East Anglia TWO Offshore Windfarm

Site Characterisation Report (Windfarm Site)

Applicant: East Anglia TWO Limited
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Glossary of Acronyms

DCO	Development Consent Order
EIA	Environmental Impact Assessment
ES	Environmental Statement
GBS	Gravity Base Structure
LAT	Lowest Astronomical Tide
m	Metre
m^3	Metre Cubed
MarSEA	Marine Evidence based Sensitivity Assessment
MMO	Marine Management Organisation
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PEL	Probable Effect Levels
SPR	ScottishPower Renewables
SQG	Sediment Quality Guidelines
SSC	Suspended Sediment Concentration
TEL	Threshold Effect Levels
ZEA	Zone Environemntal Apprasial

Glossary of Terminology

Applicant	East Anglia TWO Limited.
Construction operation and maintenance platform	A fixed offshore structure required for construction, operation, and maintenance personnel and activities.
Development area	The area comprising the Indicative Onshore Development Area and the Offshore Development Area.
East Anglia TWO project	The proposed project consisting of up to 75 wind turbines, up to four offshore electrical platforms, up to one offshore construction, operation and maintenance platform, inter-array cables, platform link cables, up to one operational meteorological mast, up to two offshore export cables, fibre optic cables, landfall infrastructure, onshore cables and ducts, onshore substation, and National Grid infrastructure.
East Anglia TWO windfarm site	The offshore area within which wind turbines and offshore platforms will be located.
European site	Sites designated for nature conservation under the Habitats Directive and Birds Directive, as defined in regulation 8 of the Conservation of Habitats and Species Regulations 2017 and regulation 18 of the Conservation of Offshore Marine Habitats and Species Regulations 2017. These include candidate Special Areas of Conservation, Sites of Community Importance, Special Areas of Conservation and Special Protection Areas.
Evidence Plan Process	A voluntary consultation process with specialist stakeholders to agree the approach to the EIA and the information required to support HRA.
Horizontal directional drilling (HDD)	A method of cable installation where the cable is drilled beneath a feature without the need for trenching.
Inter-array cables	Offshore cables which link the wind turbines to each other and the offshore electrical platforms, these cables will include fibre optic cables.
Landfall	The area (from Mean Low Water Springs) where the offshore export cables would make contact with land, and connect to the onshore cables.
Natura 2000 site	A site forming part of the network of sites made up of Special Areas of Conservation and Special Protection Areas designated respectively under the Habitats Directive and Birds Directive.
Offshore cable corridor	This is the area which will contain the offshore export cable between offshore electrical platforms and landfall jointing bay.
Offshore development area	The East Anglia TWO windfarm site and offshore cable corridor (up to Mean High Water Springs).
Offshore electrical infrastructure	This includes transmission assets required to export generated electricity to shore. This includes inter-array cables from the wind turbines to the offshore electrical platforms, offshore electrical platforms, platform link cables and export cables from the offshore electrical platforms to the landfall.
Offshore electrical platform	A fixed structure located within the windfarm area, containing electrical equipment to aggregate the power from the wind turbines and convert it into a more suitable form for export to shore.
Offshore export cables	The cables which would bring electricity from the offshore electrical platforms to the landfall.
Offshore infrastructure	All of the offshore infrastructure including wind turbines, platforms, and cables.
Offshore platform	A collective term for the offshore operation and maintenance platform and the offshore electrical platforms.
Scour protection	Protective materials to avoid sediment being eroded away from the base of the foundations as a result of the flow of water.

1 Introduction

1.1 Background

1. East Anglia TWO Limited ('the Applicant') (which is a wholly owned subsidiary of ScottishPower Renewables (SPR) UK Limited) is seeking a Development Consent Order (DCO) for the proposed East Anglia TWO project consisting of an offshore windfarm and an associated offshore cable corridor to the landfall location just north of Thorpeness.

2. The offshore components of the proposed East Anglia TWO project would comprise:

- Up to 75 wind turbines;
- Offshore electrical platforms (up to four);
- Up to one offshore construction, operation and maintenance platform;
- One meteorological mast;
- Up to 20 buoys (LiDAR, wave or guard buoys);
- Inter-array cables (a maximum of 200km combined length); platform link cables between offshore electrical platforms (each up to 15km in length with an overall maximum length of 75km);
- Fibre optic cables may also be installed; however, these would be bundled with, or secured to the outside of the inter-array, platform link or export cables; and
- Up to two export cables (up to 80km in length each).

3. A full project description is available as part of the Environmental Statement (ES) in ***Chapter 6 Project Description***.

1.2 Purpose of this Document

4. The Applicant is applying to designate the following areas for the disposal of material extracted during the construction period (e.g. drilling and / or sea bed preparation (dredging)). The proposed disposal areas are:

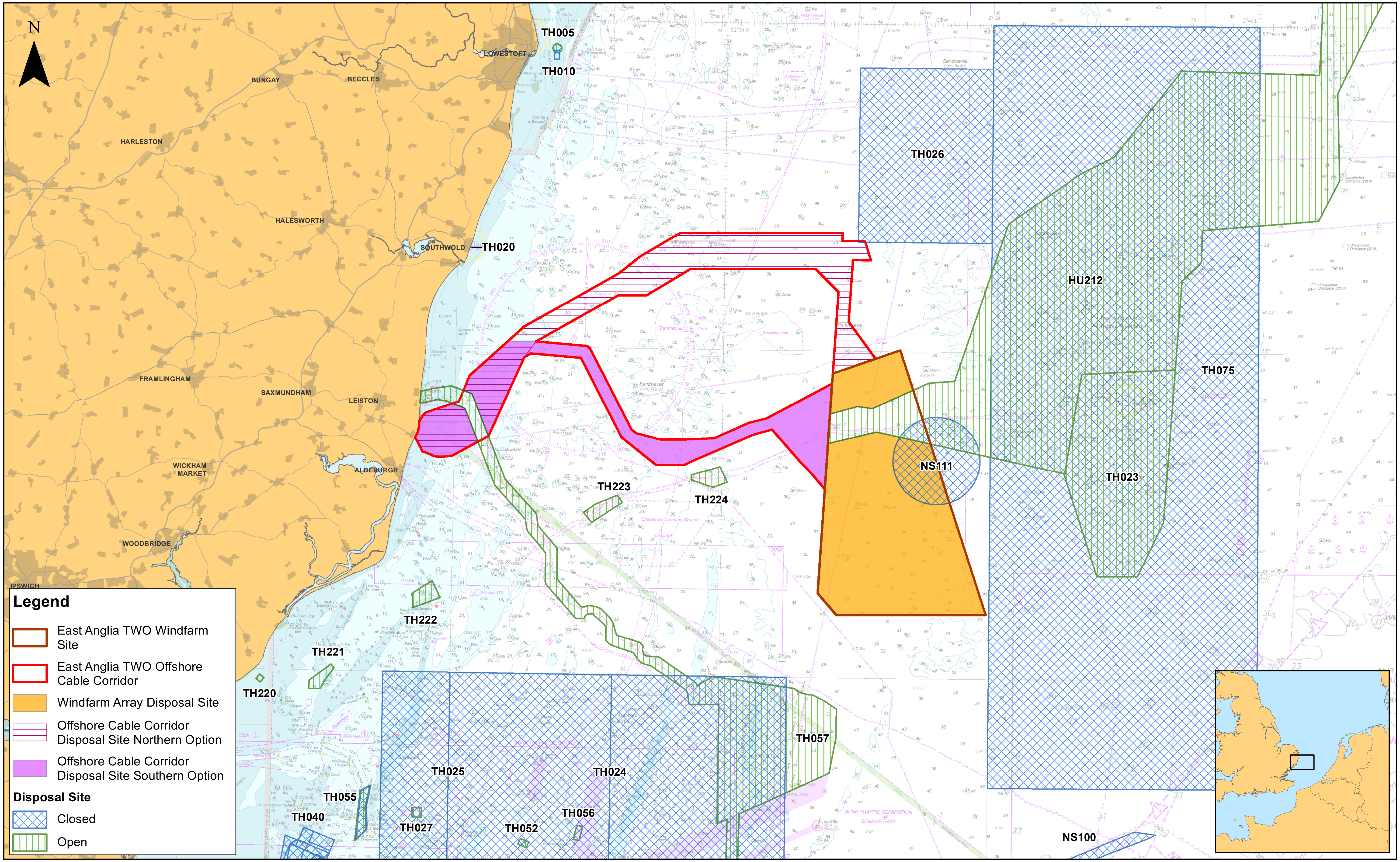
- The East Anglia TWO windfarm site; and
- The offshore cable corridor.

5. This document provides the necessary information to characterise the disposal requirements in the East Anglia TWO windfarm site. For information on the disposal requirements in the offshore cable corridor see the Site Characterisation Report (Offshore Cable Corridor) (document reference 8.16). The locations of the

proposed East Anglia TWO disposal sites are shown in ***Figure 1*** (and the coordinates to delineate the proposed East Anglia TWO windfarm site disposal site are provided in ***Appendix 1***). The areas consist of the entire East Anglia TWO windfarm site and the two offshore cable corridor route options minus areas which overlap with open disposal sites (the open and closed disposal sites are also shown on ***Figure 1***).

6. The purpose of this document is to provide the information required to enable disposal 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.



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East Anglia TWO

Disposal Site Locations

Drg No	EA2-DEV-DRG-IBR-000711
Rev	2
Date	02/09/19
Figure	1

Datum: WGS 1984
Projection: Zone 31N

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2 The Need for Disposal of Material

7. The type of foundation(s) and installation method(s) required for the East Anglia TWO wind turbines and other offshore structures are yet to be determined. However, installation will result in the generation of spoil material and therefore, practicable options for the disposal of "capital" dredged material must be assessed.

8. All spoil material would be disposed of in a disposal area adjacent to each location from where it was derived, where it would be dispersed by natural processes as described in the ES, ***Chapter 7 Marine Geology, Oceanography and Physical Processes***.

2.1 Foundation Installation

9. Foundation types currently under consideration are:

- Three or four-legged jackets on piles;
- Gravity base structures (GBS) which rely on the weight of the structure to anchor it to the sea bed;
- Suction caissons - cylindrical tubes which are installed by reducing the pressure inside the tube to draw the caisson into the sea bed;
- Three or four-legged jackets on suction caissons; and
- Monopiles - large cylindrical steel piles which are hammered into the sea bed.

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

- GBS, suction caisson or monopile for the meteorological mast foundations;
- Steel jacket(s) on pin-piles or suction caisson, or possibly a GBS for the offshore electrical platforms. Alternatively, self-installing structures may be used, probably using pin piles as would be used for a jacket foundation;
- The offshore construction, operation and maintenance platform would likely have a foundation structure similar to the offshore electrical platform(s).

11. Each of the different foundation types would require varying levels of sea bed preparation to provide a more level formation for installation. The volumes of sediment excavated differs depending on the foundation type and whether a 250 or 300m wind turbine model is used.

12. ***Table 1*** presents a summary of the physical properties of each foundation option to enable a direct comparison between them, to assist with defining the worst case scenario.

Table 1 Comparison of Physical Parameters for Different Foundation Types

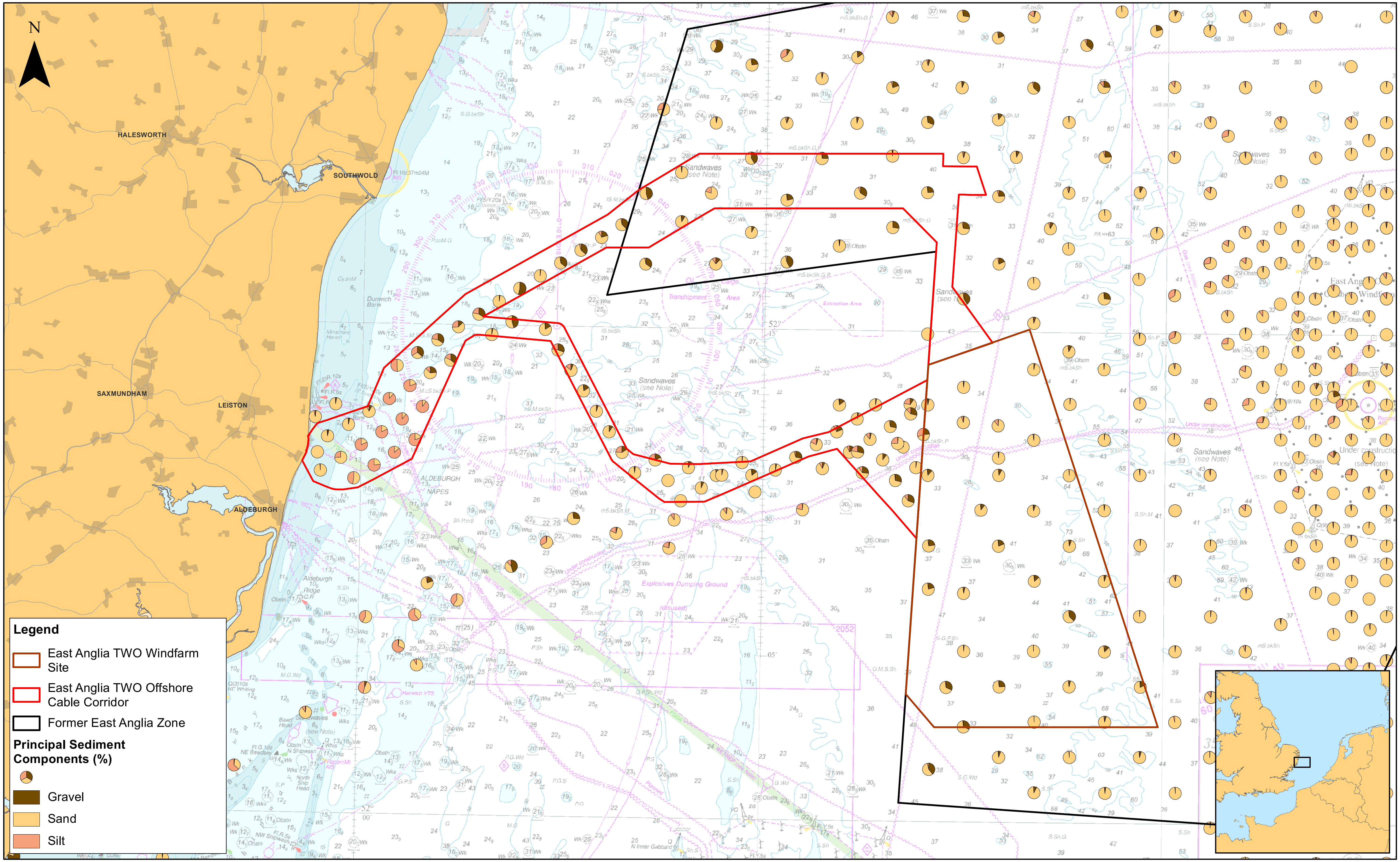
Foundation Type	Wind Turbine Blade Tip Height (m)	Maximum Foundation Dimensions (m/foundation)	Maximum Volume of Surface Sediment Release from Sea Bed Preparation (m^3/foundation)	Maximum Volume of Sub-surface Sediment Release from Foundation Drilling (m^3/foundation)
Gravity base structure	250	53 (basal diameter)	22,585	N/A
	300	60 (basal diameter)	25,875	N/A
Jacket with pin piles	250	45 x 45 (leg spacing)	19,125	3,016
	300	53 x 53 (leg spacing)	22,404.40	4,321
Jacket with suction caissons	250	14.5 (diameter per caisson)	23,731.88	N/A
	300	16 (diameter per caisson)	27,865	N/A
Suction caisson	250	31 (diameter)	13,840	N/A
	300	35 (diameter)	15,250	N/A
Monopile	250	13 (diameter)	8,485	5,972.953
	300	15 (diameter)	9,000	7,952.16

2.2 Cable Installation

13. Sand wave levelling (pre-sweeping) to a stable reference sea bed level may be undertaken in areas with large ripples and sand waves to reduce the potential that cables become unburied over the life of the project.

14. The sediment throughout the offshore development area is primarily medium sand (***Figure 2***) and therefore it is expected that the majority of the inter-array and platform link cables will be buried using a cable plough. This means that for the majority of the cable routes, no excavation and subsequent disposal of sediment would be required.

15. Anticipated sediment volumes for the excavation of sand waves are provided in ***section 4.1***.



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Rev	Date	By	Comment	Approved:	PP

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Scale @ A3

0 2.5 5 10 Km

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East Anglia TWO

Sediment Distribution

Drg No	EA2-DEV-DRG-IBR-001070	
Rev	1	Datum: WGS 1984 Projection: Zone 31N
Date	01/10/19	
Figure	2	

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2.3 Mitigation and Best Practice

16. The Applicant has committed to a number of areas of mitigation and best practice in order to minimise the potential impacts of the proposed East Anglia TWO project. The following examples of embedded mitigation are of relevance to sediment disposal:

- For piled foundation types, such as monopiles and jackets with pin piles, pile-driving will be used in preference to drilling where it is practicable to do so (where ground conditions allow). This would minimise the quantity of sub-surface sediment that is released into the water column and deposited from the installation process.
- Micrositing will be used to minimise the requirement for sea bed preparation prior to foundation installation. GBS will not be used in areas characterised by sand banks or sand waves with heights greater than 5m in further pursuance of this aim.

3 Type of Material to be Disposed

3.1 Sea Bed Sediment Type

17. Grab samples collected from within the East Anglia TWO windfarm site suggest that sea bed composition is primarily medium sand. The proportion of silt tends to be higher in deeper areas, mainly in the south-east of the East Anglia TWO windfarm site.

Spoil material generated by drilling might be different from surface material generated by other sources of sea bed preparation, being finer than the near-surface sediments and therefore having the potential to disperse more widely.

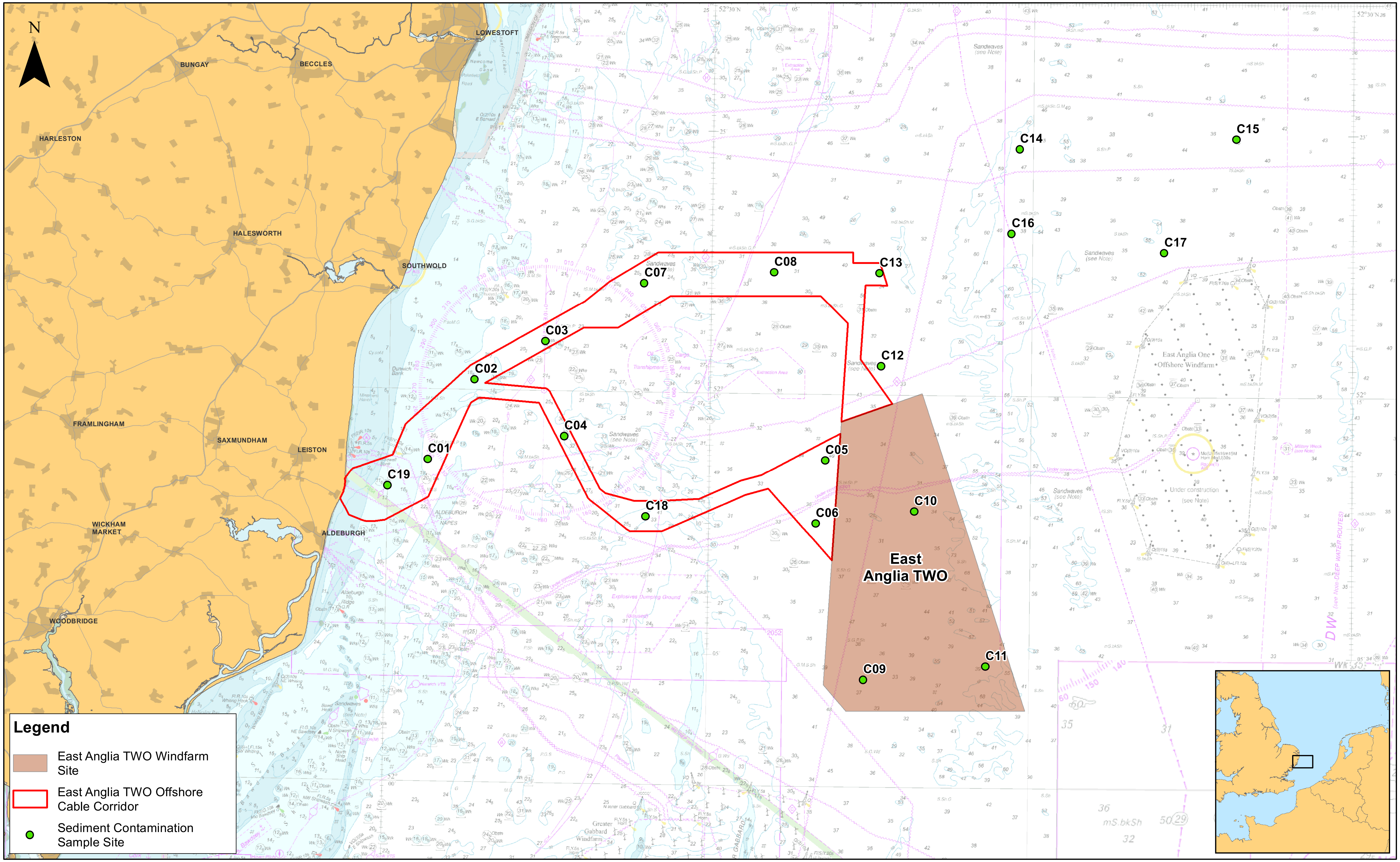
3.2 Sediment Contamination Analysis

18. The locations of the East Anglia TWO and East Anglia ONE North site specific sediment contamination sample sites are shown in ***Figure 3*** and contaminant data for heavy and trace metals are summarised in ***Table 3***. Contaminant sample numbers C09, C10 and C11 were taken within the East Anglia TWO windfarm site and are therefore of particular relevance to this report. However, reference to samples taken in the offshore cable corridor (sample numbers C01-08, C13, C18 and C19) and East Anglia ONE North windfarm site (sample numbers C14, C15, C16, C17) is provided for context.

19. Cefas Action Levels are commonly used to provide an indication of contaminant levels within sediments. Whilst these levels were specifically developed to assess dredged material, they are an accepted way of assessing the risks to the environment from other marine activities as part of the EIA process. The Marine

Management Organisation (MMO) (using the Cefas Action levels) states that, in general, contaminant levels below Action Level 1 are not considered to be of concern. Material with persistent contaminant levels above Cefas Action Level 2 are generally considered to pose an unacceptable risk to the marine environment (and therefore material is unlikely to be considered suitable for disposal to sea). For material with persistent contaminant levels between Action Levels 1 and 2, further consideration of additional evidence is required before the risk can be identified. Cefas Action Levels are summarised in the ES, ***Chapter 8 Water and Sediment Quality***.

20. If contaminant levels in the material under consideration persistently exceed Cefas Action Levels, additional assessment is required. This can be undertaken by applying the more stringent Canadian sediment quality guidelines (SQG) (CCME 2002) which also consist of two sets of concentrations: Threshold Effect Levels (TEL) and Probable Effect Levels (PEL). The Canadian SQGs also include PELs for individual polycyclic aromatic hydrocarbons (PAHs) which do not have Cefas Action Level 2 concentrations. Canadian SQGs are summarised in the ES, ***Chapter 8 Water and Sediment Quality***.



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East Anglia TWO

Location of Sediment Contamination Sample Sites

Drg No	EA2-DEV-DRG-IBR-001071
Rev	1
Date	01/10/19
Figure	3

Datum: WGS 1984
Projection: Zone 31N

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21. The difference between these values and the Cefas Action Levels is that ecotoxicological information has been used from field and laboratory testing. Therefore, the TEL and PEL concentrations represent concentrations where adverse effects may or may not occur. The lower level (TEL) represents a concentration below which adverse biological effects are expected to occur only rarely (in some sensitive species for example). The higher level (PEL), defines a concentration above which adverse effects may be expected in a wider range of organisms.

22. Levels of aluminium, iron, barium and tin were also measured however as there are no associated Cefas Action Levels or Canadian SQG values, they are not discussed further.

23. Sediment contaminant analysis was also undertaken for polychlorinated biphenyls (PCBs), PAHs and organotins. The combined PCBs[1] gave a value below 0.001mg/kg. Individual PAH concentrations were all below 0.00008mg/kg and combined 2-6 ring PAH were below 0.00128mg/kg. Concentrations of organotins were highest at site C01 (see ***Appendix 9.3*** of the ES) where they were 0.01mg/kg. None of these results exceeded Cefas Action Level 1 or Canadian TEL levels.

24. A number of samples (11) exceed Cefas Action Level 1 for concentrations of arsenic. The majority of samples that exceeded Cefas Action Levels 1 do so only marginally, remaining well below Action Level 2. All samples exceeded the TEL for concentrations of arsenic with three samples (C05, C07 and C16) also marginally exceeding the PEL.

25. The elevated levels of arsenic which were recorded are typical of the region; inshore these are associated with a history of arsenic waste disposal and offshore these are associated with estuarine and geological inputs and sea bed rock weathering (Royal Haskoning 2011). Given that there were no exceedances of Action Level 2 and levels are typical for the region, further assessment (i.e. comparison with additional sediment quality guidelines or other methods) is not deemed necessary.

26. One sample (C01) marginally exceeded Cefas Action Level 1 for cadmium, copper, nickel and zinc (***Table 3***). Sample C01 also exceeded the TEL for cadmium, copper, lead and zinc. The exceedances did not approach the higher Action Level 2 or the PEL. Considering the predominantly sandy nature of the sea bed sediments, which significantly reduces the potential for any contaminants to accumulate and for sediments to be resuspended into the water column and

[1] Based on the "ICES 7 PCBs". Seven of the 209 existing PCBs are analysed in monitoring because they are found in relatively high concentrations in technical mixtures and cover the range of toxicological properties of the PCB group

transported over long distances (see ***section 6.2.2***), these are not deemed to be of concern.

27. From the information and data presented above it can be concluded that the baseline sediment quality of the offshore development area is generally good and site specific information in relation to concentrations of contaminants in sediments does not record significantly elevated levels.

Table 2 East Anglia TWO and East Anglia ONE North Site Specific Sediment Contamination Analysis Results Compared to Cefas Action Levels (mg/kg) (see *Appendix 9.3* of the ES)

Sample station	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Vanadium	Zinc	Total Hydrocarbon Content
C01	12.6*	0.8*	33.8	52.2*	45.5*	0.09	22.8	45.4	132.3*	53.5
C02	34.2*	0.26	17.1	10.1	7.7	0.03	13.6	38.1	23.7	26.2
C03	31.7*	0.07	9.7	7	7.7	0.03	6.6	35.5	24	36.6
C04	29*	0.05	7.4	5.3	5.8	0.03	6.2	31.2	19.8	33.4
C05	43.9**	0.08	13.9	6.5	8.1	0.02	8.2	52.3	24.8	35.1
C06	28.2*	0.05	20.5	10.2	5.2	0.02	14.2	28.4	13.7	35.8
C07	42.4**	0.08	6.9	5.6	7.5	0.05	8.4	41	21.6	33.9
C08	16.4*	<0.04	6	5.5	4.7	0.03	4.2	21.4	14.2	32.0
C09	8.9*	<0.04	4.2	3.8	2.8	0.03	3.5	10.1	8.1	32.3
C10	24*	0.07	5.5	3.4	4.5	0.02	5.8	25.5	11.9	31.8
C11	7.5*	<0.04	4	5.1	2.4	0.02	3.3	8.5	7.1	32.5
C12	28.1	<0.04	8.2	6.2	6.1	0.03	6.5	32.3	18.3	34.3
C13	20.3	0.05	7.6	6.2	5.4	0.03	4.6	21.3	14.9	34.9
C14	34.9*	0.05	4.4	5	5.2	0.06	5.3	29.9	15.4	32.6
C15	9.7*	<0.04	6.5	4.4	2.9	0.02	3.9	13.6	10.6	24.5

Sample station	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Vanadium	Zinc	Total Hydrocarbon Content
C16	65.6**	0.07	7.5	4.9	5.4	0.02	10.2	49	22.6	28.2
C17	16.6*	<0.04	4.5	3.6	2.9	0.02	3.8	15.7	9.6	26.9
C18	14.1*	0.06	10	6.9	6.3	0.04	5.2	26.6	20.1	30.6
C19	20.8*	0.1	14.4	7.8	15.7	0.05	10.7	34	41.3	28.5

Yellow highlight above Cefas Action Level 1; *Above Canadian SQC TEL; **Above Canadian SQC PEL;
Orange highlight cells indicate sample locations in the East Anglia ONE North windfarm site which were gathered in the same survey and have been included for context.

4 Quantity of Material to be Disposed

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

- Sea bed preparation and levelling for foundations and cable installation; and
- Drill cuttings associated with installing foundations.

4.1 Sea Bed Preparation

4.1.1 Wind Turbines

29. The greatest volumes of near-surface sediment disturbance due to sea bed preparation activities during construction of individual wind turbines would be associated with jackets on suction caissons for the 300m wind turbines (see ***Table 1***). However, when considering the whole East Anglia TWO windfarm site, the combined effects of the larger number of smaller (250m) wind turbines on jackets with suction caissons yields the greatest volumes (**1,779,890.63m^3**).

4.1.2 Meteorological Mast

30. The sea bed preparation requirements for the one meteorological mast that would be installed is based on that for a 250m turbine which yields 23,731.88m^3 of sediment.

4.1.3 Offshore Platforms

31. There would be up to five offshore platforms (four offshore electrical and one construction, operation and maintenance platform) that would result in a maximum sea bed preparation volume of **668,800m^3**.

4.1.4 Inter-Array and Platform Link Cables

32. The total volume of sand removed during sand wave excavation during the installation of 200km of inter-array cables would be up to 400,000m^3.

33. For 75km of platform link cables it is anticipated that up to 150,000m^3 of sediment may be excavated as a result of sand wave levelling. This results in a total of up to **550,000m^3** of sediment requiring disposal in the East Anglia TWO windfarm site.

34. The volumes in this section and ***section 4.1.5*** below are based on experience from East Anglia ONE but with adequate contingency built in.

4.1.5 Export Cables

35. As described in the Site Characterisation Report (Offshore Cable Corridor) (document reference 8.16), 10% of the volume of sand wave levelling required for export cables has been attributed to the windfarm site disposal requirements

because a portion of the length of the export cables will be within the East Anglia TWO windfarm site. This volume amounts to 100,000m^3. Total volumes

36. These volumes are summarised in ***Table 3***.

Table 3 Total Worst Case Surface Sediment Disturbance

Infrastructure / Activity	Worst Case Scenario type	Worst case volume (m^3)
Sea bed preparation - Turbines	75 x 250m turbines on jackets, each with 4 suction caissons	1,779,890.63
Sea bed preparation - Meteorological mast	On a jacket with 4 suction caissons (651m^2)	23,731.88
Sea bed preparation - Offshore electrical platforms	Based on 4 platforms on jacket foundations with 4 suction caissons (4 x 5,676m^2)	535,040
Sea bed preparation - Offshore construction, operation and maintenance platform	Based on same worst case foundations footprint as the offshore electrical platforms (5,676m^2)	133,760
Inter-array cable sand wave levelling	Based on a maximum of 200km combined length	400,000
Platform link cable sand wave levelling	Based on a maximum of 75km combined length	150,000
Export cable sand wave levelling	Based on 10% of the volume of sand wave levelling required for export cables being within the East Anglia TWO windfarm site.	100,000
Total		**3,122,422.51**

4.2 Drilling

37. The greatest volumes of sub-surface sediment produced by drilling activities during construction of individual wind turbines would be associated with the use of monopiles for 60 300m wind turbines (**47,712.94m^3**).

38. The total worst case volumes of sub-surface sediment produced by drilling activities during construction are summarised in ***Table 4***.

Table 4 Total Worst Case Subsurface Sediment Disturbance

Infrastructure	Worst Case Scenario type	Worst case volume (m^3)
Turbines	60 x 300m turbines on monopiles. Worst case scenario assumes that 10% of piled foundations would require installation by drilling.	47,712.94
Meteorological mast	Monopile (equivalent to that of a 250m wind turbine foundation)	5,972.95
Offshore electrical platforms	4 x four-legged jacket foundations. Drill penetration depth of 65m and a maximum drill diameter of 4.6m each pin-pile would produce 1,080m^3 of drill cuttings	34,568
Offshore construction, operation and maintenance platform	Four-legged jacket foundation. Drill penetration depth of 65m and a maximum drill diameter of 4.6m each pin-pile would produce 1,080m^3 of drill cuttings	8,641.89
Total	-	**96,895.78**

4.3 Programme

39. It is anticipated that the offshore construction works would be completed in approximately 27 months. The time periods of specific offshore activities would vary and would be encompassed within this 27 month period.

4.4 Daily Disposal Amounts

40. The worst case assumes that up to **3,122,422.51m^3** of near-surface sediment would be removed by means of dredging throughout the entire construction period within the East Anglia TWO windfarm site. Dredged sediment would be returned to the water column at its surface layer as overflow from a dredger vessel.

41. For sub-surface sediment, it is assumed as a worst case that up to **96,895.78m^3** would be released throughout the anticipated construction programme.

42. In the East Anglia ONE modelling studies, consecutive daily releases of 22,500m^3 of sediment (mostly medium-grained sand, but also with small proportions of gravel, other sand fractions and muds) were simulated at the water surface at 15 wind turbine locations. This sediment release represents a suitable analogue for the type and magnitude of effect that would be anticipated from the proposed East Anglia TWO project. Therefore, 22,500m^3 of sediment release per day is considered as the worst case daily sediment disposal volume for the proposed East Anglia TWO project.

5 Alternatives Considered

5.1 Use of Material for Ballast

43. Where extensive excavation works are required, such as for sea bed 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.

44. As described above, the Applicant is considering the use of several different foundation types. Sand dredged locally during the sea bed preparation could be used as ballast material for GBS foundations during the foundation preparation works if geotechnically suitable for purpose. This reuse of sand would be preferable to sourcing ballast material from elsewhere in accordance with the waste hierarchy. The remainder would be disposed of as described in ***section 4*** above.

45. 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

46. The suitability and capacity of nearby existing disposal sites (***Figure 1***) has been considered.

47. The largest open disposal sites in the vicinity of the East Anglia TWO windfarm site are associated with the East Anglia ONE offshore windfarm (TH222, TH223, TH224, TH023) and the Galloper offshore windfarm (TH057). However, the marine licence conditions for these disposal sites state that they are only to be used for disposal of material derived from their associated windfarm, therefore these sites are not available to the proposed East Anglia TWO project.

6 Potential Impacts of Disposal

48. The impact of disposal of material within the East Anglia TWO windfarm site has been incorporated into impacts assessed within the East Anglia TWO EIA and presented within the ES (ScottishPower Renewables (SPR) 2019); specifically, within ***Chapter 7 Marine Geology, Oceanography and Physical Processes, Chapter 8 Marine Water and Sediment Quality*** and ***Chapter 10 Benthic Ecology***. It should be noted however that the impacts presented within the ES assess the impacts of the proposed East Anglia TWO 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.

49. ***Chapter 5 EIA Methodology*** of the ES presents an overarching method for enabling assessments of the potential impacts arising from the proposed East Anglia TWO project on the receptors under consideration. Such assessments incorporate a combination of the sensitivity of the receptor, its value (if applicable) and the magnitude of the change to determine a significance of impact. This method has been followed for the assessment of marine geology, oceanography and physical processes receptors; marine water and sediment quality receptors and benthic ecology receptors.

50. The sensitivity of a receptor is dependent upon its:

- **Tolerance:** the extent to which the receptor is adversely affected by an effect;
- **Adaptability:** the ability of the receptor to avoid adverse impacts that would otherwise arise from a particular effect; and
- **Recoverability**: 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.

51. Example definitions of sensitivity of receptor are summarised in ***Table 5***.

Table 5 Example Definition of Different Sensitivity Levels for a Generic Receptor

Sensitivity	Definition
High	Individual receptor has very limited or no capacity to avoid, adapt to, accommodate or recover from the anticipated impact. <u>Tolerance</u>: Receptor has very limited tolerance of effect <u>Adaptability</u>: Receptor unable to adapt to effect <u>Recoverability</u>: Receptor unable to recover resulting in permanent or long-term (greater than ten years) change
Medium	Individual receptor has limited capacity to avoid, adapt to, accommodate or recover from the anticipated impact.

Sensitivity	Definition
	Tolerance: Receptor has limited tolerance of effect Adaptability: Receptor has limited ability to adapt to effect Recoverability: Receptor able to recover to an acceptable status over the medium term (5-10 years)
Low	Individual receptor has some tolerance to accommodate, adapt or recover from the anticipated impact. Tolerance: Receptor has some tolerance of effect Adaptability: Receptor has some ability to adapt to effect Recoverability: Receptor able to recover to an acceptable status over the short term (1-5 years)
Negligible	Individual receptor is generally tolerant to and can accommodate or recover from the anticipated impact. Tolerance: Receptor generally tolerant of effect Adaptability: Receptor can completely adapt to effect with no detectable changes Recoverability: Receptor able to recover to an acceptable status near instantaneously (less than one year)

52. A value component may also be considered when assessing a receptor. This ascribes whether the receptor is rare, protected or threatened.

53. The magnitude of an effect is dependent upon its:

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

54. Definitions of magnitude of effect levels are summarised in ***Table 6***.

Table 6 Definitions of the Magnitude of Effect Levels for a Morphological Receptor

Value	Definition
High	Fundamental, permanent / irreversible changes, over the whole receptor, and / or fundamental alteration to key characteristics or features of the particular receptors character or distinctiveness
Medium	Considerable, permanent / irreversible changes, over the majority of the receptor, and / or discernible alteration to key characteristics or features of the particular receptors character or distinctiveness

Value	Definition
Low	Discernible, temporary (throughout project duration) change, over a minority of the receptor, and / or limited but discernible alteration to key characteristics or features of the particular receptors character or distinctiveness
Negligible	Discernible, temporary (for part of the project duration) change, or barely discernible change for any length of time, over a small area of the receptor, and/or slight alteration to key characteristics or features of the particular receptors character or distinctiveness

55. Following the identification of receptor sensitivity and magnitude of the effect, it is possible to determine the significance of the impact using an impact matrix (***Table 7***). Impacts may be deemed as being either positive (beneficial) or negative (adverse).

Table 7 Impact Significance Matrix

		Negative Magnitude				Beneficial Magnitude			
		High	Medium	Low	Negligible	Negligible	Low	Medium	High
Sensitivity	High	Major	Major	Moderate	Minor	Minor	Moderate	Major	Major
	Medium	Major	Moderate	Minor	Minor	Minor	Minor	Moderate	Major
	Low	Moderate	Minor	Minor	Negligible	Negligible	Minor	Minor	Moderate
	Negligible	Minor	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Minor

56. Impact significance is described using the definitions in ***Table 8***.

Table 8 Impact Significance Definitions

Value	Definition
Major	Very large or large change in receptor condition, both adverse or beneficial, which are likely to be important considerations at a regional or district level because they contribute to achieving national, regional or local objectives, or, could result in exceedance of statutory objectives and / or breaches of legislation
Moderate	Intermediate change in receptor condition, which are likely to be important considerations at a local level
Minor	Small change in receptor condition, which may be raised as a local issue but which is unlikely to be important in the decision-making process
Negligible	No discernible change in receptor condition
No change	No impact, therefore no change in receptor condition

57. Within ***Chapter 7 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 Foundation Installation (***section 6.1.2.1***);
- Changes in Sea Bed Level due to Foundation Installation (***section 6.1.3.1***);
- Changes in Suspended Sediment Concentrations During Inter-Array Cable and Platform Link Cable Installation (***section 6.1.2.2***);
- Changes in Sea Bed Level due to Inter-array Cable and Platform Link Cable Installation (***section 6.1.3.2***);

58. ***Chapter 8 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 ES ***Chapter 7 Marine Geology, Oceanography and Physical Processes***. The impacts which contain relevant information for this assessment are as follows:

- Deterioration in Offshore Water Quality due to Increased Suspended Sediment Concentration (SSC) due to Sea Bed Preparation including Sand Wave Levelling during Installation of Foundations (***section 6.2.1***); and
- Deterioration in Water Quality due to Re-suspension of Sediment Bound Contaminants (***section 6.2.2***).

59. ***Chapter 9 Benthic Ecology*** of the ES incorporates the potential effects of disposal on the biological characteristics of the project. This assessment also builds upon the assessment in ES ***Chapter 7 Marine Geology, Oceanography and Physical Processes***. The impacts which contain relevant information for this assessment are as follows:

- Increased Suspended Sediment Concentrations and Associated Potential Smothering of Benthic Receptors (***section 6.3.1***); and
- Remobilisation of Contaminated Sediments (***section 6.3.2***).

6.1 Potential Impacts of Sediment Disposal on Physical Characteristics

60. The assessment provided in ES ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** is supported by an evidence-base obtained from research into the physical impacts of marine aggregate dredging on sediment plumes and sea bed 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).

61. Modelling simulations undertaken for East Anglia ONE using the Delft3D plume model (ABPmer 2012) confirm the above assessments of suspended sediment concentrations and sea bed deposits arising from disturbance of surface and shallow near-surface sediments.

6.1.1 Identified Receptors for the Physical Processes Assessment

62. The East Anglia Zone Environmental Appraisal (ZEA) identified 17 receptor groups in total. The location of these is shown in ***Figure 4***.

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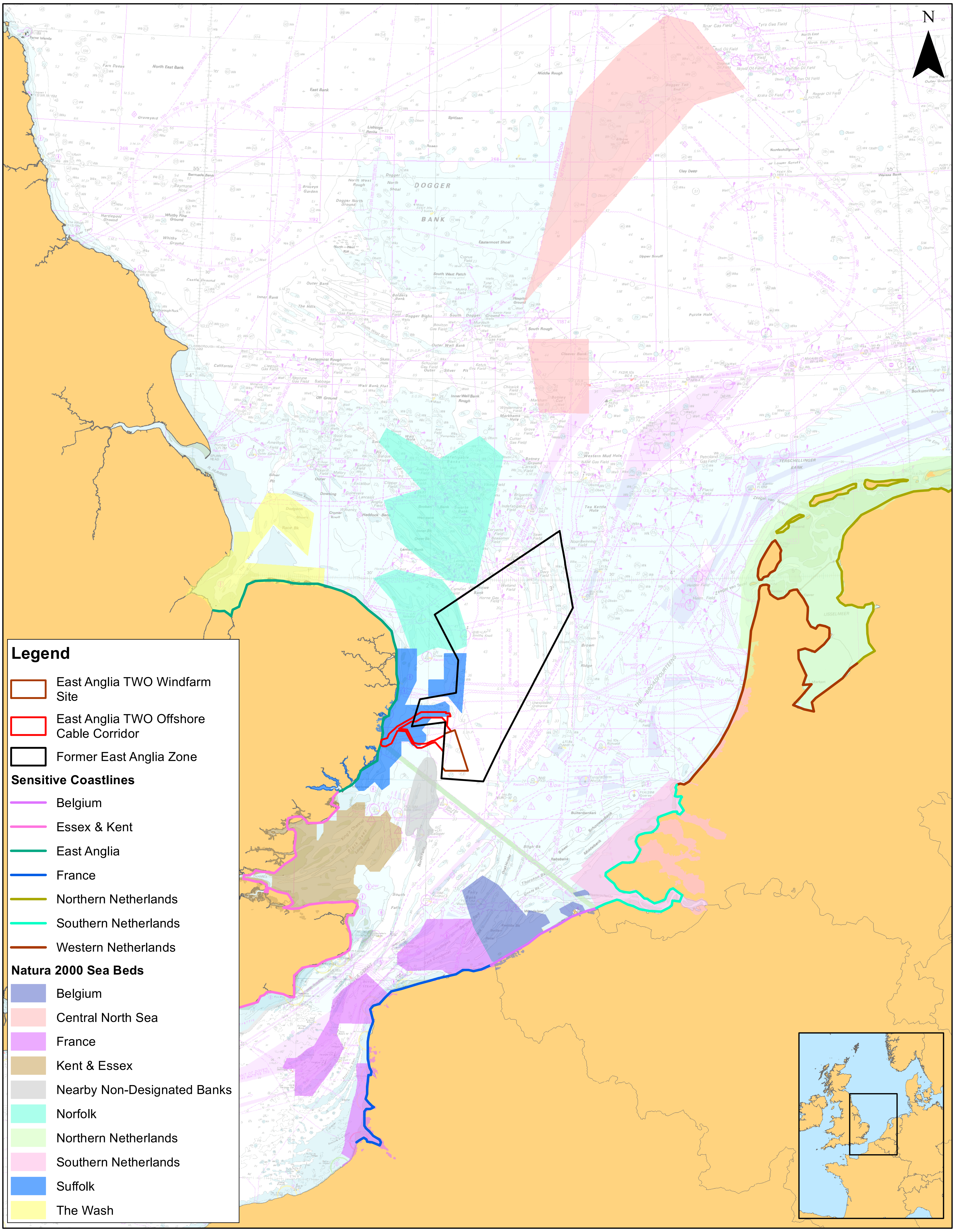

SCOTTISHPOWER RENEWABLES

East Anglia TWO

Receptor Groups for Marine Geology, Oceanography and Physical Processes

Scale @ A3: 1:2,000,000 — 0 25 50 100 Km

Rev	Date	By	Comment		
				Prepared:	FC
1	01/10/19	FC	First Issue.	Checked:	NC
				Approved:	PP

Figure	Date	Dwg No.	
4	01/10/19	EA2-DEV-DRG-IBR-001072	Datum: WGS 1984 Projection: Zone 31N

D:\Box Sync\PB4842 EA 1N and 2\PB4842 EA 1N and 2 Team\E. TECHNICAL DATA\E03 GIS\EA2\Figures\DCO\Other_Docs\SiteCharacterisation\Fig_5_EA2_ReceptorGroups_RH_20191001.mxd

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63. Seven receptor groups covered sensitive coasts in both eastern England (two receptor groups, 'East Anglia' and 'Essex & Kent') and across northern mainland Europe (five receptor groups, including 'France', 'Belgium', 'Southern Netherlands', 'Western Netherlands' and 'Northern Netherlands').

64. Nine further receptor groups were identified to cover the designated Natura 2000 sites in eastern England (five receptor groups, 'The Wash', 'Central North Sea', 'Norfolk', 'Kent & Essex' and 'Suffolk') and wider Europe (four receptor groups, 'France', 'Belgium', 'Southern Netherlands' and 'Northern Netherlands'). It should be noted that the Natura 2000 sites often comprise groupings of multiple distinct (and designated) features, such as sand banks, sand dunes, and sand and shingle beaches.

65. One further receptor group covered nearby 'non-designated sand banks' in the Outer Thames Estuary, including Inner Gabbard, Outer Gabbard, The Galloper, North Falls and one un-named bank.

6.1.2 Changes in Suspended Sediment Concentrations

66. Baseline suspended sediment concentrations within the former East Anglia Zone are typically between 1mg/l and 35mg/l, with a clear pattern of enhancement in values due to wave-stirring of sediment from the sea bed during storm conditions. During such conditions, values can reach greater than 80mg/l offshore, with up to 170mg/l recorded at the coast.

6.1.2.1 Changes in Suspended Sediment Concentrations due to Foundation Installation

6.1.2.1.1 Near-surface Sediments

67. The installation of wind turbine foundations has the potential to disturb sediments from the sea bed (near-surface sediments). The worst case scenario involves the maximum volume of up to **2,472,423m^3** of near-surface sediment removed by means of dredging and returned to the water column at its surface layer as overflow from a dredger vessel (***section 4.1***).

68. Expert-based assessment suggests that, due to the sediment particle sizes present across the East Anglia TWO windfarm site, the sediment disturbed from the sea bed by the drag head of the dredger would remain close to the bed and rapidly settle. Most of the sediment released at the water surface from the dredger vessel would rapidly (order of minutes or tens of minutes) fall to the sea bed as a highly turbid dynamic plume immediately upon its discharge.

69. East Anglia ONE modelling (ABPMer 2012) predicted that close to the release locations, suspended sediment concentrations would be very high (orders of magnitude greater than natural background levels), but of very short duration (seconds to minutes) as the dynamic plume falls to the sea bed. 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 in accordance with the direction of residual tidal flow. Sediment concentrations rapidly (within a small number of hours) returned to background levels after cessation of the release into the water column.

6.1.2.1.2 Sub-surface Sediments

70. Up to 96,895.78**m³** of deeper sub-surface sediments within the East Anglia TWO windfarm site would become disturbed during any drilling activities that may be needed at the location of each piled foundation (***section 4.2***).

71. This would cause localised and short-term increases in suspended sediment concentrations at the point of discharge of the drill cuttings. Released sediment in suspension in the water column may then be transported by wave and tidal action. Although the sub-surface sediment release volumes (under the worst case scenario) are considerably lower than those for near-surface sediments (under the worst case scenario), the sub-surface sediment would have a larger proportion of finer materials.

72. Coarser sediment fractions (medium and coarse sands and gravels) and aggregated 'clasts' of finer sediment would settle out of suspension close to the foundation location, whilst disaggregated finer sediments (fine sands and muds) would be more prone to dispersion. Due to the small quantities of sediment released, however, these disaggregated finer sediments are likely to be widely and rapidly dispersed, resulting in only low elevations in suspended sediment concentration.

73. Modelling for East Anglia ONE (ABPmer 2012) predicted that away from the immediate release locations, near-field elevations in suspended sediment concentration above background levels were low (less than 10mg/l) and within the range of natural variability. Indeed, concentrations were generally no greater than 5mg/l at 5km from the release location, indicating wide dispersion in low concentrations. Net movement of fine-grained sediment retained within the plume was to the north, in accordance with the direction of residual tidal flow, although gross movement to both the north and south was possible depending on the timing of release. Sediment concentrations arising from installation of one foundation were deemed unlikely to persist for sufficiently long that they significantly interact with subsequent operations and therefore no cumulative effect was anticipated.

74. The worst case release volumes associated with the proposed East Anglia TWO project are greater than those used in the East Anglia ONE modelling studies. However, these are likely to still be modest (tens of mg/l) due to the low volumes

of disaggregated fine-grained sediment in the drill arisings. Hence, the principle of wide dispersion in relatively low concentrations remains valid. Also, a conservative assumption was made in the modelling that all drilled sediment would disperse. However, in reality some of the drill arisings would arrive at the sea surface as larger aggregated clasts which would settle rapidly.

75. The changes in suspended sediment concentrations (magnitudes, geographical extents and durations of effect) that are anticipated above, would move across the East Anglia TWO windfarm 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 of foundations at different wind turbine locations.

6.1.2.2 Changes in Suspended Sediment Concentrations due to Inter-Array Cable and Platform Link Cable Installation

76. The installation of the inter-array and platform link cabling may require the sea bed levelling of any large sand waves that may be present along the route of any cables prior to cable installation. The profile of levelling works would be 40m wide, with an average depth of 2.5m and a slope gradient of 1:4. Sand wave levelling would be in discrete areas and not along the full length of the cable route. The volume of sediment affected due to sand wave excavation in the East Anglia TWO windfarm site is estimated to be up to **550,000m^3** (***section 4.1.4***). This would be removed by means of dredging and returned to the water column at its surface layer as overflow from a dredger vessel. The sediment released within the East Anglia TWO windfarm site at any one time, would depend on the capacity of the dredger. There would be no net loss of sand from the site.

77. It is anticipated using expert-based assessment that the changes in suspended sediment concentration due to sand wave levelling for inter-array cable and platform link cable installation would be lower than that arising from the disturbance of near-surface sediments during foundation installation activities including sea bed preparation. This is because the overall sediment release volumes would be lower and in discreet areas where sand waves are present along the alignment of the cables.

78. It is likely that some of the sand would be disposed in areas of the East Anglia TWO windfarm site where tidal currents would, over time, re-distribute the sand back over the levelled area (as re-formed sand waves). The extent of sand wave levelling required and specific disposal locations within the East Anglia TWO windfarm site would be determined post consent following detailed geophysical surveys, however, given the relatively low volumes of sand likely to be affected, the overall effect of changes to the sea bed would be minimal.

79. Modelling for East Anglia ONE (ABPmer 2012) predicted that close to the release locations, suspended sediment concentrations would be very high (orders of magnitude greater than natural background levels), but of very short duration (seconds to minutes) as the dynamic plume falls to the sea bed. Within the passive plume, suspended sediment concentration 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 in accordance with the direction of residual tidal flow. Sediment concentrations rapidly (within a small number of hours) returned to background levels after cessation of the release into the water column.

6.1.2.3 Assessment of Effect Magnitude and / or Impact Significance

80. The likely magnitudes of effect of worst case changes in suspended sediment concentrations due to foundation installation, inter-array and platform link cable installation are summarised in ***Table 9***.

Table 9 Magnitude of Effect on Suspended Sediment Concentrations Under the Worst Case Scenarios

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Effect
Foundation Installation					
Near-field*	High	Negligible	Negligible	Negligible	Medium
Far-field	Low	Negligible	Negligible	Negligible	Low
Inter-Array Cable and Platform Link Cable Installation					
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 sea bed (likely to be of the order of several hundred metres up to a kilometre from each foundation location or cable corridor) and would not cover the whole East Anglia TWO windfarm site or offshore cable corridor.

81. The effects on suspended sediment concentrations due to foundation installation and inter-array and platform link cable installation for the proposed project do not directly impact upon the identified receptor groups for marine geology, oceanography and physical processes (see ***section 6.1.1***), so there is no impact associated with the proposed East Anglia TWO project. However, the effects do have the potential to impact upon other receptors, discussed in ***sections 6.2*** and ***6.3***.

6.1.3 Changes in Sea Bed Level

6.1.3.1 Changes in Sea Bed Level due to Foundation Installation

82. The increases in suspended sediment concentrations as a result of foundation installation have the potential to deposit sediment and raise the sea bed level slightly. There would be different settling rates for the sediment types associated with the near-surface sediment disturbance compared to the deeper sub-surface sediment disturbance, so each is discussed in turn.

6.1.3.1.1 Near-surface Sediments

83. Coarser sediment would rapidly (within the order of minutes or tens of minutes) fall to the sea bed as a highly turbid dynamic plume immediately upon its discharge. Deposition of this sediment would form a ‘mound’ local to the point of release. Due to the sediment particle sizes observed across the East Anglia TWO windfarm 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.

84. The resulting mound would be a measurable protrusion above the existing sea bed (likely to be tens of centimetres to a few metres high) but would remain local to the release point. The precise configuration of height and spreading distance of each mound would vary across the East Anglia TWO windfarm site, depending on the prevailing physical conditions, but in all cases the sediment within the mound would be similar to that on the existing sea bed. This would mean that there would be no discernible change in sea bed sediment type.

85. The small fraction of fine sand and the very small proportion of mud is likely to become more widely dispersed by tidal currents before settling on the sea bed. Expert-based assessment suggests that the thickness of these deposits from the plume across the wider sea bed area would be very small (order of millimetres).

86. Previous plume modelling studies for East Anglia ONE (ABPmer 2012) supports this assessment, showing that for the most part, the deposited sediment layer across the wider sea bed was found to be less than 0.2mm thick and did not exceed 2mm anywhere. The area of sea bed 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 sea bed (a few hundred metres) due to 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 sea bed sediment layer, thus further reducing any potential effect.

6.1.3.1.2 Sub-surface Sediments

87. Expert-based assessment suggests that due to the finer-grained nature of any sub-surface sediment released during drilling for piled foundation installation,

there would be greater dispersion across a wider area, in keeping with the pattern of the tidal ellipses.

88. The previous plume modelling studies for East Anglia ONE (ABPmer 2012) considered sea bed level changes resulting from deposition of sediments from drilling eight piled (jacket) foundations. The coarser sediment deposited near to the point of release to thicknesses of up to a few centimetres and over a sea bed area within a few hundred metres of each foundation. For the most part, the deposited sediment layer across the wider sea bed area was predicted to be less than 0.025mm thick.

89. The sea bed-level changes that are anticipated above 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 of foundations.

6.1.3.2 Changes in Sea Bed Level due to Inter-array Cable and Platform Link Cable Installation

90. Up to **550,000m^3** of sediment may be released as a result of pre-sweeping of inter-array cables and platform link cables (***section 4.1***). This sediment would be disposed of within the East Anglia TWO windfarm site itself with no net loss of sand from the site other than potentially very fine sands that could be dispersed more widely although any impact as a result of this would be negligible. It is likely that some of this sand would be redistributed over time by tidal currents, back over the levelled area as re-formed sand waves. Given the relatively low volumes of sand likely to be affected, the overall effect of changes to the sea bed would be minimal.

91. The changes in suspended sediment concentration due to inter-array cable and platform link cable installation would be less than those arising from the disturbance of near-surface sediments during foundation installation activities. Therefore, the sea bed level changes would also be lower.

6.1.3.3 Assessment of Effect Magnitude and / or Impact Significance

92. The likely magnitudes of effect of worst case changes in sea bed level due to foundation installation, inter-array cable and platform link cable installation are summarised in ***Table 10***.

Table 10 Magnitude of Effects on Sea Bed Level Changes Under the Worst Case Scenarios

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Effect
Foundation Installation					
Near-field*	Medium	Negligible	Negligible	Negligible	Low

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Effect
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible
Inter-Array Cable and Platform Link Cable Installation					
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 sea bed (likely to be of the order of several hundred metres up to a kilometre from each foundation location or cable corridor), and would not cover the whole East Anglia TWO windfarm site.

93. These effects on sea bed level are considered highly unlikely to have the potential to impact directly upon the identified receptor groups for marine geology, oceanography and physical processes due to separation distances and therefore there would be no impact on the identified receptor groups..

6.1.4 Cumulative Impacts

94. Due to the negligible magnitude of effects at the far-field scale it is considered that there is no potential for cumulative impacts with other projects or activities.

6.1.5 Summary of Impacts of Sediment Disposal on Physical Characteristics

95. The conclusion of all relevant impacts on physical characteristics was that there would be no impact. Therefore, there would be no discernible effect on the physical characteristics of the proposed East Anglia TWO disposal site, should it be designated.

6.2 Potential Impacts of Sediment Disposal on Water and Sediment Quality

6.2.1 Deterioration in Offshore Water Quality due to Increased SSC

96. As discussed in ***section 6.1.1***, foundation installation, inter-array and platform link cable installation have the potential to disturb sea bed surface or shallow near-surface sediments. Mobilised sediment from these activities, including material removed by means of dredging and returned to the water column at its surface layer, may be transported by wave and tidal action in suspension in the water column forming a plume.

97. The worst case scenario changes in SSCs due to foundation installation, inter-array and platform link cable installation (including sea bed preparation, cable installation, and foundation installation including drilling) are predicted to be low in magnitude due to the localised and short term nature of the predicted sediment plumes. Baseline conditions of SSCs are expected to return to normal rapidly following cessation of activity, therefore any impact would only be present during the installation process. The sensitivity in the East Anglia TWO windfarm site is

deemed to be low due to the large volume of the receiving water and the capacity for dilution and flushing. Therefore, a **minor adverse** impact is predicted.

6.2.2 Deterioration in water quality due to re-suspension of sediment bound contaminants

98. The disposal of dredged material at the sea surface has the potential to release sediment-bound contaminants, such as heavy metals and hydrocarbons into the water column. The data in ***Table 2*** illustrates that levels of contaminants within the East Anglia TWO windfarm site and offshore cable corridor are very low.

99. There was one exceedance of Cefas Action Level 1 for arsenic within the East Anglia TWO windfarm site. This Exceedance was marginal and likely due to high concentrations of naturally occurring arsenic (***section 3.2***) however the concentration was not close to Cefas Action Level 2 (***Table 2***). , Therefore, the potential magnitude of effect is considered to be negligible.

100. Considering the negligible magnitude of effect, low receptor sensitivity (as discussed in ***section 6.2.1***) and the localised nature of the impact (see above impacts on increased SSCs), the re-suspension of contaminated sediment from construction activities is considered to have a **negligible** impact on water quality.

6.2.3 Cumulative impacts

101. Due to the negligible magnitude of effects at the far-field scale it is considered that there is no potential for cumulative impacts with other projects or activities.

6.2.4 Summary of Impacts of Sediment Disposal on Water and Sediment Quality

102. The conclusion of all relevant impacts on water and sediment quality was that there is considered to be a **minor adverse** impact on water quality due to increased SSC and a **negligible** impact on water quality as a result of the potential to release sediment-bound contaminants.

6.3 Potential Impacts of Sediment Disposal on Benthic Ecology

6.3.1 Increased Suspended Sediment Concentrations and Associated Potential Smothering of Benthic Receptors

103. As discussed in ***section 6.1***, foundation installation and inter-array and platform link cable installation have the potential to increase suspended sediment concentrations within the water column. This increase has the potential to affect the benthic ecology receptors through blockage to the sensitive filter feeding apparatus of certain species and / or smothering of sessile species upon deposition of the sediment.

104. As described in ***section 6.1***, most of the sediment released during construction would be coarse material. As a result, this would fall as a highly turbid dynamic plume upon its discharge, reaching the sea bed within minutes or tens of minutes. The resulting mound would be likely to be tens of centimetres to a few metres

high local to the release point. Sand-sized sediment would settle to the sea bed within approximately 1km along the axis of tidal flow from the location at which it was released.

105. The small proportion of fine material 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. up to 6 hours). These deposits would be very thin (generally less than 0.2mm thick and would not exceed 2mm) occurring at up to 50km from the source along the axis of tidal flow. Taking account of the spatial and temporal extents of increased suspended sediments and the thickness of deposits, this is deemed to have a low impact magnitude on benthic receptors.

106. The sensitivity of receptors in the East Anglia TWO windfarm site to increases in suspended sediments and smothering are shown below in ***Table 11***.

Table 11 Sensitivities to Increased Suspended Sediment and Smothering by Deposited Sediment (source: Tyler-Walters et al 2018; Gibb et al 2014; Tyler-Walters, Lear and Allen 2004; Tillin et al. 2015; Jackson and Hiscock 2008; Budd and Hughes 2005)

Receptor	Tolerance	Recoverability	Overall Sensitivity
Light smothering – up to 5cm of fine materials			
Circalittoral coarse sediment biotopes	Medium	High	Low
S. spinulosa	High	Immediate	Not sensitive
S. bombyx	High	High	Low
N. hombergii (proxy species for *N. cirrosa*)	Tolerant	N/A	Not sensitive
Heavy Smothering – up to 30cm of fine materials			
Circalittoral coarse sediment biotopes	Not available		
S. spinulosa	Not available (Medium*)		
S. bombyx	Not available		
N. hombergii (proxy species for *N. cirrosa*)	Not available		
Polinices pulchellus	Not available		
Ophiocten affinis	Not available		
Increased suspended sediment concentrations			
Circalittoral coarse sediment biotopes	High	High	Not sensitive
S. spinulosa	High	Immediate	Not sensitive
S. bombyx	Tolerant	N/A	Not sensitive

Receptor	Tolerance	Recoverability	Overall Sensitivity
N. hombergii (proxy species for *N. cirrosa*)	Tolerant	N/A	Not sensitive

107. The majority of receptors in the East Anglia TWO windfarm site 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. This type of impact could occur within a few metres of the disposal locations where heavy smothering (>5cm) would be expected, representing a low impact magnitude. The worst case scenario is therefore an impact of **minor adverse** significance.

6.3.2 Remobilisation of Contaminated Sediments

108. As described in ***section 6.2.2***, sediment disturbance could lead to the mobilisation of contaminants which may be lying dormant within sediment and which could be harmful to the benthos. Given the low level of contaminants present in the sediments within the development area (***section 3.2***), changes in water and sediment quality due to re-suspension of contaminants during construction have been assessed as negligible.

109. Marine Evidence based Sensitivity Assessment (MarESA) (MarLIN 2017) shows that, where contaminant levels are within environmental protection standards, marine species and habitats are not sensitive to changes that remain within these standards. As a result of the absence of significant existing contamination and the application of mitigation to avoid release of contaminants, there would be **negligible** impact with regard to benthic ecology receptors.

6.3.3 Cumulative Impacts

110. East Anglia ONE North is 10km north east of the East Anglia TWO windfarm site and there is an aggregate extraction area 3km west of the East Anglia TWO windfarm site. There is therefore potential for cumulative impacts associated with suspended sediments and deposition if there is any temporal overlap in offshore construction activities between the two projects. Any plume that does arise would move in the direction of tidal currents and, given the direction of tidal currents, there is no potential physical connection between the proposed East Anglia TWO and East Anglia ONE North projects and therefore, there would be no cumulative impacts from increases in SSCs from construction activities.

111. Small theoretical bed level changes are estimated as a result of cumulative impacts of East Anglia TWO cable installation and dredging at nearby aggregate sites. However, any changes would be small in scale, temporary and temporally distinct depending on whether aggregate dredging and construction of the proposed East Anglia TWO and East Anglia ONE North projects were carried out

at the same time. The sensitivity of benthic receptors to this level of change would be as described in ***section 6.3.1*** (low to negligible). Therefore, an overall impact of **minor adverse** significance would result.

6.3.4 Summary of Impacts of Sediment Disposal on Benthic Ecology

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

7 Summary

113. As part of the DCO application for the proposed East Anglia TWO project, the Applicant is applying to designate the East Anglia TWO windfarm site as a single disposal site. This would allow the Applicant to dispose of material extracted during construction (sea bed preparation (dredging) and drilling) for associated cable and foundation works.

114. Two alternative disposal options have been considered for the disposal of drilled and dredged material:

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

115. The sea bed sediments at the East Anglia TWO windfarm site are primarily medium sand.

116. Maximum quantities of material which would need to be excavated for foundations are provided along with maximum quantities of material released from drilling should piled foundations be utilised.

117. Most of the material released from foundation installation would deposit local to the point of release forming a mound (likely to be tens of centimetres to a few metres high). Suspended sediment concentrations close to the release location would be very high for a very short duration (seconds to minutes) as the material falls to the sea bed. The sediment within the mound would be similar to that on the existing sea bed.

118. The small fraction of fine sand and the very small proportion of mud in disturbed near-surface sediments, and any fine sub-surface sediment released by drilling activities, is likely to become more widely dispersed by tidal currents before settling on the sea bed. Suspended sediment concentrations would be less than 10mg/l above background levels and within the range of natural variability. The

thickness of these deposits across the wider sea bed area would be very small (order of millimetres). Sediment concentrations arising from installation of one foundation were deemed unlikely to persist for sufficiently long that they significantly interact with subsequent operations and therefore no cumulative effect was anticipated.

119. Sea bed levelling of any large sand waves that may be present along cable routes prior to cable installation has the potential to disturb near-surface sediments.

120. The disposal of dredged material has the potential to release sediment-bound contaminants, such as heavy metals and hydrocarbons into the water column. However, levels of contaminants within the East Anglia TWO windfarm site are generally very low. Elevated levels of arsenic, which are typical of the region, have been recorded at some locations but they are not at concentrations considered to pose an unacceptable risk to the marine environment.

121. Results of the benthic ecology assessment show that the majority of receptors in the East Anglia TWO windfarm site are not sensitive to increased suspended sediments and smothering. Adverse impacts could occur within a few metres of the disposal locations where heavy smothering would be expected, but overall the worst case impact from the proposed designation of the East Anglia TWO windfarm site disposal site would be of minor significance.

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Appendix 1

1. This appendix and ***Table A 1*** provides coordinates to delineate the disposal site for the proposed East Anglia TWO windfarm site.

Table A 1 Coordinates Delineating the East Anglia TWO Windfarm Array Disposal Site for the Proposed East Anglia TWO Project

Point	Latitude (Degree, minutes, seconds)	Longitude (Degrees, minutes, seconds)
1	02 13 12.1517	52 15 04.0220
2	02 14 12.0802	52 13 14.0875
3	02 11 09.9646	52 12 22.8452
4	02 10 03.9526	52 12 27.6542
5	02 08 00.5436	52 12 06.3319
6	02 08 10.8720	52 13 57.4938
7	02 15 32.2698	52 10 46.7329
8	02 19 46.6964	52 02 57.2810
9	02 08 40.3021	52 02 52.9694
10	02 07 14.8807	52 03 53.1326
11	02 07 53.0020	52 10 45.0723
12	02 11 27.8926	52 11 17.5182
13	02 11 30.2303	52 11 17.6860
14	02 11 32.5827	52 11 17.6383

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