE infrastructure may involve installation techniques that give rise to spoil. Whilst spoil volumes will be minimised to that necessary for safe and effective installation, it is not possible to prevent spoil generation.

3.3 RE-USE

3.3.1 Where prevention is not possible, the re-use of dredged and drilled material is the preferred option. Potential options for the re-use of dredged and drilled material can include, among other re-uses:

- Beach nourishment/replenishment schemes;
- Land reclamation schemes; and
- Habitat enhancement schemes.

3.3.2 The disposal material within the Array Areas and offshore ECC could potentially have alternative uses. Transfer of the volume of spoil material to another location where material could be re-used would consist of the movement of up to 22,374,37124,556,610 m^3 from the Array Areas and to 9,214,386 m^3 from the offshore ECC (See Table 2.1). Alternative uses are most likely to be based on land, which would require a total of up to, approximately, 2232 and 838 dredging cycles for the Array Areas and ECC disposal, respectively (assuming a hopper capacity of 11,000 m^3).

3.3.3 Collection of drill arisings would be costly due to the need for suction dredging vessels in addition to drilling vessels and the limited material produced at each foundation site means collection would not be viable.

3.3.4 Dredger movements would lead to additional environmental impacts due to increased vessel emissions that could be avoided if dredged material were disposed of in situ (i.e., close to the source of production).

3.3.5 At the time of writing, no projects have been identified that could accept the type and volume of spoil material that might be generated during the construction of VE. Therefore, even if it were technically and economically feasible to re-use the spoil material, at present there are no known projects to facilitate its re-use.

3.4 RECYCLE

3.4.1 Recycling of drilled and dredged material would involve transforming the material into a different form, for example to produce bricks or aggregate material. As outlined in the MMO guidance (MMO, 2011), these are generally land-based solutions with any material produced used in onshore construction projects. As such, the same issues with respect to vessel movements to transport the dredged material to land, as discussed above, would apply. The disposal of drilled and dredged spoil material in situ would preclude the additional environmental impacts that would arise.

3.5 OTHER RECOVERY

3.5.1 There are currently very few examples of recovery from dredged and drilled material (MMO 2011) and no such options have been identified for the spoil material from VE.

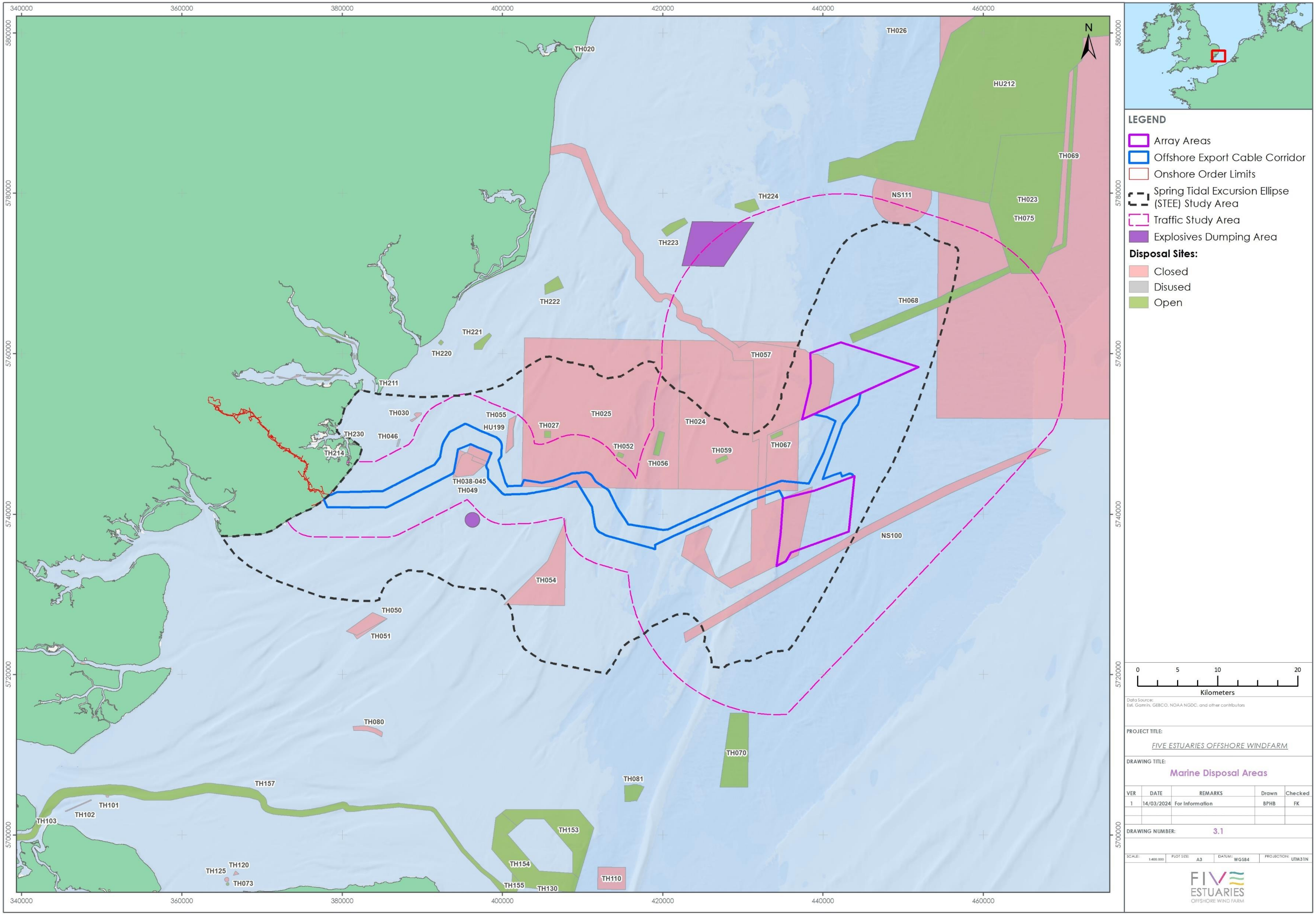
3.6 DISPOSAL

3.6.1 With regards to the potential to dispose of the produced spoil at an existing marine disposal site, four disposal sites open are located within 30 km of the Array Areas and the ECC: Inner Gabbard East; East Anglia One; Inner Gabbard; and Harwich Haven. The closest disposal sites from VE Array Areas are Inner Gabbard East and East Anglia One (16.4 km for both). Whereas the closest disposal site from ECC is Inner Gabbard (3.9 km) (see Figure 3.1).

3.6.2 Disposal sites are generally licensed to enable the disposal of material from specific locations and activities. It is not considered desirable to use an existing disposal site since they are not generally designated for additional volumes beyond those necessary for the specific purpose for which they were licensed.

3.6.3 In addition, the use of another site would require the transport of spoil material from VE to another disposal site, resulting in additional vessel movements and removal of material from the existing sediment cell, potentially hindering recovery. The receiving seabed environment at an alternative location may also be characterised by a somewhat different sediment composition. Disposal of the spoil material in situ within the VE project boundary, and close to the point of production, ensures that the spoil will be returned into a similar sedimentary environment and facilitate recovery. Disposal of material at another disposal site may also require hydrodynamic and sediment transport modelling studies to determine the capacity of the site to accommodate the additional spoil type and volumes.

3.6.4 Therefore, it is concluded that disposal at an existing marine disposal site does not represent the most efficient or environmentally robust approach to disposal of material from VE Array Area and the offshore ECC.


LEGEND
Array Areas
Offshore Export Cable Corridor
Onshore Order Limits
Spring Tidal Excursion Ellipse (STEE) Study Area
Traffic Study Area
Explosives Dumping Area
Disposal Sites:
Closed
Disused
Open
0 5 10 20
Kilometers
Data Source:
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
PROJECT TITLE:
FIVE ESTUARIES OFFSHORE WINDFARM
DRAWING TITLE:
Marine Disposal Areas
VER DATE REMARKS Drawn Checked
1 14/03/2024 For Information BPHB FK
DRAWING NUMBER: 3.1
SCALE: 1:400,000 PLOT SIZE: A3 DATUM: WGS84 PROJECTION: UTM31N
FIVE ESTUARIES
OFFSHORE WIND FARM
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TH153
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TH125
TH154
TH073
TH110
TH155
TH130

4 CHARACTERISTICS OF THE FIVE ESTUARIES OFFSHORE WIND FARM DISPOSAL SITES

4.1 PHYSICAL CHARACTERISTICS

4.1.1 This section provides a summary of the physical characteristics of the VE Array Area and offshore ECC. Further details on the physical environment are set out in Volume 6, Part 2, Chapter 2: Marine Geology, Oceanography and Physical Processes.

TIDAL AND WAVE REGIME

THE ARRAY AREAS

4.1.2 The Array Areas of VE are located in a meso-tidal setting, with the mean spring tidal range increasing from circa 2.0 m in the north to 3.0 m in the south. Peak current speeds are, approximately, 1.2 to 1.3 m/s across the Array Areas, with little difference between the northern Array Area and southern Array Area.

4.1.3 The Array Areas are exposed to longer wave fetches (distances of open water over which waves can develop) from the north to northeast. Smaller, but more frequently occurring, wave conditions generated by local winds predominantly come from southerly and southwesterly directions.

THE OFFSHORE EXPORT CABLE CORRIDOR

4.1.4 The mean spring tidal range increases from circa 2.6 m offshore to 3.6 m at the landfall. Tidal currents generally reduce with proximity to the coast, from around 1.3 m/s offshore, to less than 1 m/s at the landfall. However, currents can become considerably faster and more complex locally around the major offshore sandbank features.

4.1.5 Wave heights will tend to reduce with distance into the Outer Thames Estuary and with increased coastal proximity. This is due to decreasing water depth, decreasing fetch length in the predominant wind direction, and generally greater protection from waves generated elsewhere in the North Sea. The associated local predominant wave direction will also vary accordingly. Just offshore from the landfall, waves predominantly approach from the northeast and southwest although these waves will be refracted as they approach the coast.

SEDIMENT AND GEOLOGY

THE ARRAY AREAS

4.1.6 The seabed is found to be dominated by coarse grained sediments, with sands and gravelly sands accounting for circa 75% of the footprint of the Array Areas. The remaining areas are characterised by the presence of muddy sand, which is found in the west of the northern Array Area and in localised northeast- to southwest-trending bands in the southern Array Area.

4.1.7 Where present, sand is expected to be highly mobile. Rates of sediment transport are expected to generally be higher in the southern Array Area in comparison to the northern Array Area, consistent with increased distance from the bedload parting zone to the north of the Array Areas.

4.1.8 On the basis of the sub-bottom profile data collected during the VE geophysical survey, three main geological units have been interpreted in the Array Areas, all deposited within the past 56 Ma:

- Holocene: present day surficial sediments (largely sands and gravels) which reach a maximum thickness of 19 m below the seafloor in the northern Array Area;
- Pleistocene: variety of channel complexes of varying sizes, incising through London Clay Formation and Harwich Formation. They reach a maximum thickness of 7 m below the seafloor in the Array Areas; and
- London Clay Formation: dominated by fine-grained deep-water marine clayey silts, silty clays and clays, found at or close to the surface in much of the Array Areas.

THE OFFSHORE EXPORT CABLE CORRIDOR

4.1.9 The distribution of seabed sediments along the offshore ECC is highly complex, with coarse grained (sands and gravels) and fine grained (muddy) sediments widespread (Fugro, 2022b). In many nearshore areas (less than 20 km from the coast), rock is found at or very near to the surface, alongside extensive areas of gravelly mud. This unit likely reflects the winnowing of the underlying London Clay formation.

4.1.10 Where present, sand is expected to be highly mobile along the offshore ECC. This is particularly the case on and around the active bank systems and throughout much of the nearshore area. At the regional scale, sediment transport is broadly in a southerly direction along the offshore ECC although superimposed on this are highly complex localised patterns of sediment circulation around banks and other topographic features.

4.1.11 On the basis of the sub-bottom profile data collected during the VE geophysical survey, four main geological units have been interpreted within the offshore ECC:

- Holocene: present day surficial sediments which reach a maximum thickness of 16 m below the seafloor in the offshore ECC;
- Pleistocene: variety of channel complexes of varying sizes, reaching a maximum thickness of >12 m below the seafloor in the offshore ECC;
- London Clay Formation: dominated by fine-grained deep-water marine clayey silts, silty clays and clays, found within 2 m of the seafloor along most of the offshore ECC; and
- Harwich Formation: consists of sands and silts. Only observed within nearshore areas (<20 km from the coast) of the offshore ECC. The top of the unit was identified between 0 and 19.8 m below the sea floor, with sub-crop or outcrop also interpreted (Fugro, 2022b).

SEABED GEOMORPHOLOGY

THE ARRAY AREAS

4.1.12 Water depths within the Northern Array Area range between 25 m and 55 m below Lowest Astronomical Tide (LAT; Fugro 2022a). Depths shallow abruptly in the west, in relation to the presence of a notable plateau feature, with the seafloor being relatively flat and featureless on this plateau, with limited sediment cover. Sandwaves with superimposed megaripples are visible in the centre of the northern Array Area. The largest sandwaves measured, approximately, 12 m in height with wavelengths of, approximately, 300 m (Fugro, 2022a).

4.1.13 Water depths within the Southern Array Area range between 22 m and 60 m below LAT (Fugro 2022a). As in the Northern Array Area, depths shallow abruptly in the west. Sandwaves with superimposed megaripples, are visible in the east and centre of the Southern Array Area. The largest sandwaves measured, approximately, 12 m in height and exhibited wavelengths of, approximately, 250 m (Fugro, 2022a).

4.1.14 VE survey operations showed that some of the megaripples and sandwaves were actively mobile (Fugro, 2022a). Observations suggest that these sandwaves are migrating in a southerly direction, but at a relatively slow rate of around 1 m/yr on average.

THE OFFSHORE EXPORT CABLE CORRIDOR

4.1.15 Along the offshore ECC, water depths ranged from 0.3 m below LAT to circa 57 m below LAT. Towards the west, the seafloor is relatively flat with some rocky outcrop and sections of flat, featureless seafloor between these. Progressing further east, toward the middle and eastern part of the offshore ECC, there are large sandwaves and megaripples visible. Sandwaves are typically found to be between 0.7 and 7.5 m in height along the offshore ECC, with average wavelengths between 25 and 50 m, up to a maximum of, approximately, 260 m for the largest sandwaves (Fugro, 2022b).

4.1.16 Within the offshore ECC, megaripples are typically found to be between 0.1 and 0.8 m in height, with average wavelengths between 2 and 20 m. Most of the megaripples are present within the areas of interpreted sand, although some isolated patches were present in areas of interpreted gravelly mud, gravelly sand, and even as thin veneers within the outcrop/subcrop areas (Fugro, 2022b).

4.1.17 VE survey operations showed that some of the megaripples and sandwaves were actively mobile (Fugro, 2022a).

- The northern tip of the Galloper bank shows evidence of a number of associated sandwave features migrating over (and possible around) the underlying bank;
- Further inshore at Sunk Sand, there is clear evidence of sandwave migration to the north. Rates vary both spatially and temporally but appear to reach ~7 m/yr.

4.2 BIOLOGICAL CHARACTERISTICS

4.2.1 This section provides a summary of the biological characteristics of the disposal sites. Full details are provided in Volume 6, Part 2, Chapter 5: Benthic and Intertidal Ecology, Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology, Volume 6, Part 2, Chapter 7: Marine Mammal Ecology and Volume 6, Part 2, Chapter 4: Offshore Ornithology and their associated Technical Report annexes.

BENTHIC SUBTIDAL AND INTERTIDAL ECOLOGY

4.2.2 The benthic habitats of the southern North Sea are generally defined by the substrata of the seabed. Mobile sand dominated habitats are generally considered to be species poor and are characterised by robust species such as annelid worms and fast burrowing bivalves (Barne *et al.*, 1998, Jones *et al.*, 2004). Epibenthic flora and fauna normally occur on mixed substrata with significant coarse components, where a range of microhabitats allow colonisation by a wide array of species (Jones *et al.*, 2004).

SUBTIDAL ECOLOGY: ARRAY AREAS

4.2.3 Across the Array Areas, a total of 1,208 individuals representing 141 taxa were recorded from the 17 macrofaunal samples acquired. Benthic subtidal community structure and composition were generally dominated by Annelida, that comprised most of the enumerated taxa composition (56.0 %), followed by Arthropoda (22.7 %), Mollusca (14.2 %) and Echinodermata (3.5 %). Other phyla comprised 3.5% of the taxa composition and were represented by Cnidaria (non-burrowing anemones of the order Actiniaria), *Phoronis*, Ascidiacea and Nemertea.

4.2.4 The macrobenthic communities recorded in this study are indicative of coarse sediment habitats subject to a degree of surface sediment disturbance, as indicated by the polychaete composition, notably Hesionura elongate and species of Glycera (Künitzer *et al*., 1992; Heip and Craeymeersch, 1995) and the occurrence of crustaceans such as *Ampelisca spinipes*.

4.2.5 During pre-construction benthic ecology surveys undertaken at Greater Gabbard offshore wind farm (which overlap with the VE benthic, subtidal and intertidal ecology study area), it was identified that the most abundant taxa were the Ross worm *Sabellaria spinulosa*, the barnacle *Verruca stroemia*, the porcelain crab *Pisidia longicornis*, the sea urchin *Echinocyamus pusillus* and the polycheate worm *Lumbrineris gracilis* (GGOWL, 2005).

4.2.6 There was a clear spatial distribution in the habitat types present within the Array Areas which is reflected by sediment character. By combining and considering collectively the macrofaunal data, DDV data, PSA data and geophysical data, two biotope complexes and two biotopes within the Array Areas were identified

4.2.7 The predominant biotope complex across the VE Array Areas was faunal communities in ‘Atlantic offshore circalittoral coarse sediment’ which was recorded predominantly across the northern array, in the offshore ECC between the two array areas and present in the southern array. The higher coarseness of the sediment provides suitable substrate for the attachment of epifauna while the gravelly interstices provide microhabitats for smaller fauna. These stations generally had higher richness and diversity than those of the predominantly sandy stations. Infaunal analysis showed typical taxa including polychaetes, (*Lagis koreni, Lumbrineris cf. cingulate, Aonides paucibranchiata*), crustacean amphipods (*Ampelisca spinipes*) and echinoderms (*O. albida* and *E. pusillus*).

4.2.8 Faunal communities in Atlantic offshore circalittoral sand dominated the southern array due to the high sand and low gravel content and faunal assemblages being typical of clean sands with moderate exposure to wave or tidal action. Faunal richness and abundance were low and represented by the polychaete *Nephtys cirrosa*.

SUBTIDAL ECOLOGY: OFFSHORE EXPORT CABLE CORRIDOR

4.2.9 Across the offshore ECC the macrofaunal dataset comprised 262 taxa and 8402 individuals. Benthic subtidal community structure and composition were generally dominated by Annelida, which comprised most of the enumerated taxa composition (49.2 %), followed by Arthropoda (24.8 %), Mollusca (17.9 %) and Echinodermata (3.8 %). Other phyla comprised 4.2 % of the taxa composition and were represented by Cnidaria (*Cerianthus lloydii*, anemones of the family Edwardsiidae and non-burrowing anemones of the order Actiniaria), Sipuncula (*Golfingia elongata* and *Golfingia vulgaris*), Entoprocta (*Loxosoma annelidicola*), Enteropneusta, *Phoronis*, Ascidiacea, Nemertea and Platyhelminthes.

4.2.10 By combining and considering collectively the macrofaunal data, DDV data, PSA data and geophysical data collectively three biotope complexes and five biotopes were identified within the offshore ECC.

4.2.11 Most stations identified predominantly mixed sediments, mostly in the offshore and central ECC with these being defined within the biotope complex 'Faunal communities in Atlantic offshore circalittoral mixed sediment'. This biotope complex had the highest number of taxa and abundance, with annelids dominating. Sessile epifauna included soft corals (*Alcyonium digitatum*), bryozoans and hydroids. Characteristic mobile fauna reported from this habitat included starfish (*Asterias rubens*), sea urchins (*Psammechinus miliaris*) and brittlestars (*Ophiura albida* and *Ophiothrix fragilis*).

4.2.12 The biotope complex 'faunal communities of Atlantic circalittoral sand' and the biotopes '*G. lapidum* in impoverished infralittoral mobile gravel and sand', and *A. alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment' classified infralittoral coarse and muddy sediment stations along the nearshore section of the ECC in water depths of < 20 m BSL.

4.2.13 The marine invasive non-native species, slipper limpets *Crepidula fornicata*, was recorded in two stations in the subtidal area, which has potential to cause likely significant effects to marine ecosystems without control measures in place.

4.2.14 The cryptogenic species recorded in the grab samples included the polychaetes *Aphelochaeta marioni* and the crustacean amphipod *Crassicorophium crassicorne*. Ascidians of the family *Didemnidae* were also recorded and may therefore include cryptogenic species such as *Diplosoma listerianum*.

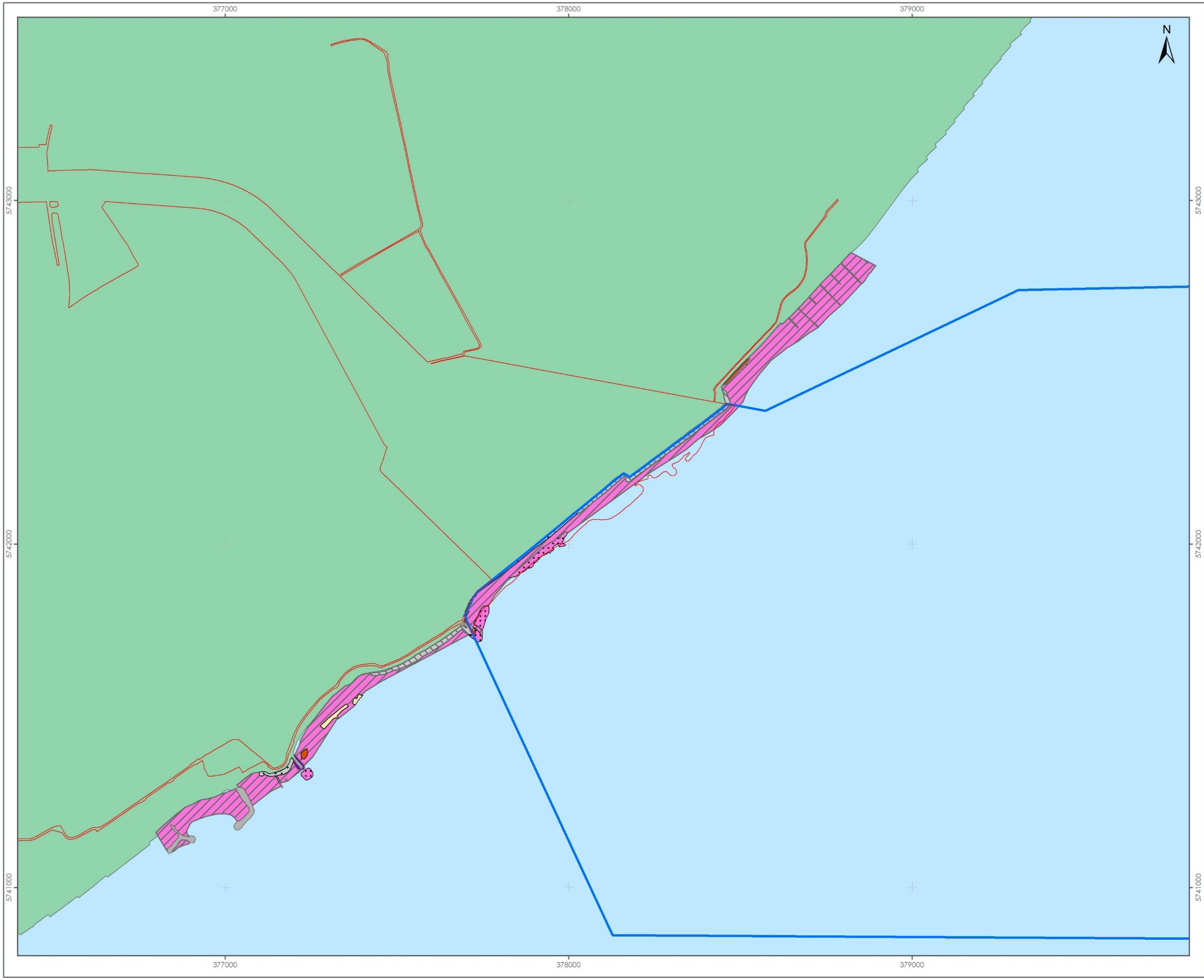
INTERTIDAL ECOLOGY: EXPORT CABLE CORRIDOR

4.2.15 The fauna colonising the hard substrata (associated with sea defence structures, bedrock boulders and cobbles) was similar across the intertidal survey area and included barnacles, limpets and the Pacific oyster, as shown in Figure 4.1. The flora was represented by seasonal green and red algae as well as perennial fucoid algae, which underpinned the biotope classification. A major biological influence on community structure is the presence of algae canopies, including ephemeral algal turfs of *Ulva* and *Porphyra*, which can increase biodiversity by supporting a variety of species that would otherwise not occur. Macroalgae such as *Fucus*, provide shelter from wave action, desiccation and heat and may act as substrate for the attachment of epifauna, as well as being a food source (Jones *et al*., 2000).

4.2.16 One habitat complex, two biotope complexes, eight biotopes and one sub-biotope were identified across the intertidal survey area during the Phase I habitat mapping. The littoral sediment habitat complex littoral sand and muddy sand (MA5) was reported to account for the majority of the intertidal area within the offshore ECC.

4.2.17 The Phase II intertidal assessment identified that the intertidal macrofaunal sediment communities were characterised by low richness and diversity, with one station being abiotic, likely associated with the exposure of the survey area and the coarseness of the sediment. Thus, only taxa that are capable of withstanding the environmental stresses of long exposure are capable of living in such environment. Taxa recorded were represented mainly by Nematoda and Platyhelminthes. Annelida comprised oligochaetes and invertebrates that are typical of shallow estuarine and marine habitats, whereas crustaceans were represented by cumacean and amphipods.

4.2.18 Marine Invasive Non-Native Species (INNS), barnacle *Austrominius modestus* and the Pacific oyster *Magallana gigaswere* were recorded on hard substrate in the intertidal survey area.



LEGEND

- Offshore Export Cable Corridor
- Onshore Order Limits

Biotope

- Barren littoral shingle MA3211
- Fucus serratus on moderately exposed lower eulittoral rock (MA1244)
- Fucus serratus on moderately exposed lower eulittoral rock (MA1244)
- Fucus spiralis on full salinity exposed to moderately exposed littoral fringe rock (MA1242)
- Littoral rock & other hard substrata (MA1)
- Littoral sand & muddy sand (MA5255)
- Mussel and/or barnacle communities (MA122) & Lancice conchilega in littoral sand (A2.245)
- Robust fucoid and/or red seaweed communities (MA123)
- Zonation: MA1, MA123 and A1.452
- Zonation: A1.113, A1.452 and MA1242
- Zonation: A1.451 and MA1242
- Zonation: A1.452, MA1242 and B3.1132

0 100 200 400
Meters

Data Source:

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Spatial Distribution of Intertidal Habitats and Biotopes (Fugro, 2022)

VER	DATE	REMARKS	Drawn	Checked
1	14/03/2024	For Information	BPHB	AdB

DRAWING NUMBER: 4.1

SCALE: 1:10,000	PLOT SIZE: A3	DATUM: WGS84	PROJECTION: UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

FISH AND SHELLFISH ECOLOGY

4.2.19 A wide range of fish and shellfish species are expected to inhabit the VE study area. Beam trawls conducted as part of the North Sea International Bottom Trawl Surveys (NSIBTS) were dominated by Norway pout (*Trisopterus esmarkii*), haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*) from 2018 to 2022. Trawls undertaken in 2020 were also dominated by American plaice (*Hippoglossoides platessoides*) and Nephrops (*Nephrops norvegicus*), and high abundances of silvery pout (*Gadiculus argenteus*) were recorded in 2021 (ICES, 1965-2022).

4.2.20 Cefas young fish surveys undertaken along the south and east coasts of the British Isles, recorded a species composition dominated by goby species (*Pomatoschistus spp.*), dab (*Limanda limanda*), common sole (*Solea solea*), plaice (*Pleuronectes platessa*), hooknose (*Agonus cataphractus*), and common dragonet (*Callionymus lyra*) from 2000 to 2010 (Burt *et al.*, 2019).

4.2.21 The characterising species recorded within site specific surveys for a number of local Offshore Wind Farm (OWF) projects (Greater Gabbard OWF, Galloper OWF, London Array OWF and Gunfleet Sands OWF) showed good agreement with the main species recorded within the more recent regional surveys, suggesting that monitoring data from local OWF evelopment remains relevant for characterisation of the VE site.

4.2.22 Several species of fish and shellfish are known to either spawn or have nursery areas in relatively close proximity to, or potentially overlapping with the VE study area (Coull *et al.*, 1998; Ellis *et al.*, 2012). Table 4.1 provides a summary of spawning timings for the identified spawning grounds within and in proximity to VE.

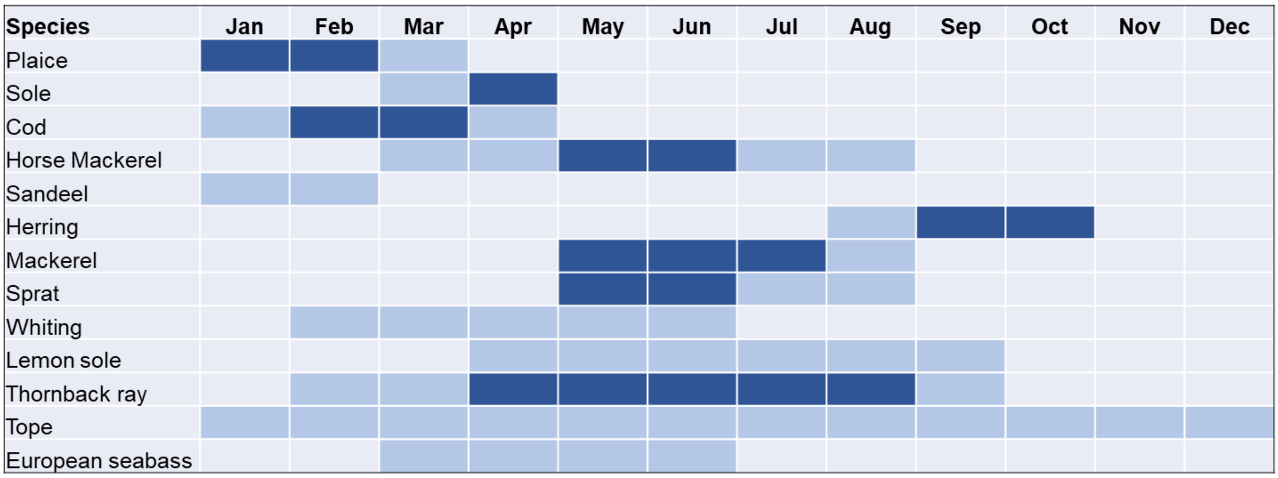
4.2.23 The North Sea provides important nursery ground habitat for a variety of fish species. ‘Low intensity’ nursery grounds that intersect the study area are present for cod, mackerel, plaice, sandeel, sole, thornback ray, tope and whiting (Ellis *et al.*, 2012). A ‘high intensity’ herring nursery ground also overlaps the nearshore section of the offshore ECC (Ellis *et al.*, 2012). Nursery grounds for lemon sole and sprat also intersect the study area (Coull *et al.*, 1998). Nursery grounds for these species are significant in size, with coverage across much of the southern North Sea and the eastern Channel.

4.2.24 The nearest seabass nursery area to the project is located within the Blackwater estuary, approximately 23 km from the offshore ECC, outside of the study area (Hyder *et al.*, 2018).

4.2.25 Shellfish of commercial importance to the region include common cockle (*Cerastoderma edule*), Norway lobster (*Nephrops norvegicus*), common whelk (*Buccinum undatum*), king scallop (*Pecten maximus*), queen scallop (Aequipecten opercularis), European lobster (*Homarus gammarus*), native oyster (Ostrea edulis), Brown crab (Cancer pagurus) have been found throughout the region of VE and recorded in NSIBTS (GGOWL, 2005; ICES, 2018 – 2022).

4.2.26 Other shellfish species have been recorded in the area of VE including pink shrimp (*Pandalus montagui*), common hermit crab (*Pagurus bernhardus*), harbour crab (*Liocarcinus depurator*), velvet swimming crab (*Necora puber*), brown shrip (*Crangon crangon*) and marbled swimming crab (*Liocarcinus amrmoreus*) (GGOWL, 2005).

Table 4.1: Summary of spawning timings in the Southern North Sea for fish species known to have spawning habitats in the VE study area (Light blue indicates spawning period, dark blue indicates peak spawning period)



MARINE MAMMALS

4.2.27 The VE site specific surveys suggested that the marine mammal species which are most likely to occur are: harbour porpoise (*Phocoena phocoena*), harbour seals (*Phoca vitulina*) and grey seals (*Halichoreus grypus*).

4.2.28 Harbour porpoise were the most commonly recorded cetacean species from project specific surveys, with these data indicating that this specie is likely to be found in relatively high densities across the entire VE area with an estimation of 1.82 individuals per km^2.

OFFSHORE ORNITHOLOGY

4.2.29 Twenty-four offshore aerial surveys have been conducted across VE area between March 2019 and February 2021. A total of 18 bird species were recorded within the Array Areas and 4 km buffer.

4.2.30 A summary of the species that were recorded during baseline aerial surveys within the VE Array Areas plus a 4 km buffer is provided in Table 4.2. The presence of the species is noted in the North (N) and South (S) Array Areas.

Table 4.2: Bird species recorded during baseline aerial surveys of the Array Areas and the 4km buffer between March 2019 and February 2021.

Species	Scientific name	Conservation status	Array Areas	4km buffer
Red-throated diver	*Gavia stellata*	Outer Thames Estuary SPA species, Birds of Conservation Concern (BoCC) (Stanbury *et al*., 2021) Green listed, Birds Directive Migratory Species, Birds Directive Annex I, International Union for Conservation of Nature (IUCN) Red List 'Least Concern' status. 'High benefit'[2] breeding population vulnerability to climate change (Pearce-Higgins 2021)	N, S	N, S
Fulmar	*Fulmarus glacialis*	BoCC Amber listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status. 'High risk' breeding population vulnerability to climate change	N, S	N, S
Gannet	*Morus bassanus*	BoCC Amber listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status. 'Limited impact' breeding population vulnerability to climate change	N, S	N, S
Cormorant	*Phalacrocorax carbo*	BoCC Green listed, Birds Directive Migratory Species 'High risk' breeding population vulnerability to climate change	S	S
Arctic skua	*Stercorarius parasiticus*	BoCC Red listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status. 'High risk' breeding population vulnerability to climate change	-	S
Great skua	*Stercorarius skua*	BoCC Amber listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status. Not assessed breeding population vulnerability to climate change	S	S
Puffin	*Fratercula arctica*	BoCC Red listed, Birds Directive Migratory Species	-	N, S

Species	Scientific name	Conservation status	Array Areas	4km buffer
		‘High risk’ breeding population vulnerability to climate change		
Razorbill	*Alca torda*	BoCC Amber listed, Birds Directive Migratory Species, IUCN Red List ‘Near Threatened’ status. ‘Medium risk’ breeding population vulnerability to climate change	N, S	N, S
Guillemot	*Uria aalge*	BoCC Amber listed, Birds Directive Migratory Species, IUCN Red List ‘Least Concern’ status. ‘Medium risk’ breeding population vulnerability to climate change	N, S	N, S
Common tern	*Sterna hirundo*	Outer Thames Estuary SPA species, BoCC Amber listed, Birds Directive Annex I, Migratory Species, IUCN Red List ‘Least Concern’ status. ‘High benefit’ breeding population vulnerability to climate change	N	N, S
Sandwich tern	*Sterna sandvicensis*	BoCC Amber listed, Birds Directive Migratory Species ‘Medium risk’ breeding population vulnerability to climate change	S	N, S
Kittiwake	*Rissa tridactyla*	BoCC Red listed, Birds Directive Migratory Species, IUCN Red List ‘Vulnerable’ status. ‘High risk’ breeding population vulnerability to climate change	N, S	N, S
Black-headed gull	*Chroicocephalus ridibundus*	BoCC Amber listed, Birds Directive Migratory Species ‘High benefit’ breeding population vulnerability to climate change	S	N, S
Little gull	*Hydrocoloeus minutus*	BoCC Green listed, Birds Directive Migratory Species, IUCN Red List ‘Near Threatened’ status. ‘Not assessed breeding population vulnerability to climate change	N	N, S
Common gull	*Larus canus*	BoCC Amber listed, Birds Directive Migratory Species, IUCN Red List ‘Least Concern’ status.	N, S	N, S

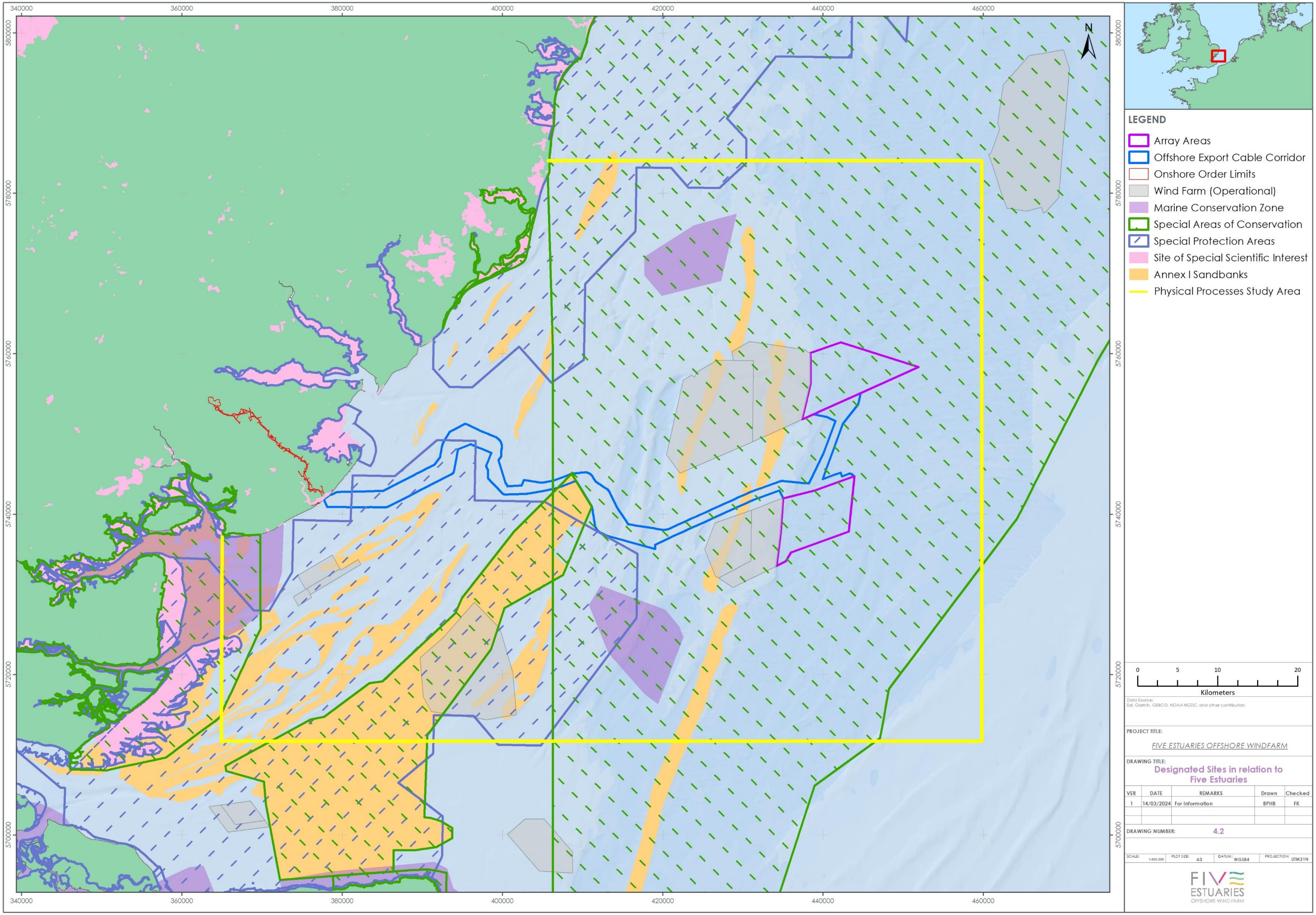
Species	Scientific name	Conservation status	Array Areas	4km buffer
		'Medium benefit' breeding population vulnerability to climate change		
Lesser black-backed gull	*Larus fuscus*	BoCC Amber listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status. 'High benefit' breeding population vulnerability to climate change	N, S	N, S
Herring gull	*Larus argentatus*	BoCC Red listed, Birds Directive Migratory Species, IUCN Red List 'Near Threatened' status. 'High risk' breeding population vulnerability to climate change	N, S	N, S
Great black-backed gull	*Larus marinus*	BoCC Amber listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status 'High risk' breeding population vulnerability to climate change	N, S	N, S

DESIGNATED SITES

4.2.31 The VE project is in close proximity to a number of sites designated for nature conservation and water quality comprising European conservation sites (i.e., Special Area of Conservation (SACs) and Special Protection Area (SPAs)) but also national designations (i.e., Sites of Special Scientific Interest (SSSIs) and designated Marine Conservation Zones (MCZs)), which are presented in Figure 2.

4.2.32 The Array Areas overlap only with the Southern North SAC. The offshore cable corridor overlaps spatially with the Margate and Long Sands SAC, the Southern North SAC and the Outer Thames Estuary SPA.

4.2.33 Further details on the SACs, SPAs, SSSIs and MCZs are provided in Volume 6, Part 2, Chapter 2: Marine Geology, Oceanography and Physical Processes.



LEGEND
Array Areas
Offshore Export Cable Corridor
Onshore Order Limits
Wind Farm (Operational)
Marine Conservation Zone
Special Areas of Conservation
Special Protection Areas
Site of Special Scientific Interest
Annex I Sandbanks
Physical Processes Study Area
N
340000
360000
380000
400000
420000
440000
460000
5800000
5780000
5760000
5740000
5720000
5700000
0
5
10
20
Kilometers
Data Source:
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
PROJECT TITLE:
FIVE ESTUARIES OFFSHORE WINDFARM
DRAWING TITLE:
Designated Sites in relation to Five Estuaries
VER | DATE | REMARKS | Drawn | Checked
1 | 14/03/2024 | For Information | BPHB | FK
DRAWING NUMBER: 4.2
SCALE: 1:400,000
PLOT SIZE: A3
DATUM: WGS84
PROJECTION: UTM31N
FIVE ESTUARIES
OFFSHORE WIND FARM

4.3 HUMAN ENVIRONMENT CHARACTERISTICS

4.3.1 This section summarises the human environment of the VE Array Areas and offshore ECC. Further detail can be found in the Commercial Fisheries; Shipping and Navigation; Marine Archaeology and Cultural Heritage; and Infrastructure and Other Marine Users ES chapters (Volume 6, Part 2, Chapter 8; Chapter 9; Chapter 11 Chapter 12, respectively) and their associated annexes.

COMMERCIAL FISHERIES

4.3.2 The VE Array Areas and offshore ECC overlaps International Council for the Exploration of the Sea (ICES) rectangles 32F2 and 32F1 respectively. The annual average landed values are £473,000 for 32F2 and £2.7 million for 32F1, for the years 2016 to 2021 (MMO, 2022).

4.3.3 A range of fleets target different fisheries across the study area, in ICES rectangle 32F1, English vessels dominate landings with dredges, pots, otter trawls and nets accounting for the majority of landings. Further offshore in ICES rectangle 32F2, Dutch beam trawlers account for a large proportion of landings.

4.3.4 The key shellfish species landed from ICES are cockles (*Cerastoderma edule*); whelks (*Buccinum undatum*); lobsters (*Homarus Gammarus*); and brown crab (*Cancer pagurus*) (for detail on landing during the period 2016-2021, see Volume 4, Annex 8.1: Commercial Fisheries Technical Baseline) (MMO, 2022).

4.3.5 The key demersal finfish species landed from ICES are sole (*Solea solea*); plaice (*Pleuronectes Platessa*); thornback ray (Raja clavate); bass (*Dicentrarchus labrax*); red mullet (*Mullus surmuletus*); brill (*Scophthalmus rhombus*); turbot (*Scophthalmus maximus*); tub gurnard (*Chelidonichthys lucerne*); whiting (*Merlangius merlangus*); Dab (*Limanda limanda*); and Flounder (*Platichthys flesus*) (for detail on landing during the period 2016-2021, see Volume 6, Part 5, Annex 8.1: Commercial Fisheries Technical Baseline) (MMO, 2022).

4.3.6 The key pelagic finfish species landed from ICES are herring (*Clupea harengus*); horse mackerel (*Trachurus trachurus*); and Sprat (*Sprattus sprattus*).

4.3.7 Landings from both rectangles have shown some fluctuation across the five-year time series (2016-2021), with a relative peak in 2019. Fluctuations are likely to be attributable to a number of factors including changes in market demand and prices, fisheries restrictions and the COVID pandemic. In offshore rectangle 32F2, landings data indicates a notable increase in landings in 2021 of squid (*Loligo*) and mullets (*Mugilidae*).

4.3.8 Landings data sourced from the EU DCF database indicates that there is likely to be some non-UK fishing activity in ICES rectangle 32F1, however, the majority of fishing activity is by English vessels. Non-UK vessels active in this rectangle include Belgian and Dutch trawlers targeting demersal species, primarily sole and plaice, and French trawlers targeting pelagic species, namely herring.

4.3.9 Further offshore, beyond the 12 NM limit and in ICES rectangle 32F2, landings across the period 2012 to 2016 were dominated by catches from Dutch trawlers targeting plaice and sole. Again, Belgian and French trawlers are also likely to be active, targeting plaice and sole, and whiting and herring respectively. Across the 2012 to 2016 time series, landings by EU vessels peaked in 2014, at 3,000 tonnes from ICES rectangle 32F1 (27% of this accounted for by plaice and sole, and 48% by herring) and 13,000 tonnes from ICES rectangle 32F2 (60% of this accounted for by plaice and sole, and 10% by herring).

SHIPPING AND NAVIGATION

THE ARRAY AREAS

4.3.10 Data on vessel traffic was recorded via AIS, Radar and visual observations over 14 full days in January 2022 (winter) and over 14 full days in June 2022 (summer) within the array traffic study area.

4.3.11 For the 14 days analysed in winter, there was an average of 102 unique vessels per day recorded within the array traffic study area and 7-8 unique vessels per day intersecting the Array Areas. The main vessel types within the array traffic study area were cargo vessels (57%), tankers (23%), and fishing vessels (9%).

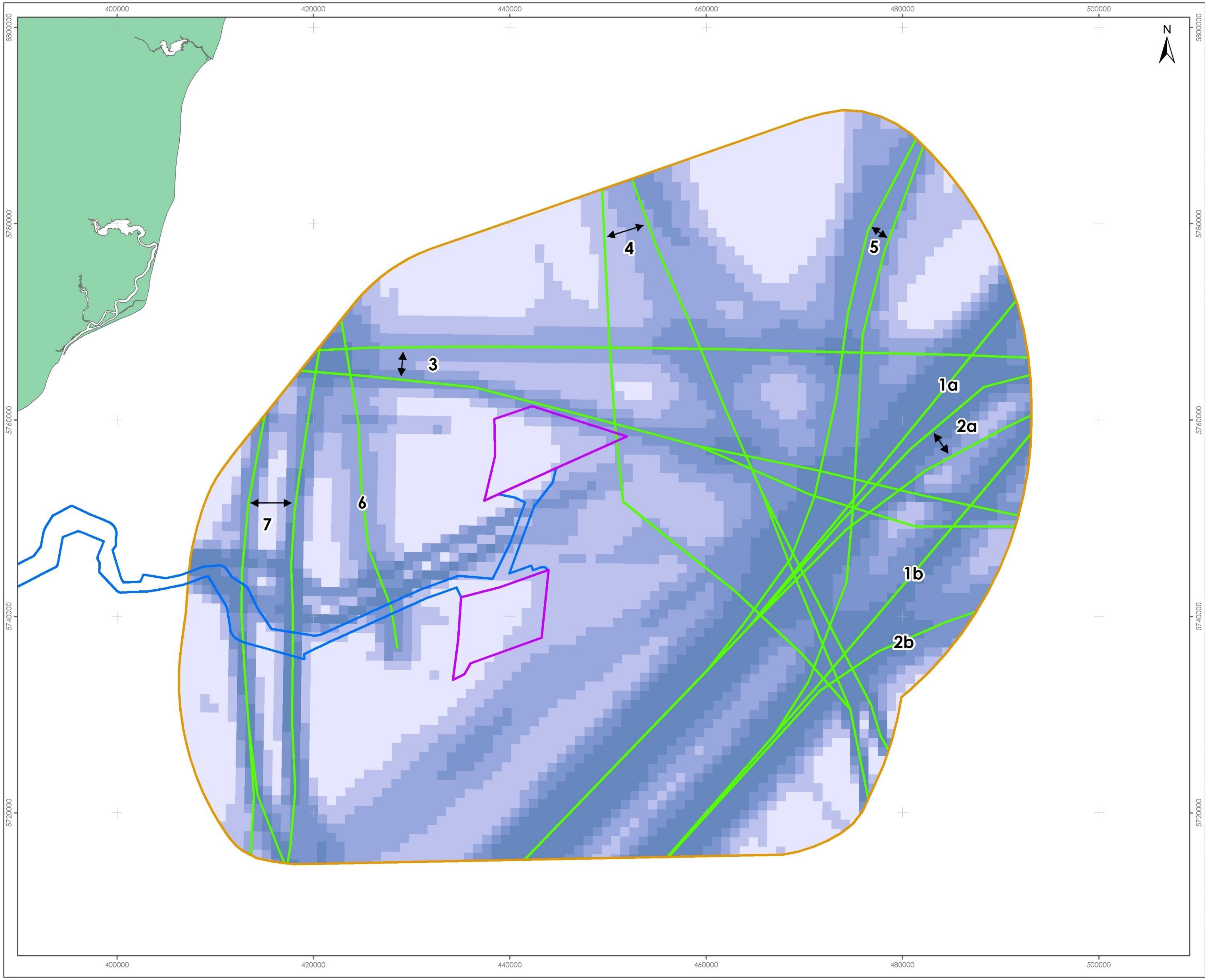
4.3.12 For the 14 days analysed in summer, there was an average of 116 unique vessels per day recorded within the array traffic study area and 12 unique vessels per day intersecting the Array Areas. The main vessel types within the array traffic study area were cargo vessels (49%), tankers (18%), and wind farm vessels (14%).

4.3.13 No recreational vessels were recorded during the winter survey period. Throughout the summer survey period an average of seven unique recreational vessels per day were recorded within the array traffic study area.

4.3.14 Vessel length was available for approximately 97% of vessels recorded throughout the two 14-day survey periods and ranged from 8 m for a sailing vessel to 400 m for a container vessel. Excluding the proportion of vessels for which length was not available, the average length of vessels within the array traffic study area throughout the winter and summer survey periods was 154 m and 140 m, respectively.

4.3.15 Vessel draught was available for approximately 89% of vessels recorded throughout the two 14-day survey periods and ranged from 1.2 m for two wind farm support vessels to 21.5 m for an oil products tanker. Excluding the proportion of vessels for which draught was not available, the average draught of vessels within the array traffic study area throughout the winter and summer survey periods was 6.4 m and 5.6 m, respectively.

4.3.16 Main commercial routes have been identified using the principles set out in MGN 654 (MCA, 2021). Further details of the process for identifying main commercial routes is provided in Section 11.2 of Volume 9, Report 10: Navigational Risk Assessment. A total of 26 main commercial routes were identified within the array routeing study area. A description for each of the high use main commercial routes are provided in Table 4.3 whilst the high use routes is presented in Figure 4.3 alongside the vessel traffic density associated with all routeing within the study area



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Array Routeing Study Area
- Vessel Routes - Mean Position

Vessel Routes Density

- Lowest
- 2
- 3
- 4
- Highest

0 2.5 5 10
Kilometers

Data Source:

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

High Use Shipping Routes of relevance to the Project

VER	DATE	REMARKS	Drawn	Checked
1	14/03/2024	For Information	BPHB	FK

DRAWING NUMBER: 4.3

SCALE: 1:350,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

Table 4.3: Details of use main commercial routes within array traffic study area.

Route number	Average vessels per day	Description
1	30	**Port of Amsterdam (Netherlands) – Dover Strait.** Generally used by cargo vessels (74%). Route 1a is eastbound only and Route 1b is westbound only.
2	22	**Dover Strait – Port of Rotterdam (Netherlands).** Used by cargo vessels (59%) and tankers (38%). Route 2a is westbound only and Route 2b is eastbound only, with the latter passing north and south of the NHR buoy.
3	11	**Harwich Haven (UK) – Port of Rotterdam (Netherlands).** Generally used by cargo vessels (77%) including DFDS Seaways and Stena Line operated Ro-Ro services between Felixstowe and Rotterdam, and between Harwich and Rotterdam respectively. This route also includes a Stena Line operated Ro-Pax service between Harwich and Rotterdam.
4	9	**Port of Hull (UK) – Port of Zeebrugge (Belgium).** Used by cargo vessels (50%) and passenger vessels (43%), including a CLdN-operated Ro-Ro services between Killingholme and Zeebrugge, and P&O Ferries-operated Ro-Ro services between Tilbury and Zeebrugge, and between Tees and Zeebrugge. Route 4a is north and southbound whereas Route 4b is southbound only.
5	7	**Dover Strait – North Europe Ports.** Used by cargo vessels (44%) and tankers (53%).
6	7	**Port of Lowestoft (UK) – Greater Gabbard OWF.** Only used by wind farm vessels (100%).
7	6	**Dover Strait – Humber Ports (UK).** Generally used by cargo vessels (68%).

THE OFFSHORE EXPORT CABLE CORRIDOR

4.3.17 Data on vessel traffic was recorded via AIS over 14 full days in January 2022 (winter) and over 14 full days in June 2022 (summer) within the offshore ECC.

4.3.18 For the 14 days analysed in winter, there was an average of 44 unique vessels per day recorded within the offshore ECC study area and 37 unique vessels per day intersecting the offshore ECC. The main vessel types within the offshore ECC study area were cargo vessels (66%), tankers (13%), and dredgers (6%).

4.3.19 For the 14 days analysed in summer, there was an average of 70 unique vessels per day recorded within the offshore ECC study area and 59 unique vessels per day intersecting the offshore ECC. The main vessel types within the offshore ECC study area were cargo vessels (40%), recreational vessels (32%), and dredgers (6%).

4.3.20 No recreational vessels were recorded during the winter survey period. Throughout the summer survey period an average of 12 unique recreational vessels per day were recorded within the ECC study area, primarily close to shore.

4.3.21 Vessel length was available for more than 99% of vessels recorded throughout the two 14-day survey periods and ranged from 5 m for a sailing vessel to 400 m for a container vessel. Excluding the proportion of vessels for which length was not available, the average length of vessels within the offshore ECC study area throughout the winter and summer survey periods was 162 m and 113 m, respectively.

4.3.22 Vessel draught was available for approximately 80% of vessels recorded throughout the two 14-day survey periods and ranged from 0.9 m for a wind farm vessel to 21 m for two container vessels. Excluding the proportion of vessels for which draught was not available, the average length of vessels within the array traffic study area throughout the winter and summer survey periods was 7.2 m and 7.5 m, respectively.

MARINE ARCHAEOLOGY

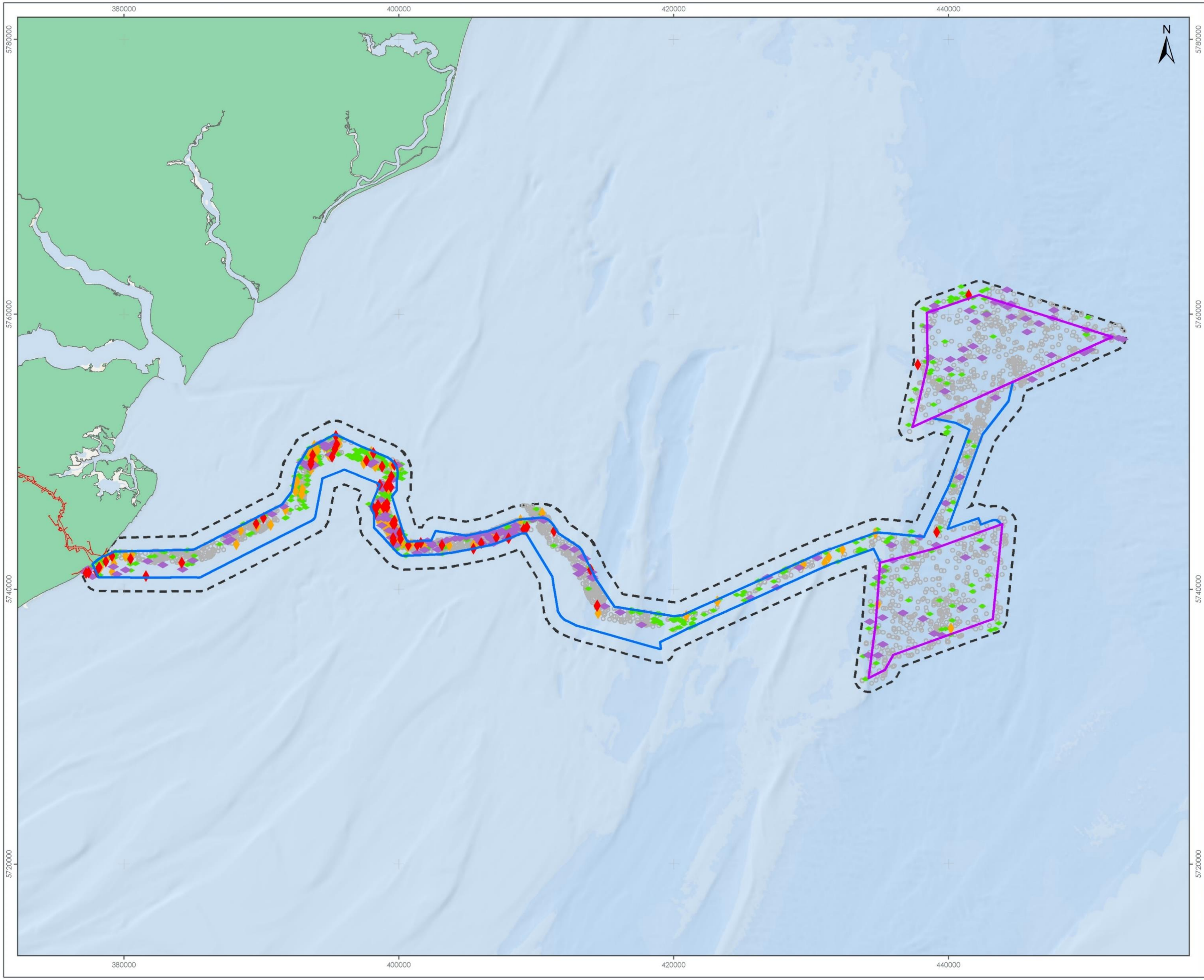
4.3.23 Two hundred and thirty-five (235) anomalies have been assessed as high archaeological potential, as seen inside scan sonar (SSS) and multi-beam echo sounder (MBES) data, showing a magnetic return of >100 nT or correlating with United Kingdom Hydrographic Office (UKHO) records. Of these, 173 have only been seen in the magnetic data and do not correlate with any records; and 62 UKHO records correlate with magnetic data which were not otherwise seen in SSS or MBES data (Figure 4).

4.3.24 Ninety-eight anomalies of medium archaeological potential were identified. These did not corelate with any known UKHO/National Record of the Historic Environment (NRHE) records but may represent debris associated with anomalies of high archeological potential (Figure 4).

4.3.25 The low potential anomalies have been characterised as a mixture of small features, often boulder like, or isolated linear features and modern debris such as rope, chain, fishing gear or lost equipment (Figure 4).

4.3.26 Magnetic anomalies under 100 nT with no corresponding records or research resources and no corresponding anomalies in any of the assessed geophysical datasets have also been assigned low archaeological potential (Figure 4).

4.3.27 More details on marine archaeological interests in VE study area are provided in Volume 6, Part 2, Chapter 9: Offshore archaeology and cultural heritage.



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits

Anomalies of Archaeological Potential

- High
- High (mag only)
- Medium
- Low
- Low (mag only)

0 2.5 5 10
Kilometers

Data Source:
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Anomalies of Archaeological Potential relevant to Five Estuaries

VER	DATE	REMARKS	Drawn	Checked
1	14/03/2024	For Information	BPHB	FK

DRAWING NUMBER: 4.4

SCALE: 1:250,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

INFRASTRUCTURE AND OTHER USERS

RENEWABLE ENERGY DEVELOPMENT

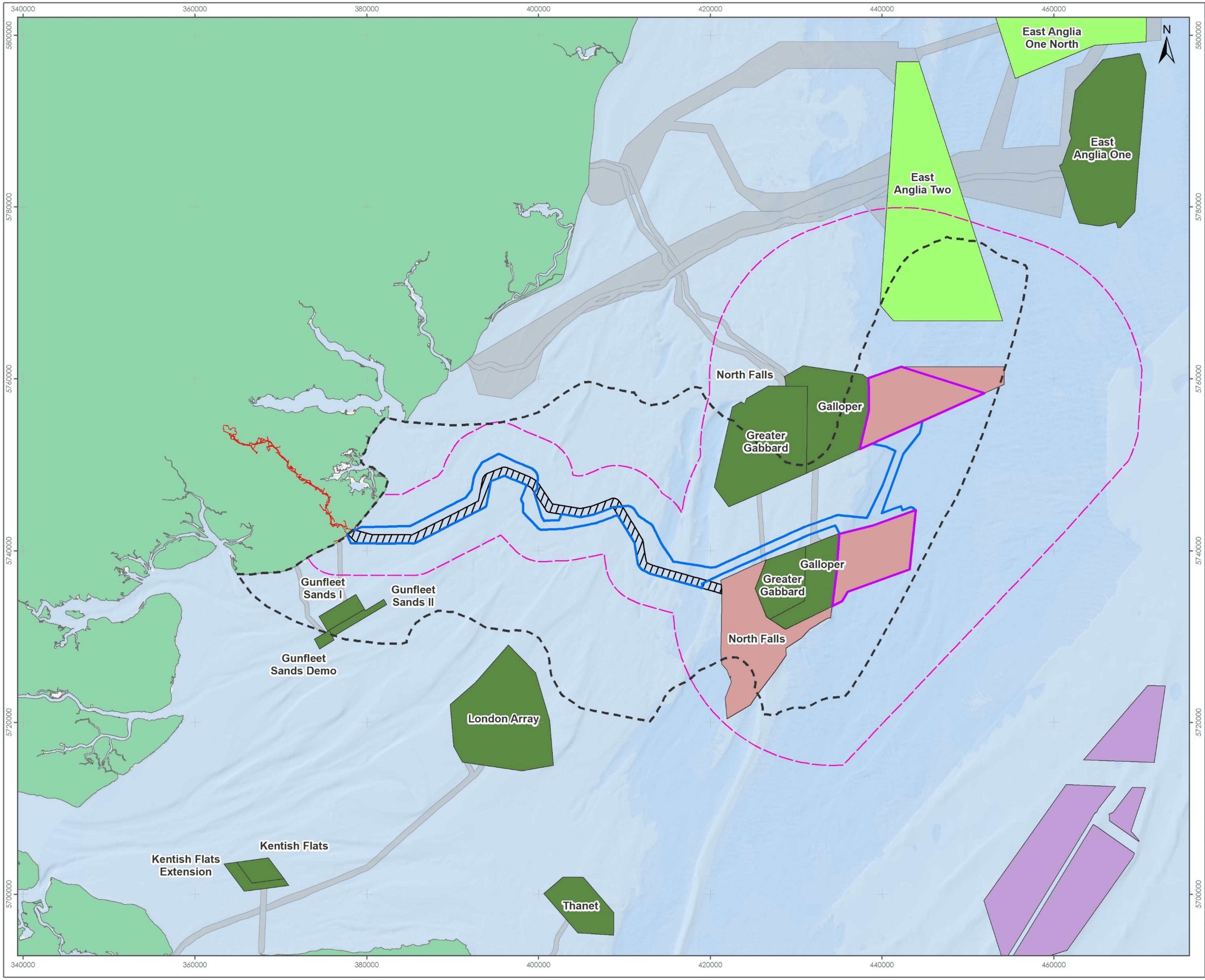
4.3.28 There are a number of existing and planned wind farm developments of potential relevance to this assessment, in particular with respect to potential cumulative impacts (Figure 5).

SUBSEA CABLES

4.3.29 'Subsea cables' is a broad term for a range of cables that are beneath the sea surface, these cables are typically (but not exclusively) subsea telecoms, power cables and interconnector cables).

4.3.30 There are two operational telecommunication cables present directly with the VE northern Array Area: Concerto 1S and Farland. The Applicant is currently engaging with the owners of these assets to discuss crossing and proximity agreements.

4.3.31 Two interconnector cables are present in the area of study. The BritNed Interconnector (1,000 MW high-voltage direct-current (HVDC)) is located approximately 0.9 km south of the southern VE Array Area and the NeuConnect Interconnector (1,400 MW HVDC) for a which a marine license was granted on March 2022 with a currently proposed route passes through the VE northern array. In both cases, the Applicant is currently engaging with the owners of these assets to discuss crossing and proximity agreements.



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Spring Tidal Excursion Ellipse (STEE) Study Area
- Traffic Study Area
- Offshore Wind Farm Cable Routes (TCE)
- North Falls Scoping Offshore Cable Route

Offshore Wind Farm (Status)

- Operational
- Under Construction
- Consented
- In Planning
- Concept/Early Planning

0 5 10 20

Kilometers

Data Source:
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Other Marine Users of relevance to Five Estuaries

VER	DATE	REMARKS	Drawn	Checked
1	14/03/2024	For Information	BPHB	FK

DRAWING NUMBER: 4.5

SCALE:	1:400,000	PLOT SIZE:	A3	DATUM:	WGS84	PROJECTION:	UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

MARINE DISPOSAL SITES

4.3.32 There are 24 disposal sites located within the vicinity of the VE study area, of which four are open, two are disused and 18 are closed (Table 4.4).

Table 4.4: Marine disposal sites located within the vicinity of the study area.

Code	Disposal Site	Distance to Array Area (km)	Distance to offshore ECC (km)	Distance from STEE (km)
Open				
TH056	Inner Gabbard East	16.4	7.2	0.0
TH052	Inner Gabbard	20.6	3.9	0.0
TH027	Harwich Haven	30.0	4.2	0.0
TH023	East Anglia One	16.4	24.0	5.4
Disused				
TH054	Area 108/3	26.4	3.4	0.0
TH046	The Well	48.3	4.0	0.0
Closed				
TH057	Galloper OWF	0.0	0.0	0.0
TH024	Warren Spring Exptl Area 2/1	0.4	0.0	0.0
NS100	BRITNED	0.5	6.3	0.0
TH075	Warren Spring Exptl Area 1	2.3	9.5	0.0
TH025	Warren Spring Exptl Area 2	13.2	0.0	0.0
NS111	North Sea Dredge Test	16.2	21.6	0.0
TH055	North West Shipwash	34.3	0.1	0.0
HU199	North West Shipwash	34.3	0.2	0.0
TH042	Roughs Tower	36.8	0.0	0.0
TH045	Roughs Tower Extension	37.1	0.0	0.0
TH040	Roughs Tower L	37.1	0.0	0.0
TH049	Roughs Tower 'E'	37.5	0.1	0.0

Code	Disposal Site	Distance to Array Area (km)	Distance to offshore ECC (km)	Distance from STEE (km)
TH028	Roughs Tower M	37.5	0.3	0.0
TH041	Roughs Tower C	37.5	0.3	0.0
TH044	Roughs Tower A	37.8	0.5	0.0
TH039	Roughs Tower D	37.8	1.0	0.0
TH043	Roughs Tower B (Circular)	38.8	1.5	0.0
TH030	Harwich Rock Dump	46.3	4.1	0.0

MARINE AGGREGATE SITES

4.3.33 There are 16 marine aggregate sites located within the VE study area, of which 4 are Exploration and Option areas; and 12 are Production areas (Table 4.5). There is no direct overlap with the VE array and ECC.

Table 4.5: Marine aggregate sites within the VE study areas.

Licence Area	Operator	Area Name	Status	Distance from Array Area (km)	Distance from offshore ECC (km)	Distance from STEE (km)
Exploration and Option Area						
524	DEME Building Materials Ltd	Thames D	Exploration and Option Area	1.7	8.5	0.0
1809	Volker Dredging Ltd	East Orford Ness	Exploration and Option Area	7.4	12.1	5.5
1802	Aggregate Industries UK Ltd	North Falls	Exploration and Option Area	7.2	13.2	0.0
528/2	Hanson Aggregates Marine Ltd	Outer OTE	Exploration and Option Area	25.1	14.0	0.0
Production Areas						
509/1	Tarmac Marine Ltd	Longsand	Production Area*	33.7	0.1	0.0

Licence Area	Operator	Area Name	Status	Distance from Array Area (km)	Distance from offshore ECC (km)	Distance from STEE (km)
509/2	Tarmac Marine Ltd	Longsand	Production Area	34.5	1.6	0.0
510/2	CEMEX Marine Ltd	Longsand	Production Area	22.3	3.5	0.0
509/3	Tarmac Marine Ltd	Longsand	Production Area	26.8	5.8	0.0
510/1	CEMEX Marine Ltd	Longsand	Production Area	26.8	5.8	0.0
508	Britannia Aggregates Ltd	Longsand	Production Area	26.8	5.8	0.0
507/1	CEMEX Marine Ltd	Shipwash	Production Area	25.0	9.6	0.0
507/4	CEMEX Marine Ltd	Shipwash	Production Area*	20.5	12.9	0.0
498	Britannia Aggregates / Volker Dredging Ltd	North Inner Gabbard	Production Area	11.1	15.6	8.0
501	Westminster Gravels Ltd	North Falls East	Production Area	10.6	16.9	6.6
507/6	CEMEX Marine Ltd	Shipwash	Production Area*	15.1	17.2	2.2
507/5	CEMEX Marine Ltd	Shipwash	Production Area*	17.9	21.5	6.2

MILITARY AREAS

4.3.34 As shown in Figure 6, the Array Areas overlap with the North Galloper (X5121) Navy Practice and Exercise Areas (PEXA), with the entirety of the southern array and most of the northern array within the PEXA. In addition, the ECC overlaps the North Galloper (X5121), Outer Gabbard (X5117) and Gunfleet (X5118) PEXAs, with the South Galloper (X5120) and Kentish Knock (X5119) PEXAs located to the south.

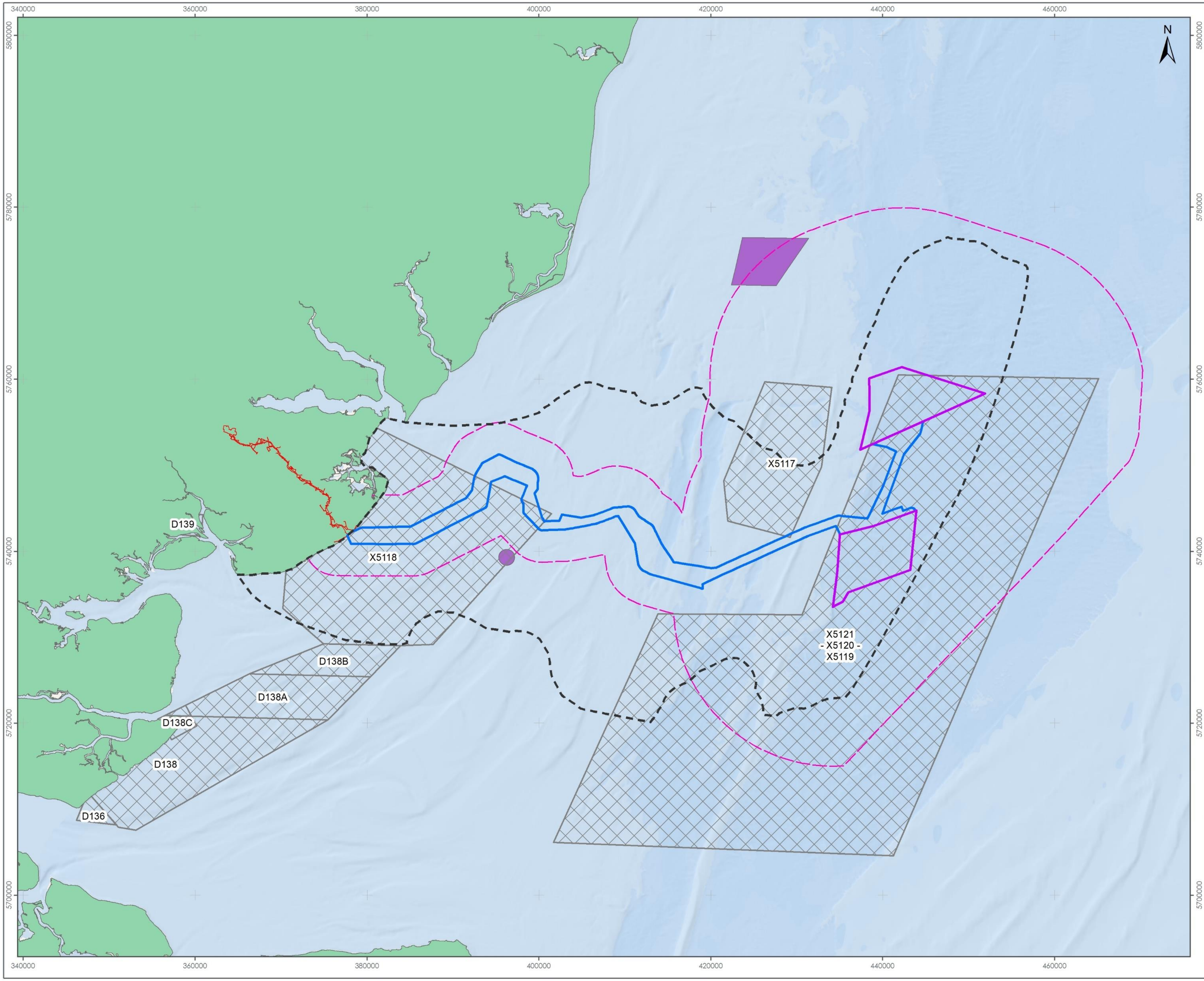
4.3.35 All areas are used for practicing mine laying and sweeping and there are no areas designated as submarine exercise areas within the vicinity of the infrastructure and other marine users study area. The nearest live firing area is Shoeburyness Range Sea Danger Area which is located 11.8 km south of the ECC.

UNEXPLODED ORDONANCE (UXO) AND RISK AREAS

4.3.36 Two explosive dumping areas have been identified in the vicinity of the VE study area: East Swin (Kings Channel), a disused designated explosives dumping ground located in the eastern part of the Gunfleet (X5118) PEXA, 6 km from the ECC; and East of Orford Ness, a disused designated explosives dumping ground located approximately 14 km to the northeast of the northern Array Area.

MARINE STRUCTURES

4.3.37 HM Fort Roughs, also known as Roughs Tower, is an offshore platform located approximately 12 km offshore, within the offshore ECC. Since 1967, the decommissioned Roughs Tower has been occupied and claimed as a sovereign state, known as the Principality of Sealand. The structure is located within UK territorial waters and is currently not recognised as a principality. From available information there is no indication that this structure is a designated Scheduled Monument or is otherwise listed.



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Spring Tidal Excursion Ellipse (STEE) Study Area
- Traffic Study Area
- PEXA Areas
- Explosives Dumping Area

0 5 10 20

Kilometers

Data Source:
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Other Marine Users of relevance to Five Estuaries

VER	DATE	REMARKS	Drawn	Checked
1	14/03/2024	For Information	BPHB	FK

DRAWING NUMBER: 4.6

SCALE: 1:400,000	PLOT SIZE: A3	DATUM: WGS84	PROJECTION: UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

5 CHARACTERISTICS OF THE DISPOSAL MATERIAL

5.1 PHYSICAL CHARACTERISTICS

THE ARRAY AREAS

DRILLED MATERIAL

5.1.1 The spoil material derived from drilling activities will be different in nature to that disposed of via seabed preparation/dredging as these drilled materials will include predominantly sediment/rock from deeper in the soil profile.

5.1.2 The sub surface geology consists of three main units outlined in Section 4.1 above: Holocene; Pleistocene; and London Clay formation, which remain similar to the surficial sediments.

5.1.3 The exact proportions of these deposits that will form the basis of the drill arisings deposited on the seabed will vary according to the drilling locations and the depth to which drilling occurs.

5.1.4 However, the drill arising materials that settle onto the seabed will comprise predominantly sand, gravels, with smaller proportions of silt and clay that do not disaggregate into its particulate constituents. The physical characteristics of this material will, therefore, be not too dissimilar to existing seabed sediments.

DREDGED MATERIAL

5.1.5 The surficial sediments have been collected within the North array (eight samples) and South array (six samples) and the Interconnector (three samples). The analyses of these samples indicate that the surficial sediment is composed of a mix of sand, gravel and fines (mud) (Figure 7).

5.1.6 Although the actual process of disposal may result in a slight change to the existing particle size composition of seabed sediments, the material disposed in situ via seabed preparation and cable trenching would be similar to the existing material as the spoil disposal will occur close to the site of production.

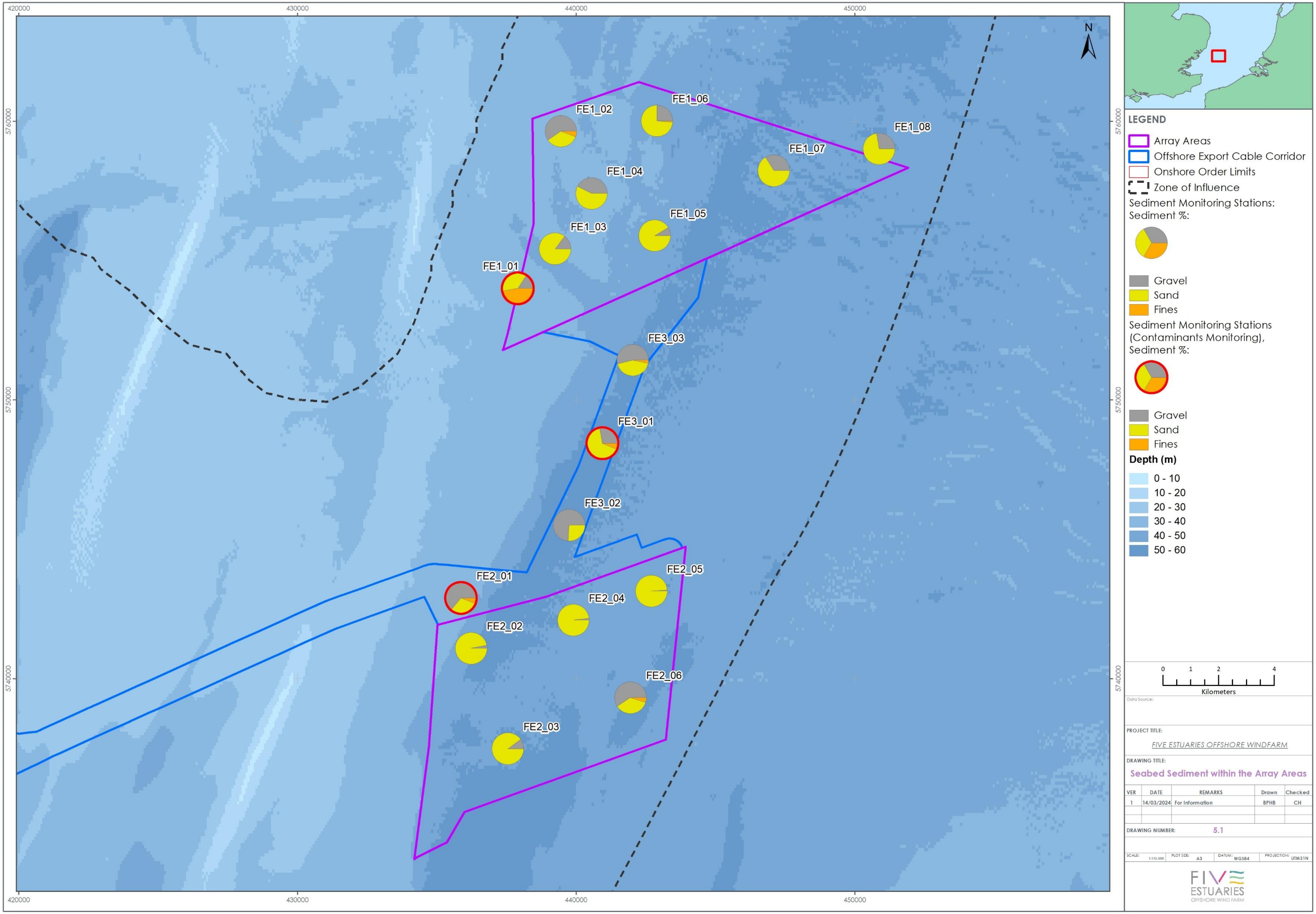
THE OFFSHORE EXPORT CABLE CORRIDOR

DRILLED MATERIAL

5.1.7 The sub surface geology consists of four main units outlined in section 5.1 above: Holocene; Pleistocene; London Clay formation and Harwich formation only observed within the nearshore areas (< 20 km).

5.1.8 As with the Array Areas, the exact proportions of these deposits that will form the basis of the drill arisings deposited on the seabed will vary according to the drilling locations and the depth to which drilling occurs.

5.1.9 As with the Array Areas, the drill arising materials that settle onto the seabed will comprise predominantly sand, gravels, with smaller proportions of silt and clay that do not disaggregate into its particulate constituents. The physical characteristics of this material will, therefore, be not too dissimilar to existing seabed sediments.



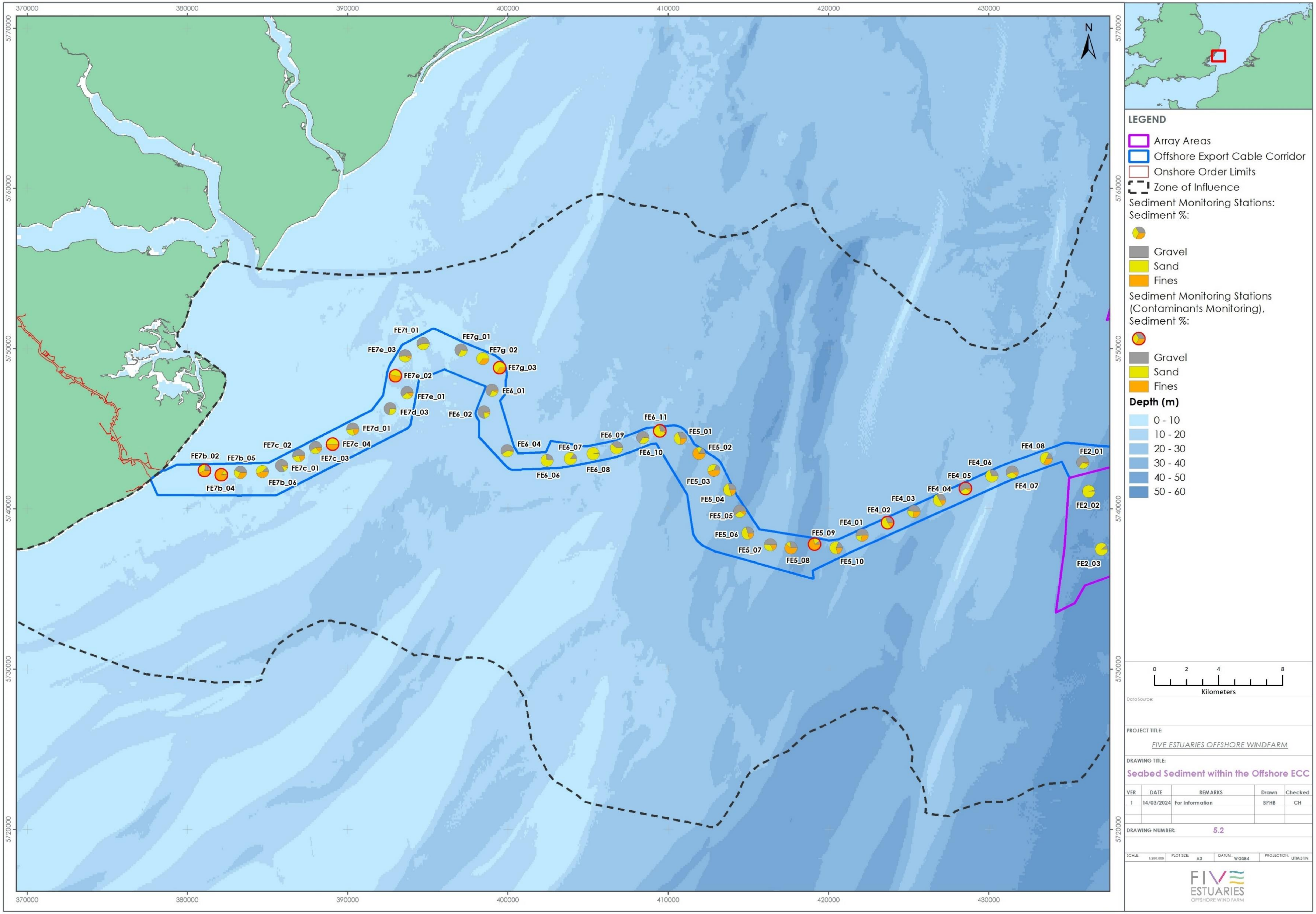
420000
430000
440000
450000
5760000
5750000
5740000
N
FE1_01
FE1_02
FE1_03
FE1_04
FE1_05
FE1_06
FE1_07
FE1_08
FE3_01
FE3_02
FE3_03
FE2_01
FE2_02
FE2_03
FE2_04
FE2_05
FE2_06
LEGEND
Array Areas
Offshore Export Cable Corridor
Onshore Order Limits
Zone of Influence
Sediment Monitoring Stations:
Sediment %:
Gravel
Sand
Fines
Sediment Monitoring Stations (Contaminants Monitoring), Sediment %:
Gravel
Sand
Fines
Depth (m)
0 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
0 1 2 4
Kilometers
Data Source:
PROJECT TITLE:
FIVE ESTUARIES OFFSHORE WINDFARM
DRAWING TITLE:
Seabed Sediment within the Array Areas
VER | DATE | REMARKS | Drawn | Checked
1 | 14/03/2024 | For Information | BPHB | CH
DRAWING NUMBER: 5.1
SCALE: 1:115,000
PLOT SIZE: A3
DATUM: WGS84
PROJECTION: UTM31N
FIVE ESTUARIES OFFSHORE WIND FARM

DREDGED MATERIAL

5.1.10 The surficial sediments have been collected along the ECC at 44 locations. This sediment comprises a mix of sand, gravel and fines (mud), varying greatly between stations (Figure 8).

5.1.11 Sand ranged from 11.64% (station FE7c_01) to 97.30% (station FE6_08). Gravel ranged from 0.07% (station FE7e_02) to 82.14% (station FE7c_01). Fines were absent from 3 stations, at the remaining fines ranged from 0.45% (station FE7f_01) to 84.15% (station FE7b_04). Furthermore, the silt content was consistently higher than the clay content.

5.1.12 As with the Array Areas, although the actual process of disposal may result in a slight change to the existing particle size composition of seabed sediments, the material disposed in situ via seabed preparation and cable trenching would be similar to the existing material as the spoil disposal will occur close to the site of production.



LEGEND
Array Areas
Offshore Export Cable Corridor
Onshore Order Limits
Zone of Influence
Sediment Monitoring Stations:
Sediment %:
Gravel
Sand
Fines
Sediment Monitoring Stations (Contaminants Monitoring),
Sediment %:
Gravel
Sand
Fines
Depth (m)
0 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
N
Kilometers
0
2
4
8
FE7f_01
FE7g_01
FE7e_03
FE7g_02
FE7g_03
FE7e_02
FE7e_01
FE6_01
FE7d_03
FE6_02
FE7d_01
FE7c_02
FE7c_04
FE7b_02
FE7b_05
FE7c_01
FE7c_03
FE7b_06
FE7b_04
FE6_04
FE6_07
FE6_09
FE6_11
FE5_01
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FE6_10
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Data Source:
PROJECT TITLE:
FIVE ESTUARIES OFFSHORE WINDFARM
DRAWING TITLE:
Seabed Sediment within the Offshore ECC
VER | DATE | REMARKS | Drawn | Checked
1 | 14/03/2024 | For Information | BPHB | CH
DRAWING NUMBER: 5.2
SCALE: 1:200,000
PLOT SIZE: A3
DATUM: WGS84
PROJECTION: UTM31N
FIVE ESTUARIES
OFFSHORE WIND FARM

5.2 CHEMICAL CHARACTERISTICS

5.2.1 This section summarises the chemical characteristics of sediments in the VE Array Areas and offshore ECC. Further detail can be found in Volume 6, Part 2, Chapter 3: Marine Water and Sediment Quality.

THE ARRAY AREAS

5.2.2 Three samples within the Array Area have been analyzed for contaminants, one each within the North Array, South Array and Interconnector areas.

5.2.3 The metal concentrations within the arrays samples were all below Cefas Guideline Action Level 1(CAL1). However, arsenic concentration exceeded the Canadian Threshold Effect level (TEL) but were below the Probable Effect level (PEL).

5.2.4 Dibutyltin (DBT), Tributyltin (TBT), Polycyclic Aromatic Hydrocarbons (PAHs), Total Hydrocarbon Content (THC), Organochlorine Pesticides (OCP) and Polychlorinated biphenyl (PCB) concentrations were less than their respective Level of Detection (LoD).

THE OFFSHORE EXPORT CABLE CORRIDOR

5.2.5 Eight samples within the ECC area have been analyzed for contaminants.

5.2.6 Of the eight metals used as the standard measures for sediment quality analysis (Cefas Guideline Action Levels; Canadian SQG's), four reported levels under these threshold guidelines, including CAL1. The four metals for which the levels were above the thresholds were: Arsenic at 4 stations both CAL 1 and Tel were exceeded, whilst two of the stations exceeded PEL; Cadmium, at one station where concentration exceeded CAL1; Chromium, at one station where concentration exceeded CAL1; and Nickel, at four stations which exceeded CAL1.

5.2.7 DBT, TBT and OCP concentrations were less than their respective LoD.

5.2.8 In general, concentration of total PAHs were higher at stations along the nearshore section of the offshore ECC. However, all concentrations of individual PAHs were below their respective Sediment Quality Guidelines (SQGs). One station exceeded CAL1 for C1-naphthalenes and C2-naphthalenes.

5.2.9 Along the offshore ECC, THC content generally showed a pattern of decreasing concentrations with distance offshore.

5.2.10 The concentrations of individual PCB congeners analysed were below the LoD (< 0.00008 mg/kg) at four stations. At the remaining stations, all of which are along the nearshore section of the ECC, the concentration of selected PCB congeners was greater than the LoD. As such, sum of the 25 congeners was between <0.00200 mg/kg and <0.00244 mg/kg. These values were all below CAL1.

5.3 BIOLOGICAL CHARACTERISTICS

5.3.1 Biological characteristics were detailed above in Section 5.2. Further details can be found in Volume 6, Part 2, Chapter 5: Benthic and Intertidal Ecology and Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology.

6 ASSESMENT OF THE POTENTIAL ADVERSE EFFECTS

6.1.1 The following section of the document provides an overview of the key findings of the VE EIA relevant to the disposal of dredged and/or drilled material in situ.

6.2 PHYSICAL ENVIRONEMNT

6.2.1 Marine processes are not themselves receptors in the majority of cases. However, changes to these processes may have an impact on other sensitive receptors. This section summarises the findings of the impact assessment of these physical changes on sensitive biological and human receptors.

6.2.2 A wide range of potential changes to physical processes have been considered, including short-term sediment disturbance due to construction activities, scour around foundations and the potential for changes to the coast and nearby bank systems, arising from the blockage of waves and tides.

6.2.3 Even using a worst case MDS approach for the EIA, it has been found that for all receptor groups, the level of effect significance is either Negligible or Low for all phases of development. Accordingly, all of the potential effects to physical processes receptors are therefore Not Significant in terms of the EIA Regulations (Volume 6, Part 1, Chapter 3: EIA Methodology).

6.2.4 Further details on the impact assessment can be found in Volume 6, Part 2, Chapter 2: marine geology, oceanography and physical processes and Volume 6, Part 2, Chapter 3: Marine Water and Sediment Quality.

POTENTIAL CHANGES TO SUSPENDED SEDIMENT CONCENTRATION (SSC)

6.2.5 The actual magnitude and extent of change in SSC and bed levels will depend in practice on a range of factors, such as the actual total volumes and rates of sediment disturbance, the local water depth and current speed at the time of the activity, the local sediment type and grain size distribution, the local seabed topography and slopes, etc. There will be a wide range of possible combinations of these factors and so it is not possible to predict specific dimensions with complete certainty. To provide a robust assessment, a range of realistic combinations have been considered, based on conservatively representative location (environmental) and project (MDS) specific information, including a range of water depths, heights of sediment ejection/initial resuspension, and sediment types.

6.2.6 This wider range of results can be summarised broadly in terms of four main zones of effect, based on the distance from the activity causing sediment disturbance. These zones are entirely consistent with the results of observational (monitoring) evidence and numerical modelling of analogous activities.

- 0 to 50 m zone: zone of highest SSC increases and greatest likely thickness of deposition. All gravel sized sediment likely deposited in this zone, also a large proportion of sands that are not resuspended high into the water column, and also most or all dredge spoil in the active phase. Plume dimensions and SSC, and deposit extent and thickness, are primarily controlled by the volume of sediment released and the manner in which the deposit settles.
- 50 to 500 m zone: zone of measurable SSC increase and measurable but lesser thickness of deposition. Mainly sands that are released or resuspended higher in the water column and resettling to the seabed whilst being advected by ambient tidal currents. Plume dimensions and SSC, and deposit extent and

thickness, are primarily controlled by the volume of sediment released, the height of resuspension or release above the seabed, and the ambient current speed and direction at the time.

- 500 m to the tidal excursion buffer distance: zone of lesser but measurable SSC increase and no measurable thickness of deposition. Mainly fines that are maintained in suspension for more than one tidal cycle and are advected by ambient tidal currents. Plume dimensions and SSC are primarily controlled by the volume of sediment released, the patterns of current speed and direction at the place and time of release and where the plume moves to over the following 24 hours.
- Beyond the tidal excursion buffer distance or anywhere not tidally aligned to the active sediment disturbance activity: there is no expected impact or change to SSC nor a measurable sediment deposition.

6.2.7 The study area is characterised by naturally high levels of suspended sediment concentration which result from ongoing coastal erosion and regular stirring of the bed by the action of tidal currents and wave driven orbital currents. In shallower waters (< circa 30 m) during storm events, these waves driven currents can result in very high SSC (thousands of mg/l or more) close to the bed in areas where mobile sediment is present. Accordingly, even when SSC increases occur in response to windfarm construction activities, they are expected to be comparable to (or less than) the increases which occur naturally under baseline conditions.

6.2.8 The assessment set out in this section has considered potential changes to pathways, rather than impacts on receptors for both the Array Areas and offshore ECC. Accordingly, no assessment of significance is provided. Furthermore, the potential impact is unlikely to affect the intertidal or landfall area.

POTENTIAL MORPHOLOGICAL IMPACTS TO SANDBANKS AND DESIGNATED AREAS OF SEABED

6.2.9 The sediments comprising the sandwave features will be predominantly sand, although a small proportion of fines and gravel may also be present. Individual sandwaves will require removal via MFE or by multiple dredging cycles to complete the required corridor. If dredging is undertaken, the preference is for the dredge spoil to be returned to the seabed in the vicinity of the dredged area.

6.2.10 The tidal current regime (peak current speeds on a mean spring tide of circa 0.8 to 1.3 m/s) is sufficiently strong to cause mobility of sand on a regular basis. The tidal current regime will not measurably change as a result of the localised levelling, or as a result of any other aspect of the Project. The volume of sediment available in each local system will be locally redistributed by the levelling (via MFE and/or dredging and disposal of removed material back into the water column nearby) but will not change in an overall net sense. As the controlling factors will also not change, the levelled areas and sandwave features will have the potential to recover in time to a new (dynamically evolving) natural state.

6.2.11 The exact timescale for recovery cannot be calculated with certainty. Based only on the overall rate of observed bedform migration (which is not the main or only mechanism for recovery and is proportional to the long-term net sediment transport rate), the timescale for recovery in the more energetic parts of the offshore ECC is estimated to be in the order of 5 to 10 years; longer timescales of 'at least' 10 years can be inferred for the Array Areas, based on the relatively low observed rate of bedform migration. However, short-term sediment mobility will also contribute to local sandwave recovery (Volume 6, Part 5, Annex 2.1: Physical Processes Baseline Technical Report).

6.2.12 A shorter estimated timescale is obtained when considering the instantaneous rate of transport during higher flow periods. As shown by the detailed sand transport modelling (Volume 6, Part 5, Annex 2.1: Physical Processes Baseline Technical Report), instantaneous transport rates of 0.36 to 3.6 m^3/m/hr may be active up to four times per day (peak flood and ebb) for a few days either side of the peak of spring tides. At a representative mid-level rate of 1 m^3/m/hr, and assuming a representative 70 m wide corridor and a representative volume of 75,000 m^3 sediment displaced per sandwave, it could take in the order of (75,000 m^3/[1 m^3/m/hr x 70 m x 4 hr/day x 4 days]) 70 spring tidal cycles (~2.7 years) as a minimum to move the displaced volume of sediment back into the levelled area. The actual rate of recovery will be slightly longer as not all sediment transported into the area will be retained in the longer term. The rate of transport and so the rate of recovery could be around three times faster or slower than this, depending upon location along the offshore ECC or within the Array Areas. The overall rate of recovery would also vary in proportion to the volume displaced (relative to the representative value of 75,000 m^3).

6.2.13 The final shape of the bedform following recovery may be similar to its original condition (e.g., rebuilding a single crest feature, although likely displaced in the direction of natural migration) or it might change (e.g., a single crest feature might bifurcate or merge with another nearby bedform). All such possible outcomes are consistent with the natural processes and bedform configurations that are already present in the Study Area and would not adversely affect the onward form and function of the individual bedform features.

6.2.14 The levelled areas are not considered likely to create a barrier to onward sediment transport. Evidence from aggregate dredging activities indicates that if any changes occur to the flow conditions or wave regime, these are localised in close proximity to the dredge pocket (with widths and lengths of several kilometers). The proposed works will be at a much smaller scale and footprint, with trench widths expected to be in the order of up to 50 m, in water depths of at least 30 m. This means there is likely to be little to no influence on the flow or wave regime, which in turn means little to no change to the regional scale sediment transport processes across the Array Areas and offshore ECC.

6.2.15 The Project overlaps with Margate and Long Sands SAC, the Outer Thames Estuary SPA and the Southern North Sea SAC all of which are internationally important sites. However, the seabed in these areas has been shown to be dynamic and is assessed to have some capacity to recover from disturbance. Accordingly, they are assessed as having **medium** sensitivity/ importance.

6.2.16 The magnitude of impact to the seabed is predicted to be **negligible** (neutral). This assessment of magnitude is based on the fact that no sediment is being removed from the local sediment transport system, only redistributed. Accordingly, net rates of sediment transport to/ from designated areas of seabed will remain unaltered from the baseline.

6.2.17 The overall level of effect of morphological change has therefore been assessed as being of **minor adverse** significance which is not significant in EIA terms.

POTENTIAL IMPACTS TO LANDFALL MORPHOLOGY

6.2.18 The coastline within the landfall area is heavily managed with an almost continuous concrete sea wall at the back of the beach, fronted by a mixture of sloped smooth and/or rock revetment. The character of the beach and coastline in the landfall area is presently stable due to the coastal defences present; however, the future stability of the coastline will remain dependent on the future management policies and activities for both the local area and for coastal regions up drift (to the northeast).

6.2.19 HDD is the established solution for trenchless installation, however it should be noted that other technologies exist, such as micro-boring. HDD will cause minimal direct disturbance to the existing coastline because it will not interact directly with, or leave any infrastructure exposed in, the active parts of the beach (between the entry and exit points of the drill) and so will not impact upon littoral processes in these areas. Provided that the cable remains buried beyond the exit of the HDD, there is no possibility for it to interact with, or have any effect on nearshore beach processes or morphology. The design of the HDD operation will take this into account.

6.2.20 Although the HDD exit pits may be present for a number of months, the potential for these temporary features to modify the wave regime will be limited as the HDD exit pits will be temporarily infilled with rock bags or concrete mattressing. Accordingly, water depths within their footprint of all nearshore affected areas will remain similar to baseline levels. Depending upon the position of the spoil mounds in the intertidal and the rate and pattern of any redistribution of the material (controlling the change of water depth in their footprint), there may be potential for these to locally modify the nearshore wave regime through the differently distributed transmission of wave energy across the beach. This could theoretically result in a morphological response although this would be highly localized to the area around the mounds. The potential for local changes to become more widespread would also be limited by the presence of the groynes.

6.2.21 If the HDD exit pits remain open during winter months, there will be a high likelihood that the material comprising the spoil mounds will be at least partially redistributed offshore and across the beach during storm events.

6.2.22 Open-cut installation in the intertidal zone could be carried out using one or more methods described for the offshore export cables (if and where suitable for use in the intertidal zone). However, ploughing is expected to displace the greatest volume of material out of the trench and therefore is considered to represent the MDS. Excavation of the trench with a plough would result in the formation of berms either side of the trench. The size of these berms will be dependent upon the trench width, cable burial depth and nature of the disturbed sediments.

6.2.23 Whilst the trenches are open (assumed to be a period of days to a few weeks), it is possible that the material in the berms could be mobilised by the action of tidal currents and waves and locally redistributed. Accordingly, the potential extent of change to beach/ intertidal morphology could extend across a wider area than the immediate footprint of the trench and berms. However, it is anticipated that the full volume of the berms adjacent to the trench would only be present on the seabed/ beach for a relatively short period of time (order of days to a few weeks, depending on the pattern of tidal inundation and wave action in that time) and therefore the extent to which this redistribution of material could occur is anticipated to be limited. Furthermore, given that the berms would only be present for a very short period of time, any changes to hydrodynamics and sediment transport would also be highly localized and there would be no potential for longer term change to coastal morphology.

6.2.24 Within the lower intertidal/ shallow subtidal, it is anticipated that reworking by currents and/ or waves will quickly (in the order of days to several weeks) redistribute and smooth any remaining local disturbances after the trench has been backfilled, returning the area of the trench (and associated works) to a natural state (e.g., elevation and sediment type) that will be in equilibrium with the baseline environment.

6.2.25 Cable protection will be buried in the intertidal section and out to 1,600 m seaward of Mean High Water Spring (MHWS) and will not consist of loose rock or gravel. If the cable protection is installed below the (winter) beach level it will present no barrier to the passage of waves and so cause no change to long-term patterns of sediment transport.

6.2.26 Cable protection in shallow areas could theoretically work in a similar way to a submerged offshore breakwater, affecting wave transformation processes closer to shore. This in turn could potentially alter the wave approach to the shore leading to wave focusing on areas of the beach not presently eroding, resulting in long-term lowering. The structures themselves could also locally intercept sediment being transported by wave and tidal driven currents. However, whilst it can reasonably be expected to be the case that there will be some localized change to waves and hydrodynamics immediately within the vicinity of the rock berms, the potential for wider morphological change to the beach at the landfall is considered to be very limited.

6.2.27 The magnitude of change to the beach at the landfall is assessed to be **low** (adverse). Although some highly localised (i.e., order of 10s of metres) morphological change can reasonably be expected to occur immediately adjacent to the HDD exit pits and trench, the spatial extent is expected to be limited. There is no potential for longer term morphological change to the beach that could subsequently result in impacts to the adjacent Holland Haven Marsh SSSI which is located landward of the existing sea defences.

6.2.28 A low magnitude of change to the coastline receptor of medium importance results in an effect of **minor adverse** significance which is not significant in EIA terms.

POTENTIAL CHANGES TO THE SEABED AND SEAWATER CHEMISTRY

6.2.29 Baseline water and sediment quality of the study areas is generally good and site-specific information in relation to concentrations of contaminants in sediments does not record significantly elevated levels of anthropogenic contaminants (see Section 5.2 and Volume 6, Part 2, Chapter 3: Marine Water and Sediment Quality) beyond those expected in the region. The level of contaminants in the dredged material is equivalent to those present in disposal sites and therefore no notable increase or accumulation in sediment bound contamination in the disposal sites is anticipated from the disposal of material.

6.2.30 The disposal of dredged material at the sea surface, and the associated SSC (see above) has the potential to release sediment-bound contaminants, such as heavy metals and hydrocarbons into the water column. The release of contaminants is likely to be rapidly dispersed with the tidal currents; and therefore, increased bioavailability resulting in adverse eco-toxicological effects is not expected. Furthermore, under normal circumstances, very small concentrations of contaminants enter to the dissolved phase, with the vast majority adhering to the sediment particles when temporarily entering suspension in the water column. Partition coefficients may be applied to estimate the concentration of the contaminants entering the dissolves phase which typically result in a reduction of several orders of magnitude than the concentrations associated with suspended sediments. As such, it is considered highly unlikely that the Maximum Allowable Concentration (MAC) Environmental Quality Standards (EQS) threshold will be exceeded for any of the substances as a result of disturbing sediment from the proposed activities, given the fates of the plumes. Moreover, given the short-term nature of the works and presence of the sediment plumes, any small uplift in the water concentrations of EQS substances would be anticipated to return to background levels very quickly.

6.3 BIOLOGICAL AND HUMAN ENVIRONMENT

6.3.1 For all of these assessments, the effects defined within Volume 6, Part 2, Chapter 2: Marine Geology, Oceanography and Physical Processes have been interpreted with regard to their subsequent impact on various receptors. The sensitivity of various receptors to these effects (increased suspended sediment concentrations, sediment deposition and potential loss of seabed habitats) has been determined based on relevant literature and an assessment of the significance of any impacts undertaken.

6.3.2 A summary of the key impacts relating to the activities described in this document on biological and human receptors assessed within the ES is provided in Table 6.1. The relevant chapters/documents of the ES are also referenced where further detail of the relevant impact assessments can be found.

Table 6.1: Summary of impact from disposal of dredged/drilled seabed material within boundaries of VE disposal sites

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Notes
Benthic					
Temporary habitat disturbance	**Volume 6, Part 2, Chapter 5: Benthic Ecology**	Low adverse	Medium in worst case	Minor adverse	Array Areas and ECC
		Low adverse	Low	Minor adverse	Landfall
Temporary increase in SSC and sediment deposition		Low adverse	Medium in worst case	Minor adverse	Array Areas and ECC
		Low adverse	Medium in worst case	Minor adverse	Landfall
Direct and indirect seabed disturbances leading to the release of sediment contaminants		Negligible	High	Minor adverse	Arrays area and ECC
Increased risk of introduction or spread of marine invasive non-native species		Negligible	High	Minor adverse	Array Areas and ECC
Marine Water and Sediment Quality					

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Notes
Deterioration in water quality due to suspension of sediments	**Volume 6, Part 2, Chapter 3: Marine Water and Sediment Quality**	Array Area: Low; Offshore ECC: Low	Array Area: Negligible Offshore ECC: > Sensitivity of identified bathing waters: Low > Sensitivity of identified Shellfish Water Protected Areas: Low > Sensitivity of the Essex and Harwich Approaches coastal water bodies: Low	Negligible for Array Area impacts Offshore ECC: > Bathing Waters: minor adverse > Shellfish Water Protected Areas: minor adverse > Essex and Harwich Approaches coastal water bodies: minor adverse	N/A
Release of sediment-bound contaminants from disturbed sediments		Array Area: Low Offshore ECC: Low	Array Area: Negligible Offshore ECC: > Sensitivity of identified bathing waters: Low > Sensitivity of identified	Negligible for Array Area impacts Offshore ECC: > Bathing Waters: minor adverse > Shellfish Water Protected	N/A

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Notes
			Shellfish Water Protected Areas: Low > Sensitivity of the Essex and Harwich Approaches coastal water bodies: Low	Areas: minor adverse > Essex and Harwich Approaches coastal water bodies: minor adverse	
Accidental releases or spills of materials or chemicals		Array Area: Low Offshore ECC: Low	Array Area: Negligible Offshore ECC: > Sensitivity of identified bathing waters: Negligible > Sensitivity of identified Shellfish Water Protected Areas: Low > Sensitivity of the Essex and Harwich Approaches coastal water bodies: Low	Negligible for array area impacts Offshore ECC impacts: > Bathing Waters: negligible adverse > Shellfish Water Protected Areas: negligible adverse > Essex and Harwich Approaches coastal water	N/A

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Notes
				bodies: negligible adverse	
Fish and shellfish					
Behavioural impacts	**Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology**	Low	Low	Minor adverse	Group 1 VERS
		Low	Low	Minor adverse	Group 2 VERS
		Herring: Low Seahorse: Negligible Seabass: Low All other Group 3: Low	Herring: Medium Seahorse: High Seabass: Low All other Group 3: Low	Herring: Minor adverse Seahorse: Minor adverse Seabass: Minor adverse All other Group 3: Minor adverse	Group 3 VERS
Behavioural impacts of shell fish		Low	Low	Minor adverse	N/A
Temporary increase in SSC and sediment deposition		Native oyster: Negligible Spawning Downs herring: Low Spawning Blackwater	Native oyster: Medium Spawning Downs herring: Medium Spawning Blackwater herring: Medium Sandeel: Low	Native oyster: Minor adverse Spawning Downs herring: Minor adverse Spawning Blackwater herring: Minor	N/A

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Notes
		herring: Low Sandeel: Low All other fish and shellfish: Low	All other fish and shellfish: Low	adverse Sandeel: Minor adverse All other fish and shellfish: Minor adverse	
Direct and indirect seabed disturbances leading to the release of sediment contaminants		Negligible	Medium	Minor adverse	N/A
Accidental pollution events during the construction phase resulting in potential effects on fish and shellfish receptors		Low	Medium	Minor adverse	N/A
Temporary habitat loss/disturbance from construction operations including foundation installation and cable laying operations		Sandeel: Low Spawning Downs herring: Low Spawning blackwater herring: Negligible Native oyster: Negligible Shellfish: Low	Sandeel: Medium Spawning Downs herring: Medium Spawning blackwater herring: Medium Native oyster: Low Shellfish: Low All other fish receptors: Negligible	Sandeel: Minor adverse Spawning Downs herring: Minor adverse Spawning blackwater herring: Minor adverse Native oyster: Negligible Shellfish: Minor adverse	N/A

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Notes
		All other fish receptors: low		All other fish receptors: Negligible	
Marine mammals					
Disturbance from other construction activities	**Volume 6, Part 2, Chapter 7: Marine Mammal Ecology**	Low	Harbour porpoise: Low Harbour seal: Negligible Grey seal: Negligible	Negligible	N/A
Collision risk from construction vessels		Negligible	High	Minor adverse	N/A
Disturbance from construction vessels		Low	Cetaceans: Low Grey seals: Negligible	Negligible	N/A
Change in water quality from construction activities		Negligible	Negligible	Negligible	N/A
Change in fish abundance/distribution from construction activities		Negligible	Low	Negligible	N/A
Ornithology					
Direct disturbance and displacement	**Volume 6, Part 2, Chapter 4: Offshore Ornithology**	Red-throated diver: Negligible Common scoter: Negligible	Red-throated diver: High Common scoter: High Razorbill: Medium Guillemot: Medium	Red-throated diver: Minor adverse Common scoter: Minor adverse Razorbill: Minor adverse	N/A

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Notes
		Razorbill: Negligible Guillemot: Negligible		Guillemot: Minor adverse	
Direct impacts through effects on habitats and prey species		Low	N/A	Negligible or minor adverse	N/A
Commercial fisheries					
Array Area and offshore ECC pre-construction and construction activities and physical presence of constructed wind farm infrastructure leading to reduction in access to, or exclusion from established fishing grounds	**Volume 6, Part 2, Chapter 8: Commercial Fisheries**	UK potting fishery: Medium UK netting fishery: Low-Medium UK beam trawl fishery: Low UK demersal otter trawl fishery: Low UK demersal seine fishery: Low UK hooked gear fishery: Low-Medium Dutch bean trawl fishery:	UK potting fishery: Medium UK netting fishery: Low-Medium UK beam trawl fishery: Low UK demersal otter trawl fishery: Low UK demersal seine fishery: Low UK hooked gear fishery: Low Dutch bean trawl fishery: Low-medium Belgian beam trawl fishery: Low Dutch, French and Belgian demersal otter trawl fishery: Low	UK potting fishery: Minor adverse UK netting fishery: Minor adverse UK beam trawl fishery: Minor adverse UK demersal otter trawl fishery : Minor adverse UK demersal seine fishery: Minor adverse UK hooked gear fishery: Minor adverse Dutch bean trawl fishery: Minor adverse Belgian beam trawl fishery: Minor adverse Dutch, French and Belgian demersal otter trawl fishery:	N/A

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Notes
		Low Belgian beam trawl fishery: Low Dutch, French and Belgian demersal otter trawl fishery: Low Dutch and French pelagic trawl fishery: Negligible	Dutch and French pelagic trawl fishery: Negligible	Minor adverse Dutch and French pelagic trawl fishery: Negligible	
Displacement from Array Areas and offshore ECC leading to gear conflict and increased fishing pressure on adjacent grounds		UK potting fishery: Medium UK netting fishery: Low-Medium UK beam trawl fishery: Low UK demersal otter trawl fishery: Low UK demersal	UK potting fishery: Low UK netting fishery: Low-Medium UK beam trawl fishery: Low UK demersal otter trawl fishery: Low UK demersal seine fishery: Low UK hooked gear fishery: Low Dutch bean trawl	UK potting fishery: Minor adverse UK netting fishery: Minor adverse UK beam trawl fishery: Minor adverse UK demersal otter trawl fishery: Minor adverse UK demersal seine fishery: Minor adverse UK hooked gear fishery: Minor adverse	N/A

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Notes
		seine fishery: Low UK hooked gear fishery: Low-Medium Dutch bean trawl fishery: Low Belgian beam trawl fishery: Low Dutch, French and Belgian demersal otter trawl fishery: Low Dutch and French pelagic trawl fishery: Negligible	fishery: Low-medium Belgian beam trawl fishery: Low Dutch, French and Belgian demersal otter trawl fishery: Low Dutch and French pelagic trawl fishery: Negligible	Dutch bean trawl fishery: Minor adverse Belgian beam trawl fishery: Minor adverse Dutch, French and Belgian demersal otter trawl fishery: Minor adverse Dutch and French pelagic trawl fishery: Negligible	
Construction activities leading to disturbance of commercially important fish and shellfish resources leading to displacement or disruption of fishing activity		UK potting fishery: Medium Dutch and French pelagic trawl	UK potting fishery: Low Dutch and French pelagic trawl fishery: Low All other fleets: Low	UK potting fishery: Minor adverse Dutch and French pelagic trawl fishery: Minor adverse	N/A

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Notes
		fishery: Low All other fleets: Low		All other fleets: Minor adverse	
Increased vessel traffic associated with VE within fishing grounds leading to interference with fishing activity		UK potting fishery: Medium UK netting fishery: Medium UK beam trawl fishery: Low UK demersal otter trawl fishery: Low UK demersal seine fishery: Low UK hooked gear fishery: Medium Dutch bean trawl fishery: Low Belgian beam	UK potting fishery: Low UK netting fishery: Low UK beam trawl fishery: Low UK demersal otter trawl fishery: Low UK demersal seine fishery: Low UK hooked gear fishery: Low Dutch bean trawl fishery: Low Belgian beam trawl fishery: Low Dutch, French and Belgian demersal otter trawl fishery: Low Dutch and French	UK potting fishery: Minor adverse UK netting fishery: Minor adverse UK beam trawl fishery: Minor adverse UK demersal otter trawl fishery: Minor adverse UK demersal seine fishery: Minor adverse UK hooked gear fishery: Minor adverse Dutch bean trawl fishery: Minor adverse Belgian beam trawl fishery: Minor adverse Dutch, French and Belgian demersal otter trawl fishery: Minor adverse Dutch and French	N/A

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Notes
		trawl fishery: Low Dutch, French and Belgian demersal otter trawl fishery: Low Dutch and French pelagic trawl fishery: Low	pelagic trawl fishery: Low	pelagic trawl fishery: Minor adverse	
Shipping and navigation					
Vessel displacement and increased collision risk	**Volume 6, Part 2, Chapter 9: Shipping and navigation**	N/A	N/A	Array Areas: Broadly acceptable Offshore ECC: Tolerable	N/A
Third-party with project vessel collision risk		N/A	N/A	Array Areas: Braodly acceptable Offshore ECC: Broadly acceptable	N/A
Reduced access to local ports and harbours and reduction in under keel clearance		N/A	N/A	Array Areas: Broadly acceptable Offshore ECC: Tolerable	N/A
Offshore archaeology					

Potential impact	Relevant section of ES	Magnitude of impact	Sensitivity of receptor	Significance of effect	Notes
Direct impact (i.e., sediment removal, penetration, compression and disturbance)	**Volume 6, Part 2, Chapter 11: Offshore Archaeology and Cultural Heritage**	Negligible	Negligible to High	Minor to Negligible	N/A
Indirect impact (i.e., exposure to chemical and/or biological processes)		Negligible	Negligible to High	Minor to Negligible	N/A

7 MONITORING

7.1.1 Based on the findings of the impact assessments presented in the Environmental Statement (ES), and summarised within this document, long-term impacts of disposal of spoil and dredged material within the VE Array Areas and Offshore ECC are not anticipated. This is due to the limited increase in seabed level and the temporary nature of any sediment plumes generated.

7.1.2 Sediment deposition resulting from disposal activities is also predicted to only result in short-term, spatially discrete impacts and the fact that the seabed material due to be dredged and disposed of in situ has been shown via specific sampling not to be heavily contaminated, indicates that contamination via this activity will not arise.

7.1.3 The only potential longer-term impact of disposal that may occur will be the creation of discrete sandwave features adjacent to each foundation location where disposal has been carried out. No adverse impacts are predicted as the source material that will form these sandwaves will remain predominantly be sand, the same as currently exists in these locations. Therefore, following an initial effect on benthic communities due to the deposition of this sediment, recovery of existing benthic communities is expected to occur.

7.1.4 To verify these predictions, it is proposed that formal post-construction benthic monitoring be carried out. Any monitoring will be designed to test specific hypotheses and the exact objectives of this post-construction monitoring will be discussed and agreed with the relevant statutory authorities. Where necessary, monitoring will take place in line with the marine licence requirements and relevant guidelines (Cefas *et al.* 2004) and over a timescale to be agreed with statutory authorities. Any monitoring proposals will also take account of the key recommendations set out in the Cefas Strategic Review of Offshore Wind Farm Monitoring Data Associated with FEPA Licence Conditions (Please see Volume 9, Report 9.32: Offshore In Principle Monitoring Plan for more details).

8 CONCLUSIONS

8.1.1 This document represents the site characterisation for the VE Array Areas and offshore ECC. It forms the proposal for licensed disposal sites within the Array Areas and the offshore ECC for drill arisings, and material from foundation seabed preparation, cable installation preparation, and in relation to the ECC, excavation of HDD exits pits. This is required by the MMO to allow them to consider the potential impacts of disposal within these sites.

8.1.2 Noting that all the information required for a site characterisation to support a disposal licence application is contained within the wider ES, this document takes the form of a 'framework' document that provides a summary of the key points of relevance to site characterisation and refers to more detailed information and data presented within the relevant sections of the ES at this stage.

8.1.3 The source of material proposed to be disposed of within the array and ECC will be sediment dredged from the upper layer of the existing seabed via suction hopper dredger as part of foundation seabed preparation works and cable installation preparation, and/or materials from the deeper soil profile and upper sediments derived from drilling activities for piled foundations.

8.1.4 Within the Five Estuaries Offshore Wind Farm Array Area Disposal Sites, an upper estimate of 22,374,37124,556,610 m^3 of material will be disposed of *in situ*. Within the Five Estuaries Offshore Wind Farm Cable Corridor Disposal Site, an upper estimate of 9,214,386 m^3 of material will be disposed of *in situ*.

8.1.5 Where drilling is required to facilitate the installation of piles to target depth, the drill arisings will be disposed of at sea, adjacent to the foundation location.

8.1.6 No moderate or major adverse impacts (i.e., significant in EIA terms) have been identified, with only negligible to minor adverse impacts predicted on certain receptors, including benthic habitats.

8.1.7 In conclusion, based on the proposals for disposal within the VE boundaries, the nature of the material to be disposed of, the receiving environment and the predictions of the EIA work done to date of the impact of these activities on physical, biological and human receptors, no significant adverse impacts (in EIA terms) are predicted.

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