FOREWIND

DOGGER BANK
TEESSIDE A & B

March
2014

Environmental Statement Chapter 12 Appendix F Disposal Site Characterisation Document

Application Reference 6.12.6

Cover photograph: Installation of turbine foundations in the North Sea

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	Appendix 12F Disposal Site Characterisation
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31 January 2014	1	Pre DCO submission	JL	BLO	AL
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1. Introduction

1.1.1. Site characterisation is the process whereby a proposed marine disposal site is described in terms of its existing environment, using all available data sources. A full site characterisation report must be submitted to the Marine Management Organisation (MMO) in order to inform the decision making process with regard to proposed marine disposal. Such a report should contain the following information as a minimum:

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

1.1.2. This document represents the site characterisation for Dogger Bank Teesside A & B within tranches A and B of the Dogger Bank Zone (**Figure 1.1**). The document relates to the proposed disposal of seabed material within the boundaries of Dogger Bank Teesside A and Dogger Bank Teesside B only, exclusive of the temporary work areas of 1km around each of the two wind farm sites. It should be noted that the temporary work area on the eastern margin of Dogger Bank Teesside A does not extend for the full distance of 1km but terminates at the International Boundary. No works activities, temporary or otherwise will occur beyond the international boundary. Disposal of material within the export cable corridor is not being sought.

1.1.3. This document has been developed following review of the formal response by the MMO (20 December 2013) to the draft Development Consent Order (DCO) submitted by Forewind on 4 November 2013 as part of the Preliminary Environmental Information 3 (PEI3) consultation stage.

1.1.4. Within the response from the MMO, comment 2.5.6 stated the following with respect to disposal of material within the project site and the need for Forewind to undertake a site characterisation:

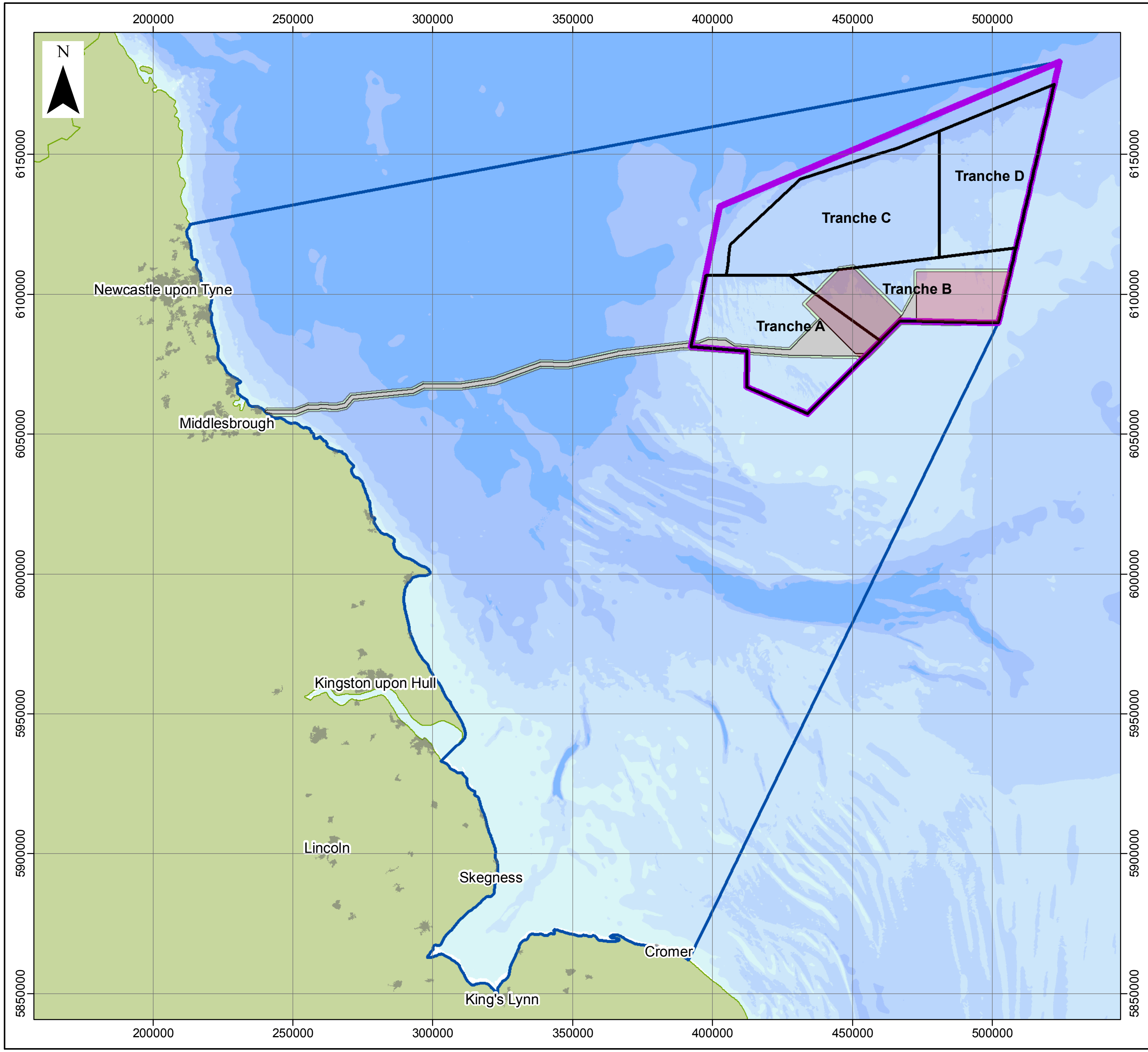
"Section 2(4) (page 70) states that "this licence authorises the disposal of up to 1,107,411m^3 of material [1]*of natural origin within the offshore Order limits produced during construction drilling and seabed preparation…" Spoil material from drill arising or seabed preparations must be disposed of to a licensed disposal site. If this material is to be disposed of within the array boundary, an application must be submitted for the area to become a licensed disposal site, in which case a full site characterisation will be required. Details of how such a*

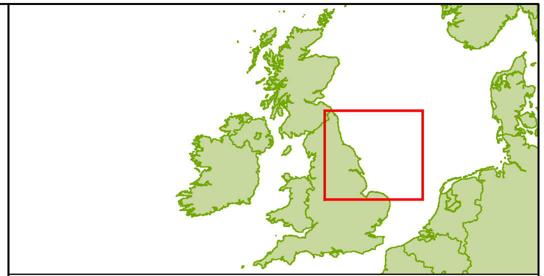
[1] Note that this figure relates to the amount of material stated in the Creyke Beck Disposal Site Characterisation Report submitted as an example document in Chapter 12, Appendix G of the Dogger Bank Teesside A & B PEI3 documentation. Exact amounts relevant to Dogger Bank Teesside A & B are defined in Table 2.3.

characterisation could be undertaken can be found in 'Birchenough, A.C. and Vivian, C. M.G. Case Studies to Demonstrate the Selection of Dredged Material Disposal Sites at Sea".

1.1.5. Noting that all of the information required for site characterisation to support a disposal application would be contained within the Dogger Bank Teesside A & B Environmental Statement (Forewind 2014), this document takes the form of a 'framework' document that provides a summary of the key points relevant to site characterisation and refers the reader back to the more detailed information and data presented within various sections of the ES.

1.1.6. This document is being submitted as part of the final project documentation for Dogger Bank Teesside A & B.





LEGEND

- Zone development envelope
- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

0 20 40
Kilometres

Data Source:
Round 3 offshore wind farm boundary © Crown Copyright, 2012,
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 1.1 Map of Dogger Bank Zone

VER	DATE	REMARKS	Drawn	Checked
2	04/10/2013	PEI3	FK	AL
3	05/12/2013	Final ES	GC	AL
4	13/02/2014	DCO Submission	GC	RZ

DRAWING NUMBER: **F-OFL-MA-001**

SCALE	PLOT SIZE	DATUM	PROJECTION
1:2,100,000	A4	WGS84	UTM31N

FOREWIND

2. Need for a New Disposal Site

2.1. Dogger Bank Teesside A & B

The Dogger Bank Zone

2.1.1. The Dogger Bank Zone is located in the North Sea off the east coast of Yorkshire (see **Figure 1.1**). It is the largest of the UK Round 3 offshore wind zones, covering an area of 8,660km^2, with its outer limit running just within and broadly parallel to the UK continental shelf limit, as defined by the UK Hydrographic Office. At its closest point, it is located 125km off the Yorkshire coast.

Tranche A & B

2.1.2. The Dogger Bank Zone has a target capacity of 7.2GW which is intended to be developed via a series of individual wind farm projects which will be developed in phases, based on the identification of development areas referred to as 'tranches'.

2.1.3. Forewind have used the concept of Zone Appraisal and Planning (ZAP) to produce recommendations for the tranche boundaries. Each tranche is defined with enough area to ensure there is flexibility in locating the wind farms therein. The locations of the individual wind farms are defined through a process of detailed survey, data collection, constraint mapping and technical and commercial modelling, and then further refined through the Environmental Impact Assessment (EIA) and consultation process.

2.1.4. Tranche A is an area in the south west of the Dogger Bank Zone consisting of approximately 2,000km^2. Tranche B is located in the south east of the Dogger Bank Zone and has an area of approximately 1,500km^2. The Dogger Bank Teesside A project boundary is located entirely within Tranche B. The Dogger Bank Teesside B project boundary is located primarily within Tranche B with some, an area of approximately 200km^2, extending into the eastern margin of Tranche A.

The Projects

2.1.5. Dogger Bank Teesside A & B is comprised of two discrete projects (Dogger Bank Teesside A and Dogger Bank Teesside B) which are located primarily in Tranche B of the Dogger Bank Zone (**Table 2.1** & **2.2**). Dogger Bank Teesside A is located in the eastern part of Tranche B and covers an area of 560km^2. Water depths within the site range between 20 to 35m below Lowest Astronomical Tide (LAT).

2.1.6. Dogger Bank Teesside B is located primarily in the western part of Tranche B, with a small area extending into the eastern part of Tranche A, and covers an area of 593km^2. Water depths within this site range between 20 to 40m below LAT.

2.1.7. Disposal activities will be limited to the boundaries of Dogger Bank Teesside A and Dogger Bank Teesside B only.

Table 2.1 Dogger Bank Teesside A boundary co-ordinates (WGS84)

Points	Latitude	Longitude
TSA-1	55° 7.074' N	2° 34.514' E
TSA-2	55° 7.116' N	3° 5.934' E
TSA-3	55° 6.414' N	3° 5.645' E
TSA-4	55° 5.443' N	3° 5.246' E
TSA-5	55° 4.471' N	3° 4.848' E
TSA-6	55° 3.499' N	3° 4.449' E
TSA-7	55° 2.528' N	3° 4.051' E
TSA-8	55° 1.556' N	3° 3.654' E
TSA-9	55° 0.584' N	3° 3.256' E
TSA-10	54° 59.692' N	3° 2.892' E
TSA-11	54° 58.682' N	3° 2.479' E
TSA-12	54° 58.641' N	3° 2.463' E
TSA-13	54° 57.669' N	3° 2.066' E
TSA-14	54° 57.291' N	3° 1.912' E
TSA-15	54° 57.306' N	3° 0.836' E
TSA-16	54° 57.334' N	2° 58.711' E
TSA-17	54° 57.337' N	2° 58.470' E
TSA-18	54° 57.607' N	2° 34.614' E

Table 2.2 Dogger Bank Teesside B boundary co-ordinates (WGS84)

Points	Latitude	Longitude
TSB-1	55° 7.466' N	2° 8.743' E
TSB-2	55° 7.801' N	2° 13.068' E
TSB-3	54° 58.242' N	2° 30.113' E
TSB-4	54° 57.658' N	2° 29.117' E
TSB-5	54° 50.319' N	2° 16.670' E
TSB-6	54° 50.317' N	2° 15.801' E
TSB-7	55° 0.666' N	1° 57.272' E

Project Components

2.1.8. The following section provides a summary of the project components of Dogger Bank Teesside A & B. For more details, please refer to **Chapter 5 Project Description** of the ES.

2.1.9. The key components of each of the Dogger Bank Teesside A and Dogger Bank Teesside B projects are listed below. The overall number of components across Dogger Bank Teesside A & B are the numbers below multiplied by two:

- Up to 200 wind turbines per project;
- Turbine foundations and associated support and access structures;
- One offshore converter platform, and associated foundation per project;
- Up to four offshore collector platforms, and associated foundations per project;
- Up to two offshore accommodation or helicopter platform(s) for operations and maintenance activities, and associated foundations per project;
- Offshore cabling (comprising inter-array, export and platform interconnecting cables):
- Crossing structures at the points where project cables cross existing subsea cables and pipelines or other Dogger Bank project cables;
- Up to five offshore meteorological monitoring stations per project;
- Scour and cable protection (where necessary);
- Up to ten vessel mooring buoys per project; and
- Onshore cabling.

2.1.10. If the application for development consent is successful, the construction period per project could be up to six years. The maximum construction period over which the construction of Dogger Bank Teesside A & B could take place is 11 years and six months (taking into account the timeframes associated with project consent and other limitations on project timings).

Summary of foundation options

2.1.11. The final foundations for Dogger Bank Teesside A & B will be chosen following detailed design, which will take into account 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.

2.1.12. For the purposes of the EIA the following turbine and offshore platform foundations have been considered in the assessment:

- Steel monopile;
- Concrete monopile;
- Suction bucket monopole;
- Multileg foundation with:
  - driven piles
  - suction buckets
  - screw piles
  - jack-up foundations
- Conical gravity base;
- Flat-base gravity base;
- Jacket foundation (potentially using driven piles, suction buckets, and/or screw piles); and
- Semi-submersible gravity base foundation.

2.1.13. The wording of the draft DCO for Dogger Bank Teesside A & B also limits the development to these foundation types.

2.1.14. Further details on the various foundation options assessed within the EIA are provided in **Chapter 5** of the ES (Forewind 2014).

2.2. Predicted sources and amounts of spoil

Source of spoil

2.2.1. Spoil will be generated via the installation of all of the foundation types listed above, from drilling of monopiles and/or pin-piles used to support jacket foundations, to seabed preparation prior to gravity base installation.

2.2.2. Depending on the local ground conditions, 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.

2.2.3. 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).

2.2.4. For gravity base foundations, any soft mobile surface sediment in the area of foundation installation will need to be removed from the seabed to provide a firm, level surface. As a realistic worst case, initial ground investigations suggest that in some areas of tranches A and B, a 0.75m thick layer of top sediment may have to be excavated before installation of some of these foundations.

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

2.2.6. For the purposes of the impact assessments presented in the Dogger Bank Teesside A & B ES (Forewind 2014), it has been assumed that the spoil arisings (either via sidecasting/dredging for seabed preparation or drill arisings) will be disposed of next to each foundation location and within the boundary of Dogger Bank Teesside A or Dogger Bank Teesside B (inclusive of the temporary works areas around each site).

Volumes of spoil

2.2.7. In order to enable the EIA process to be undertaken using the Rochdale Envelope approach, the realistic worst-case scenario with respect to volumes of spoil generated via these foundation installation methods has been calculated and assessed in individual chapters of the Dogger Bank Teesside A & B ES, as well as being presented in detail in **Chapter 5** of the ES (Forewind 2014).

2.2.8. The total volumes required for disposal within Dogger Bank Teesside A & B and being sought for inclusion in the deemed Marine Licence for this project are presented in **Table 2.3**.

Table 2.3 Summary of worst case total values for spoil arisings per foundation type (per project)

Element	Drilled 12m concrete monopile	Drilled multileg	Gravity base foundation
Spoil Volume (m^3) Dogger Bank Teesside A	968,789	64,500	648,165
Spoil Volume (m^3) Dogger Bank Teesside B	968,789	64,500	648,165
Spoil Volume (m^3) Dogger Bank Teesside A & B	1,937,578	129,000	1,296,330

2.2.9. From **Table 2.3** it can be noted that of all the various foundation options that could be used at Dogger Bank Teesside A & B, the maximum amount of spoil that would be produced from Dogger Bank Teesside A & B will be 1,937,578m^3.

2.2.10. Should the foundations that are installed be a combination of drilled concrete monopiles and other foundations (jackets/gravity base foundation), the total amount of spoil generated will be less than 1,937,578m^3.

2.3. Consideration of alternative disposal options

2.3.1. 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 Dogger Bank Teesside A & B. The consideration of alternatives to disposal of dredged and/or drilled material within Dogger Bank Teesside A & B 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.

Option 1: Disposal at existing licensed marine disposal site

2.3.2. With respect to disposal at an existing marine disposal site, the closest open marine disposal site to Dogger Bank Teesside A & B is HU015 which is located at its closest point 176km of Dogger Bank Teesside A & B. Currently, HU015 is used for the disposal of maintenance dredged material from the port of Bridlington. However, the maximum quantity that is currently authorised for disposal in any one year is 30,000 tonnes (Cefas 2011). Furthermore, transfer of the proposed amounts of material due to be dredged from Dogger Bank Teesside A & B (a maximum of 1,937,578m^3) to HU015 would require approximately 325 round trips of at least 250km per trip with a commercial-scale suction dredger (assuming a hopper capacity of 6,000m^3).

2.3.3. This scale of dredger movements would lead to environmental impacts due to fuel emissions that would be avoided if the dredged material was permitted to be disposed of *in situ* as per the methods and assessment presented in the Dogger Bank Teesside A & B ES (Forewind 2014).

2.3.4. To enable further disposal of material at the HU015 site (which, notably, is within the Flamborough Head SAC boundary), further site characterisation of the area around the existing disposal site would also be required as well as hydrodynamic modelling studies to determine the capacity of this site in terms of additional disposal material. Noting that the conclusions of this characterisation (as set out in the Dogger Bank Teesside A & B ES) have demonstrated no major adverse impacts of disposal activities on any receptors in this area, there is no strong argument for undertaking another site characterisation in the area around the existing HU015 site if one has already been carried out for the Dogger Bank Teesside A & B area.

2.3.5. It is also important to note that the complete removal of just under 2,000,000m^3 of sediment from the Dogger Bank cSAC (as would occur if disposal were not permitted on site) would increase the potential for there to be an adverse effect on the conservation objectives, and thus, overall integrity of this site.

2.3.6. Therefore, it is concluded that disposal at existing marine disposal sites does not represent the most logical or environmentally robust approach to disposal of material from Dogger Bank Teesside A & B.

Option 2: Disposal via alternative uses

2.3.7. Alternative disposal options to the *in situ* disposal of dredged and/or drilled material or disposal at the HU015 disposal site to the west of Dogger Bank Teesside A & B are listed below;

- Use in beach nourishment schemes;
- Use in land reclamation schemes; and/or
- Use in habitat enhancement schemes.

2.3.8. In theory, the material proposed to be dredged and/or drilled within Dogger Bank Teesside A & B could potentially be used for alternative uses, including beach nourishment, land reclamation and/or habitat enhancement. However, as per transfer of this material to the existing marine disposal site (HU015), transfer of the proposed amounts of material due to be dredged from Dogger Bank Teesside A & B (a maximum of 1,937,578m^3) to another location where this alternative use may be required would require approximately 325 round trips of at least 250km per trip with a commercial-scale suction dredger (assuming a hopper capacity of 6,000m^3).

2.3.9. This scale of dredger movements would lead to environmental impacts due to fuel emissions that would be avoided if the dredged material was permitted to be disposed of in situ as per the methods and assessment presented in the Dogger Bank Teesside A & B ES (Forewind 2014).

2.3.10. At the time of writing, no specific projects have been identified that could accept material from Dogger Bank Teesside A & B but it is judged unlikely that any single project requiring sediments for uses such as those listed above would require as much as 1,937,578m^3 of material.

2.3.11. Therefore, it is expected that even if all this material could be disposed of via alternative uses, this would be via multiple projects in different locations. This would, therefore, increase the number of dredger transits to and from Dogger Bank Teesside A & B with the related environmental impacts such as those associated with fuel emissions.

2.3.12. As outlined in relation to Option 1, the removal of just under 2,000,000m^3 of sediment from the Dogger Bank cSAC may also lead to adverse effects on the integrity of this site.

2.3.13. In conclusion, as the EIA has not identified any significant adverse (in EIA terms) impacts on receptors via this proposed disposal activity, it is concluded that whilst potential alternative options for use of this material may exist, disposal *in situ* remains the most viable option. The Habitats Regulation Assessment (HRA) process related to Dogger Bank Teesside A & B has also concluded no adverse effect on the integrity of the Dogger Bank cSAC via proposed disposal activity. Further details on the rationale for disposal within Dogger Bank Teesside A & B are provided below.

Rationale for characterising the site as a disposal site

2.3.14. Disposal of material derived from the construction process within the boundaries of Dogger Bank Teesside A & B is judged to be the most pragmatic and sensible solution on technical, operational, cost and environmental grounds. The ES for Dogger Bank Teesside A & B has presented a robust assessment of the potential environmental impacts of this activity on all receptors and has concluded that there will be no significant (in EIA terms) impacts upon any receptors as a result of disposal *in situ*.

2.3.15. The material proposed to be disposed of within Dogger Bank Teesside A & B as a result of seabed preparation works for gravity base foundations will be identical to the existing seabed material as the source of this material will be the top 0.75m of existing seabed sediments. Therefore, the overall sediment composition of the site is not predicted to change as a result of this activity. The surface sediments in this area have also been shown not to contain any contaminants at levels over which adverse ecological effects are predicted so there is also no risk of chemical contamination from the proposed disposal – see **Chapter 10, Marine Water and Sediment Quality.**

2.3.16. The predicted increases in suspended sediment concentrations and subsequent deposition on the seabed are also judged not to result in any significant adverse impacts on receptors in the area.

2.3.17. Drill arisings will be different to the material currently forming the seabed sediments in tranches A and B as Quaternary deposits currently underlying the recent Holocene sediments will, potentially, be deposited on the seabed. However, precedents for this type of activity exist on other UK offshore wind farms (including Lynn, Inner Dowsing and Lincs), with preliminary monitoring of drill arisings comprising Quaternary deposits on other sites indicating that whilst these deposits remain for up to 4 years post-disposal, their physical dimensions have reduced and there has also been an accumulation of sediment around and over these deposits, which in turn has enabled benthic communities to re-establish in these areas. These preliminary data appear to indicate a lack of long-term impacts on seabed ecology as a result of the disposal of drill arisings (Centrica 2013).

2.3.18. With respect to the potential contaminant levels of the drill arisings, it is noted that in their Section 56 response to the Dogger Bank Creyke Beck application (MMO, November 2013), the MMO raised concerns over the potential for these arisings to contain higher levels of contaminants than surface sediments which have been shown to not occur at levels over which adverse ecological effects are predicted (see above).

2.3.19. Whilst it is accepted that the drill arisings may contain higher proportions of muds/fines than surface sediments, the potential for these to contain contaminants is judged to be negligible due to the position of these muds in the soil profile. The time period at which these muds would have been deposited is much earlier than when anthropogenic inputs (contaminants) would have existed, therefore, contaminant levels in these deep muds are expected to be zero.

3. Characteristics of the Disposal Site

3.1. Physical characteristics

Bathymetry and topography

3.1.1. All of Dogger Bank Teesside A and the majority of Dogger Bank Teesside B lie within Tranche B, therefore, much of the following text relates to Tranche B. However, as a small part of Dogger Bank Teesside B lies within Tranche A, some reference is also made to this area.

3.1.2. Tranche B was divided into three main zones:

- Areas less than 25m below LAT; predominantly in the form of a plateau in the south east of Tranche B;
- Areas between 25 and 35m below LAT; these depths dominate most of Tranche B; the seabed here is generally low relief, with gradients of less than three degrees; and
- Areas greater than 35m below LAT; these depths occur in the north of Tranche B in the form of north west to south east elongated gullies up to 6m deep with gradients up to six degrees along their sides.

3.1.3. The part of Tranche A occupied by Dogger Bank Teesside B comprises an area between 20m and 30m below LAT; these depths dominate much of Tranche A where the seabed is generally low relief compared to deeper areas.

Tidal and wave regime

3.1.4. Data on tidal currents in the Dogger Bank Teesside A & B region were collected via three discrete deployments of current profilers over a period from November 2010 to March 2013 (Gardline 2011).

3.1.5. Dominant tidal current directions over this period are from a broad range of directions from the north east sector through the south east sector to the south west sector. Current velocities are mainly less than 0.4m/s. The maximum extreme velocities for return periods of one, ten and 100 years were 0.88m/s, 0.98m/s and 1.11m/s, respectively (Mathiesen and Nygaard 2010).

3.1.6. Data from the waverider buoy located in Tranche A (for time series between 23 September 2010 and 19 May 2011) results showed that most waves approach the site from the northern sector. For the Tranche A buoy, the mean significant wave height for the time series period was 1.7m and the maximum value was 6.0m.

Solid geology

3.1.7. The top 200m of the geology of Dogger Bank is dominated by sediments deposited during the Quaternary (Pleistocene followed by Holocene). The deeper Pleistocene formations preserved beneath tranches A and B of Dogger Bank comprise a variety of sedimentary units including marine, non-marine and intertidal sediments and till. Some units may be incised glacial sediments deposited in sub-glacial valleys. It is likely that some of these units approach within 50m of the seabed beneath tranches A and B.

3.1.8. The shallower Pleistocene units are dominated by the Dogger Bank Formation, which rests uncomfortably on the underlying formations. It comprises two main units; Older Dogger Bank and Younger Dogger Bank, both of which are clay-rich formations with multiple sand-rich layers of glacial origin. The Dogger Bank Formation is present at or near the seabed, underlying Holocene sands, and in some areas underlying Botney Cut Formation channel infills.

Holocene

3.1.9. The Dogger Bank is formed mostly from a core of Pleistocene sediment, but is surrounded and covered by a veneer of Holocene sediments that reach 10m in thickness around its margins and greater than 25m thickness in infilled channels on Dogger Bank itself. The Bligh Bank and Indefatigable Grounds Formations and the Terschellinger Bank Member of the Nieuw Zeeland Gronden Formation are marine sands. There are also two older Holocene units (Well Hole and Elbow Formations) which were deposited in terrestrial tundra through to estuarine and intertidal environments.

Seabed sediments

3.1.10. GEMS (2011) and Gardline (2013), using geophysical data, showed that the majority of seabed sediments across Tranche B and north east Tranche A are sandy. Particle size analyses (Gardline 2011, 2012) show that the medium particle diameter (d50) for tranches A and B fall predominantly between 0.15mm and 0.22mm (fine sand) and 0.16mm and 0.19mm (fine sand), respectively, with a few samples in the medium to coarse sand categories. Most of the seabed sand samples contain less than 5% gravel and less than 5% mud, and can be categorised as slightly gravelly sand.

3.1.11. Gardline (2013) showed that patches of gravel occur across the east and south east of Tranche B. Median particle diameters (d50) range from 1.8mm to 10.5mm, with gravel percentages between 49% and 93%. The mud content of the gravel areas is predominantly less than 5%. Seabed gravel is rare across north east Tranche A (Dogger Bank Teesside B) (GEMS 2011).

Bedforms and sediment transport

3.1.12. The Dogger Bank Zone seabed is largely benign and featureless because tidal current velocities are relatively weak at less than 0.4m/s. However, megaripples (wavelengths between 0.5 and 25m) sculpted into both gravel and sand substrates are present in patches across Dogger Bank Teesside A & B.

3.1.13. Gardline (2013) observed megaripples within the gravelly sand areas of Dogger Bank Teesside A. The crests of the megaripples are aligned north-north west to south-south east and north to south, with amplitudes varying from 1.4m to 2.2m. Only limited bedforms occur in the north eastern part of Tranche A (Dogger Bank Teesside B) (GEMS 2011).

Suspended sediment concentrations

3.1.14. Eisma (1981) showed that the general distribution of suspended sediment in the southern North Sea is characterised by values lower than 2mg/l across Dogger Bank. Eisma and Kalf (1987) carried out a water sampling programme in January 1980 and differentiated general surface concentrations from bottom concentrations. They showed that across Dogger Bank, the concentrations were similar at both elevations, ranging from 1mg/l across south Dogger Bank to 2mg/l across north Dogger Bank.

3.1.15. More details on the physical environment within Dogger Bank Teesside A & B are provided in **Chapter 9 Marine Physical Processes** of the ES (Forewind 2014).

3.2. Biological characteristics

Benthic subtidal ecology

3.2.1. Based on initial zonal-wide habitat mapping undertaken in 2010, the dominant biotope associated with the Dogger Bank Zone is SS.SSa.IFiSa.NcirBat (*Nephtys cirrosa* and *Bathyporeia spp*. in infralittoral sand) (EMU 2010) which appears to be found across the majority of the Dogger Bank Zone, this may also include areas comprising more mixed sediment types based on habitat maps published in Diesing *et al.* (2009) as well as the EUNIS map.

3.2.2. These community types correspond well with the 'Bank' community described by Wieking and Krönke (2001) which occupies the flat shallow seabed areas on top of the Dogger Bank.

3.2.3. These habitats found on the Dogger Bank are among the most common habitats found below Mean Low Water Spring (MLWS) around the coast of the United Kingdom and correspond with the UK BAP habitat "subtidal sands and gravel" (UK BAP - see Maddock 2008). This habitat occurs in a range of environmental conditions, and the mix of sand or gravel, and any bedforms present on the surface of the seabed, depends on factors such as tidal and wave strengths.

3.2.4. The full list of biotopes recorded within Dogger Bank Teesside A & B are shown below in **Table 3.1**.

3.2.5. The biotopes identified within Dogger Bank Teesside A & B were then grouped based on their similarities to produce Valued Ecological Receptors (VERs) against which impact assessments have been undertaken. Three VERs dominate Dogger Bank Teesside A & B;

- VER A: Sandy sediment supporting relatively low diversity benthic communities which form part of the Annex I Sandbank Feature;
- VER B: Coarse sediments with medium to high diversity benthic communities which form part of the Annex I Sandbank Feature; and
- VER C: Muddy sand sediments with medium diversity benthic communities (including sea pens) which form part of the Annex I Sandbank Feature.

3.2.6. More details on the benthic subtidal ecology of the Dogger Bank Teesside A & B site are provided in **Chapter 12 Marine and Intertidal Ecology** of the ES (Forewind 2014).

Table 3.1 Biotopes recorded within Dogger Bank Teesside A & B

Biotope (JNCC Marine Habitats Classification (V04.05))**t**	**Biotope description**
SS.SSa.CFiSa.ApriBatPo	*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand
SS.Ssa.CFiSa	Circalittoral fine sand
SS.SMx.CMx	Circalittoral mixed sediment
SS.SSa.IMuSa.EcorEns	*Echinocardium cordatum* and *Ensis* spp. in lower shore or shallow sublittoral muddy fine sand
SS.SCS.CCS.MedLumVen	*Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or Gravel
SS.SMx.CMx.OphMx	*Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment
SS.SCS.ICS.SLan	Dense *Lanice conchilega* and other polychaetes in tide-swept infralittoral sand
SS.SSa.CMuSa.AbraAirr	*Amphiura brachiata* with *Astropecten irregularis* and other echinoderms in circalittoral muddy Sand
SS.SMu.CFiMu.SpnMeg	Seapens and burrowing megafauna in circalittoral fine mud

3.3. Fish and shellfish ecology

3.3.1. A number of fish species have defined spawning and nursery grounds within and in the vicinity of Dogger Bank Teesside A & B. Species known to spawn include herring, cod, plaice, whiting, sole, sandeel, mackerel and sprat. Of these species, only sandeel is recorded as having a high intensity of spawning in and around Dogger Bank Teesside A & B.

3.3.2. Of the species listed above all but plaice also have nursery grounds within the extent of Dogger Bank Teesside A & B as do hake, anglerfish (monkfish), blue whiting, ling, spurdog and tope.

3.3.3. In terms of key demersal spawning habitats Dogger Bank Teesside A & B comprises seabed habitat that has the potential to support sandeel populations. However these specific sediment types are not only present in these areas, but widely distributed throughout the Dogger Bank and the wider Central North Sea. Furthermore the presence of suitable sandeel habitat does not necessarily imply that sandeel will be present in a given area. Even assuming a population is below the area's carrying capacity, it is unlikely that all of the most suitable habitat will be fully occupied by sandeel (Greenstreet 2007).

3.3.4. With respect to herring spawning, as stated above, areas of Dogger Bank Teesside A & B lie within defined herring spawning grounds, although these grounds are now considered to be historic. Herring spawning is currently confined to small areas along the English east coast, from the Farne Islands to the Dowsing area (ICES 2010).

3.3.5. Herring are noted to spawn on discrete substrates, namely coarse sediments with low proportions of fines. The distribution of sediment types within the Dogger Bank Teesside A & B study area, derived from PSA of grab samples collected during the EIA characterisation benthic survey showed that coarse sediments (with a relatively high percentage of gravel) were found only in the discrete parts of Dogger Bank Teesside A.

3.3.6. Data from the International Herring Larval Survey (IHLS) collected since 2006 by the Dutch element of the IHLS survey over the Dogger Bank region recorded no larvae in this area (Schmidt *et al*. 2008). A lack of herring larvae in this area was also noted from a 2011 ichthyoplankton survey undertaken by IMARES (van Damme *et al*. 2011).

3.3.7. A number of elasmobranch species are known to occur in the study area including basking shark, smooth-hounds, spurdog, tope, blonde ray, cuckoo ray, spotted ray, thornback ray and undulate ray. Many of these elasmobranch species are afforded protection via OSPAR and/or BAP classifications.

3.3.8. Based on a review of commercial landings data for this region, sandeel is the main species landed by weight and amongst the principal species landed by value. Plaice is the main species caught in terms of value. Other species, including turbot, lemon sole, sole, dab, brill, haddock, whiting, gurnards, monkfish and hake are also of commercial importance in the Dogger Bank Teesside A & B area.

3.3.9. In terms of shellfish, whelk, edible crab and *Nephrops* are the principal shellfish species landed in this area.

3.4. Marine mammals

3.4.1. Data on marine mammal distribution in and around Dogger Bank Teesside A & B has been presented in detail in **Chapter 14 Marine Mammals** in the ES (Forewind 2014), based on an extensive review of existing data and also analysis of data from boat based and aerial bird and marine mammal surveys across this area between January 2010 and July 2012.

3.4.2. The desk-based review highlighted the following marine mammal species were likely to occur in and around Dogger Teesside A & B;

- Harbour porpoise (common throughout the year);
- Minke whale (regular throughout the year);
- White-beaked dolphin (common throughout year);
- Bottlenose dolphin (occasional);
- Common dolphin (occasional);
- Atlantic white-sided dolphin (occasional);

- Risso's dolphin (occasional);
- Killer whale (occasional);
- Grey seal (regular throughout the year); and
- Harbour seal (occasional).

3.4.3. Harbour porpoise were the most commonly recorded cetacean species from project specific surveys, with these data indicating that this species is likely to be found in relatively high densities across the entire Dogger Bank Zone. Individuals sighted within the zone are part of the South-western North Sea management unit forming part of the wider North Sea population. For the purpose of the EIA, a value representing harbour porpoise and potential harbour porpoise combined was used (0.7161 individuals per km^2).

3.4.4. With respect to pinnipeds, densities of grey seal are highest in the west and south west areas of the Dogger Bank Zone. For the purposes of providing a conservative impact assessment the maximum mean at sea density estimate of 0.085 per km^2 is used for Dogger Bank Teesside A and 0.23 per km^2 for Dogger Bank Teesside B.

3.4.5. The potential interaction of grey seals recorded within the Dogger Bank Zone and populations that form part of UK SACs is important to understand and a review of tagging data indicated that there was connectivity between the Dogger Bank Zone and grey seals from the following UK SAC populations:

- Berwickshire and North Northumberland SAC (Farne Islands) – pups and adults;
- Isle of May SAC - pups; and
- Humber Estuary SAC (Donna Nook) – adults.

3.4.6. For harbour seal, due to the distance from shore of the Dogger Bank Zone, the number of sightings of harbour seal was very low representing their low likelihood of occurrence.

3.4.7. More details on marine mammal distribution within the Dogger Bank Teesside A & B area are provided in **Chapter 14** of the ES (Forewind 2014).

3.5. Designated Sites of nature conservation importance

3.5.1. Dogger Bank Teesside A & B lie entirely within the boundary of the Dogger Bank cSAC (**Figure 3.1**). The Dogger Bank cSAC has been designated due to the following Annex I habitat:

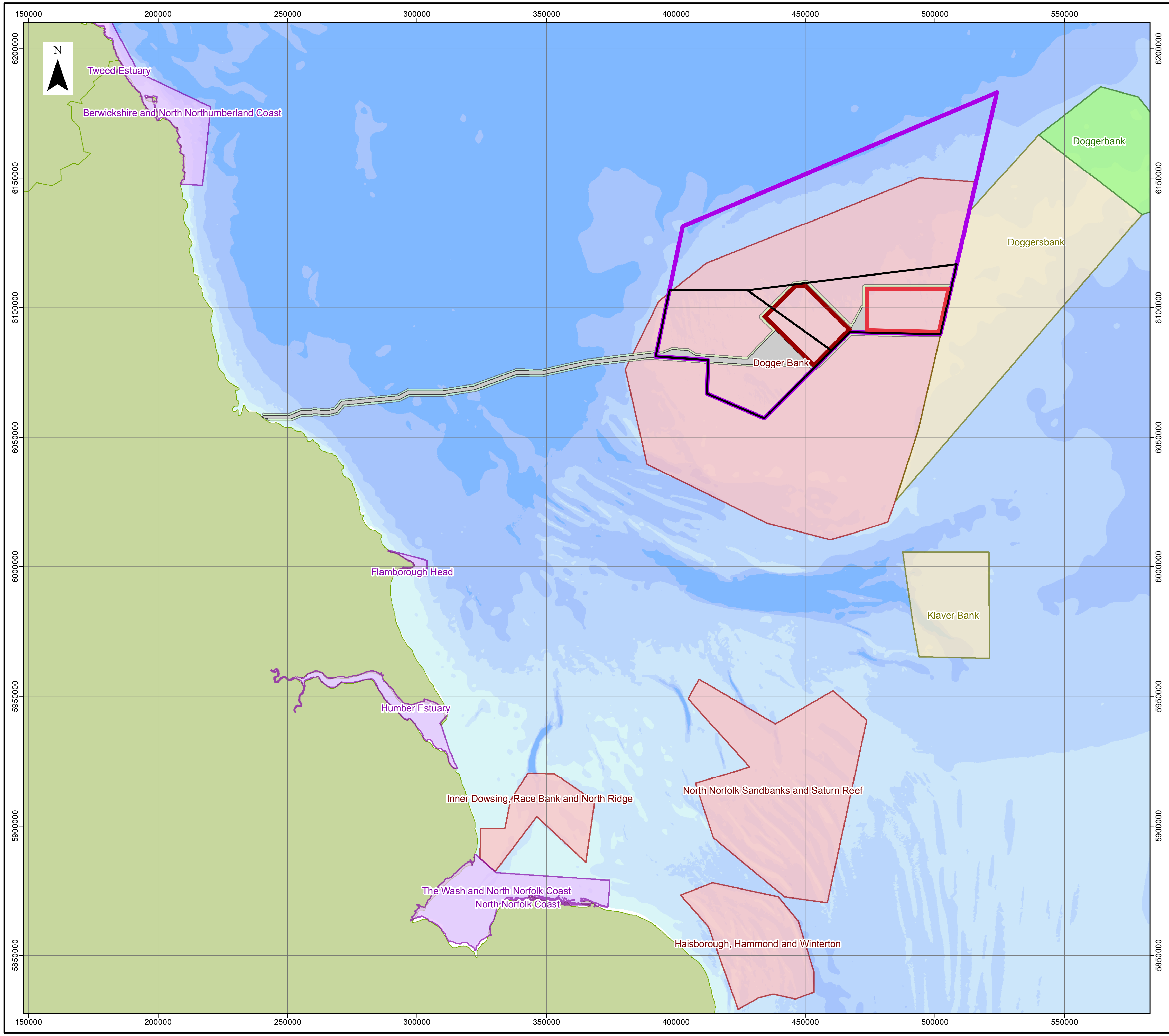
- 1110 Sandbanks which are slightly covered by sea water all the time.

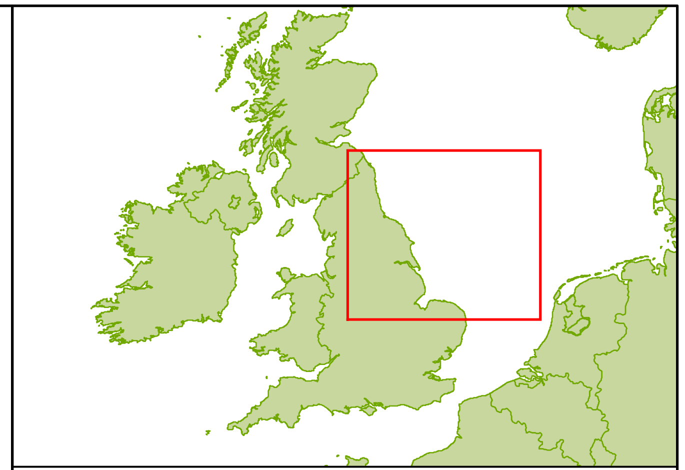
3.5.2. The Dogger Bank is located within the Southern North Sea Regional Sea. This site represents an offshore sandy mound, composed of moderately mobile, clean sandy sediments (sands and gravelly sands) in full salinity. It is non-vegetated and is subject to intermediate coastal influence. In general the biological communities on the Dogger Bank are typical of fine sand and muddy sand sublittoral sediments. Species typical of these communities include the polychaetes *Nephtys cirrosa* and *Magelona sp*., mobile amphipods of the genus

Bathyporeia, the brittlestar *Amphiura filiformis*, and bivalve molluscs such as *Tellina fabula* (formerly *Fabulina fabula*) and *Mysella bidentata* (Wieking & Kröncke 2001). Epifaunal species include the hermit crab *Pagurus bernhardus*, sand eels *Ammodytes* spp., plaice *Pleuronectes platessa* and the starfish *Asterias rubens*. The grade for the feature is 'A' as it is a typical example of this type of Annex I sandbank habitat (JNCC 2011).

3.5.3. The Dogger Bank is a highly productive area due to its shallowness, topography, hydrography and sediment types (Wieking & Kröncke 2001). It is influenced by cool Atlantic water masses coming from the north and warmer inflow from the English Channel to the south resulting in the creation of a front in the northerly region where these two masses meet. The warmer waters from the English Channel, located on the top of the bank and in more southerly regions, are enriched by riverine input (Kröncke 1992) and remain mixed throughout the year whilst the cool Atlantic waters to the north of the bank exhibit seasonal stratification during spring and summer (Wieking & Kröncke 2005; Weston *et al.* 2005). Phytoplankton production on the bank occurs throughout the year supporting a high biomass of species at higher trophic levels year-round and creating a region that is biologically unique in the North Sea (Kröncke & Knust 1995).

3.5.4. More details on the distribution of sites of nature conservation importance in the wider region are provided in **Chapter 8 Designated Sites** of the (Forewind 2014).





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area
- SAC with Marine Components
- Offshore cSAC
- Germany SCI
- Netherlands SCI

0 10 20 40
Kilometres

Data Source:
SAC & SCI data © JNCC, 2012.
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 3.1 Regional context of the study area including SACs and SCIs

VER	DATE	REMARKS	Drawn	Checked
1	24/05/2013	Draft	LW	RZ
2	03/10/2013	PEI3	LW	RZ
3	07/02/2014	DCO Submission	JE	RZ

DRAWING NUMBER: **F-OFL-MA-203**

SCALE	1:1,500,000	PLOT SIZE	A3	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND

3.6. Human environment characteristics

Commercial fisheries

3.6.1. A comprehensive assessment of commercial fishing activity in and around Dogger Bank Teesside A & B has been undertaken for the EIA and has identified a range of activity, involving UK and non-UK vessels using various gears to target a range of species.

3.6.2. Within ICES rectangles 38F2 and 39F2 (the ICES rectangles that have been identified as the Local Study Area for the ES), plaice is the most important species by value landed.

3.6.3. Flatfish, such as plaice, turbot and lemon sole are principally targeted by vessels operating beam trawls, although seine netters will also target the species in areas where a suitable substrate allows (clean seabed). Vessels are almost exclusively over-15m.

3.6.4. In terms of intra-annual variation, beam trawling, principally for plaice, records the highest values and effort between April and September, with June to July being the most important months. Otter trawling and seine netting also record the highest landings during this period, largely as a result of their targeting the same species. It should be noted, however, that a spike in landings values and effort for otter trawls in May can be attributed to landings of sandeel.

3.6.5. Inter-annual variation has been assessed by review of ten years of landings data. Plaice landings have fluctuated over the last decade, with the lowest landings recorded between 2006 and 2008, increasing to their second highest value in 2010. Port landings data show that four of the top five ports, which take 91.1% of the value landings from 38F2 and 39F2, are in the Netherlands, with the remaining port located in the UK. This is because the majority of the UK North Sea beam trawling fleet is owned and operated by Dutch fishing interests, i.e. Anglo-Dutch.

3.6.6. For UK-registered vessels (albeit many owned and operated by Dutch companies), within Dogger Bank Teesside A & B, the principal fishing methods include beam trawling, otter trawling and seine netting for flatfish. The majority of plaice landings by UK beam trawlers are recorded as being caught in the central North Sea area including the Dogger Bank Zone. Landings by UK otter trawlers, targeting flatfish, show plaice landings in the central North Sea corresponding to the same pattern of landings for the species by UK beam trawlers.

3.6.7. Dutch registered vessels are found predominantly in areas to the south of the Dogger Bank Zone and none have been recorded by MMO surveillance sightings within the Wind Farm Study Area. The main methods used by Dutch registered vessels include beam and demersal otter trawls. For both methods of fishing low landing values have been recorded for Dutch vessels in the ICES rectangles within the Wind Farm Study Area. The areas to the south and west of the Wind Farm Study Area have greatest landing values.

3.6.8. Danish vessels actively target the sandeel fishery in and around the Dogger Bank region. The majority of sandeel activity is concentrated on the western Dogger Bank Zone boundary, with a small area in the northwest of Dogger Bank

Teesside B. Seine netting activity is concentrated in the south of the Dogger Bank Zone, with minimal activity apparent in Dogger Bank Teesside A & B.

3.6.9. Data on catch values reflect the seasonal sandeel fishery between April and July when sandeel are in the water column feeding. In terms of annual landings the values of sandeel catch have fluctuated over the last decade, from an initial high value in 2002, to a ten year low in 2007 but have since increased, most significantly in 2010 and 2011. Changes to the annual allocation of sandeel quota in recent years directly affected the value of this fishery.

3.6.10. There is a low amount of Belgian fishing activity in and around Dogger Bank Teesside A & B, with Belgian vessels predominantly targeting the mixed flatfish fishery.

3.6.11. Both surveillance sighting data and VMS data indicate activity by German registered vessels has not been recorded within the boundaries of either Dogger Bank Teesside A or Dogger Bank Teesside B. In the ICES rectangles in which Dogger Bank Teesside A & B is located, sandeels and plaice represent the majority of landing values.

3.6.12. Low numbers of Swedish and Norwegian vessels have also been recorded fishing within and around Dogger Bank Teesside A & B, with the focus of this activity to the west of the sites. These vessels are targeting the sandeel fishery alongside Danish vessels which dominate this fishery.

Renewable energy developments

3.6.13. Given the offshore location of the Dogger Bank Zone, there is an absence of other developers' wind farm projects in the near vicinity. However, 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. **Table 3.2** provides the current development status and information on timescales of each project, to give an indication of any potential overlap in activities.

Table 3.2 Offshore wind farm projects (operational, under construction or in planning) within the study area

Project	Status	Distance from Dogger Bank Teesside A & B
Dogger Bank Creyke Beck A & B (R3)	Examination	4km Dogger Bank Teesside B
Hornsea Zone Project One and Project Two (R3)	Project One - Examination Project Two – pre-application	95km Dogger Bank Teesside B
Teesside Offshore Windfarm (R1)	Fully Operational	199km Dogger Bank Teesside B
Blyth Offshore Demonstration Site	Awaiting consent	207 Dogger Bank Teesside B
Westermost Rough (R2)	Consented	175km Dogger Bank Teesside B
Triton Knoll (R2)	Consented	169km Dogger Bank Teesside B
Humber Gateway (R2)	Consented	116km Dogger Bank Teesside B
Dudgeon (R2)	Consented	182km Dogger Bank Teesside B
Race Bank (R2)	Consented	192km Dogger Bank Teesside B
East Anglia Offshore Windfarm Zone and East Anglia ONE (R3)	Examination	Zone: 185 EA1: 273 Dogger Bank Teesside B
Sheringham Shoal (R2)	Fully operational	201km Dogger Bank Teesside B
Lincs (R2)	Fully operational	212km Dogger Bank Teesside B
Inner Dowsing (R1)	Fully operational	217km Dogger Bank Teesside B
Lynn (R1)	Fully operational	222km Dogger Bank Teesside B

Subsea cables and pipelines

3.6.14. Within the boundaries of Dogger Bank Teesside A & B there are no subsea cables or pipelines. However one active telecommunications cable, TATA Northern Europe (Operator TATA Communications) is in close proximity to the southern corner of the boundary of Dogger Bank Teesside B.

3.6.15. Other cables and pipelines occur outwith the Dogger Bank Zone, including operational and proposed export cables serving other wind farms closer to shore. A network of pipelines serving gas platforms and terminals lies to the south of the Dogger Bank Zone.

Marine disposal sites

3.6.16. There are no marine disposal grounds within the Dogger Bank Teesside A & B project boundary. As discussed in Section 2.3, the nearest marine disposal site to Dogger Bank Teesside A & B is HU015 which at its closest point is located some 176km away.

Oil and gas operators and other uses

3.6.17. The Cygnus gas field is situated to the south east and south of Dogger Bank Teesside A & B respectively (licence blocks 44/11a and 44/12a) and is under development. Within this field, the planned Cygnus Alpha and Cygnus Bravo developments are approximately 43km and 25km respectively from the boundary of Dogger Bank Teesside A & B.

3.6.18. There are a number of different licences within and in close proximity to Dogger Bank Teesside A & B and the Dogger Bank Teesside A & B Export Cable Corridor.

3.6.19. Currently licenced blocks 44/4a, 44/5 and 45/1overlap with the southern boundary of Dogger Bank Teesside A. All licence blocks within the Dogger Bank Teesside B boundary have been relinquished since the 27th round.

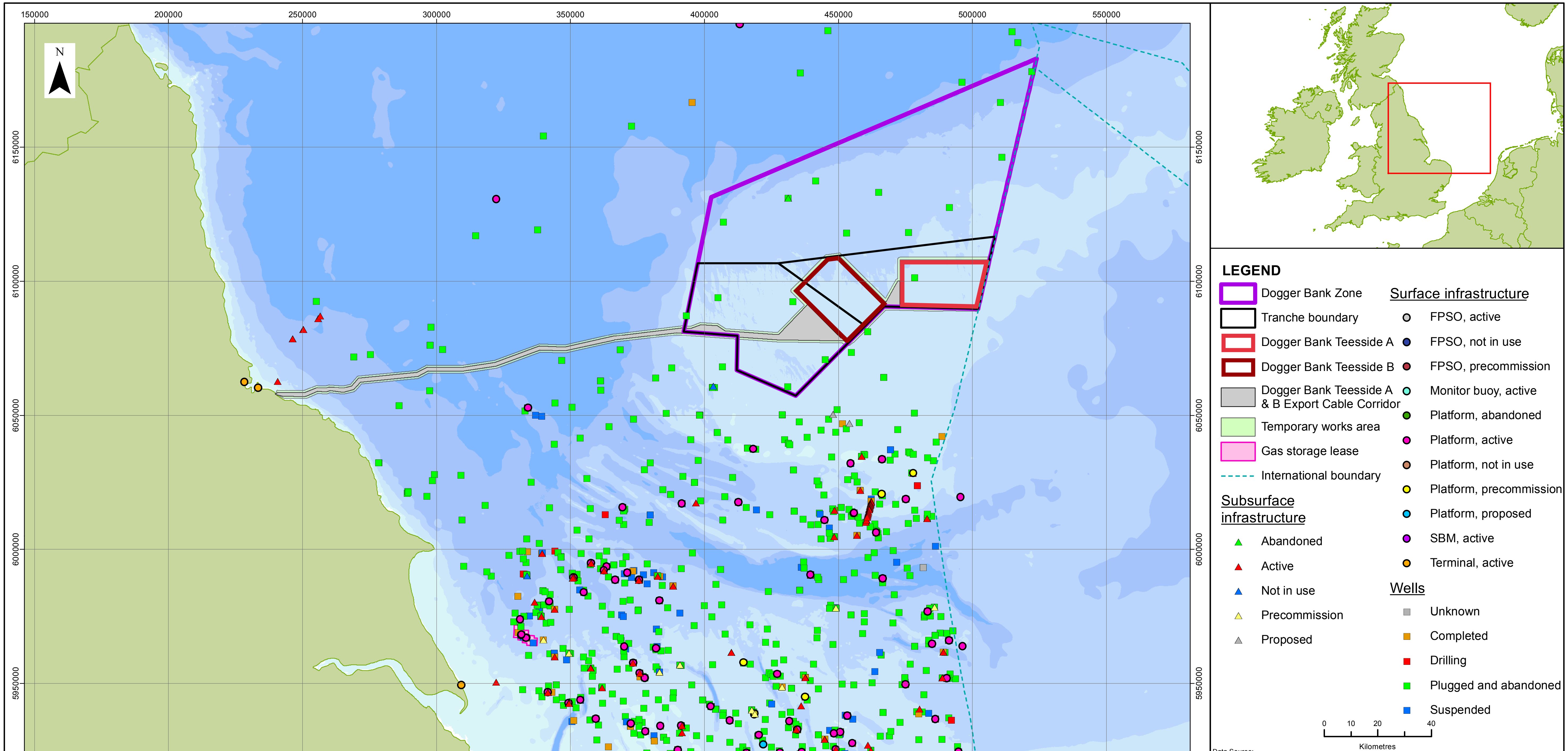
3.6.20. The eastern boundary of Dogger Bank Teesside A is adjacent to Dutch exploration block E01 and a distance 39km from exploration block E03 and 13.6km from E04.

3.6.21. There is currently no surface infrastructure within either Dogger Bank Teesside A or Dogger Bank Teesside B (**Figure 3.2**- existing oil and gas infrastructure). The closest existing gas platforms are Cavendish, approximately 53km southwest of Dogger Bank Teesside B; Munro, approximately 45km south of Dogger Bank Teesside B; and Tyne, approximately 45km south east of Dogger Bank Teesside B.

Marine aggregate extraction

3.6.22. There are three sites of relevance to Dogger Bank Teesside A & B on account of their proximity to the development area:

- Application Area 466/1 is approximately 65km and 28km respectively to the northwest of the northern boundary of Dogger Bank Teesside A & B. The decision is expected soon on the application to extract up to 3 million tonnes of sand and gravel over an initial 15 year period, although this may be extended. CEMEX estimates that 200,000 tonnes/year will be extracted in the first five years, increasing to 600,000 tonnes/year thereafter.
- Application areas 485/1 and 485/2 (also CEMEX sites), approximately 90km and 86km respectively to the southwest of the western boundary of Dogger Bank Teesside A and 63km and 59km respectively to the west of Dogger Bank Teesside B.



Data Source:
Oil & Gas data © DECC 2013
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 3.2 Existing oil and gas infrastructure

VER	DATE	REMARKS	Drawn	Checked
1	16/08/2013	Draft	FK	PT
2	03/10/2013	PEI3	JE	PT
3	06/02/2014	DCO Submission	LW	TR

DRAWING NUMBER:

F-OFL-MA-578

SCALE	1:1,500,000	PLOT SIZE	A3	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND

Shipping and navigation

3.6.23. Data on shipping traffic within 10nm (18.5km) of Dogger Bank Teesside A & B was collated via a specific marine traffic survey looking at vessel tracks from Automatic Identification System (AIS) data and radar data, over 28 days in winter 2011 / 2012, 14 days in spring / summer 2012 and 14 days in spring 2013.

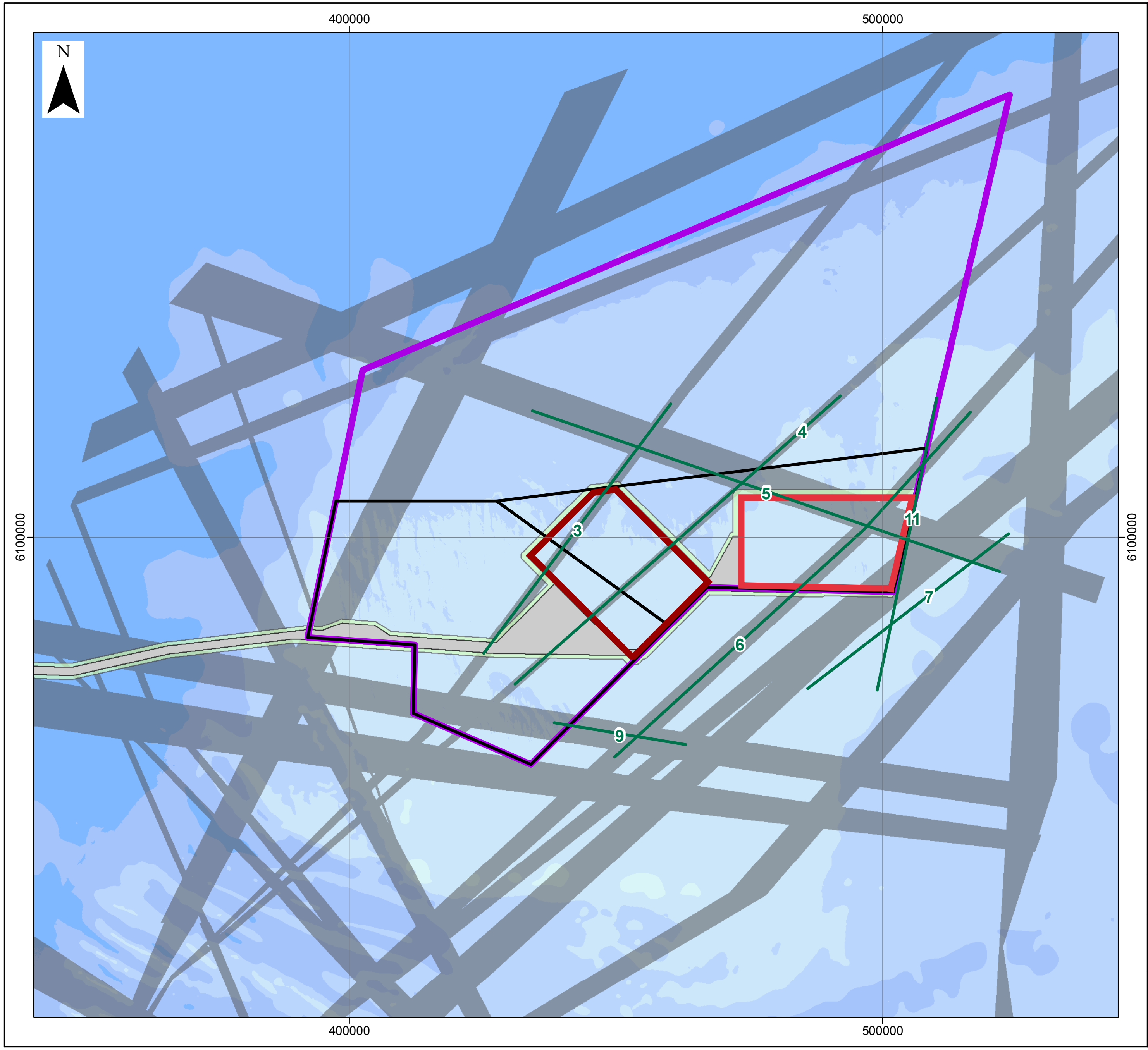
3.6.24. The average number of vessels recorded on AIS and Radar per day passing within 10nm of Dogger Bank Teesside A & B was seven vessels during the winter 2011/2012 survey period, ten vessels during the spring/summer 2012 survey period and ten vessels during spring 2013. In terms of vessels actually intersecting Dogger Bank Teesside A, there were approximately one to two vessels per day during winter 2011/2012, approximately three during spring/summer 2012 and approximately 4 during spring 2013. The average number of vessels recorded on AIS and Radar intersecting Dogger Bank Teesside B was two to three vessels per day during all of the surveys.

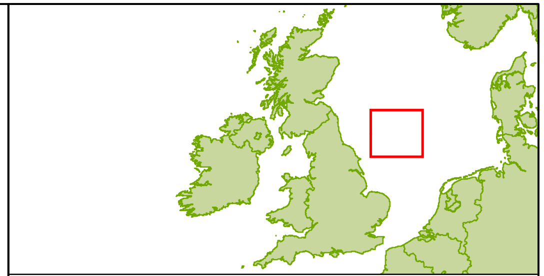
3.6.25. In total, 11 main commercial vessel routes have been identified as transiting within 10nm (18.5km) of the Dogger Bank Zone, seven of which intersect the buffer around Dogger Bank Teesside A & B. A brief description of the traffic on each of the seven routes is given in **Figure 3.3** and **Table 3.3**.

3.6.26. The most frequently used route (Route 7) is that between the Humber, UK and Baltic with cargo vessels and tankers, transiting through the south of the Dogger Bank Teesside A & B buffer zone, once a day.

Table 3.3 Description of the seven main routes identified which intersect Dogger Bank Teesside A & B 10nm (18.5km) buffer, separated from the ten main routes identified which intersect the Dogger Bank Zone.

Route	Route description	Vessel numbers	Vessel types
3	Immingham, UK and Egersund, Norway.	One vessel every 13 days.	Vessels on this route consist of cargo vessels and tankers.
4	Hull/Grimsby, UK and Helsinki, Finland.	One vessel every 12 days.	The majority of vessels on this route are cargo vessels.
5	Forth, UK and Germany.	One vessel every six days.	Cargo, tanker.
6	Immingham, UK and Moss, Norway.	One vessel every three days.	Vessels on this route mainly comprise cargo vessels and tankers.
7	Humber, UK and Baltic.	One vessel every day.	Cargo, tanker.
9	Newcastle, UK and Hamburg, Germany.	One vessel every 13 days.	The majority of vessels on this route are cargo vessels.
11	Thames, UK and Norway.	One vessel every nine days.	The majority of vessels on this route are cargo vessels.





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Teesside A & B temporary works area
- 90th percentile lane
- Main route

0 10 20
Kilometres

Data Source:
Shipping data © Anatec, 2012
Offshore wind farm boundaries © Crown Copyright, 2013,
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 3.3 Map of traffic routes

VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	GC	GS
2	03/10/2013	PEI3	GC	GS
3	07/02/2014	DCO Submission	JE	GS

DRAWING NUMBER: **F-OFL-MA-604**

SCALE	1:1,100,000	PLOT SIZE	A4	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND

Marine archaeology

3.6.27. Information on marine archaeological features in and around Dogger Bank Teesside A & B has been collated via a review of existing desk-based data sources and also a review of site-specific geophysical and geotechnical data.

3.6.28. With respect to palaeo-archaeological features, there are no known submerged prehistoric receptors within Dogger Bank Teesside A & B. There is also minimum potential for Pleistocene archaeological remains within discrete areas of the Yarmouth Roads Formation, Egmond Ground Formation and Eem Formation. Potential exists for Late Pleistocene/Holocene archaeological remains (*in situ* sites and isolated artefacts).

3.6.29. Two (A1) wrecks been recorded in the geophysical data (WA70586, WA70587) within the boundary of Dogger Bank Teesside A. Within Dogger Bank Teesside B, four (A1) wrecks (WA70636, WA70637, WA70505, WA70640) were recorded.

3.6.30. A review of the geophysical data has also identified 32 (A2) anomalies within Dogger Bank Teesside A and 25 (A2) anomalies in Dogger Bank Teesside B.

3.6.31. More details on marine archaeological interests in and around Dogger Bank Teesside A & B are provided in **Chapter 18 Marine and Coastal Archaeology** of the ES (Forewind 2014).

4. Characteristics of the Material to be Disposed

4.1. Physical, chemical, and biological (including toxicology) properties of material to be disposed

Sources of information on material to be disposed

4.1.1. Detailed survey data has been collected across Dogger Bank Teesside A & B as part of EIA characterisation studies. These data allow a comprehensive characterisation of the physical, chemical and biological characteristics of the sediments proposed to be disposed of within the site, either via dredging associated with seabed preparation or via drill arisings.

4.1.2. A summary of data-sets relevant to seabed sediments in Dogger Bank Teesside A & B is provided below in **Table 4.1**, along with a cross-reference to chapters and/or Annexes of the ES where additional details on these surveys is provided.

Key characteristics of the material to be disposed

4.1.3. As outlined in Section 2.2, the source of any sediment disposed of within Dogger Bank Teesside A & B will be material dredged as part of seabed preparation prior to installation of gravity base foundation structures and/or material from drilling activities associated with drilled monopile foundation installation.

4.1.4. Therefore, the materials potentially disposed of *in situ* will be both shallow seabed (i.e. sediments from seabed level to approximately 1m beneath existing seabed level), as well as material from deeper in the soil profile from any drilling process.

4.1.5. The following sections provide a summary of the key characteristics of both these sources of material under discrete sub-headings. The characteristics as defined here are the same as those used within the impact assessments presented in **Chapters 9, 12 and 13** of the ES (Forewind 2014).

Table 4.1 Summary of data sources relevant to seabed sediments in Dogger Bank Teesside a & B

Survey	Relevant data	Corresponding chapter of Environmental Statement
Geophysical (bathymetry, sidescan sonar, sparker and pinger seismic)	Bathymetry, interpreted seabed surface geology, sub-surface geology in form of isopachs	9
Geotechnical (17 boreholes with combined CPTs and 80 CPTs across Tranche B and * CPTs in Tranche A)	Data on sub-surface geology	9
Benthic (51 grab and 55 camera sample sites across Tranche B)	Particle Size Analysis (PSA) data, information on benthic infaunal and epifaunal communities	12
Sediment chemistry grab survey (11 sample sites across Tranche B)	Contaminant levels for heavy metals, organotins, total petroleum hydrocarbons (TPH), polyaromatic hydrocarbons (PAHs and total PAHs) and organochlorine pesticides	12
2m beam trawl surveys	Information on epifaunal communities, including demersal fish	13
Otter trawl surveys	Information on epifaunal communities, including demersal and pelagic fish	13

Physical characteristics

Dredged material (seabed preparation)

4.1.6. The dominant sediment type identified within Dogger Bank Teesside A & B that will be dredged and disposed of in situ via seabed preparation works is sand (**Figure 4.1**). Particle size analyses (Gardline 2011, 2012) show that the medium particle diameter (d50) for tranches A and B fall predominantly between 0.15mm and 0.22mm (fine sand) and 0.16mm and 0.19mm (fine sand), respectively, with a few samples in the medium to coarse sand categories. Most of the seabed sand samples contain less than 5% gravel and less than 5% mud, and can be categorised as slightly gravelly sand.

4.1.7. Gardline (2013) showed that patches of gravel occur across the east and south east of Tranche B (**Figure 4.1**). Median particle diameters (d50) range from 1.8mm to 10.5mm, with gravel percentages between 49% and 93%. The mud content of the gravel areas is predominantly less than 5%. Seabed gravel is rare across north east Tranche A (Dogger Bank Teesside B) (GEMS, 2011).

4.1.8. The distribution of different sediment size ranges across the project area (based on grab samples) is presented below in **Table 4.2**.

Table 4.2 Average particle size distribution based on surface sediment samples from Tranche B

Size range (mm)	Average (%)
0.50-20	2.60
0.355-0.50	1.95
0.25-0.355	5.96
0.18-0.25	27.27
0.125-0.18	60.34
0.09-0.125	0.40
0.063-0.09	0.16
<0.063	1.32
Total	100

Drill arising material

4.1.9. The material that will potentially be disposed of following drilling activities is different in nature to that disposed of via seabed preparation as these drilled materials will include seabed sediments and also sediment from deeper in the soil profile.

4.1.10. RPS Energy (2012) analysed borehole data from Dogger Bank Teesside A & B to estimate average particle size characteristics for drill arisings. **Table 4.3** describes the average particle size distribution for Dogger Bank Teesside A & B boreholes (7 in total).

Table 4.3 Average particle size distribution in boreholes across Dogger Bank Teesside A & B.

Size range (mm)	Size	Average (%)
>60	Cobble	0
2-60	Gravel	2
0.06-2	Sand	55
0.0002-0.06	Silt	23
<0.002	Clay	18

4.1.11. According to RPS Energy (2012) the drill arisings will contain the following proportions of sediment size:

- Fraction 1: 55% of the drilling volume comprises sand with particle size of 0.06-2mm and assumes 100% disaggregation; and
- Fraction 2: 28.7% of the drilling volume (23% silt and 18% clay with particle size less than 0.06mm, assuming 70% disaggregation in to its particulate constituents).

4.1.12. The other 16.3% of silt and clay will not disaggregate into its constituent particles (based on the analysis of RPS Energy, 2012) and so will settle rapidly to the seabed (as larger 'lumps') without entering the plume.

4.1.13. Therefore, in summary, the drill arising materials that settle onto the seabed will comprise predominantly sand, 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.

Chemical characteristics

Dredged material

4.1.14. In terms of sediment chemistry, a site-specific sediment chemistry grab sample survey was undertaken across Tranche B in 2012. All survey methodologies were developed following consultation with the MMO and their advisors and were in line with guidance provided by Cefas (Cefas 2002; Cefas et al. 2004) and Ware and Kenny (2011). Sediment chemistry sampling was undertaken at 11 grab sampling locations within Tranche B, and a further 3 grab sample locations within Tranche A were located within the Dogger Bank Teesside B boundary.

4.1.15. During the survey a 0.1m^2 stainless-steel Day grab was used to collect seabed samples for analysis. Samples were analysed for the following metals and hydrocarbons;

- Arsenic;

- Cadmium;
- Chromium;
- Copper;
- Lead;
- Mercury;
- Nickel;
- Polyaromatic Hydrocarbons (PAH);
- Petroleum Hydrocarbons; and
- Polychlorinated Biphenyls (PCB).

4.1.16. Only one of the 14 sites (site 17) within Tranche B had concentrations of heavy metals (chromium, copper and nickel) that resulted in exceedance of Cefas Action Level 1. This site also had concentrations of copper that exceeded the Canadian Sediment Quality Guideline Probable Effect Levels (PELs).

4.1.17. Site 17 in Tranche B also recorded levels of chromium and napthalene that exceeded Canadian Sediment Quality Guidelines Threshold Effects Level (TEL). In addition Site 10 in Tranche B also recorded levels of naphthalene that exceeded the Canadian Sediment Quality Guidelines TEL.

4.1.18. From the information and data presented above it can be concluded that sediment contaminant concentrations do not record significantly elevated levels of any contaminants. The predominantly sandy nature of the seabed sediments within Dogger Bank Teesside A & B significantly reduces both the potential for any contaminants to accumulate and for sediments to be re-suspended into the water column and transported over long distances, thus reducing the potential for far-field effects.

Drill arising material

4.1.19. In terms of sediment chemistry for the 'at-depth' material that may be disposed of onsite following drilling activities, no specific data has been collected but sediment contamination and/or naturally occurring high levels of certain chemicals within this material is not expected due to the depth and geological age of these materials.

4.1.20. The drill arisings are a combination of sand derived predominantly from the Holocene and mud derived predominantly from the underlying Pleistocene units (the Dogger Bank Formation). Given the plume is comprised mainly of mud-sized particles derived from a geological unit that is greater than 10,000 years old, makes it is highly unlikely to contain any contaminants. The Holocene sands contain less than 5% mud, and again the vast majority of this sediment will be pre-industrial. Furthermore, analysis of the surface sediments samples for metals and hydrocarbons, as reported in Chapter 10 of the ES, did not identify significantly elevated levels of contamination.

4.1.21. Further details of the chemical characteristics of the dredged and/or drilled material can be found in **Chapters 10** and **12** of the ES (Forewind 2014).

Biological characteristics

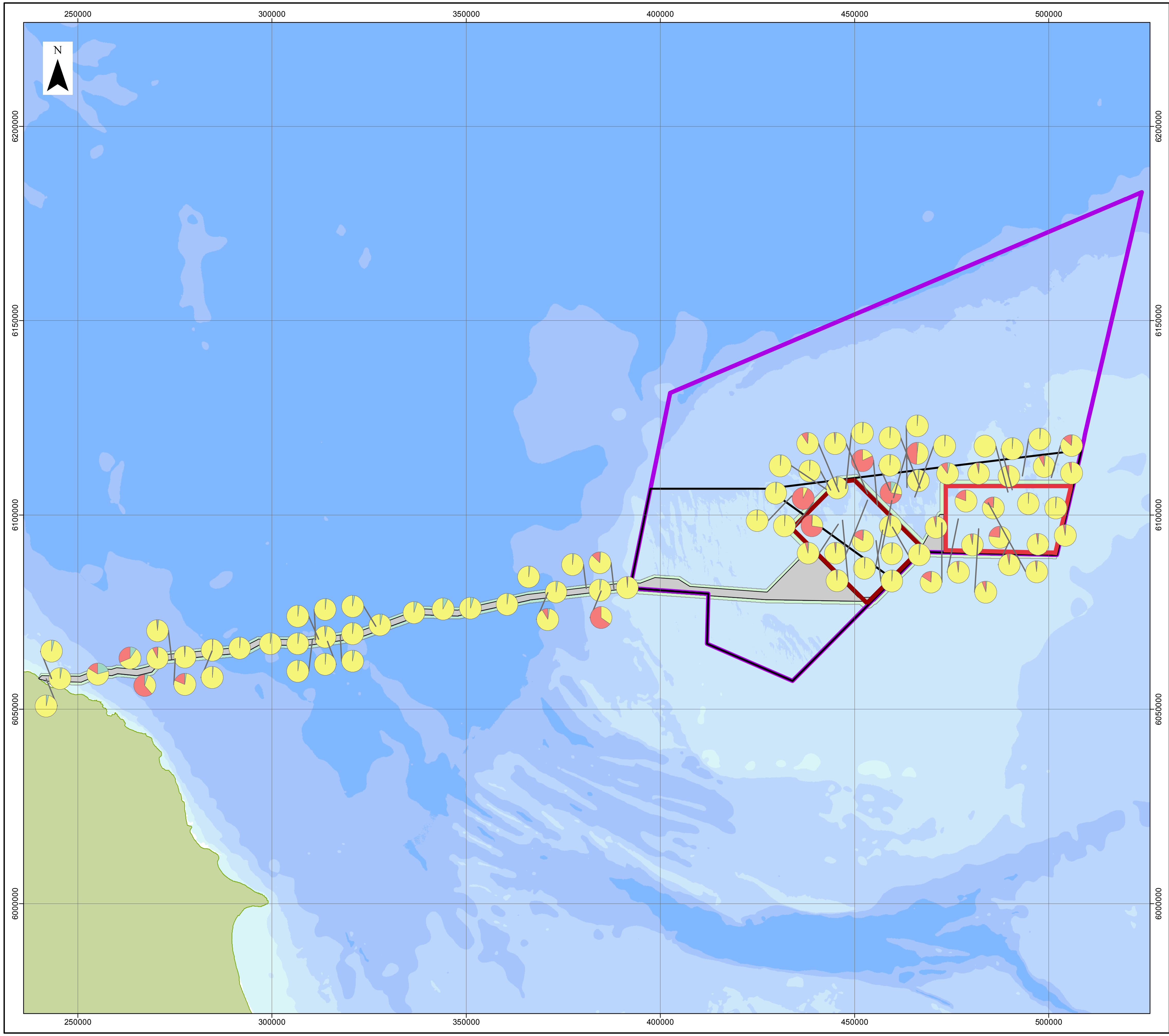
Dredged material

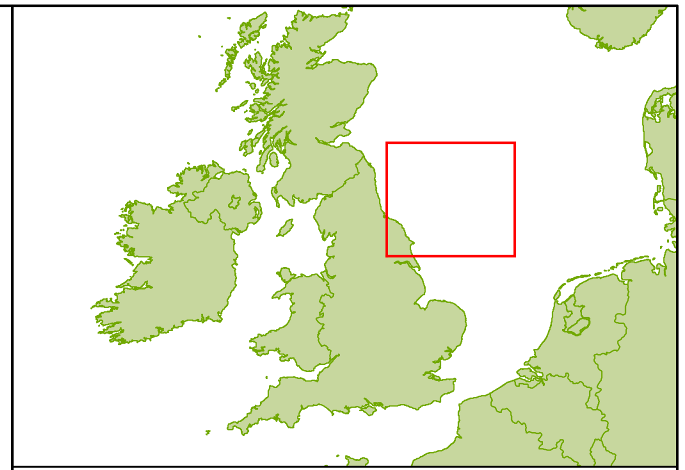
4.1.22. The biological characteristics of the seabed sediments likely to be dredged as part of seabed preparation prior to GBS foundation installation have been defined via the site-specific surveys summarised in **Table 4.1**.

4.1.23. Based on the review of grab, DDV, trawl and PSA data the following broad patterns of infaunal and epifaunal biotopes were identified across Dogger Bank Teesside A & B.

4.1.24. The biotopes identified within Dogger Bank Teesside A & B were then grouped based on their similarities to produce Valued Ecological Receptors (VERs) against which impact assessments have been undertaken. Three VERs dominate Dogger Bank Teesside A & B (**Figure 4.2**);

- VER A: Sandy sediment supporting relatively low diversity benthic communities which form part of the Annex I Sandbank Feature;
- VER B: Coarse sediments with medium to high diversity benthic communities which form part of the Annex I Sandbank Feature; and
- VER C: Muddy sand sediments with medium diversity benthic communities (including sea pens) which form part of the Annex I Sandbank Feature.





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

Marine sediment fractions (%)

- Fines
- Sand
- Gravel

0 10 20 40
Kilometres

Data Source:
Sediment Samples © Gardline Environmental Limited, 2012
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

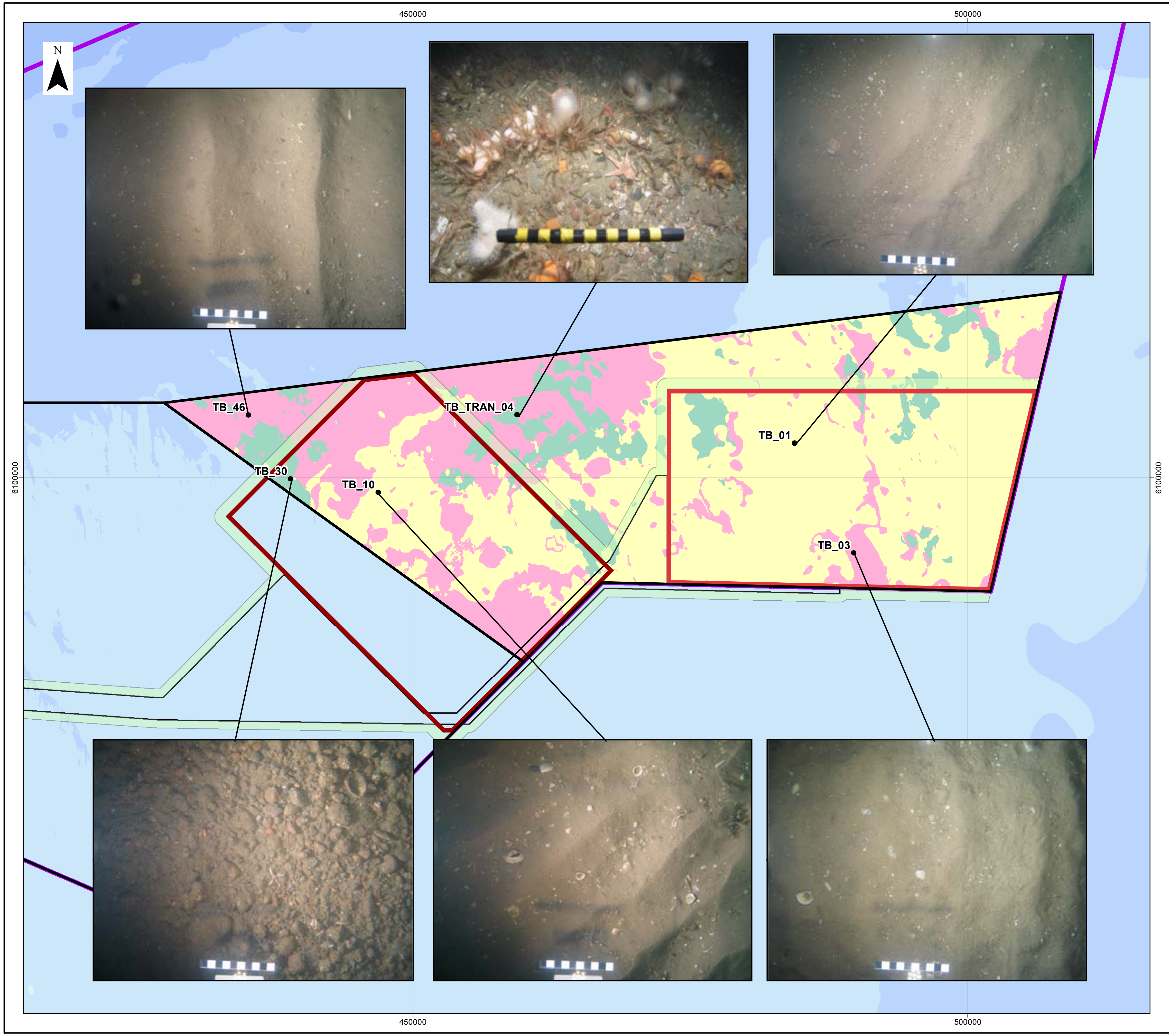
Figure 4.1 Distribution of the principal sediment components in the study area

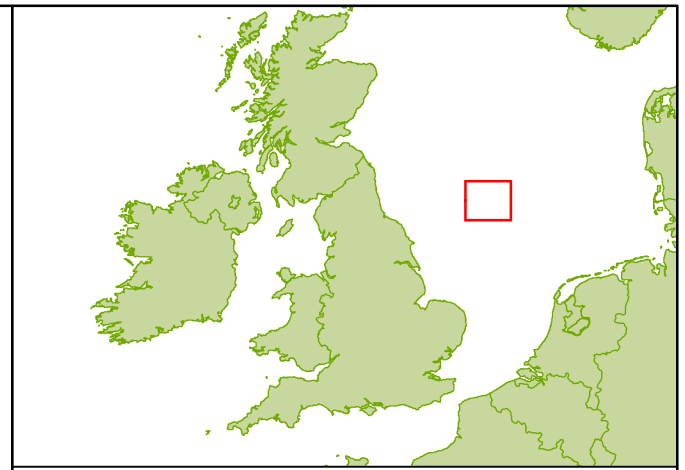
VER	DATE	REMARKS	Drawn	Checked
1	03/10/2013	PEI3	LW	RZ
2	07/02/2014	DCO Submission	JE	RZ

DRAWING NUMBER: **F-OFL-MA-233**

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

FOREWIND





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

Valued Ecological Receptor (VER)

- A
- B
- C

0 2.5 5 10
Kilometres

Data Source:
VERS © Envision, 2013
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 4.2 Spatial distribution of VERs across Tranche B

VER	DATE	REMARKS	Drawn	Checked
1	29/05/2013	Draft	LW	RZ
2	03/10/2013	PEI3	LW	RZ
3	07/02/2014	DCO Submission	JE	RZ

DRAWING NUMBER: **F-OFL-MA-204**

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

FOREWIND

4.2. Method of dredging/drilling and proposal

Dredging (seabed preparation)

4.2.1. Seabed preparation can include one or all of the following options:

- Removal of soft, mobile, or uneven sediments;
- The levelling of the seabed without removal of sediments; and
- Installation of a stone or aggregate foundation bed as an alternative levelling strategy or to ensure full baseplate contact with the seabed.

4.2.2. Seabed preparation would typically take place over an area slightly larger than the base footprint of the foundation and could take a range of shapes depending on the equipment used and the geometry of the foundation to be laid, for example rectangular or circular.

4.2.3. Seabed preparation involves mechanical levelling, typically using suction dredging where sediments are to be moved or removed. It is expected that any dredging required for seabed preparation will be undertaken via a modern, commercial scale trailer hopper suction dredger and/or static dredging, as used to extract sand and gravel for the marine aggregates industry.

4.2.4. For trailer hopper suction dredging this process typically results in dredge tracks of 2 to 3m width and up to 0.3 m depth being created at each pass of the dredger head on the seabed. Successive dredging over the same area can reduce the seabed level by up to 5m. For static dredging, a vessel anchors over a particular area and extracts material to the required depth.

4.2.5. Modern dredging vessels and their associated positioning systems enable seabed dredging to be very exact and able to be undertaken within discrete areas. Material dredged from the seabed can then be re-deposited in another area of the site via discharge directly from the same dredger.

4.2.6. It has been assumed that disposal of dredged material will take place approximately 500m from the seabed preparation site (i.e. within Dogger Bank Teesside A & B). It has been assumed that seabed preparation (including disposal activities) at each site will take up to five days.

Drilling

4.2.7. Steel piles are driven by a large crane mounted hammer and are typically designed to be hammered to the desired penetration depth. However, in some cases the pile may reach a point of refusal and cannot be driven to the required penetration depth due to difficult ground conditions. In this event it is possible to drill out some or all of the volume of sediment inside the pile to reduce the driving resistance and allow the pile installation to be completed.

4.2.8. In the case of concrete monopiles it is fundamental to the foundation concept that drilling must be carried out, since driving concrete piles with a hammer is not appropriate. Various drilling methodologies are possible, but drills are typically lifted by crane into a part-installed pile, ride inside the pile during drilling, and are removed in the event driving recommences.

4.2.9. Drills may only bore out to a diameter equal to the internal diameter of the pile, or they may be capable of expanding their cutting disk below the tip of the pile and boring out to the piles maximum outer diameter or greater (under-reaming). Drilling systems are available in sizes ranging from those required for small jacket pin piles, to large diameter concrete monopiles. Water is continuously pumped into the drill area and any drill arisings generated are flushed out and allowed to disperse naturally at the sea surface.

4.2.10. Soil conditions for Dogger Bank Teesside A & B are such that for steel monopiles and multileg driven piles, only limited need for drilling is anticipated. In the case of concrete monopile wind turbine foundations it is assumed that all piles would have to be fully drilled.

4.3. Details of amount to be dredged/drilled

4.3.1. Details of the amounts predicted to be dredged and disposed of within Dogger Bank Teesside A & B are presented in Section 2. In summary, it is predicted that a maximum total volume of 1,937,578m3 of material could be removed and deposited back in situ via construction activities associated with Dogger Bank Teesside A & B. This amount of disposal relates to drilling of concrete monopiles within Dogger Bank Teesside A & B.

5. Assessment of Potential Adverse Effects

5.1. Evaluation of potential adverse effects of *in situ* disposal of dredge/drill material

5.1.1. The following section of the document provides an overview of the key findings of the Dogger Bank Teesside EIA relevant to the disposal of dredged and/or drilled material in situ within Dogger Bank Teesside A & B. **Table 5.1** (below) also provides a summary of the potential impacts of disposal activities on biological and human environment parameters.

Physical environment

5.1.2. In carrying out an impact assessment, marine processes are not in themselves receptors in the majority of cases, but changes to these processes may have an impact on other sensitive receptors (Lambkin *et al*. 2009). Therefore, the approach adopted in the EIA for Dogger Bank Creyke Beck, and referenced here, is to describe the potential changes to marine processes due to the development, but not provide an assessment of the significance. A summary of the findings of the impact assessments of these physical changes on sensitive biological and human receptors is provided in relevant sections below.

Dredged material

5.1.3. Following the *in situ* disposal of seabed sediments associated with seabed preparation works, it is predicted that this material will form sandwave features comparable in size to similar features that already exist within the Dogger Bank region. Therefore, no large-scale changes to the local wave and tidal regime are envisaged as a result of this activity (see **Chapter 9**)

5.1.4. With respect to changes to the sediment regime, for installation of a conical GBS, a worst case volume of 3,675m^3 is assumed for the side cast seabed preparation sediment. A conservative particle size distribution for released sediment due to seabed preparation is based on an average from samples collected across Tranche B, with samples with greater than 3% gravel removed. The data shows that on average about 62% of the sediment (2,279m^3) less than 0.18mm is suspended in the plume model and 38% greater than 0.18mm remains (1,396m^3) at the source position as a residual side cast mound.

5.1.5. As the amount of residual material predicted to remain at the source position is greater for the drill arising process compared to dredging for seabed preparation, it can be assumed that the dimensions outlined below for the drill arising sections represent the worst-case, and therefore, no further assessment of the behaviour and fate of the side-cast seabed preparation material is provided here.

5.1.6. Similarly, for the proportion of sediment that is mobilised to form a plume, the worst-case sediment plume assessed within the EIA is actually based on the release of drill arisings from 12m concrete monopole foundations (see below) as this represents a greater volume of material entering the plume, thus, the worst-case scenario. Therefore, as per the dimensions of the seabed mounds, the values provided below in the “Drill Arising Material” sub-section are representative of the worst-case for increased suspended sediment concentrations and it should be assumed that the suspended sediment values from material released via seabed preparation of GBS foundations will be less.

Drill arising material

5.1.7. For installation of a 12m monopole foundation, a worst case volume of 6,220m^3 is estimated for the drill arisings which are released at the sea surface. An estimate of the average particle size characteristics for drill arisings was made by RPS Energy (2012b). These data and data from seabed sediment samples shows that about 63% of the sediment (3,919m^3) is suspended in the plume model and 37% (2,301m^3) settles rapidly to the seabed without entering the plume. The deposition of sediment from drill arisings is, therefore, considered as the worst case scenario in terms of the amount of residual material that will be deposited on the seabed. The following sections provide more assessment of the fate and behaviour of this 2,301m^3 of material which will be deposited on the seabed.

Footprint / form of deposited material

5.1.1. The results from geotechnical assessments of the surface sediments show that the friction angle of the top 15-20cm of seabed sediment is around 30°, exemplary of that applying to loose granular sand (**Appendix 9A**). Immediately beneath the loose upper layer, the friction angle quickly rises indicatively to 45-50°.

5.1.2. An assumption is made that the non-suspended sediment initially forms a cone on the seabed with a friction angle of 30^o. In its undisturbed state this would produce a 9m high cone with a circular seabed footprint of about 750m^2 (diameter approximately 31m).

5.1.3. This is an extremely idealised worst case situation in that an assumption is made that the sand drops vertically through the water column from a point source without the effect of at least some dispersion by tidal currents and waves as it settles through the water column. In reality, as the sediment settles through the column it will be transported horizontally as well as vertically and would not deposit as the idealised cone, but as a flatter and wider based ‘mound’. The geometry of this mound would depend on the particle size of the sediment, the settling velocity and the different forces applied to it as it falls through the water column (waves and tidal currents). It is difficult to determine what this shape would be so a cone shape has been chosen, because this was quantifiable.

5.1.4. Over time, due to subsequent reworking of the sediment pile, it will be reduced in height and distributed over a wider area of seabed. Given that the predominant driver for sediment transport across Dogger Bank is waves, it is believed conceptually that a cone that stands 9m proud of the seabed would be impacted regularly by waves and the sediment both transported along the bed and suspended into the water column through this process.

5.1.5. The sediment raised into the water column by the wave would then be transported by both the wave itself and tidal currents. The wave provides the initial energy to get the sediment up off the seabed and then tidal currents transport it, albeit only a short distance because of its particle size. Over time the gradual erosion of the top of the cone through wave action and its transport would lower the cone height, and it's shape would be adapted into some form of low mound.

5.1.6. The shape of the mound would be difficult to determine precisely (and could not be modelled), but given the predominant north and south tidal current directions, and predominant waves from the north, it is assumed that most transport would be north and south forming an elongate north-south mound similar in shape to a sand wave. This is not a sand wave in the true sense (i.e. a bedform created by bedload transport by tidal currents) but is 'sand-wave-like'.

5.1.7. The predominant tidal current directions are north and south, and the predominant wave direction is from the north, and so the sediment pile will be redistributed mainly in those directions to form a 31m wide (assuming little transport in other directions) feature. Natural sand waves across Tranche A have an average wavelength of 100m (range 50-150m) and average crest height of 0.5m (maximum 2m).

5.1.8. As a best estimate, if a sand wave-like feature created by installation of a single foundation is assumed to form from 2,301m^3 of sediment (total sediment minus dispersed sediment in the plume), that is 100m wavelength and 31m wide, it will have a crest height of about 1.5m. The footprint of this feature will be about 3,100m^2.

5.1.9. The formation of such features from an initial pile of sand has not been modelled or monitored. This is because computational modelling would not be suitable for this issue and a conceptual analysis of the likely behaviour of this sediment is more appropriate. The type of modelling that is suggested would have to be morphological modelling. There is low confidence in this form of modelling and it would not provide the solution in terms of timescale and types of change. Hence, a conceptual approach was adopted.

Potential changes in seabed particle size

5.1.10. With respect to how the drill arising material may potentially change the particle size of existing seabed sediments, the seabed sediments of Dogger Bank are the surface expression of the thicker Holocene sands that sit on top of the Dogger Bank Formation which is predominantly mud. The build-up of these sand bodies has taken place over a long period of time under similar conditions to the present day, and hence they are expected to have similar particle sizes at depth to those on the seabed.

5.1.11. Hence, in the modelling of the drill arisings scenario the sand fraction is broken down into its constituent particle sizes based on the surface averages.

5.1.12. The average particle size distribution of the drill arisings (this includes the Holocene sands and the Dogger Bank Formation mud) is described in **Appendix 9A** Table 2.9. It shows that about 41% of the sediment is mud which is predominantly derived from the Dogger Bank Formation. The Holocene sands contain very low quantities of mud. About 55% of the sediment (on average) is sand-sized, with a particle size distribution similar to that of the seabed sediments (**Appendix 9A** Table 2.8). This sand is mainly derived from the Holocene unit.

5.1.13. Sediment particles larger than 0.18mm will deposit at the source position. **Appendix 9A** Table 2.8 shows that a high proportion (87%) of the sand in the drill arisings falls between 0.125 and 0.25mm (fine sand). On average, the sand of the drill arisings contains 60% between 0.125mm and 0.18mm and 27% between 0.18mm and 0.25mm. The 0.125-0.18mm component will be dispersed in the plume, but the 0.18-0.25mm component will deposit at the source position. This means that the median particle size of the disposed sediment will become slightly coarser (i.e. the median will shift towards the coarser part of the 0.125-0.25mm range) but will still remain within the fine sand classification. The particle size distribution of the sediment deposited at the source position will not be significantly different from the surrounding seabed sediments.

5.1.14. The mud fraction and the fraction of sand less than 0.18mm are assumed to disperse in the plume. This means that the sediment deposited at the source position will contain no mud regardless of how much mud the drill arisings contained at the initial time of dispersal. Hence, although there is a difference between the mud contents of the drill arisings and the surrounding seabed, this variance does not make any difference with respect to the effect on the seabed at the disposal site.

5.1.15. This issue is discussed further below in the context of the potential for changes in overall seabed particle size composition to change benthic communities.

Potential effect of recurrent elevated suspended sediment levels

5.1.16. JNCC/NE have also raised concerns, via consultation to date on both Dogger Bank Creyke Beck and Dogger Bank Teesside A & B, about the potential for repeated impacts from elevated suspended sediment levels over a longer time frame, i.e. the entire construction period. Whilst this issue relates to increased suspended sediment levels produced from the entire 30-day construction period modelled within the EIA (which includes cable installation), comment on this issue is provided here in the context of increased suspended sediment levels produced via the “release of drill arisings component” of the overall plume model.

5.1.17. In their consultation responses, JNCC/NE requested further clarification on how or whether any sediment plume produced during each 30-day modelling period will disperse between construction events. Without this information, JNCC/NE felt that there may be a cumulative, additive effect, or that in any one place increased suspended sediment concentrations remain over a longer time period.

5.1.18. The relevance of this concern was that JNCC/NE was how this potential effect from persistent suspended sediment plumes may impact epibenthos, and how these, in turn, may potentially relate to the “restore” conservation objective for Dogger Bank SCI.

5.1.19. To address this concern, Forewind commissioned DHI, who undertook the original plume dispersion modelling, to run the existing Dogger Bank Teesside A & B plume model again to produce plots that showed the proportion of the 30-day modelling period (expressed as a % figure) in which 100mg/l was exceeded.

5.1.20. The rationale for this further assessment was that the MarLIN benchmark for increased suspended sediment concentrations is defined as thus;

5.1.21. "*An arbitrary short-term, acute change in background suspended sediment concentration e.g. a change of 100mg/l for 1 month*".

5.1.22. Therefore, the sensitivity assessments used within Chapter 12 of the ES to assess impacts on benthic habitats from increased suspended sediment concentration are already based on a change of 100mg/l over a month period. If the revised plots demonstrated that there were no areas where 100mg/l levels were present for 100% of the 30-day period (i.e. the month duration used as the MarLIN benchmark value), then it could be assumed that the existing impact assessments remained valid and already took account of this potential issue of persistent, recurrent suspended sediment levels.

5.1.23. From **Figure 5.1** (below), it is possible to note that 100mg/l was not exceeded in any area for more than 30% (9 days) of the 30-day modelling period. Therefore, this demonstrates that longer-term persistent values of 100mg/l or more are not predicted to arise at any point during the construction process and, therefore, the MarLIN sensitivity assessment benchmark for increased suspended sediments used to assess the impacts within Chapter 12 of the ES remain valid.

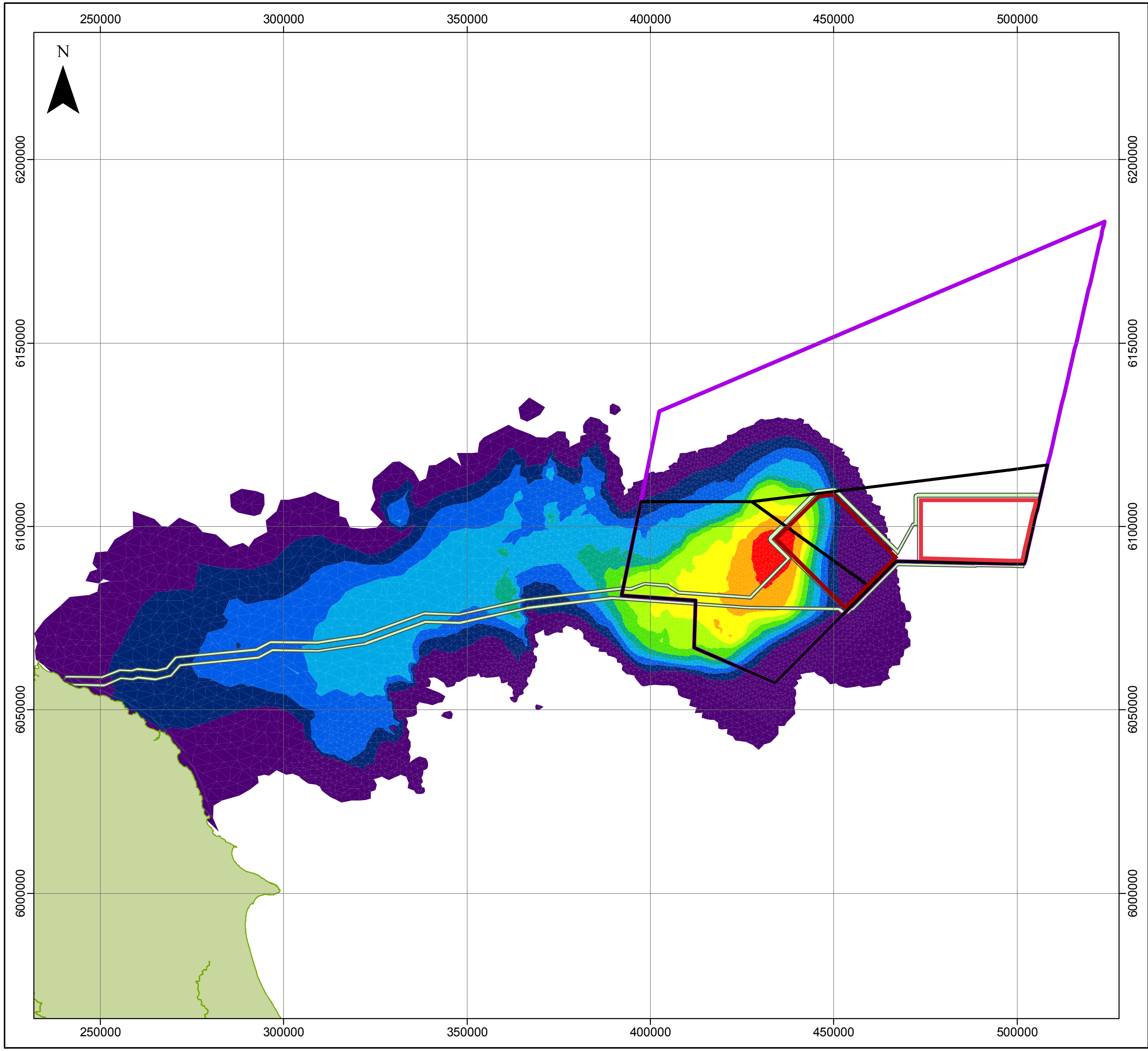
5.1.24. As per the reasons outlined in paragraph 5.1.2, no significance of impact has been assigned to these physical effects. A summary of the assessment of significance of these changes on sensitive biological and human receptors is provided in **Table 6.1**.

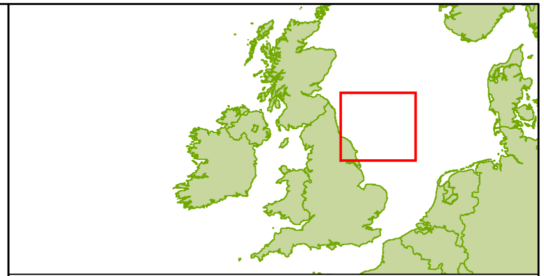
Biological and human environment

5.1.25. The Dogger Bank Teesside A & B Environmental Statement provides detailed impact assessments related to disposal activities on a number of sensitive biological and human environment receptors, including benthic habitats, fish spawning and nursery habitats, marine mammals, birds, commercial fisheries, marine archaeology, shipping and navigation and other marine users and infrastructure.

5.1.26. For all these assessments, the effects defined within the Marine Physical Processes chapter (Chapter 9) have been interpreted with regard to their subsequent impact on various receptors. The sensitivity of 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.

5.1.27. **Table 5.1** below provides a summary of the key impacts on biological and human receptors assessed within the Environmental Statement that are related to proposed disposal activities. The relevant section of the Environmental Statement, where further details of these impact assessments can be found, is also provided.





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

Exceedance of 2 mg/l (%)

- Above 90
- 80 - 90
- 70 - 80
- 60 - 70
- 50 - 60
- 40 - 50
- 30- 40
- 20 - 30
- 10 - 20
- 0 - 10
- Below 0

0 10 20
Kilometres

Data Source:
Modelling © Danish Hydraulic Institute, 2013

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 5.1 Fraction of time where suspended sediment concentration of 100mg/l is exceeding in the bottom layer for a 12 monopole array

VER	DATE	REMARKS	Drawn	Checked
1	08/04/2013	Draft	FK	DB
2	07/10/2013	PEI3	LW	DB
3	06/02/2014	DCO Submission	JE	DB

DRAWING NUMBER: **F-OFL-MA-423**

SCALE	1:1,600,000	PLOT SIZE	A4	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND

Table 5.1 Summary of impacts from disposal of dredged/drilled seabed material within boundaries of Dogger Bank Teesside A & B

Potential impact	Relevant section of ES	Sensitivity of receptor	Magnitude of effect	Significance of impact (including designed in measures)	Notes
Chapter 12: Marine and Intertidal Ecology					
Physical disturbance to habitats and species and temporary habitat loss	**Chapter 12: Marine and Intertidal Ecology:** Section 6.2 to 6.6	Low	Low	**Negligible** (all VERs apart from VER C) **Minor adverse** (VER C)	Deposition of coarser (non-plume) material onto seabed via seabed prep/drill arising disposal considered as a temporary physical disturbance to habitats
Increased suspended sediment concentration and sediment deposition		Low	High	**Negligible** (all VERs)	Worst-case values based on volume of sediment released via drill arisings from 12m concrete monopoles and associated array/export cable installation
Release of sediment contaminants resulting in potential effects on benthic ecology		Medium	Negligible	**Negligible** impact on VEs A, B and C in wind farm sites (and furthest offshore part of the cable corridor) **Minor adverse** impact on VERs D to I (cable corridor)	Sediment contamination levels within Dogger Bank Creyke Beck are low
Increased suspended sediment concentration leading to impacts on plankton and primary productivity		Low	Low	**Negligible** (all VERs)	Worst-case values based on volume of sediment released via drill arisings from 12m concrete monopoles

Potential impact	Relevant Section of ES	Sensitivity of receptor	Magnitude of effect	Significance of impact (including designed in measures)	Notes
Fish and Shellfish Ecology					
Temporary physical disturbance/ loss of seabed habitat – direct effects	**Chapter 13: Fish and Shellfish Ecology**	Low	Low	**Minor adverse**	Relevant receptor is benthic fish eggs
		Medium	Low	**Minor adverse**	Relevant receptor is sandeel eggs
		Low	Low	**Minor adverse**	Relevant receptor is herring eggs
		Low	Low	**Minor adverse**	Relevant receptor is shellfish eggs
		Low	Low	**Minor adverse**	Relevant receptor is juvenile and adult fish species
		Medium	Low	**Minor adverse**	Relevant receptor is adult sandeels
		Low	Low	**Minor adverse**	Relevant receptor is adult shellfish
Temporary disturbance of seabed – increased suspended sediment concentrations		Low	Low	**Minor adverse**	Relevant receptor is fish eggs and larvae
		Low	Low	**Minor adverse**	Relevant receptor is sandeel eggs
		Low	Low	**Minor adverse**	Relevant receptor is herring eggs
		Low	Low	**Minor adverse**	Relevant receptor is juvenile and adult fish species
		Low	Low	**Minor adverse**	Relevant receptor is adult sandeels
		Low	Low	**Minor adverse**	Relevant receptor is adult shellfish

Potential impact	Relevant Section of ES	Sensitivity of receptor	Magnitude of effect	Significance of impact (including designed in measures)	Notes
Marine Mammals					
None	**Chapter 14: Marine Mammals**	NA	NA	**NA**	No impacts predicted on marine mammals as a result of seabed preparation/disposal within Dogger Bank Teesside A & B
Sites of Nature Conservation Importance					
Temporary increases in suspended sediment concentrations and associated deposition.	**Chapter 8: Designated Sites**	Relevant impacts from the disposal of material from seabed preparation and/or drilling on the Dogger Bank SAC are assessed within individual ES chapters, including Chapter 12 (Marine and Intertidal Ecology) and Chapter 9 (Marine Physical Processes) - see above for details on these potential impacts. The Habitats Regulation Assessment (HR) report also includes a full assessment of the potential for disposal activity to impact on the integrity of the Dogger Bank cSAC.			
Commercial Fisheries					
Temporary/Complete Loss or Restricted Access to Traditional Fishing Grounds (Disposal activities will lead to temporary loss/restricted access to fishing grounds)	**Chapter 15: Commercial Fisheries**	Low	Low	**Minor adverse**	Relevant receptor is Dutch and UK beam/otter trawlers –
		Low	Low	**Minor adverse**	Relevant receptor is Danish, Norwegian, German, Swedish and UK sandeel fishery
		Medium	Medium	**Moderate adverse**	Relevant receptor is seine net fishery
		Low	Low	**Minor adverse**	Relevant receptor is the Danish gillnet fishery
Interference with fishing activities (Potential for vessels involved in disposal activities to interfere with commercial fishing activities via damage to static gear buoys or change in trawling tows)		Low	Negligible	**No discernible impact**	Relevant receptor is mobile gear fisheries
		Low	Negligible	**Minor adverse**	Relevant receptor is static gear fisheries

Potential impact	Relevant Section of ES	Sensitivity of receptor	Magnitude of effect	Significance of impact (including designed in measures)	Notes
Impacts on commercially exploited fish and shellfish populations	**Chapter 15: Commercial Fisheries**	Low/Medium	Low	**Minor adverse**	Full assessment of potential impacts of construction (including disposal activities) presented in Chapter 13: Fish and Shellfish Ecology – see details earlier in this table
Shipping and Navigation					
Presence of construction activities: impacts on existing marine vessels transit routes due to deviation and increased journey times	**Chapter 16: Shipping and Navigation**	Low	Low	**Negligible**	NA
Presence of construction vessels: displacement of existing vessel transit routes leading to increased vessel to vessel collision risk		High	Medium	**Moderate adverse**	**Minor adverse** impact after successful implementation of mitigation measures (including use of NTMs, marine vessel coordination and 500m safety zones)
Marine and Coastal Archaeology					
Indirect effects (deposition of sediment on existing receptors)	**Chapter 18: Marine and Coastal Archaeology**	Probability of indirect impact = <1%	Negligible	**No impact**	NA
Direct effects		Med/High	High	**Negligible**	Negligible impact if all mitigation (avoidance) implemented

Potential impact	Relevant Section of ES	Sensitivity of receptor	Magnitude of effect	Significance of impact (including designed in measures)	Notes
Other Marine Users and infrastructure) (including marine aggregate extraction, recreational users and cables/pipelines)					
No impacts predicted.	**Chapter 17: Other Marine Users**	No impact	No impact	No impact	No impacts on other marine activities in the wider region are predicted from disposal activities

6. Monitoring

6.1.1. Based on the findings of the impact assessments presented in the Dogger Bank Teesside A & B Environmental Statement (Forewind 2014) and summarised within this document, long-term impacts of disposal of spoil within Dogger Bank Teesside A & B are not anticipated, due to the temporary nature of any sediment plumes and increased suspended sediment concentrations related to these plumes.

6.1.2. The deposition of sediment 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.

6.1.3. 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 still 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.

6.1.4. To verify these predictions, it is proposed that formal post-construction benthic monitoring be carried out. It is important that any monitoring is 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 2002; 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 (Cefas 2010).

7. Conclusions

7.1.1. This document has been produced following consultation between Forewind and the MMO (including discussions with Cefas) on the subject of the need for a separate Marine Licence to cover disposal activities associated with foundation installation for Dogger Bank Teesside A & B in the Dogger Bank Round 3 Zone.

7.1.2. This document represents the site characterisation for Dogger Bank Teesside A & B as required by the MMO, to allow a consideration of the potential impact of disposal within this site.

7.1.3. Noting that all the information required for site characterisation to support a disposal application would be contained within the Dogger Bank Teesside A & B ES, this document takes the form of a 'framework' document that provides a summary of the key points relevant to site characterisation and refers the reader back to the more detailed information and data presented within various sections of the ES (Forewind 2014).

7.1.4. The source of material proposed to be disposed of within Dogger Bank Teesside A & B will be sediment dredged from the upper 0.75m of the existing seabed via a trailer suction hopper dredger as part of seabed preparation works, prior to GBS foundation installation and/or materials from the deeper soil profile and top layers of upper sediments derived from drilling activities associated with monopile installation.

7.1.5. Based on a review of geotechnical, geophysical and grab data, an upper estimate of 1,937,578m^3 of material from the two projects will be disposed of *in situ* in the form of shallow dredged sediments and possibly also drill arisings.

7.1.6. With respect to the disposal of dredged material, this is expected to take place adjacent to the seabed preparation site, in an easterly or westerly direction (to avoid the dominant tidal flows transporting the material back to the seabed preparation site).

7.1.7. 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.

7.1.8. Based on contaminant analysis undertaken as part of the EIA, the sediments to be disposed from the seabed preparation works are predominantly sand (specifically sand, gravelly sand and sandy gravel).

7.1.9. Data from a site-specific sediment chemistry survey indicates that these surface sediments are not contaminated. The biological characteristics of the sediments to be disposed of (and the receiving environment) have also been assessed. They are dominated by three broad habitat types:

- VER A: Sandy sediment supporting relatively low diversity benthic communities which form part of the Annex I Sandbank Feature;
- VER B: Coarse sediments with medium to high diversity benthic communities which form part of the Annex I Sandbank Feature; and

- VER C: Muddy sand sediments with medium diversity benthic communities (including sea pens) which form part of the Annex I Sandbank Feature.

7.1.10. The impacts of disposal via either the return of dredged material to the water column and seabed and/or the placement of drill arisings adjacent to foundations has been fully assessed within the Dogger Bank Teesside A & B ES (Forewind 2014).

7.1.11. 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.

7.1.12. In conclusion, based on the proposals for disposal within the Dogger Bank Teesside A & B 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.

7.1.13. The HRA process for Dogger Bank Teesside A & B has also concluded that these proposed disposal activities will not result in an adverse effect on the integrity of the Dogger Bank cSAC (refer to the **HRA Report**, which has been submitted and is available alongside the ES for Dogger Bank Teesside A & B).

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