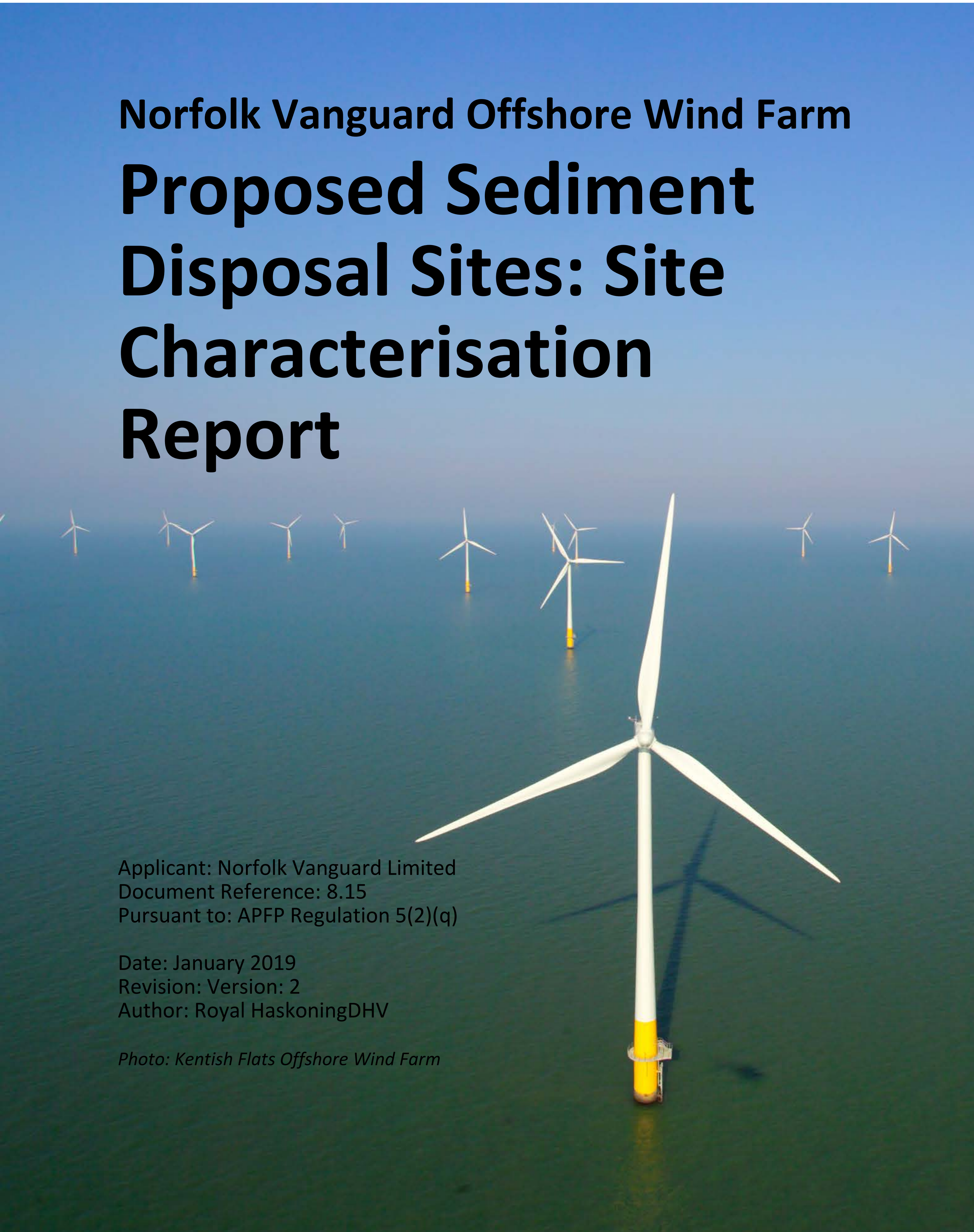

Norfolk Vanguard Offshore Wind Farm

Proposed Sediment Disposal Sites: Site Characterisation Report

Applicant: Norfolk Vanguard Limited
Document Reference: 8.15
Pursuant to: APFP Regulation 5(2)(q)

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Photo: Kentish Flats Offshore Wind Farm

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Glossary

DCO	Development Consent Order
ES	Environmental Statement
GBS	Gravity Based Structure
MW	Megawatt
NV East	Norfolk Vanguard East
NV West	Norfolk Vanguard West
OWF	Offshore Wind Farm
SAC	Special Area of Conservation

Terminology

Array cables	Cables which link the wind turbine generators and the offshore electrical platform.
Capital dredging	Dredging of an area which has not previously been dredged (see Maintenance Dredging) for a new capital project, e.g. an offshore wind farm, port or harbour.
Interconnector cables	Buried offshore cables which link offshore electrical platforms.
Landfall	Where the offshore cables come ashore.
Maintenance dredging	The action of dredging to keep an existing navigation channel open
Offshore accommodation platform	A fixed structure (if required) providing accommodation for offshore personnel. An accommodation vessel may be used instead.
Offshore cable corridor	The area where the offshore export cables would be located.
Offshore electrical platform	A fixed structure located within the wind farm area, containing electrical equipment to aggregate the power from the wind turbine generators and convert it into a more suitable form for export to shore.
Offshore export cables	The cables which transmit electricity from the offshore electrical platform to the landfall.
Offshore project area	The overall area of Norfolk Vanguard East, Norfolk Vanguard West and the provisional offshore cable corridor.
Safety zone	An area around a vessel which should be avoided during offshore construction.
Scour protection	Protective materials to avoid sediment being eroded away from the base of the foundations as a result of the flow of water.
The Applicant	Norfolk Vanguard Limited.
The OWF sites	The two distinct offshore wind farm areas, Norfolk Vanguard East and Norfolk Vanguard West.
The project	Norfolk Vanguard Offshore Wind Farm, including the onshore and offshore infrastructure.

1 INTRODUCTION

1.1 Background

1. Norfolk Vanguard Limited (an affiliate company of Vattenfall Wind Power Ltd (VWPL), 'the Applicant') is seeking a Development Consent Order (DCO) for the proposed Norfolk Vanguard offshore wind farm (herein 'the project' or 'Norfolk Vanguard'), an offshore wind farm (OWF) in the southern North Sea.

2. The OWF comprises two distinct areas, Norfolk Vanguard East (NV East) and Norfolk Vanguard West (NV West) ('the OWF sites'), located approximately 47km from the closest point of the Norfolk Coast. NV East covers an area of approximately 297km^2 and NV West covers an area of around 295km^2.

3. The offshore wind farm (OWF) comprises two distinct areas, Norfolk Vanguard East (NV East) and Norfolk Vanguard West (NV West) ('the OWF sites'). The offshore wind farm would be connected to the shore by offshore export cables installed within the offshore cable corridor from the wind farm to a landfall point at Happisburgh South, Norfolk. From there, onshore cables would transport power over approximately 60km to the onshore project substation at Necton, Norfolk.

4. Once built, Norfolk Vanguard would have an export capacity of up to 1800MW, with the offshore components comprising:

- Wind turbines;
- Offshore electrical platforms;
- Accommodation platforms;
- Met masts;
- Lidar;
- Array cables;
- Inter-connector cables; and
- Export cables.

5. The key onshore components of the project are as follows:

- Landfall;
- Onshore cable route, accesses, trenchless crossing technique (e.g. Horizontal Directional Drilling (HDD)) zones and mobilisation areas;
- Onshore project substation; and
- Extension to the Necton National Grid substation and overhead line modifications.

6. A full project description is given in the Environmental Statement (ES), Chapter 5 Project Description.

7. Norfolk Vanguard Limited is currently considering constructing the project in either a single phase or two phases (up to a maximum of 1800MW). The layout of the wind turbines will be defined post consent but will be based on the following maxima:

- 1800MW in NV East, 0MW in NV West; or
- 0MW in NV East, 1800MW in NV West.

8. Any other potential layouts that are considered up to a maximum of 1800MW (e.g. 1,200MW in NV West and 600MW in NV East; 600MW in NV West and 1,200MW in NV East; or 900MW in NV West and 900MW in NV East) lie within the envelope of these scenarios.

9. Construction of the project under either approach would be anticipated to commence between 2020 and 2021 for the onshore works, and around 2024 for the offshore works; further detail on construction programme is provided in section 4.3.

1.2 Purpose of this Document

10. Norfolk Vanguard Limited is applying to designate the following areas for the disposal of material extracted during the construction period (e.g. drilling and / or seabed preparation (dredging)). The proposed disposal areas are:

- NV East;
- NV West; and
- The section of the offshore cable corridor from the western boundary of the Haisborough, Hammond and Winterton SAC to the OWF sites, excluding the deep-water shipping route.

11. The locations of the proposed disposal sites are shown in Figure 1.1 and the coordinates are provided in Appendix 1 of this report.

12. The purpose of this document is to provide the information required to enable site designation. Accordingly, this document sets out:

- The need for disposal of material;
- Alternatives considered;
- The location of the disposal sites;
- The types of material to be disposed of;
- The quantity of the material to be disposed; and
- Potential impacts of disposal.

13. Version 2 of this document is provided to update the total volume of drill arisings following the increase in the number of piles associated with the Offshore Electrical

Platforms, as detailed in the Change Report (document reference Pre-ExA;Change Report;9.3).

14. In addition, and in response to comment 1.11 of the Marine Management Organisation (MMO's) relevant representation [RR-186], the total volume of sediment to be disposed of following cable installation has been updated to remove the 3,000,000m^3 associated with export cable trenching works. This sediment would not be raised and would therefore not require disposal. Therefore, while the offshore chapters of the ES (document reference 6.1; Chapters 8, 9, 10, 11 and 12) are correct to consider this within a conservative assessment of impacts associated with suspended sediment, this volume is not included in the DCO with regards to disposal volumes and should not be included in this Site Characterisation Report. The Applicant's response to the MMO's relevant representation is detailed in Appendix 1 of the SoCG (document reference Rep1-SoCG-11.1).

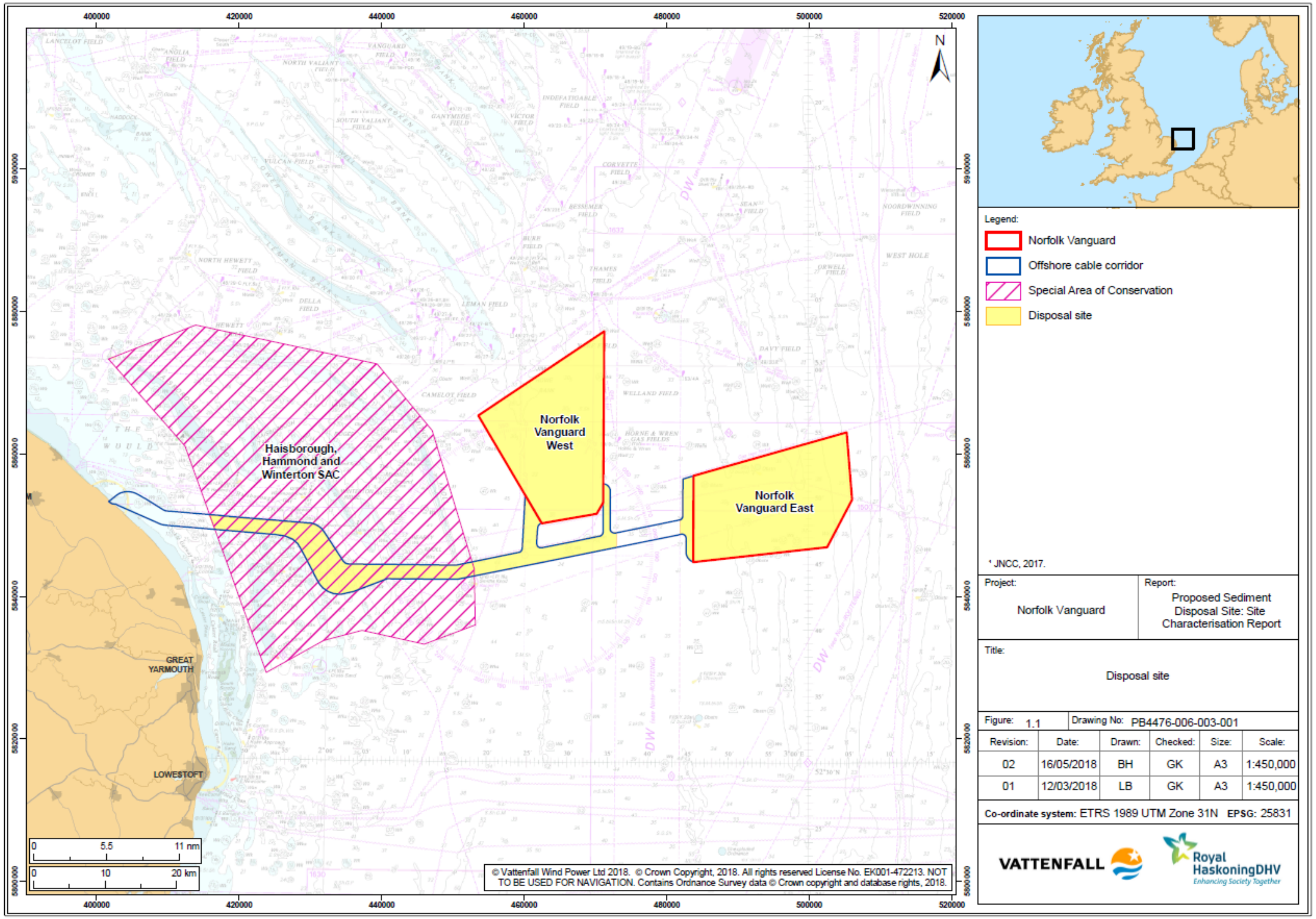

Figure 1.1 Proposed disposal sites

2 THE NEED FOR DISPOSAL OF MATERIAL

15. The type of foundation and installation method required for the wind turbines and other offshore structures associated with Norfolk Vanguard are yet to be determined. Foundation types currently under consideration include gravity base structures (GBS), monopiles, suction caissons, quadropod or tripod pin-piles (jackets) and tension leg floating foundations.

16. Seabed preparation and potential drilling of pin-piles and monopiles if required would result in the production of material which requires disposal. Therefore, practicable options for the disposal of "capital" dredged material must be assessed.

17. Furthermore, the option of sandwave levelling (pre-sweeping) to a stable reference seabed level may be undertaken to reduce the potential that cables become unburied over the life of the project. Natural England has requested that where sandwave levelling is undertaken within the Haisborough, Hammond and Winterton SAC, any disturbed seabed sediment should be deposited back into the SAC to ensure material is not lost from the system. Further information about how this would be achieved is provided in section 5.4.13 of Chapter 5 Project Description of the Norfolk Vanguard ES.

2.1 Foundation installation

18. As previously stated there are several possible foundation types currently being considered for the wind turbines. Within these categories there are a number of variants which include:

- GBS – which rely on the weight of the structure to anchor it to the seabed;
- Quadropod and tripod - jacket foundations with either three or four feet attached to the seabed with either 3 or 4 suction caissons or piles;
- Suction caissons – cylindrical tubes which are installed by reducing the pressure inside the tube to draw the caisson into the seabed;
- Monopiles – large cylinders which are hammered into the seabed; and
- Tension leg floating foundations – a floating platform which is attached to the seabed by taught mooring lines to a gravity anchor or up to four suction caissons or piled anchors.

19. The following foundation options are also being considered for the other offshore infrastructure:

- Jacket, GBS or monopile for meteorological mast (met mast) foundations;
- Jacket or GBS for offshore convertor platforms and accommodation platforms;
- Anchored or monopile LiDAR; and

- Anchored buoys.

20. Further information on the foundation types being considered for the project can be found in Chapter 5 Project Description of the Norfolk Vanguard Environmental Statement.

21. Information regarding the maximum predicted amounts of material arising from the installation of foundations is provided in Section 4 of this document. The installation processes associated with the need for sediment disposal are summarised below.

2.1.1 Piled jacket foundations

22. For jacket foundations some dredging may be required for levelling the seabed prior to the installation of a pile template (if used). However, it should be possible to spread this material close to the installation works.

23. Based on preliminary geotechnical information from the OWF sites (Fugro 2017b), it is thought that pile driving would be possible across the whole project site, which will not generate spoil material. However, until more detailed geotechnical assessments are carried out, the possibility of drilling must be considered at some locations. As at the date of this document, Norfolk Vanguard has very limited information to assess the percentage of drilled piles required.

24. If drilling is required it will generate some spoil material that will require removal and disposal. It is proposed that the spoil will be disposed of within the wind farm area, adjacent to each location from where the material was derived, with the spoil subsequently winnowed away by the natural tide and wave driven processes as described in Chapter 8 Marine Geology, Oceanography and Physical Processes.

2.1.2 Gravity Base Structures

25. For GBS, it is possible that seabed preparation would be required. This is dependent on the ground conditions present. The preference is that GBS foundations are installed where no or limited ground preparation is required with micro-siting used to minimise any dredging requirements. Assessment of the available geophysical data (Fugro, 2016) indicates that there are areas within the OWF sites which if chosen for GBS foundation locations would require seabed preparation. The worst case scenario for GBS therefore assumes an excavation to level of an area of sandwaves up to 5m in depth and 60m diameter for the largest GBS foundations.

2.1.3 Suction Caisson

26. As with GBS, it is possible that seabed preparation will be required for suction caisson foundations. The worst case excavation estimated volumes are predicted to be no worse than for the GBS foundations, as identified above.

2.1.4 Monopiles

27. It is expected that monopiles will be positioned to avoid seabed preparation, however if sand waves are present, the seabed might need to be levelled first by excavation to the trough of the sand wave. The worst case assumption is that excavation to 5m depth is required from an area with a diameter of 15m.

28. If drilling is required it will generate some spoil material that will require removal and disposal. It is proposed the spoil will be disposed of within the wind farm area, adjacent to each location from where the material was derived, with the spoil subsequently winnowed away by the natural tide and wave driven processes.

2.1.5 Floating Tension Leg Foundation

29. For floating tension leg foundations, it is possible that seabed preparation would be required, depending on the ground conditions present. The preference is that the piled or gravity anchors are installed where no or limited ground preparation is required with micro-siting used to minimise any dredging requirements. Assessment of the available geophysical data (Fugro, 2016) indicates that there are areas within the OWF sites which if chosen for floating foundation locations would require seabed preparation. The worst case scenario therefore assumes an excavation to level of an area of sandwaves up to 5m in depth across an area of 90m by 90m for gravity anchors for the largest foundations.

30. In all cases it is proposed that material will be redistributed within the wind farm area and close to the individual foundation locations.

2.2 Cable installation

31. Seabed preparation could be required for installation of all offshore electrical cables including:

- Up to 600km of array cables;
- Up to 200km of export cable trenches (including approximately 30km of export cable trenching within the OWF sites);
- Up to 150km of interconnector cable trenches; and
- Fibre optic cables may also be installed; however, these would be bundled with the electrical cables and installed within the same trenches.

32. Any dredged seabed material would be disposed of within the cable corridor or wind farm area, with the exception of material removed from within the SAC which would be disposed of back within the SAC to ensure that this material is not lost from the system.

2.3 Embedded mitigation

33. Norfolk Vanguard Limited has committed to a number of areas of embedded mitigation in order to reduce the potential impacts of the project. The following examples of embedded mitigation are of relevance to sediment disposal:

- Reduction of turbine numbers by committing to use larger turbines within the range of 9MW to 20MW and thereby reducing the volume of foundation pre-sweeping required.
- Committing to using a High Voltage Direct Current (HVDC) solution in order to reduce the number of export cables and offshore electrical platforms when compared to the High Voltage Alternating Current (HVAC) option. This significantly reduces the volume of pre-sweeping required, particularly in the Haisborough Hammond and Winterton SAC.
- Pre-construction surveys (secured within the relevant DMLs and in accordance with the In Principle Monitoring Plan, document 8.12) to be undertaken in advance of any cable and foundation installation works. The methodology for the pre-construction surveys would be agreed with the MMO, in consultation with Natural England. The results of this survey would be used to plan the location of wind turbines and the routing of all Norfolk Vanguard cables, including micrositing where possible. The locations and cable routes would then be agreed with the MMO and Natural England through agreement of the final Cable Statement (document 7.1).
- All seabed material arising from the Haisborough, Hammond and Winterton SAC during cable installation would be placed back into the SAC using an approach, to be agreed with the MMO in consultation with Natural England, which would ensure that the sediment is available to replenish the sandbank features.
- Sediment would not be disposed of within 50m of confirmed core *Sabellaria* reef in with advice from Natural England.

3 TYPE OF MATERIAL TO BE DISPOSED

34. As discussed below, materials to be disposed of would be comprised either of seabed and shallow near-bed surface sediments as a result of dredging, or, sub-surface sediments, if drilling is required. Details on the physical characteristics of the seabed and subsurface material across the offshore project area are presented within Chapter 8 Marine Geology, Oceanography and Physical Processes with the main characteristics summarised within this chapter.

3.1 Seabed Sediment Type

35. This section describes the surface and subsurface sediment types which may be dredged or drilled as part of Norfolk Vanguard construction and would therefore require disposal.

3.1.1 Seabed Surface Sediments

36. A regional seabed sediment grab sampling campaign was completed between September 2010 and January 2011 for the former East Anglia Zone which encompassed NV West, NV East and the eastern extent of the offshore cable corridor. Additional surveys were undertaken by Fugro (2017a) between 29th October and 10th November 2016 to fill gaps in the former East Anglia Zone data and to cover the entire length of the offshore cable corridor. The survey methodology and sampling effort was agreed with Natural England and the MMO.

3.1.1.1 Norfolk Vanguard West

37. The particle size characteristics of all the seabed sediment samples collected in NV West (a total of 48) are presented in Appendix 8.1 of the ES. The dominant sediment type is medium-grained sand with median particle sizes (d50) mainly between 0.32 and 0.39mm. The mud content is less than 5% in 75% of the samples. However, 15% of the samples contain greater than 10% mud, ranging from 10% to 77%. The gravel content varies from zero to 10% in 98% of the samples.

3.1.1.2 Norfolk Vanguard East

38. A total of 52 seabed sediment samples have been collected in NV East. The dominant sediment type is medium-grained sand (90-100% sand) with median particle sizes between 0.20mm and 0.35mm, with most samples (90%) containing less than 4% mud. The gravel content varies from zero to 5% in 95% of the samples (see ES Appendix 8.1 for further details).

3.1.1.3 Offshore cable corridor

39. A total of 20 seabed sediment samples have been collected in the section offshore cable corridor proposed for designation as a disposal site. The seabed within this area can be broadly characterised as predominantly sand, with small areas of slightly gravelly sand and gravelly sand. Most samples (65%) contained over 90% sand; 75% of samples contain less than 3% mud; and 60% of samples contained 5% or less gravel content.

3.1.2 Sub-surface sediments

40. Sub-surface sediments within NV West and the offshore cable corridor are described using data collected during the October 2016 to November 2016 surveys conducted by Fugro and reported in Fugro (2016). NV East (formerly East Anglia FOUR) was surveyed in 2012 and reported in Fugro (2016).

41. The geology of the offshore project area generally consists of Holocene sand deposits overlying a series of Pleistocene sands and clays.

42. The sequence between the Westkapelle Ground Formation and the Twente Formation is Pleistocene in age, whereas the Elbow Formation and Bligh Bank Formation are Holocene. The thickness of the Holocene sediment varies from less than 1m to greater than 20m in the sand wave fields and sand banks.

3.1.2.1 Norfolk Vanguard West

43. Fugro (2016) described nine geological formations (Table 3.1). The sequence between the Westkapelle Ground Formation and the Twente Formation is Pleistocene in age, whereas the Elbow Formation and Bligh Bank Formation are Holocene.

Table 3.1 Geological formations present under the Norfolk Vanguard West site (Fugro Survey B.V., 2016)

Formation	Lithology (BGS Lexicon http://www.bgs.ac.uk/lexicon)
Bligh Bank	Marine, medium- or fine- to medium-grained, clean, yellow-brown sands
Elbow	Brackish-marine, fine-grained sands and clays with discontinuous basal peat bed
Twente	Fine-grained, well-sorted, wind-blown periglacial sands
Brown Bank	Brackish-marine, grey-brown silty clays. Pass upwards into lacustrine clays in the east, include interbeds gravelly sand towards base in west
Swarte Bank	Infilled glacial tunnel valleys
Yarmouth Roads	Mainly riverine, fine or medium-grained grey-green sands, typically non-calcareous, with variable clay lamination and local intercalations of reworked peat

Formation	Lithology (BGS Lexicon http://www.bgs.ac.uk/lexicon)
Winterton Shoal	Fine- or medium-grained sands with minor clay laminations
Smith's Knoll	Fine to medium-grained, muddy marine sands, with clay intercalations in the east
Westkapelle Ground	Marine clays with thin sandy laminae passing gradationally upwards to sand with thin clay laminae

3.1.2.2 NV East

44. Fugro described three geological formations within NV East. In ascending order, these are the Pleistocene Yarmouth Roads Formation comprising 0 to 100m of sands and channel infills, overlain by the Pleistocene Brown Bank Formation comprising 5 to 10m of silty clay, capped by 0 to 20m of Bligh Bank Formation (Holocene sand). The Holocene sand varies in thickness from several metres beneath sand banks and sand waves to a thinner veneer in deeper areas.

45. The base of the Yarmouth Roads Formation was not reached by the sub-bottom profilers across NV East (the former East Anglia FOUR site), and so the older formations described at NV West (Fugro, 2016) were not delineated across NV East.

3.1.2.3 NV West

46. The Bligh Bank Formation blankets the majority of the site as a thin seabed veneer and represents the sediment currently being reworked into sand banks, sand waves and megaripples. The formation is present across most of the NV West site, except along the western margin where Holocene sand is absent or only a patchy veneer and Pleistocene formations outcrop at the seabed.

3.1.2.4 Offshore Cable Corridor

47. Fugro (2017a) completed the geophysical survey of the offshore cable corridor between 1st September and 15th November 2016 using different profilers in three sub-sections (west, central and east), with the western and central subsections encompassing the Haisborough, Hammond and Winterton SAC. The western and central sub-sections were surveyed using a pinger with a 5m penetration. Due to the small penetration depth of the pinger in these sub-sections, the shallow geological sequence is only divided into Holocene sands and the underlying undifferentiated Pleistocene sediments. In the area around Newarp Banks, there was little sub-sea structure observed. The seafloor comprises predominantly modern Holocene sand (most present in the dunes) overlying pre-Holocene formation. Within this section of the cable route, there appears to be a subcrop of the sandy Yarmouth Roads Formation beneath the Holocene sands. Between Newarp Banks and Smith's Knoll,

the shallow geology could only be extrapolated from the geotechnical investigation locations with a low reliability. Seismic reflectors which could represent the base Holocene were sporadic and absent entirely beneath the large sandbanks. Historic mapping shows subcrops of Brown Bank and Eem Formations beneath the Holocene sediments within this section of the cable corridor proposed for designation. Geophysical data (Fugro, 2017a) reveals fine, flat-lying bedding, with channelling at its base which is indicative of the Brown Bank Formation between Newarp Banks and Winterton Ridge. Between Winterton Ridge and Smith's Knoll, there is bedding indicative of a subcropping Eem Formation.

3.2 Sediment Contamination Analysis

48. Alongside defining the biological and physical characteristics of the Norfolk Vanguard offshore project area, the surveys conducted by Fugro in 2016 also took 30 samples (using a 0.1m^2 Day grab) to test the level of contaminants in the seabed.

49. Of the 30 sediment samples obtained, seven stations from within the offshore cable corridor (four of which are located within the area proposed area for disposal site designation), three stations from within NV East and three stations from within in NV West were analysed to provide coverage across the offshore project area and to determine whether analysis of the remaining 17 samples was required. Following agreement from Cefas that the analysis of these 13 samples was adequate to determine the chemical nature of the seabed, the remaining samples were discarded. Table 3.2 provides reference to the sample numbers which are located within the proposed disposal site area and their respective locations. A spatial representation is provided in Chapter 9, Figure 9.2 of the Norfolk Vanguard ES.

Table 3.2 Contaminant samples and their associated location

Location	Sample Number
NV East	16_MS, 20_MS, 19_MS
NV West	05_MS, 02_MS, 03_MS
Area of Cable Corridor to be designated as disposal site	38_CR, 41_CR, 45_CR, 48_CR 56 CR

50. Sediment contaminant data is summarised in Table 3.3. Data highlighted in yellow indicates concentrations of contaminants over Cefas Action Level 1 (Cefas, undated) (there are no concentrations greater than Cefas Action Level 2). All organotin and PCB results were below the limits of detection (0.004 mg/kg and 0.0001 mg/kg respectively) and therefore have not been included in the table.

51. The data summarised in Table 3.3 illustrates that sediment contamination within the offshore cable corridor and the OWF sites is low. Only two sites (in NV West) exceeded Cefas Action Level 1 and this was just for concentrations of arsenic at 03_MS and 56_CR (highlighted in Table 3.3). These exceedances are marginal as they are only just

over the Action Level 1 concentration. The elevated levels of arsenic which were recorded are typical of the region; in the offshore environment these are associated with estuarine and geological inputs and sea bed rock weathering.

52. Since the results indicate relatively low levels of contamination across the site, analysis of the additional stored samples was not considered necessary; this was confirmed with Cefas and the MMO on 3rd April 2017. Owing to the low levels of contamination within the offshore study area and offshore cable corridor, further assessment (i.e. comparison with additional sediment quality guidelines or other methods) is deemed unnecessary.

Table 3.3 Sediment contamination analysis results compared to Cefas Action Levels.

Contaminant (mg/kg)	Sample site in NV West			Sample site in NV East			Sample sites in offshore cable corridor proposed for designation				
	02_MS	03_MS	05_MS	19_MS	16_MS	20-MS	38_CR	41_CR	45-CR	48-CR	56_CR
Arsenic	16.7	20.4	16.7	17.3	10.7	7.89	10	11.4	9.75	11.9	35.2
Mercury	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Chromium	12.8	5.3	7.8	15.8	11.6	4.9	2.2	<2	9.1	12.8	4
Copper	2.08	1.45	<1	2.87	1.95	<1	<1	<1	1.78	3.35	<1
Lead	7.53	5.12	5.96	6.61	5.69	2.64	<2	2.34	4.75	8.36	6.36
Nickel	5.3	3.4	3.5	7.5	5.5	3.2	1.3	1.26	4.4	6.7	2.8
Zinc	17.7	12	13.3	21.3	18.6	9.2	5.8	5.5	14.4	22.6	14.2
Acenaphthene	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.00101	<0.001
Acenaphthylene	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Anthracene	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00111	0.00129	<0.001
Benzo(a)anthracene	0.00183	<0.001	<0.001	0.00192	0.00429	<0.001	<0.001	<0.001	0.00392	0.00415	<0.001
Benzo(a)pyrene	0.00234	0.00152	<0.001	0.00236	0.00543	<0.001	<0.001	<0.001	0.00392	0.00558	<0.001
Benzo(b)fluoranthene	0.00362	0.00234	<0.001	0.00327	0.0074	<0.001	<0.001	<0.001	0.00695	0.00759	<0.001
Benzo(e) pyrene	<0.005	<0.005	<0.005	<0.005	0.00605	<0.005	<0.005	<0.005	0.0058	0.00703	<0.005
Benzo(ghi)perylene	0.00284	0.00187	<0.001	0.00242	0.00526	<0.001	<0.001	<0.001	0.00514	0.0068	<0.001
Benzo(j)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	0.00148	<0.001	<0.001	0.00141	0.00341	<0.001	<0.001	<0.001	0.0030	0.00319	<0.001
Chrysene + Triphenylene	<0.003	<0.003	<0.003	<0.003	0.00579	<0.003	<0.003	<0.003	0.00618	0.00629	<0.003
Chrysene	<0.003	<0.003	<0.003	<0.003	0.00418	<0.003	<0.003	<0.003	0.00434	0.00432	<0.003
Dibenzo(ah)anthracene	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Dibenzothiophene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Fluoranthene	0.00386	0.00186	<0.001	0.00395	0.00933	<0.001	<0.001	<0.001	0.00879	0.00809	<0.001
Fluorene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Indeno(1,2,3-c,d)pyrene	0.00243	0.0015	<0.001	0.00233	0.00491	<0.001	<0.001	<0.001	0.00452	0.00528	<0.001
Naphthalene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.00599	0.00616	<0.005
Perylene	<0.005	<0.005	<0.005	0.00112	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Phenanthrene	<0.005	<0.005	<0.005	<0.005	0.00845	<0.005	<0.005	<0.005	0.00953	0.00958	<0.005
Pyrene	0.00340	0.00160	<0.001	0.00351	0.00779	<0.001	<0.001	<0.001	0.00739	0.00699	<0.001
Triphenylene	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Total Hydrocarbons	22.1	10	3.06	11.8	26.2	1	<0.9	<0.9	33.1	47 3	<0.9

4 QUANTITY OF MATERIAL TO BE DISPOSED

53. Material to be disposed may arise from the following sources:

- Seabed preparation for foundations;
- Drill arising when installing foundations; and
- Seabed levelling for cable installation.

54. Taking a precautionary approach, it has been estimated that a maximum of 50% of the foundation locations within NV East and NV West would require drilling. Drill arisings would fall rapidly to the seabed in the vicinity of the activity and would not be brought to the surface for disposal.

55. As discussed in Section 1.1, Norfolk Vanguard could be installed in a single or two phased approach. The spatial requirements for a single or two phased approach are the same and therefore the volume of sediment arising would be the same regardless of the build out scenario. However, the construction programme would vary and this is outlined in Section 4.3 of this document.

4.1 Seabed Preparation

56. Table 4.1 shows the volumes associated with seabed preparation for foundation and cable installation within the proposed disposal sites (NV East and/or NV West and section of the offshore cable corridor). The maximum sediment removal during foundation installation would be from floating foundations with gravity anchors, any other foundation options would result in less material.

57. The maximum sediment disturbance in relation to seabed levelling for offshore export cable installation would be in relation to a trench length of 200km. This is based on four HVDC cables in two trenches to the wind farm site with a maximum length of 100km from landfall to the offshore electrical platform.

58. Cable installation will require preparation of the offshore export cable route (pre-sweeping by dredging) excluding the nearshore within the 10m water depth contour as Norfolk Vanguard Limited has committed to no seabed preparation in this area. These activities are outlined in Table 4.1. Subsequent trenching (e.g. by jetting or ploughing) will then be required to bury the cables. This sediment would not be raised and would therefore not require disposal. The impacts associated with trenching are assessed in the ES (Document reference 6.1; Chapters 8, 9, 10, 11 and 12).

Table 4.1 Total disturbance/preparation footprints during construction

Infrastructure	Worst Case Scenario type	Worst Case Scenario volume (m^3)
Seabed preparation – turbines	90 x 20MW turbines on floating foundations with gravity anchors	3,645,000
Array cable pre-sweeping	Width 20m x 600,000m	36,000,000
Interconnector pre-sweeping	Width 20m x 150,000m	9,000,000
Seabed preparation – offshore electrical platforms	Based on two 100m x 75m platforms	75,000
Seabed preparation - accommodation platforms	Based on two 100m x 75m platforms	75,000
Seabed preparation - met masts	Based on 40m diameter x 2 met masts	12,566
Export cable pre-sweeping within OWF sites	Based on 2 cable trenches	1,800,000
Total volume to be deposited in NV East and/or NV West	**3,807,570m^3 foundation pre-sweeping; and 46,800,000m^3 Cable pre-sweeping.**	**50,607,566**
Export cable pre-sweeping within the offshore cable corridor	Based on 2 cable trenches	600,000
Total volume to be deposited in the offshore cable corridor		**600,000**
Maximum amount of sediment to be deposited within the SAC		**500,000**

59. In terms of the deposition of dredged material, the sediment dredged from within the Haisborough, Hammond and Winterton SAC will be deposited within this site to ensure that the sediment remains within the SAC, all other dredged material will be deposited at a suitable location within the disposal sites.

4.2 Drilling

60. Table 4.2 shows the volumes associated with drilling for foundation installation within NV East and/or NV West. The maximum sediment arising during foundation drilling would be from:

- Monopile turbine foundations,
- Accommodation platforms on six-legged foundations (one pile per leg)
- Offshore electrical platforms on six-legged foundations with three piles per leg (18 piles in total) and
- Met masts on quadropods.

61. It should be noted that should piled foundations which require drilling be used, then the volume of pre-sweeping for floating foundations described above would be minimised or avoided.

Table 4.2 Maximum drill arisings during construction

Infrastructure	Worst Case Scenario type	Worst Case Scenario volume (m^3)
Turbines	45 (50%) x 20MW turbines on monopiles	397,608
Offshore electrical platforms	2 x six-legged platforms with three piles per leg	14,137
Accommodation platforms	2 x six-legged platforms with one pile per leg	1,696
Met masts	2 x quadropods	1,131
Lidar	2 x monopile	188
Total		**414,761m^3**

4.3 Programme

62. The full construction window is expected to be up to approximately four years for the full 1800MW capacity. Table 4.3 and Table 4.4 provide indicative construction programmes for the single phase and two phase options, respectively.

Table 4.3: Indicative Norfolk Vanguard construction programme – single phase

		2024				2025				2026				2027				2028			
Indicative Programme	**Approximate duration**	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Foundation installation	20 months																				
Array & interconnector cable installation	19 months																				
Export cable installation	6 months																				
Wind turbine installation	20 months																				
Total construction works	23 months																				

Table 4.4: Indicative Norfolk Vanguard construction programme – two phase

		2024				2025				2026				2027				2028			
Indicative Programme	**Approximate duration**	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Foundation installation	2 x 8 months																				
Array & interconnector cable installation	2 x 7 months																				
Export cable installation	2 x 3 months																				
Wind turbine installation	2 x 8 months																				
Total construction works	2 x 12 months																				

4.4 Daily Disposal Amounts

63. It is anticipated, that approximately 50,000m^3 of daily sediment disposal may be required based on 3 to 4 dredge and deposit activities per day for foundation seabed preparation and/or cable pre-sweeping.

64. It is anticipated that construction of the turbine foundations would either be over a 20 month period under a single phase approach or two 8 month periods under the phased approach. Seabed preparation would be a small proportion of this programme and therefore it can be expected that the daily disposal rate quoted above would only occur for limited and discrete periods within the construction phase.

5 ALTERNATIVES CONSIDERED

5.1 Use of Material for Ballast

65. Where extensive excavation works are required, such as for seabed preparation for foundation installation, it is possible that material could be retained and used for infill works or ballast material, if geotechnically suitable for purpose. Ballast material is heavy material which is used to enhance stability of foundations and is likely to be composed of locally dredged sand.

66. As described above, Norfolk Vanguard Limited is considering the use of several different foundation types. Sand dredged locally during the seabed preparation could be used as ballast material for GBS foundations during the foundation preparation works if geotechnically suitable for purpose (ballast material is likely to be composed of locally dredged sand). The remainder would be disposed of as described in section 4 above.

67. The use of excavated material as ballast would depend on a suitable foundation type being used and the results of detailed post-consent geotechnical investigations. However, for the purposes of the EIA, and as a worst case for this report, it has been assumed that all drilled and dredged material would be disposed of on site, rather than being used as ballast material.

5.2 Other Disposal Sites

68. Through consultation with Natural England during the Norfolk Vanguard Evidence Plan Process it was identified that it is preferable to dispose of dredged sediment as close to the source as possible, in particular in the Haisborough Hammond and Winterton SAC, in order to minimise potential disturbance impacts.

69. However, the suitability and capacity of existing disposal sites within a 50km radius of the Norfolk Vanguard has also been considered (Table 5.1).

Table 5.1Existing Disposal Sites within 60km of the Norfolk Vanguard offshore project area

Site Name	Site ID	Area km^2	Distance from Norfolk Vanguard offshore project area (km)
East Anglia THREE/East Anglia ONE	HU212	935	0
Great Yarmouth	HU150	0.673	19
Cross Sands 2	HU176	0.301	21
Burgh Castle Yacht Station	HU208	0.015	25
Reedham Marina	HU159	0.001	29
Lowestoft Circular North	TH005	0.431	29
Lowestoft Marina Temporary Disposal Site	TH011	<0.001	31
Dudgeon	HU147	55	50

70. The largest sites within 50km of Norfolk Vanguard are East Anglia THREE/East Anglia ONE (HU212) and Dudgeon (HU147). None of the other disposal sites listed in Table 5.1 are considered large enough to accommodate worst case scenario of up to 51,207,566m^3 (50,607,566m^3 within the OWF sites and 600,000m^3 within the proposed section of the offshore cable corridor) of sediment that could require disposal through the construction of Norfolk Vanguard.

71. The East Anglia ONE/East Anglia THREE and Dudgeon disposal sites have been licenced specifically to receive material from within those wind farms and would therefore not be able to receive any material from Norfolk Vanguard.

72. There may also be an option to utilise the material as a form of coastal defence. This approach is currently being proposed for coastal protection at the Bacton Gas Terminal and will require large volumes of sand to be dredged from elsewhere to be brought to the site, however, in this specific case, the project is planned to be completed before Norfolk Vanguard construction commences.

73. Any such use would have to be agreed with all the relevant local authorities and the Environment Agency as part of the strategic approach to Shoreline Management in the region and a further assessment undertaken.

6 POTENTIAL IMPACTS OF DISPOSAL

74. The impact of disposal of material within the OWF sites and offshore cable corridor has been incorporated into impacts assessed within the Norfolk Vanguard EIA and presented within the ES; specifically within Chapter 8 Marine Geology, Oceanography and Physical Processes, Chapter 9 Marine Water and Sediment Quality and Chapter 10 Benthic and Intertidal Ecology. It should be noted however that the impacts presented within the ES assess the impacts of the project as a whole and so the specific parts of the assessment that consider disposal of sediment have been drawn out and are presented below.

75. The assessment methodology for sediment and seabed changes associated with the installation of foundations, array cables and the export cables is provided in Chapter 8 Marine Geology, Oceanography and Physical Processes.

76. The assessment of significance has been based on the following;

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

77. The sensitivity and value of discrete morphological receptors have been assessed using expert judgement and described with a standard semantic scale. Definitions are provided in Chapter 8 Marine Geology, Oceanography and Physical Processes.

78. The magnitude of effect is dependent upon its;

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

79. The magnitude of effect has been assessed using expert judgement and described with a standard semantic scale. Definitions for each term are provided in Chapter 8 Marine Geology, Oceanography and Physical Processes.

80. Within Chapter 8 Marine Geology, Oceanography and Physical Processes of the ES, impacts on the physical characteristics of the site have been assessed. The impacts which contain relevant information for this assessment are as follows:

- Changes in suspended sediment concentrations due to seabed preparation for wind turbine floating foundation installation;
- Changes in suspended sediment concentrations due to drill arisings for installation of piled foundations for wind turbines;
- Changes in seabed level due to seabed preparation for wind turbine foundation installation;
- Changes in seabed level due to drill arisings for installation of piled foundations for wind turbines;
- Changes in suspended sediment concentrations during offshore export cable installation;
- Changes in seabed level due to disposal of sediment from sand wave levelling in the offshore cable corridor;
- Changes in seabed level due to offshore export cable installation;
- Changes in suspended sediment concentrations during array and interconnector cable installation; and
- Changes in seabed level due to array and interconnector cable installation.

81. Chapter 9 Marine Water and Sediment Quality of the ES incorporates the potential effects of disposal on water and sediment quality. This assessment directly builds upon the assessment in Chapter 8 Marine Geology, Oceanography and Physical Processes. The impacts which contain relevant information for this assessment are as follows:

- Deterioration in water quality due to increased suspended sediment concentrations during installation of foundations;
- Deterioration in water quality due to increased suspended sediment concentrations due to drill arisings for installation of piled foundations;
- Deterioration in water quality due to increased suspended sediment concentrations during seabed preparation for the installation of the offshore export cables;
- Deterioration in water quality due to increased suspended sediment concentrations during array and interconnector cable installation; and
- Deterioration in water quality due to re-suspension of sediment bound contaminants.

82. In the ES, Chapter 10 Benthic and Intertidal Ecology incorporates the potential effects of disposal on the biological characteristics of the project. This assessment also builds upon the assessment in Chapter 8 Marine Geology, Oceanography and Physical Processes. The impacts which contain relevant information for this assessment are as follows:

- Temporary habitat loss / disturbance;
- Temporary increase in suspended sediment concentrations and associated sediment deposition; and
- Changes to water quality due to re-mobilisation of contaminated sediments.

83. The impact assessments presented in the ES discuss the impacts of constructing Norfolk Vanguard in one or two phases. The results indicate that there is no material difference in the impacts on marine physical processes, water and sediment quality, or benthic ecology for either phasing option, and therefore phasing is not discussed further in this report.

6.1 Norfolk Vanguard East

6.1.1 Potential Impacts of Sediment Disposal on Physical Characteristics in NV East

84. As discussed in section 1.1, the following infrastructure could be located in NV East (or NV West):

- Between 90 (20MW) and 200 (9MW) wind turbines;
- Up to two offshore electrical platforms;
- Up to two accommodation platforms;
- Up to two met masts;
- A network of up to 600km of array cables; and
- Inter-connector cables joining the electrical platforms.

85. The installation of wind turbine foundations and electrical cables has the potential to disturb sediments from: (i) the seabed (surface or shallow near-surface sediments, e.g. from seabed levelling); and (ii) from several tens of metres below the seabed (sub-surface sediments, e.g. from foundation drilling), depending on installation type and method.

86. Section 4.1, shows that up to 50Mm^3 of sediment arising from seabed preparation could be deposited in NV East.

6.1.1.1 Changes in suspended sediment concentrations due to foundation installation in NV East

87. Foundation installation has the potential to disturb the seabed and shallow near-bed sediments through the dredging required pre-installation and subsequent release of dredged material to the site. In some cases, foundation installation will require drilling activities to be conducted, therefore potentially impacting sub-surface sediments. These impacts are discussed in turn.

6.1.1.1.1 Seabed and shallow near-bed sediments

88. Seabed sediments and shallow near-bed sediments within NV East would be disturbed during any levelling or dredging activities to create a suitable base prior to foundation installation.

89. For a sediment release from a single turbine foundation, the worst case scenario is associated with the dredging volume for each 20MW floating foundation with a gravity anchor. This could result in a maximum preparation area of 90m by 90m. This yields a worst case dredging volume of 40,500m^3 per foundation based on a sediment disturbance depth of 5m.

90. The worst case total volume for the project is based on levelling a 90m by 90m area per floating foundation for up to 90 20MW turbines. The maximum total preparation volume for foundation installation would be approximately 3.81Mm^3 (Table 4.1). This figure includes seabed preparation for 90 wind turbines, two meteorological masts, two electrical platforms and two accommodation platforms on GBS foundations. The worst case total volume of sediment disturbed as a result of cable installation within the OWF sites is estimated to be 46.8Mm^3, this is based on the installation of 600km of array cable, 150km of interconnector cable and 30km of export cable (Table 4.1). The assessment assumes that the sediment would be returned to the water column at the sea surface during disposal from the dredger vessel.

91. This process would cause localised and short-term increases in suspended sediment concentrations both at the point of dredging at the seabed and, more importantly, at the point of its discharge back into the water column.

92. The sediment within NV East is comprised of predominantly medium-grained sand (90-100% sand) with median particle sizes (d_{50}) between 0.20mm and 0.35mm. Once released from the dredger vessel, this coarse sand and the small proportion of gravel, will rapidly (in the order of minutes to tens of minutes) fall to the sea floor as a highly turbid dynamic plume (within a few tens of metres along the axis of tidal flow).

93. Some of the finer sand fraction from the release and the very small proportion of mud that is present are likely to remain in suspension for a longer period of time and form a passive plume which will be advected by tidal currents. Due to the sediment sizes present, this is likely to exist as a measurable but modest concentration (tens of mg/l) plume for around half a tidal cycle (up to six hours) and sediment would fall to the sea bed in relatively close proximity to its release (within a few hundred metres up to around a kilometre along the axis of tidal flow) within a short period of time (hours). Whilst lower suspended sediment concentrations would extend further from the

dredged area, along the axis of predominant tidal flows, the magnitudes would be indistinguishable from background levels.

94. Due to the predominance of medium-grained sand across NV East, the sediment disturbed by the drag head of the dredger at the seabed would remain close to the bed and settle back to the bed rapidly.

95. The conclusions of the assessment on changes in suspended sediment concentrations due to foundation installation in NV East, presented in Chapter 8 Marine Geology, Oceanography and Physical Processes of the ES, are based on the results of modelling simulations undertaken for the East Anglia ONE site (approximately 21km from the Norfolk Vanguard OWF sites) using the Delft3D plume model (ABPmer, 2012b). The sediment types across East Anglia ONE (5% gravel, 93% sand and 2% mud) are similar to those across NV East (3% gravel, 95% sand and 2% mud). Also, the tidal regimes within East Anglia ONE are similar to those in NV East; hence it is considered a suitable study to support the Norfolk Vanguard assessment.

96. In the East Anglia ONE modelling studies (ABPmer, 2012b), consecutive daily releases of 22,500m^3 of sediment (mostly medium-grained sand, but also with small proportions of gravel, other sand fractions and mud) were simulated at the water surface at 15 wind turbine locations. Although, this sediment release is about half the release volume from each of the 20MW wind turbine foundations (40,500m^3), it can still be used as a comparative analogue for a single or two concurrent foundation installations (in NV West or in NV East) to establish the broad magnitude of effect.

97. The ABPmer (2012b) model predicted that close to the release locations, suspended sediment concentrations would be high (orders of magnitude in excess of natural background levels), but of very short duration (seconds to minutes) as the dynamic plume falls to the seabed. Within the passive plume, suspended sediment concentrations above background levels were low (less than 10mg/l) and within the range of natural variability. Net movement of fine-grained sediment retained within the passive plume was to the north, in accordance with the direction of residual tidal flow. Suspended sediment concentrations were predicted to rapidly return to background levels after cessation of the release into the water column.

98. There would be little additional effect of scaling-up from the modelled 15 foundations to the 90 foundations proposed across Norfolk Vanguard because the modelled results show that after completion of installation of a foundation, the suspended sediment concentrations do not persist but rapidly return to background levels. Hence, the release of sediment from one foundation installation would not last for a long enough time to interact with the next installation. This would be the case regardless of the number of foundations that were installed and so the

cumulative effects of 15 and 90 installations would be similarly small. Given this finding from the modelled consecutive installation of 15 wind turbine foundations (ABPmer, 2012b), it is expected that effects from installation of 90 foundations across the whole of Norfolk Vanguard would be similar, although with the point of release moving across the site with progression of the construction sequence.

6.1.1.1.2 Sub-surface sediments

99. Deeper sub-surface sediments within the site could become disturbed during any drilling activities that may be needed at the location of each piled foundation. Although it is not confirmed that drilling will be required the possibility of drilling must be considered as a worst case scenario. Up to 50% of turbines may require drilling activities as part of the foundation installation process. It should be noted that should piled foundations which require drilling be used, then the volume of pre-sweeping for floating foundations described above would be minimised or avoided.

100. The drilling process would result in the production of drill arisings, which would cause localised and short term increases in suspended sediment concentrations at the point of discharge of the drill arisings.

101. The worst case scenario for the total volume of drill arisings released during the construction period would consist of a total of 414,761m^3 for 1800MW capacity in NV East (with 50% of turbine foundations plus other platforms requiring drilling). Although the sub-surface sediment release quantities involved under this worst case scenario for drill arisings are considerably lower than those involved in the worst case scenario for the surface and near-bed sediments from pre-sweeping, the sediment types would differ, with a larger proportion of finer materials and therefore it is important to assess the potential impact of drill arisings.

102. The disturbance effects at each structure location are likely to last for no more than a few days of construction activity. Expert-based assessment suggests that the coarser sediment fractions (medium and coarse sands and gravels) and aggregated 'clasts' of finer sediment would settle out of suspension in relatively close proximity to the foundation location, whilst disaggregated finer sediments (fine sands and muds) would be more prone to dispersion across a wider area. Due to the small quantities of sediment release involved, however, these disaggregated finer sediments are likely to be widely and rapidly dispersed, resulting in only low elevations in suspended sediment concentration until they ultimately come to rest on the seabed.

6.1.1.1.3 Assessment of effect magnitude and / or impact significance

103. The worst case changes in suspended sediment concentrations due to seabed preparation for foundation installation are likely to have the magnitudes of effect shown in Table 6.1.

Table 6.1 Magnitude of effect on suspended sediment concentrations due to foundation installation in NV East under the worst case scenario

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Effect
Near-field*	High	Negligible	Negligible	Negligible	Medium
Far-field	Low	Negligible	Negligible	Negligible	Low

*The near-field effects are confined to a small area, likely to be several hundred metres up to a kilometre from each foundation location.

104. The effects on suspended sediment concentrations due to offshore cable installation (including any sand wave levelling) would have **no impact** upon the marine physical processes of NV East. This is because the processes are active along the seabed and are not affected by sediment suspended in the water column. The impact of suspended sediment on water quality and benthic receptors is discussed in section 6.1.2 and 6.1.3.

6.1.1.2 Changes in seabed levels due to foundation installation in NV East

105. The increases in suspended sediment concentrations associated with the impact discussed in section 6.1.1.1 have the potential to result in changes in seabed levels as the suspended sediment deposits on the surrounding seabed potentially raising the seabed level slightly. There would be different settling rates for the different sediment types associated with the seabed and shallow near-bed sediment disturbance and the deeper sub-surface sediment disturbance, so each is discussed in turn.

6.1.1.2.1 Seabed and shallow near-bed sediments

106. Expert-based assessment suggests that the coarser sediment would rapidly (within the order of minutes or tens of minutes) fall to the bed as a highly turbid dynamic plume immediately upon its discharge, forming a deposit ('mound') local to the point of release. Due to the sediment grain sizes observed across the site (predominantly medium sand or coarser, with very little fine sand or muds), a large proportion of the disturbed sediment would behave in this manner.

107. When the medium sand and courser material settle out the resulting mound would be a measurable protrusion from the sea bed (likely order of tens of centimetres to a few metres in height) but would remain highly localised to the release point. The material within the mound would be similar to that on the existing sea bed and

therefore there would be no significant change in sediment type. Also, the overall change in elevation of the seabed is small compared to the absolute depth of water (greater than 20m). The change in seabed elevation is within the natural change to the bed caused by sand waves and sand ridges and hence the blockage effect on physical processes would be negligible.

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

109. In addition to the local mounds, the very small proportion of mud present within the sediment would form a passive plume and become more widely dispersed before settling on the seabed. The East Anglia ONE modelling (ABPmer, 2012b) considered seabed level changes resulting from deposition of sediments from the passive plume due to seabed preparation for 15 foundations. The deposited sediment layer across the wider seabed was found to be less than 0.2mm thick in most areas and did not exceed 2mm anywhere. The area of seabed upon which deposition occurred (at these low values) extended a considerable distance from the site boundary (around 50km), but in doing so only covered a very narrow width of seabed (a few hundred metres). This is because the dispersion of the plume followed the axis of tidal flow. The previous assessment also concluded that this deposited sediment has the potential to become re-mobilised and therefore would rapidly become incorporated into the mobile seabed sediment layer, thus further reducing any potential effect.

110. Using the plume modelling studies for East Anglia ONE as part of the expert-based assessment suggests that deposition of sediment from the NV East plume would occur across a wide area of seabed and would be very thin (millimetres). Given that the maximum sediment volume released through seabed preparation would be less than the modelled release at East Anglia ONE; the worst case thickness of sediment deposited from the plume will also be less (given similar hydrodynamic conditions). Hence, it is anticipated that the worst case sediment thicknesses at NV East would not likely exceed a maximum of 1.5mm and be less than 0.15mm over larger areas of the seabed.

111. This expert-based assessment is supported by an evidence-base obtained from research into the physical impacts of marine aggregate dredging on sediment plumes and seabed deposits (Whiteside *et al*., 1995; John *et al*., 2000; Hiscock and Bell, 2004; Newell *et al*., 2004; Tillin *et al*., 2011; Cooper and Brew, 2013).

6.1.1.2.2 Sub-surface sediments

112. Expert-based assessment suggests that due to the finer-grained nature of any sub-surface sediment released into the water column from drilling, there would be greater dispersion across a wider area, in keeping with the pattern of the tidal ellipses.

113. The bed level changes that are anticipated would move across the site with progression of the construction sequence as the point of sediment release (and hence geographic location of the zone of effect) changes with the installation at different locations.

114. A very conservative worst case scenario has also been considered whereby the sediment released from the drilling is assumed to be wholly in the form of aggregated 'clasts' of finer sediment that remain on the sea bed (at least initially), rather than being disaggregated into individual fine-grained sediment components immediately upon release. Under this scenario, the worst case assumes that a 'mound' would reside on the sea bed near the site of its release, in this case surrounding the wind turbine foundations.

115. The maximum footprint of an individual mound arising would be 2,356m^2 from a 20MW monopile turbine foundation.

116. The maximum footprint for drilling mounds associated with the whole project would be 414,761m^2 for 100 (50%) of the 9MW monopile foundations, as well as accommodation platforms on six-legged foundations, offshore electrical platforms on six-legged foundations with three piles per leg, and met masts on quadropods.

6.1.1.2.3 Assessment of effect magnitude and/or impact significance

117. The models of East Anglia ONE were successfully calibrated and verified with existing data, and so there is high confidence in the assessment of effects, including their scaling up from modelling results of a sub-set of wind turbines to the whole NV East project area.

118. The changes in seabed levels due to foundation installation under the worst case sediment dispersal scenario are likely to have the magnitudes of effect shown in Table 6.2.

Table 6.2 Magnitude of effects on seabed level changes due to sediment deposition following foundation installation under the worst case sediment dispersal scenario

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Effect
Near-field[1]	Medium	Negligible	Negligible	Negligible	Low
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible

119. It was concluded that the overall impact of foundation installation activities on sea bed levels in NV East would be **negligible impact**.

6.1.1.3 Changes in suspended sediment concentrations during cable installation in NV East

120. The installation of the array, export and interconnector cables has the potential to disturb seabed sediment to a depth of up to 5m. Disturbance could be through levelling of sand waves that may be present along the cables prior to installation or directly through installation of the cable (worst case scenario is jetting) and finally through the disposal of dredged material back onto the site, temporarily increasing sediment concentrations in the water column.

121. Any excavated sediment due to sand wave levelling for the array and interconnector cables would be disposed of within the OWF site itself. For the worst case scenario, it is assumed that sand wave levelling may be required for 100% of the array and interconnector cables, and for up to 30km of export cables in the OWF sites. This equates to a total of approximately 3Mm^3 per square kilometre of seabed (see ES Chapter 8 Marine Geology, Oceanography and Physical Processes for further details).

122. Optimisation of array cable and interconnector cable alignment, depth and installation methods during detailed design would ensure that effects are minimised.

123. The direct impact of change to the substrate elevation is likely to affect a about 2% of the OWF sites given the sediment characteristics. In addition, the dynamic nature of the sandwaves in this area means that any direct changes to the seabed associated with sandwave levelling are likely to recover over a short period of time due to natural sand transport pathways.

124. Any excavated sediment due to sandwave levelling for the array, interconnector and sections of export cables would be disposed of within the Norfolk Vanguard OWF sites. This means there will be no net loss of sand within the site. It is likely that some of this sand could be disposed on the upstream side of the cable where tidal currents would, over time, re-distribute the sand back over the levelled area (as re-formed sand waves). The overall effect of changes to the seabed would therefore be minimal. The

[1] The near-field effects are confined to a small area of seabed (likely to be several hundred metres up to a kilometre from each foundation location) and would not cover the whole of Norfolk Vanguard.

predominance of medium-grained sand (which represents most of the disturbed sediment) means that most of the sediment would settle out of suspension within a few tens of metres along the axis of tidal flow from the point of installation along the cable and persist in the water column for less than a few tens of minutes.

125. Mud-sized material (which represents only a very small proportion of the disturbed sediment) would be advected a greater distance and persist in the water column for longer and form a passive plume which would become advected by tidal currents. Due to the sediment sizes present, this is likely to exist as a measurable but modest concentration plume (tens of mg/l) for around half a tidal cycle. Sediment would eventually settle to the seabed in proximity to its release (within a few hundred metres up to around a kilometre along the axis of tidal flow) within a short period of time (hours). Whilst lower suspended sediment concentrations would extend further from the cable, along the axis of predominant tidal flows, the magnitudes would be indistinguishable from background levels.

6.1.1.3.1 Assessment of effect magnitude and / or impact significance

126. The worst case changes in suspended sediment concentrations due to array cable and interconnector cable installation (including any necessary sand wave levelling) are likely to have the magnitudes of effect described in Table 6.3.

Table 6.3 Magnitude of effect on suspended sediment concentrations due to cable installation in NV East under the worst case scenario

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Effect
Near-field* (offshore)	Low	Negligible	Negligible	Negligible	Low
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible

*The near-field effects are confined to a small area of seabed (likely to be of the order of several hundred metres up to a kilometre from the cable), and would not cover the entirety of the seabed area within Norfolk Vanguard or the entirety of the cable corridor.

127. Overall, these effects will have **no impact** on identified receptors associated with the suspended sediment generated by disposal of material due to interconnector and array cable installation in NV East.

6.1.1.4 Changes in seabed levels during cable installation in NV East

128. The increases in suspended sediment concentrations associated with the impact described in section 6.1.1.3 have the potential to result in changes in seabed levels as the suspended sediment deposits on the seabed.

129. Expert-based assessment suggests that coarser sediment disturbed during cable installation (including pre-sweeping) would fall rapidly to the seabed (minutes or tens

of minutes) as a highly turbid dynamic plume immediately after it is discharged. Deposition of this sediment would form a linear mound (likely to be tens of centimetres high) parallel to the cable as the point of release moves along the excavation. Due to the coarser sediment particle sizes observed across the site (predominantly medium-grained sand), a large proportion of the disturbed sediment would behave in this manner and be similar in composition to the surrounding seabed. This would mean that there would be no significant change in seabed sediment type.

130. A very small proportion of mud would also be released to form a passive plume and become more widely dispersed before settling on the seabed. Expert-based assessment suggests that due to the dispersion by tidal currents, and subsequent deposition and re-suspension, the deposits across the wider seabed would be very thin (millimetres).

6.1.1.4.1 Assessment of effect magnitude and / or impact significance

131. Expert-based assessment indicates that changes in suspended sediment concentration due to array cable and interconnector cable installation (including any deposition arising from spilled sediment from sand wave levelling) would be minor and are likely to have the magnitudes of effect shown in Table 6.4.

Table 6.4 Magnitude of effect on seabed level changes due to array cable interconnector and export cable installation in NV East (including sand wave levelling) under the worst case scenario

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Effect
Near-field*	Low	Negligible	Negligible	Negligible	Low
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible

*The near-field effects are confined to a small area of seabed (likely to be of the order of several hundred metres up to a kilometre from the cable), and would not cover the whole of Norfolk Vanguard.

132. These effects on seabed level are considered highly unlikely to have the potential to impact directly upon the identified receptor groups for marine physical processes. Any impacts will be of a significantly lower magnitude than those seabed level impacts already considered for the installation of foundations. Consequently, the overall impact of array cable and interconnector cable installation activities under a worst case scenario on seabed level changes for identified morphological receptor groups is therefore considered to be **negligible impact** in NV East.

6.1.1.5 Summary of impacts of sediment disposal on physical characteristics in NV East

133. As the conclusion of all relevant impacts on physical characteristics was that there would be negligible impact, it is unlikely that there would be any discernible effect on the physical characteristics of the sites due to the proposed sediment disposal.

6.1.2 Potential Impacts of Sediment Disposal on Water and Sediment Quality in NV East

134. Disposal of sediment has the potential to change water quality, either through increased sediment concentrations resulting from the disposal plume or impacts associated with the release of sediment bound contaminants. This is considered in detail in Chapter 9 Marine Water and Sediment Quality of the ES.

135. A summary of the potential impacts to water and sediment quality due to sediment disposal is summarised below.

6.1.2.1 Change in water quality due to re-suspension of sediments in NV East

136. Seabed sediments and shallow near-bed sediments within NV East would be disturbed during any levelling or dredging activities to create a suitable base prior to the installation of foundations. The worst case scenario assumes that sediment would be dredged and returned to the water column at the sea surface as overflow from a dredging vessel. This process would cause localised and short-term increases in suspended sediment concentrations both at the seabed and at the point of discharge into the water column, however the disturbance effect at each wind turbine location are likely to last for no more than a few days.

137. Section 6.1.1.1 outlines the volumes of sediment that will be disposed of in NV East in the worst case scenario of foundations, export cable and array and interconnector cable installation.

6.1.2.1.1 Assessment of effect magnitude and / or impact significance

138. The changes in suspended sediment concentrations due to seabed preparation are predicted to be low in magnitude due to the localised and short term nature of the predicted sediment plumes. Baseline conditions of suspended sediment concentrations are expected to return to normal rapidly following cessation of activity, therefore any impact will only be present during the installation process. The sensitivity in the offshore project area is deemed to be low due to the large volume of the receiving water and the capacity for dilution and flushing and therefore a **minor adverse** impact significance is predicted.

6.1.2.2 Change in water quality in NV East due to re-suspension of contaminants within sediment

139. The disposal of dredged material has the potential to release sediment-bound contaminants, such as heavy metals and hydrocarbons, into the water column.

140. The data discussed in section 3.2 of this report shows that the levels of contaminants within the NV East site are very low, with no reported exceedance of Cefas Action

Level 1 during sampling undertaken in 2016. Therefore, the potential magnitude of the effect is considered negligible.

6.1.2.2.1 Assessment of effect magnitude and / or impact significance

141. As a result of the negligible magnitude of effect and low receptor sensitivity, the re-suspension of contaminated sediment from construction activities is considered to be of **negligible** significance.

6.1.2.3 Summary of impacts of sediment disposal on water and sediment quality in NV East

142. As the conclusion of all relevant impacts on water and sediment quality was that they would be of minor and negligible significance it is considered that, should NV East be designated a disposal site, impacts to water and sediment quality would be of no greater than **minor adverse** significance.

6.1.3 Potential Impacts of Sediment Disposal on Benthic Ecology in NV East

143. Chapter 10 Benthic and Intertidal Ecology of the ES provides a detailed assessment of the impacts of the project on benthic habitats and species. Provided below is a summary of the important findings which relate to the disposal of sediment.

6.1.3.1 Increased suspended sediment concentrations

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

145. The worst case scenario would result in 50,607,566m^3 of sediment being disposed of in NV East due to seabed preparation (sand wave levelling of up to 5m) for the following:

- Foundations;
  - 90 turbines on floating foundations with gravity anchors with 90m by 90m preparation diameter;
  - Two offshore electrical platforms and two accommodation platforms with 7,500m^2 preparation areas each;
  - Up to 60m diameter pre-sweeping for two met masts;
- Cable installation with 20m disturbance width;

- 30km of export cables;
- 600km of array cables; and
- 150km of interconnector cables.

146. As discussed in section 6.1.1.1 the sediment in NV East is predominantly medium grain sand with very small percentages of mud and gravel. As a result, this sediment would fall as a highly turbid dynamic plume upon its discharge, reaching the seabed within minutes or tens of minutes and within tens of metres along the axis of tidal flow from the location at which it was released. The resulting mound would be likely to be tens of centimetres to a few metres high. The small proportion of fine sand and mud would stay in suspension for longer and form a passive plume. This plume (tens of mg/l) would be likely to exist for around half a tidal cycle (i.e. approximately 6 hours). Sediment would settle to the seabed within approximately 1km along the axis of tidal flow from the location at which it was released. These deposits would be very thin (millimetres).

147. Additionally, the potential sediments raised from drillings may form clasts on the seabed, however this would be temporary and within the seabed preparation footprint.

6.1.3.1.1 Assessment of effect magnitude and / or impact significance

148. The sensitivity of the receptors in NV East to increases in suspended sediments and smothering are shown below in Table 6.5. Sensitivity to increased suspended sediments and light smothering is shown to be low or 'not sensitive'. No information is available on the sensitivity to heavy smothering (around 30cm or greater), a conservative medium sensitivity is assumed for the assessment. As discussed above, this level of impact could occur within a few meters of the disposal location for Norfolk Vanguard and is deemed to have low magnitude. The worst case scenario is an impact of **minor adverse** significance.

Table 6.5 Sensitivities to increased suspended sediment and smothering by deposited sediment (source: Tyler-Walters, Lear and Allen, 2004; Ager, 2005; Tillin 2015)

Receptor	Tolerance	Recoverability	Overall sensitivity
Light smothering – up to 5cm			
Circalittoral coarse sediment biotopes	Moderate	High	Low
***N. cirrosa* (using *N. hombergii* as a proxy)**	Tolerant	N/A	Not sensitive
S. spinulosa	Low	Immediate	Not sensitive
S. bombyx	Low	High	Low
Heavy smothering – up to 30cm			
Circalittoral coarse sediment biotopes	Not available		

Receptor	Tolerance	Recoverability	Overall sensitivity
***N. cirrosa* (using *N. hombergii* as a proxy)**	Not available		
S. spinulosa	Not available		
S. bombyx	Not available		
Increased Suspended Sediment Concentrations			
Circalittoral coarse sediment biotopes	High	High	Not sensitive
***N. cirrosa* (using *N. hombergii* as a proxy)**	Tolerant	N/A	Not sensitive
S. spinulosa	Low	Immediate	Not sensitive
S. bombyx	Tolerant	N/A	Not sensitive

6.1.3.2 Re-mobilisation of contaminated sediments

149. Given the low level of contaminants present in the sediments within NV East (see section 3.2), changes in water and sediment quality throughout the study area due to re-suspension of contaminants during construction have been assessed as minor.

150. Marine Evidence based Sensitivity Assessment (MarESA) (MarLIN, 2017) shows that, where contaminants levels are within environmental protection standards, marine species and habitats are not sensitive to changes that remain within these standards.

151. All construction activities will be covered by a Construction Environmental Management Plan (CEMP) as well as emergency plans in the case of an accidental spillage or leak to ensure no release of contaminants as a result of the project. In addition to this, all vessels must adhere to the requirements of the MARPOL Convention Regulations with appropriate preventative and control measures.

6.1.3.2.1 Assessment of effect magnitude and / or impact significance

152. As a result of the absence of existing contamination and mitigation to avoid release of contaminants, there would be **no impact** to the benthic or intertidal ecology.

6.1.3.3 Summary of impacts of sediment disposal on benthic ecology in NV East

153. As the conclusion of all relevant impacts on benthic ecology was that they would range from no impact to minor adverse significance it is considered that, should the proposed NV East disposal site be designated, impacts would occur to benthic species however these would be no greater than of minor adverse significance.

6.2 Norfolk Vanguard West

6.2.1 Potential Impacts of Sediment Disposal on Physical Characteristics in NV West

154. The particle size characteristics of all the seabed sediment samples collected in NV West (a total of 48) are presented in Appendix 8.2 of the ES. The dominant sediment type is medium-grained sand with median particle sizes mainly between 0.32 and 0.39mm. The mud content is less than 5% in 75% of the samples. However, 15% of the samples contain greater than 10% mud, ranging from 10% to 77%. The gravel content varies from zero to 10% in 98% of the samples.

155. These substrate types, as well as sediment transport, wave and tidal processes, are similar to NV East. The maximum infrastructure that could be installed in NV West would be the same as NV East and therefore the potential impacts are as described in section 6.1.1 for NV East.

6.2.2 Potential Impacts of Sediment Disposal on Water and Sediment Quality in NV West

156. The disposal of dredged material has the potential to release sediment-bound contaminants, such as heavy metals and hydrocarbons, into the water column.

157. The data discussed in section 3.2 of this report shows that the levels of contaminants within NV West are very low, with marginal exceedances of arsenic which are deemed to be from natural sources. Therefore, the potential magnitude of the effect is considered **negligible**.

6.2.3 Potential Impacts of Sediment Disposal on Benthic Ecology in NV West

6.2.3.1 Increased suspended sediment concentrations

158. The sensitivity of the receptors in NV West to increases in suspended sediments and smothering are shown below in Table 6.6. The majority of receptors in NV West are not sensitive to increased suspended sediments and smothering. *S. spinulosa* and *S. bombyx* use sediment to build tubes and can therefore thrive in environments with increased suspended sediments. The maximum sensitivity is shown for *S. spinulosa,* where smothering reaches a level at which there is no tolerance, in which case the recoverability would be medium when the deposited sediments disperse resulting in medium sensitivity.

159. The maximum infrastructure requirements and therefore potential suspended sediment volumes could either be located in NV East or NV West and therefore the impact magnitude would be low as described in section 6.1.3.1.1.

160. This type of impact could occur within a few meters of the disposal location for Norfolk Vanguard and is discussed above, this represents a low magnitude. The worst case scenario is therefore an impact of **minor adverse** significance.

Table 6.6 Sensitivities to increased suspended sediment and smothering by deposited sediment (source: Tyler-Walters, Lear and Allen, 2004; Tillin et al., 2015; Jackson & Hiscock, 2008; Ager, 2005)

Receptor	Tolerance	Recoverability	Overall sensitivity
Light smothering – up to 5cm			
Circalittoral coarse sediment biotopes	Moderate	High	Low
***S. spinulosa* on stable circalittoral mixed sediment**	High	High	Not sensitive
S. spinulosa	Low	Immediate	Not sensitive
S. bombyx	Low	High	Low
A. alba	Low	Immediate	Not sensitive
Heavy smothering – up to 30cm			
Circalittoral coarse sediment biotopes	Not available		
***S. spinulosa* on stable circalittoral mixed sediment**	None	Medium	Medium
S. spinulosa	Not available		
S. bombyx	Not available		
A. alba	Not available		
Increased Suspended Sediment Concentrations			
Circalittoral coarse sediment biotopes	High	High	Not sensitive
***S. spinulosa* on stable circalittoral mixed sediment**	High	High	Not sensitive
S. spinulosa	Low	Immediate	Not sensitive
S. bombyx	Tolerant	N/A	Not sensitive
A. alba	Tolerant	N/A	Not sensitive

6.2.3.2 Re-mobilisation of contaminated sediments

161. Given the low level of contaminants present in the sediments within the NV West site (see section 3.2), changes in water and sediment quality throughout the study area due to re-suspension of contaminants during construction have been assessed as negligible.

162. Marine Evidence based Sensitivity Assessment (MarESA) (MarLIN, 2017) shows that, where contaminants levels are within environmental protection standards, marine species and habitats are not sensitive to changes that remain within these standards.

163. All construction activities will be covered by a CEMP as well as emergency plans in the case of an accidental spillage or leak to ensure no release of contaminants as a result of the project. In addition to this, all vessels must adhere to the requirements of the MARPOL Convention Regulations with appropriate preventative and control measures.

6.2.3.2.1 Assessment of effect magnitude and / or impact significance

164. As a result of the absence of existing contamination and mitigation to avoid release of contaminants, there would be **no impact** to the benthic or intertidal ecology.

6.2.3.3 Summary of impacts of sediment disposal on benthic ecology in NV West

165. As the conclusion of all relevant impacts on benthic ecology was that they would range from no impact to minor adverse significance it is considered that, should the proposed NV West disposal site be designated, impacts would occur to benthic species however these would be no greater than **minor adverse** significance.

6.3 Offshore cable corridor

6.3.1 Potential Impacts of Sediment Disposal on Physical Characteristics in the offshore cable corridor

166. A total of four HVDC cables will connect the offshore wind farm to landfall. These cables will be installed in two trenches (two cables per trench), with a maximum total trench length of 200km. In terms of the worst case scenario. The sediment released due to disposal of pre-swept sediment in the offshore cable corridor would equate to approximately 600,000m^3. The sediment released at any one time would be subject to the capacity of the dredger (s); however as agreed with Natural England, disposal would be at least 50m from *Sabellaria* reef identified during pre-construction surveys.

167. Trenching for the offshore export cables would be back filled either naturally or through the use of a trenching tool with no sediment disposal and therefore this is not discussed further in this report, but is assessed in the ES.

6.3.1.1 Potential Impacts of Sediment Disposal on Physical Characteristics in the SAC

168. The southern portion of the Haisborough, Hammond and Winterton SAC is comprised of a series of sand ridges. These sand bank features are a primary reason for the designation of the SAC and the driving mechanisms for the formation and maintenance of these banks includes physical characteristics; tidal currents, waves and sea-level change, whilst sediment transport (supply to/loss from) is also important in enabling growth or decay.

169. The SAC is designated for two Annex I habitats 'Sand banks slightly covered by sea water all the time' and 'Reefs' formed by *Sabellaria spinulosa*. The Conservation Objectives for this SAC are:

- Maintain the Annex I Sand banks in Favourable Condition, implying that existing evidence suggests the feature to be in favourable condition; and
- Maintain or restore the Annex I reefs in Favourable Condition, implying that the feature is degraded to some degree.

170. The Information to Support the HRA (document 5.3) provides an assessment of the potential effects associated with Norfolk Vanguard in relation to these conservation objectives.

6.3.1.2 Changes in Suspended Sediment Concentrations during export cable installation in the offshore cable corridor

171. There are similarities in water depth, sediment types and metocean conditions between the offshore cable corridor for Norfolk Vanguard and the East Anglia ONE OWF. Hence, the earlier modelling studies (discussed in section 6.1.1.1) provide a suitable analogue for the present assessments and the sediment would be dispersed in a similar manner.

172. In water depths greater than 20m LAT, peak suspended sediment concentrations would be typically less than 100mg/l, except in the immediate vicinity (a few tens of metres) of the release location.

173. Following cessation of installation activities, any plume would have been fully dispersed as a result of advection and diffusion. Sediments arisings from the offshore cable corridor would tend to be advected to the north.

6.3.1.2.1 Assessment of effect magnitude and / or impact significance

174. The effects on suspended sediment concentrations due to offshore cable installation (including any sand wave levelling) would have **no impact** upon the offshore cable corridor (including within the Haisborough, Hammond and Winterton SAC) for marine physical processes. This is because the receptors are dominated by processes that are active along the seabed and are not affected by sediment suspended in the water column.

6.3.1.3 Changes in Seabed Levels during to export cable installation in the offshore cable corridor

175. The increases in suspended sediment concentrations associated with the impact discussed above (section 6.3.1.2) has the potential to result in changes in seabed levels as the suspended sediment deposits on the seabed.

176. The East Anglia ONE plume modelling simulations (ABPmer, 2012b) suggest that sand-sized material (which represents most of the disturbed sediment) would settle out of suspension within less than 1km from the point of installation within the offshore cable corridor and persist in the water column for less than a few tens of minutes. Due to the coarser sediment particle sizes observed across the site (predominantly medium-grained sand), a large proportion of the disturbed sediment would behave in this manner.

177. The footprint and thickness of the disposed sediment would be dependent on the method of placement, the volume deposited at any one time, the local water depth and the ambient environmental conditions during disposal. The ABPmer sandwave bed levelling assessment (Appendix 7.1 of the Information to Support the HRA, document 5.3) concludes that the spoil would be likely to range from 0.05m to 4.2m. Sandwaves within the indicative spoil zone typically have amplitudes of 3 to 6 m and wavelengths of about 100m. Therefore, there is already some variation in seabed depths within the disposal area and depending on the deposition characteristics (i.e. location, thickness and extent) the result would likely be within the range already encountered within the indicative spoil zone.

178. The commitment to keep the dredged sand within the sandbank system of the SAC enables the sand to become re-established within the local sediment transport system by natural processes and encourages the re-establishment of the bedform features. Appendix 7.1 of the Information to Support the HRA (document 5.3) estimates transport rates for sand within the SAC of between $0.01m^3/m/$ hr to $3.4m^3/m/$ hr, which are also within the range modelled for the wider region of the Southern North Sea (HR Wallingford, 2012).

6.3.1.3.1 Assessment of effect magnitude and / or impact significance

179. The East Anglia ONE plume modelling simulations discussed above and the ABPmer sandwave levelling assessment indicates that the changes in seabed elevation would be temporary and within the existing variation in seabed morphology. This means that, given these low magnitude changes in seabed level arising from sediment disposal the impact on bed level changes is considered to be of **negligible impact** for offshore cable corridor (including within the SAC).

6.3.1.4 Summary of impacts of sediment disposal on physical characteristics in the offshore cable corridor

180. As the disposal of sediment would be local to dredged area there will be no net gain or loss of sediment from the offshore project area. Therefore, it is considered that there would be no significant impact to the physical characteristics of the section of the offshore cable corridor proposed for designation as a result of installation of the offshore export cable.

6.3.2 Potential Impacts of Sediment Disposal on Water and Sediment Quality in the offshore cable corridor

181. Disposal of sediment within the offshore cable corridor has the potential to change water quality, either through increased sediment concentrations in the water column or impacts associated with the release of sediment bound contaminants.

6.3.2.1 Change in water quality due to re-suspension of sediments

182. Following deposition of sediment arising from pre-sweeping, coarse sediment would settle rapidly to the seabed. Mud-sized material (which represents only a very small proportion of the disturbed sediment) would be advected a greater distance and persist in the water column for longer and form a passive plume which would become advected by tidal currents. Due to the sediment sizes present, this is likely to exist as a measurable but modest concentration plume (tens of mg/l) for around half a tidal cycle. Sediment would eventually settle to the seabed in proximity to its release (within a few hundred metres up to around a kilometre along the axis of tidal flow) within a short period of time (hours). Whilst lower suspended sediment concentrations would extend further from the cable, along the axis of predominant tidal flows, the magnitudes would be indistinguishable from background levels.

183. The magnitude of the impact is therefore anticipated to be low and, combined with low sensitivity of the receptor, the overall significance is predicted to be **minor adverse**.

6.3.2.2 Change in water quality due to re-suspension of contaminants within sediment

184. Disturbance of seabed sediments has the potential to release any sediment-bound contaminants, such as heavy metals and hydrocarbons, into the water column. The data in section 3.2 indicates the low levels of contaminants in the sediment within the offshore cable corridor; only one marginal exceedance in Cefas Level 1 for Arsenic is reported.

185. As a result of the low magnitude of effect, the re-suspension of contaminated sediment from construction activities is considered to be of **negligible** significance.

6.3.2.3 Summary of impacts of sediment disposal on water and sediment quality in the offshore cable corridor

186. As the worst case conclusion of all relevant impacts on the physical characteristics of the offshore cable corridor was **minor adverse** significance, there will be no greater impact on the water and sediment quality within the offshore cable corridor as a result of sediment extraction and subsequent disposal required for the installation of the offshore export cable.

6.3.3 Potential Impacts of Sediment Disposal on Benthic Ecology in the offshore cable corridor

6.3.3.1 Increased suspended sediment concentrations

187. As discussed in previous sections, there are likely to be increases in suspended sediment concentrations in the water column due to activities relating to the export cable installation.

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

6.3.3.1.1 Assessment of effect magnitude and / or impact significance

189. The sensitivity of these receptors to increases in suspended sediments and smothering are shown below in Table 6.7. As some areas of potential *S. spinulosa* reef were found along the offshore cable corridor, there is the potential for these areas to be impacted by increased suspended sediment concentrations and smothering. As *S. spinulosa* rely on suspended solids in order to filter feed and build tubes, they are often found in areas of high levels of turbidity and have been found to maintain a cumulative growth rate a few hundred metres from primary aggregate extraction sites (Davies *et al.,* 2009).

Table 6.7 Sensitivities to increased suspended sediment and smothering by deposited sediment (source: Tillin, 2016; Tillin & Marshall, 2015; Tillin, 2016b)

Receptor	Tolerance	Recoverability	Overall sensitivity
Light smothering – up to 5cm			
Circalittoral coarse sediment	Not available		
Circalittoral mixed sediment	Not available		

Receptor	Tolerance	Recoverability	Overall sensitivity
***Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel**	Medium	High	Low
***Sabellaria spinulosa* on stable circalittoral mixed sediment**	High	High	Not sensitive
***Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand**	Not available		
Heavy smothering – up to 30cm			
Circalittoral coarse sediment	Not available		
Circalittoral mixed sediment	Not available		
***Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel**	Medium	Medium	Medium
***Sabellaria spinulosa* on stable circalittoral mixed sediment**	None	Medium	Medium
***Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand**	Not available		
Increased Suspended Sediment Concentrations			
Circalittoral coarse sediment	Not available		
Circalittoral mixed sediment	Not available		
***Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel**	Medium	High	Low
***Sabellaria spinulosa* on stable circalittoral mixed sediment**	High	High	Not sensitive
***Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand**	High	High	Not sensitive

190. As shown in Table 6.7, the greatest overall sensitivity of biotopes recorded within the offshore cable corridor to smothering or increased suspended sediment is likely to be medium, with this occurring when between 5cm and 30cm of sediment is deposited on the receptor.

191. Any disposal would be located to avoid Sabellaria reef and therefore the sensitivity of receptors is considered to be low, resulting in an impact of **minor adverse** significance.

6.3.3.2 Re-mobilisation of contaminated sediments

192. Given the low level of contaminants present in the sediments within the offshore cable corridor (Table 3.3), changes in water and sediment quality throughout the study area due to re-suspension of contaminants during construction have been assessed as negligible.

193. Marine Evidence based Sensitivity Assessment (MarESA) (MarLIN, 2017) shows that, where contaminants levels are within environmental protection standards, marine species and habitats are not sensitive to changes that remain within these standards.

194. All construction activities will be covered by a CEMP (as well as emergency plans in the case of an accidental spillage or leak to ensure no release of contaminants as a result of the project. In addition to this, all vessels must adhere to the requirements of the MARPOL Convention Regulations with appropriate preventative and control measures.

6.3.3.2.1 Assessment of effect magnitude and / or impact significance

195. As a result of the absence of existing contamination and mitigation to avoid release of contaminants, there would be **no impact** to the benthic or intertidal ecology.

6.3.3.3 Summary of impacts of sediment disposal on benthic ecology in the offshore cable corridor

196. As the conclusion of all relevant impacts on benthic ecology was that they would range from **no impact** to **minor adverse** significance it is considered that, should the proposed disposal site be designated within the offshore cable corridor, impacts would occur to benthic species however these would be no greater than of minor adverse significance.

6.4 Cumulative impacts

197. Given that only minor impacts are predicted within NV East, NV West and the section of the cable corridor which is proposed to be designated as a disposal site there is not predicted to be any cumulative effects between each site's associated disposal activities.

198. Consideration is given in ES Chapters 8, 9 and 10 to potential cumulative effects on the seabed (and therefore on the marine physical processes, water and sediment quality and benthic ecology) associated with other plans and projects. Those of relevance to sediment disposal are:

- Installation of foundation structures for Norfolk Vanguard and installation of the proposed East Anglia THREE and Norfolk Boreas projects;
- Installation of the offshore export cable for Norfolk Vanguard and Norfolk Boreas; and
- Installation of the offshore export cable for Norfolk Vanguard and marine aggregate dredging activities in adjacent areas of the seabed.

6.4.1 Cumulative Impacts on Physical Characteristics as a Result of Adjacent Wind Farms

199. The impacts of the foundation and offshore cable installation activities were identified to be of negligible impact for Norfolk Vanguard alone.

200. The construction programmes of NV East, East Anglia THREE, and/or Norfolk Boreas may overlap depending on the final construction programmes. The Norfolk Vanguard cable corridor and its landfall would be common to the Norfolk Boreas project and so there is potential for cumulative impacts to arise during construction.

201. The worst case scenario from a marine physical processes perspective would be for all projects to be constructed at the same time. This would provide the greatest opportunity for interaction of sediment plumes and a larger change in seabed level during their construction. The combined change in seabed level sediment plume from foundation and cable installation could have a greater spatial extent and be greater in a vertical sense than each individual project.

202. As for Norfolk Vanguard alone, the majority of suspended sediment arising from each project would fall rapidly to the seabed after the start of construction and therefore the potential cumulative impact would be of negligible magnitude. The receptor sensitivity would also be negligible and therefore it is considered that the cumulative impact of two or three projects constructing in this area at the same time would be **negligible.**

6.4.2 Cumulative Impacts on Physical Characteristics as a Result of Marine Aggregate Dredging

203. In order to assess the potential for cumulative effects between the installation of the offshore cable and marine aggregate dredging activities in adjacent areas of the seabed, reference has been made to the EIA for the East Anglia ONE project. Although the cable corridor location is different, the results in relation to physical processes provide a useful and appropriate analogy for Norfolk Vanguard.

204. The East Anglia ONE EIA was supported by numerical modelling, using Delft3D plume modelling software, of the potential for interactions of sediment plumes arising from offshore cable installation with those arising from marine aggregate dredging sites (and indeed other seabed activities) located within one spring tidal excursion distance from the East Anglia ONE offshore cable corridor. The modelling showed that some interaction could potentially occur between dredging plumes and plumes from cable installation and that the spatial extent of the combined plume is slightly greater than for the plumes originating from the offshore cable installation only. Whilst maximum plume concentrations would be no greater under the cumulative scenario, a larger geographical area might experience increases in suspended

sediment concentrations than for the offshore cable installation only scenario. Following cessation of cable burial and aggregate dredging activities, a few hundred metres away from the immediate release locations maximum theoretical bed level changes of up to 2mm were identified by the model, with maximum levels of around 0.8mm at greater distances.

205. Norfolk Vanguard is located over 5km from the nearest aggregate extraction site (North Cross Sands). Considering the results from East Anglia ONE described above, the potential cumulative impacts between offshore cable installation for Norfolk Vanguard and nearby marine aggregate dredging activities would be **negligible** as a conservative estimate.

6.4.3 Cumulative Impacts on Marine Water and Sediment Quality as a Result of Adjacent Wind Farms

206. As described above, the short duration of sediment disturbance anticipated during these installation activities means that changes in water quality due to sediment plumes would be temporary and short term.

207. As a result, it is considered that the cumulative impact for two or three projects would not increase the impact significance predicted as a result of construction of Norfolk Vanguard alone (i.e. either **minor adverse or negligible** impact significance).

6.4.4 Cumulative Impacts on Marine Water and Sediment Quality as a Result of Marine Aggregate Dredging

208. The maximum plume concentrations associated with Norfolk Vanguard and Marine Aggregate dredging would be no greater overall (as shown by modelling for the East Anglia ONE EIA) and therefore the cumulative impact magnitude would be low. As Norfolk Vanguard is located over 5km from the nearest aggregate extraction site the potential risk of plumes overlapping would be less than assessed for East Anglia ONE.

209. As a result, it is considered that the potential cumulative impacts would also be of low magnitude. With the sensitivity of the water being low, an overall impact significance of **minor adverse** is predicted.

6.4.5 Cumulative Impacts on Benthic Ecology as a Result of Suspended Sediment Concentrations and Associated Sediment Deposition in the OWF Sites

210. As there is no physical overlap with the Norfolk Vanguard OWF sites and other projects, the potential cumulative impacts on benthic ecology are limited to those associated with increased suspended sediment from the adjacent Norfolk Boreas and East Anglia THREE projects.

211. There is potential for the construction phase of NV East to overlap with Norfolk Boreas and East Anglia THREE. The majority of suspended sediment from Norfolk Vanguard is expected to settle to the seabed within tens of metres of the source location and the small proportion of fine sand and mud would settle to the seabed within approximately 1km forming a very thin deposit (millimetres) with the sediment travelling with the tidal flow. The East Anglia THREE EIA (EATL, 2015) provides similar estimates and it is assumed that the Norfolk Boreas impacts will be comparable. Cumulative impacts would only occur if sediment is deposited at locations on the edge of each wind farm, within range of potential overlap of sediment deposition. This will be few in number and as the cumulative impact of deposition would only be millimetres in sediment depth the cumulative impact would be **negligible** at these edge locations, with **no impact** for the majority of locations within the OWF sites.

6.4.6 Cumulative Impacts on Benthic Ecology as a Result of Marine Aggregate Dredging

212. As discussed above, theoretical bed level changes of up to 2mm are estimated as a result of cumulative impacts from the Norfolk Vanguard cable installation and dredging at nearby aggregate sites. The sensitivity of benthic receptors to this level of change would be as described in Section 6.3 and the magnitude of this level of change is negligible and therefore the cumulative impact significance will be **negligible.**

7 SUMMARY

213. As part of the DCO application for the proposed Norfolk Vanguard project, Norfolk Vanguard Limited is applying to designate the Norfolk Vanguard OWF sites (NV East and NV West) and a section of the offshore cable corridor as disposal sites. This would allow Norfolk Vanguard Limited to dispose of material extracted during construction drilling and seabed preparation (dredging) for associated cable and foundation works. The sea bed sediments in each disposal site are predominantly sand.

214. The following alternative disposal options have been considered for the disposal of drilled and dredged material:

- Use of the material for ballast for certain foundation types;
- Use of material for coastal defence; and
- Use of other existing disposal sites.

215. Worst case scenarios for maximum quantities of material which would need to be excavated for foundations and cable pre-sweeping are provided along with maximum quantities of material released should piled foundations be utilised.

216. The results show that the sediment deposited following pre-sweeping would remain of a similar nature to the adjacent ambient sea bed sediments. Consequently, any subsequent transport would occur at the same time and in the same manner as the ambient sea bed sediments.

217. Release of sediment within NV East and/or NV West would result in finer grained material associated with the passive plume phase deposited over a wide area with a deposited sediment layer predicted of less than <0.2 mm thick. Under the prevailing hydrodynamic conditions, this material would be readily re-mobilised and would therefore quickly be incorporated into the mobile surficial sea bed sediment layer.

218. The footprint and thickness of the sediment deposited in the offshore cable corridor would be dependent on the method of placement, the volume deposited at any one time, the local water depth and the ambient environmental conditions during disposal. The spoil height is likely to be within the range of seabed morphology already encountered within the indicative spoil zone. The deposited sediment would then be incorporated back into the natural sediment transport processes.

219. Sand sized material from drilling would settle out of suspension within 1km of the release location and persist in the water column for no more than tens of minutes. Once this material has settled to the sea bed, it would quickly be incorporated into the natural mobile bed regime.

220. Effects from any one foundation installation are unlikely to persist long enough in the same locality to significantly interact with subsequent operations and so no cumulative effects are expected.

221. No significant changes in water quality as a result of sediment contaminant release are expected due to the low levels of existing contaminants and therefore, no resultant impacts on the benthic fauna are predicted.

222. The marine fauna present within disposal sites are largely tolerant of the increases in sediment suspension and deposition predicted and therefore would not be significantly impacted by the proposed designation of the disposal sites.

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APPENDIX 1 DISPOSAL SITE COORDINATES

NV East Coordinates	NV West Coordinates
52.83165975 3.089663732	52.82745401 2.571058029
52.77195845 3.037967087	52.81318673 2.557873102
52.75294008 2.759441455	52.80087038 2.443729775
52.8615654 2.759505629	52.93585798 2.309230886
52.91675232 3.078496861	53.0435604 2.571197052
52.83165975 3.089663732	52.82745401 2.571058029

Coordinates for the section of the SAC section of the offshore cable corridor proposed for designation		
52.7470054379 2.26388059407	52.7227212206 1.98127107549	52.7499555052 2.03229375995
52.7470100953 2.26426235271	52.7232075077 1.98080416621	52.7497015436 2.03266312094
52.7470188936 2.26476903634	52.7341790907 1.97095380235	52.7496284982 2.03277276849
52.7470232793 2.26493169318	52.7357659388 1.96966599204	52.7495575779 2.03288614367
52.7470307626 2.26509404313	52.756483419 1.95105071859	52.7493181889 2.03328104793
52.7470617174 2.26564989207	52.7566707095 1.95084592123	52.7492494641 2.03339803532
52.7470722912 2.26581178589	52.7628064284 1.94532879155	52.7491830036 2.03351852207
52.7470859455 2.2659730532	52.7672666739 1.94090552777	52.7489591307 2.0339374123
52.7471332692 2.2664743266	52.7676477667 1.94057721425	52.7488949995 2.03406127719
52.7471476107 2.26661369698	52.7715492825 1.93670708747	52.7488332601 2.03418840157
52.7471642527 2.26675237105	52.7769550412 1.9259906532	52.7486257866 2.03462962572
52.751397192 2.29969882372	52.7809759476 1.9108270394	52.7485665011 2.03475987812
52.7428423669 2.30413213799	52.782819594 1.88919863001	52.7485097267 2.03489313555
52.7336437122 2.30456463066	52.7828565448 1.88854605168	52.7483194706 2.03535495133
52.7314073313 2.28714951765	52.7831574668 1.88125109239	52.7482652604 2.03549108995
52.7294551604 2.2719652909	52.783191574 1.88120571753	52.7482136713 2.03562996602
52.7292172745 2.26944547031	52.7880635362 1.76358912817	52.7480413852 2.03611055128
52.7290650427 2.26671178683	52.7961418453 1.7585308025	52.7479924713 2.03625202028
52.7290363063 2.26506143193	52.8024877384 1.75455581574	52.747946277 2.03639595199
52.7290248868 2.26429495727	52.8066646253 1.75193877719	52.7477926382 2.03689340938
52.7290491415 2.18820638347	52.8065956879 1.75367869567	52.7477492111 2.03703965657
52.7290311971 2.1232083774	52.8058931608 1.76927256155	52.7477085929 2.03718807864
52.7122683892 2.05403112345	52.8051166903 1.78254504587	52.7475742073 2.03770044884
52.7120886937 2.05319684658	52.804708219 1.79240899575	52.747536434 2.03785090928
52.7119865754 2.05272275602	52.8045790531 1.79564027933	52.7475015473 2.0380032511
52.7117692596 2.05137389981	52.8040326805 1.80928408579	52.7473869466 2.03852850989
52.708759546 2.02906766995	52.8040313807 1.80931649709	52.747354983 2.03868256855
52.7086266629 2.0278717116	52.8039611416 1.81106759953	52.7473259709 2.0388382065
52.7085965578 2.02751218612	52.8037606091 1.8160634362	52.7472316056 2.0393742827
52.7085279314 2.026301606	52.8023300621 1.8514885109	52.7472055718 2.03953135649
52.7085150855 2.02508594956	52.8011740347 1.88003557254	52.7471825446 2.03968970029
52.7085209377 2.02472309245	52.8008375917 1.88829392255	52.7471087883 2.04023448007
52.7085646571 2.02365903755	52.7998479573 1.91250354906	52.7470887907 2.04039392993
52.7092146122 2.01382448072	52.7995010242 1.92096191407	52.7470718419 2.0405543349
52.709504492 2.01137253796	52.7981005613 1.95495623813	52.7470189846 2.04110566932
52.7095663004 2.0110136377	52.7976911045 1.96344574009	52.7470051007 2.04126687462
52.709806185 2.00982760519	52.7973432031 1.96684485453	52.7469942955 2.04142871893
52.7115692183 2.00212632076	52.7967261609 1.9700889337	52.7469625461 2.04198443277
52.7121634222 2.00002029742	52.7951374327 1.97606100085	52.7469548301 2.04214676158

Coordinates for the section of the SAC section of the offshore cable corridor proposed for designation		
52.7122636949 1.99972657537	52.7935535194 1.98032139517	52.7469502127 2.04230941054
52.71262373 1.99876588383	52.7910312738 1.98547745535	52.7469412753 2.04278358867
52.7153991077 1.99191023104	52.7888786557 1.98872470054	52.7469397647 2.04295501541
52.7155152135 1.99164544094	52.786272486 1.9917801897	52.7469510456 2.0524413017
52.7162161901 1.99016472499	52.7509447924 2.03107623886	52.7469887097 2.09054075142
52.7163450752 1.98991238122	52.7508685831 2.03116364766	52.7470293647 2.18902793634
52.7168534864 1.98905222083	52.7506353528 2.03143966146	52.7470292467 2.19143178153
52.7174612869 1.98816492422	52.7504541984 2.03164587463	52.7470256507 2.21801374096
52.7216275133 1.98254960542	52.7503752158 2.03174371122	
52.7221181191 1.98193149851	52.7501076842 2.03208606944	
52.7225789776 1.98141837527	52.7500306051 2.03218794554	

Coordinates for the section of the offshore cable corridor outside the SAC proposed for designation		
52.8339308348 2.58592098135	52.8442356001 2.58544200439	52.7529400804 2.75944145493
52.7944049748 2.58629642286	52.8436846777 2.58564539548	52.7531851721 2.75845942097
52.7940777139 2.5863133156	52.8426365527 2.58590887947	52.7533175874 2.75797537708
52.7937404987 2.58636582417	52.842477666 2.58592939357	52.7536018323 2.75702242768
52.7934059481 2.58645315918	52.7754162368 2.43369479292	52.7539114881 2.75609123196
52.7930753813 2.58657497367	52.7753909467 2.43369277151	52.7542459432 2.75518362652
52.7927501028 2.58673078737	52.7754179605 2.43370278749	52.7544222659 2.75473923255
52.7924313968 2.58691998384	52.7751321642 2.43368891369	52.7547926668 2.75387035899
52.7921205208 2.58714181645	52.7747936382 2.43370756637	52.7549865615 2.75344630994
52.7918187015 2.58739540845	52.7744564902 2.43376123118	52.7553912624 2.75262003279
52.7915271291 2.58767975894	52.7741220506 2.43384969735	52.7557035536 2.75203741998
52.7912469554 2.58799374591	52.7737916401 2.43397261344	52.7558178403 2.7518242035
52.7909792854 2.58833612775	52.7734665623 2.43412949633	52.7560390719 2.75143820144
52.7907251748 2.58870555668	52.773148099 2.43431972242	52.7564968722 2.75069097678
52.7904856262 2.58910056985	52.7728375077 2.43454254399	52.7567332154 2.75033012148
52.790261585 2.58951961315	52.7725360137 2.43479707891	52.757220204 2.74963482333
52.7900539361 2.58996102932	52.7722448069 2.43508232259	52.7577254572 2.74897587334
52.7898634968 2.59042307886	52.7719650369 2.43539714948	52.7582479769 2.74835457576
52.7896910201 2.59090393693	52.771697806 2.43574031619	52.7587867308 2.74777216118
52.7895371853 2.59140170685	52.7714441701 2.43611046888	52.7590618636 2.74749589744
52.7894026002 2.591914426	52.7712051289 2.43650614483	52.7593406537 2.74722977905
52.7892877953 2.59244006877	52.7709816268 2.43692578583	52.7599086528 2.74672850511
52.7891932236 2.59297656295	52.7707745447 2.43736773234	52.7604896051 2.74626932803
52.7891192589 2.59352179113	52.7705846995 2.43783024273	52.7610823623 2.74585315973
52.7890661913 2.59407360266	52.7704128409 2.43831149039	52.7616857544 2.74548082203
52.7890342316 2.59462982246	52.7702596458 2.43880957713	52.7619910669 2.74531132386
52.7890235064 2.59518825252	52.7701257195 2.43932253909	52.7622985886 2.74515305405
52.7890340556 2.59574669271	52.7700115908 2.43984834971	52.7629196541 2.74487050325
52.7890658403 2.59630293917	52.769917709 2.44038493615	52.7632328906 2.74474636382
52.7890955279 2.59661267607	52.7698444444 2.44093018216	52.7635647581 2.74463373696
52.7895220292 2.60000859587	52.769792087 2.44148193552	52.7693835495 2.74463520785
52.7711597566 2.60000879106	52.7697608421 2.44203801846	52.7796456902 2.74463779475
52.7646206359 2.54805602637	52.7697508344 2.44259623946	52.7800481525 2.7446378957
52.7515678315 2.44493419045	52.7697621027 2.44315439475	52.7813817694 2.74463823206
52.7488339445 2.42343247363	52.7697946019 2.44371028315	52.7819867411 2.74463838408
52.7486544558 2.42202197979	52.7698330755 2.44410607018	52.7827712117 2.74463858103

Coordinates for the section of the offshore cable corridor outside the SAC proposed for designation		
52.7336437122 2.30456463066	52.7785873865 2.51320770002	52.7834429797 2.74445905203
52.7428423669 2.30413213799	52.7799080406 2.52366226071	52.7837662098 2.74433994303
52.751397192 2.29969882372	52.785101698 2.56485337509	52.7838805709 2.74429963742
52.7538685333 2.31897008028	52.7851874773 2.56534006831	52.7838897098 2.74429541155
52.7540767131 2.32059465803	52.7853022615 2.56586567418	52.7842067233 2.74414881312
52.7540844741 2.32065522571	52.7854368259 2.5663783597	52.7845264897 2.74396450873
52.7540921051 2.32071477825	52.785590641 2.56687609932	52.7846335528 2.74389005277
52.7543812957 2.32297187759	52.7857630984 2.56735693196	52.784721734 2.74383775541
52.7637652075 2.39641115042	52.7859535198 2.56781895937	52.7848678574 2.74373613413
52.7638228726 2.39683150309	52.7861611518 2.56826035812	52.7851710968 2.74348717437
52.763918182 2.39736733139	52.7863851756 2.56867938536	52.7854642587 2.74320729883
52.7640337103 2.39789223913	52.7866247089 2.5690743892	52.7857461864 2.74289760966
52.7641690003 2.39840415397	52.786878805 2.56944381021	52.7860157676 2.74255933043
52.7643235198 2.39890105933	52.787146462 2.56978619021	52.786271937 2.74219379429
52.7644966583 2.39938099298	52.7874266233 2.5701001782	52.7865136852 2.74180244388
52.7646877332 2.39984206026	52.7877181844 2.57038453328	52.7867400561 2.74138682544
52.7648959903 2.40028244298	52.7880199942 2.570638135	52.7869501569 2.74094857691
52.7651206083 2.40070040381	52.7883308619 2.57085998183	52.7871431585 2.74048943085
52.7653606999 2.40109429213	52.78864956 2.57104919557	52.7873182979 2.74001119664
52.7656153198 2.40146255437	52.7889748328 2.57120503022	52.7874748849 2.73951576492
52.7658834613 2.40180373548	52.7893053953 2.57132686899	52.7876123007 2.73900508825
52.7661640679 2.40211649213	52.7896399433 2.57141423312	52.7877178039 2.73853548264
52.7664560312 2.40239958683	52.7899771568 2.57146677298	52.7877548638 2.7383447871
52.7667581998 2.40265190113	52.7904155112 2.5714902141	52.7878275267 2.73794612292
52.7670693821 2.40287244153	52.8274540145 2.57105802875	52.7879044873 2.73740201331
52.7673883486 2.4030603365	52.8131867294 2.55787310168	52.7879221282 2.73722872428
52.7677138425 2.40321484226	52.8008703767 2.4437297746	52.7879605802 2.73685100647
52.768044578 2.40333535022	52.8008203027 2.44338434104	52.7879955852 2.73629527387
52.7683792493 2.40342138246	52.8006994669 2.44270264341	52.7880093625 2.73573701323
52.7687165378 2.40347260051	52.8005515048 2.44203566671	52.7880018595 2.73517842768
52.7688950674 2.40348114204	52.8003770669 2.44138634501	52.7879731044 2.73462172138
52.8360155103 2.40880753048	52.8002801545 2.44106920223	52.7879331854 2.73417955848
52.9358579796 2.30923088578	52.8000674773 2.44045169528	52.7878285918 2.73333881553
53.0435604003 2.57119705172	52.7999519468 2.44015201058	52.8066080133 2.73333864553
52.8509858276 2.57107339471	52.7997031366 2.43957242921	52.8066969793 2.73355568697
52.8509683763 2.57199653801	52.7994315836 2.43902134196	52.8069039933 2.73399808345
52.8509153553 2.57292492488	52.7992876489 2.43875724746	52.8071274312 2.73441816147
52.8508271419 2.57384597674	52.7989842534 2.43825340911	52.8073664104 2.73481426351
52.8507040847 2.57475605724	52.7986612801 2.43778386845	52.807619989 2.73518482432
52.85054667 2.57565157184	52.7983201497 2.43735069238	52.8078871654 2.73552838418
52.8503555192 2.57652898574	52.7981432417 2.43714834214	52.8081668866 2.73584358594
52.8501313864 2.57738483135	52.7977777137 2.43677323162	52.808458049 2.73612918391
52.8498751572 2.57821573359	52.7975894949 2.43660088425	52.8087595021 2.73638405275
52.8495878426 2.57901840846	52.7972031863 2.43628754956	52.8090700575 2.73660718591
52.8492705791 2.57978968837	52.7968051361 2.43601716111	52.8093884897 2.73679770161
52.8489246178 2.58052652964	52.796397097 2.43579090402	52.8097135431 2.73695484572
52.8485513245 2.58122602292	52.7959808639 2.43560977584	52.8100439329 2.73707800075
52.8481521743 2.58188540664	52.7955901033 2.43548309242	52.8103783564 2.73716667682
52.8477287418 2.58250207897	52.7952274456 2.43540173553	52.8107154948 2.73722052503
52.8472827003 2.58307360675	52.7951439826 2.43539505671	52.8108962118 2.73723056539
52.8468158098 2.58359773597	52.7944994269 2.43521090467	52.8576751531 2.73723419291
52.8463299129 2.58407239628	52.7923625955 2.43505005144	52.8615654787 2.75950562996

Coordinates for the section of the offshore cable corridor outside the SAC proposed for designation		
52.8458269292 2.58449571734 52.8453088439 2.58486603042 52.8447777018 2.58518187284	52.8316597519 3.08966373204 52.7719584516 3.03796708749	52.9167523228 3.07849686127