RWE

RWE Renewables UK Dogger Bank South (West) Limited

RWE Renewables UK Dogger Bank South (East) Limited

Dogger Bank South Offshore Wind Farms

Preliminary Environmental Information Report

Appendix 8-1 – Marine Physical Processes Technical Note

24/04/2023

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Dogger Bank South Offshore Wind Farms

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Marine Physical Processes Method Statement

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GLOSSARY OF ACRONYMS

DCO	Development Consent Order
EIA	Environmental Impact Assessment
ES	Environmental Statement
ETG	Expert Topic Group
GBS	Gravity Based Solution
HDD	Horizontal Directional Drill
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
MCZ	Marine Conservation Zone
MW	Megawatt
National Grid ESO	National Grid Electricity Systems Operator
NNR	National Nature Reserve
O&M	Operation and Maintenance
OCP	Offshore Converter Platform
PEIR	Preliminary Environmental Information Report
SAC	Special Area of Conservation
SPA	Special Protection Area
S-P-R	Source-Pathway-Receptor
SSSI	Site of Special Scientific Interest
UKHO	United Kingdom Hydrographic Office

GLOSSARY OF TERMINOLOGY

Array areas	The two distinct offshore wind farm areas (Dogger Bank South East and Dogger Bank South West) which are collectively known as Dogger Bank South offshore wind farms.
Array cables	Cables which link the wind turbine generators and the offshore substation platform.
Evidence Plan Process	A voluntary consultation process with specialist stakeholders to agree the approach to EIA and information to support HRA.
Horizontal Directional Drilling (HDD)	A method of cable installation where a cable is drilled beneath a feature without the need for trenching.
Jointing Bay	Underground structures constructed at regular intervals along the onshore export cable route to join sections of cable and facilitate installation of the cables into the buried ducts.
Landfall	The location where the offshore cables come ashore.
Offshore export cables	The cables which bring electricity from the offshore substation platform to the transition joint bay.
Onshore grid connection point	The electricity transmission network connection location for the Projects.
RWE Renewables	RWE Renewables UK (Swindon) Ltd.
Scour Protection	Protective materials used to avoid sediment being eroded away from the base foundations and cables as a result of the water flow.
Transition joint bay	An underground structure at the landfall that houses the joint between the offshore export cables and the onshore export cables.
The Projects	Dogger Bank South West and Dogger Bank South East (collectively referred to as Dogger Bank South offshore wind farms).

1 INTRODUCTION

1. The purpose of this method statement is to build upon the information provided in the withdrawn Dogger Bank South Offshore Wind Farms (the Projects) Environmental Impact Assessment (EIA) Scoping Report (Royal HaskoningDHV, 2021). It aims to outline the proposed approach to be taken in the assessment of marine physical processes (including the intertidal areas of the possible landfall locations) effects of the proposed Projects.

2. This method statement and the consultation around it form part of the Projects' Evidence Plan Process. The aim is to gain agreement on this method statement from all members of the Seabed Expert Topic Group (ETG) which will be recorded through the agreement log.

1.1 Background

3. A Scoping Report for the Projects' EIA was submitted to the Planning Inspectorate on 9th November 2021. Further background information on the Projects can be found in the Scoping Report which is available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010125/EN010125-000010-DBSP-Scoping%20Report.pdf

4. The request for a Scoping Opinion was withdrawn on 16th December 2021. An updated Scoping Report will be provided to the Planning Inspectorate in mid-2022.

5. This method statement has been produced following a full review of the pre-Scoping Seabed ETG meeting minutes (meeting held 28th September 2021), any relevant comments received from stakeholders on the withdrawn Scoping Report and experience of the Evidence Plan Process from other offshore wind farms.

1.2 Development Programme

6. The anticipated Development Consent Order (DCO) programme is outlined in **Table 1-1.**

7.

Table 1-1 - Development programme

Deliverable	Indicative Date
EIA Scoping Report submission	Summer 2022
Preliminary Environmental Information (PEI) submission	February 2023
Environmental Statement (ES) and DCO submission	November 2023

1.3 Evidence Plan Process Programme

8. The Evidence Plan Terms of Reference provides an overview of the Evidence Plan Process and expected logistics. **Table 1-2** provides an indication of anticipated meetings for discussion of marine physical processes. However, these are initial dates and therefore could be subject to change as the Projects progress.

Table 1-2 - Evidence Plan Process programme

Meeting	Date
Pre-Scoping Seabed ETG meeting	28th September 2021
Seabed ETG meetings as required	2022 and 2023
PEI Report (PEIR) Seabed ETG meetings to discuss the findings of the PEI	Q4 2022
Pre-submission Seabed ETG meetings to discuss updates to the PEIR prior to submission of the ES	Q2 and Q3 2023

1.4 Survey Programme

9. The baseline characterisation will be informed by a suite of geophysical and (initial) geotechnical surveys described in **Table 1-3**. The geophysical surveys of the array area and possible offshore export cable corridor(s) commenced in March 2022 for approximately six months. Geophysical surveys will be supported by a targeted benthic and sediment survey, planned for August 2022, which will acquire seabed images and grab samples of seabed sediments.

Table 1-3 - Baseline survey programme

Survey Area	Commencement Date	Survey Techniques
Array	March 2022	Multibeam echosounder Side-scan sonar Sub-bottom profiler Benthic and sediments
Possible offshore export cable corridor(s)	June 2022	
Array	Summer 2022	Geotechnical investigations – five boreholes and ten Cone Penetration Tests (CPTs)

2 INDICATIVE WORST CASE SCENARIOS

10. This section provides an overview of the Projects and the current indicative worst case scenarios for marine physical processes. It sets out the design and main components of the offshore wind farms and their infrastructure. It also describes the key activities that would be undertaken during construction, operations and maintenance (O&M) as well as decommissioning. At this early stage the project description is indicative for the purpose of informing the method statement.

11. The Project Description for PEIR and ES will describe the final project design (also known as Rochdale Envelope) for the DCO application. Each chapter of the PEIR and ES will define the worst case scenario arising from the construction, O&M and decommissioning phases of the Projects for the relevant receptors and impacts. Additionally, each chapter will consider separately the anticipated cumulative impacts of the Projects with other relevant projects on the receptors under consideration.

12. The parameters discussed in this section are based on the best available information for the Projects at the time of writing and are subject to change as the project progresses.

2.1 Wind Turbine Foundations

13. The size and capacity of the wind turbines will be decided later, prior to final investment decision. Technology develops rapidly and available sizes of turbines are expected to increase over the coming years. Fifteen MW wind turbines are now in production and are expected to represent the lower end of the design envelope. Based on industry developments to date, wind turbine capacity is likely to increase between the time of scoping and construction. Therefore, in order to future proof the EIA and DCO, maximum parameters for larger capacity wind turbines than are currently in existence would be estimated and the EIA would be undertaken on a range of wind turbine parameters and associated foundations.

14. The Projects' design envelope allows for up to 200 wind turbines, subject to the wind turbine capacity used. A range of foundation options including monopile, jackets on pin piles and suction bucket jacket foundations are in the current project design envelope. Review of geotechnical data, metocean data, environmental considerations and techno-economic parameters including the size of wind turbines selected, and supply chain constraints will be used to select the final wind turbine foundation type(s). The location of the wind turbines will be finalised pre-construction based on ground investigation and constraints identified in the PEIR and ES.

15. It is possible that scour protection would be installed, where required, during construction in order to mitigate the effects of scour and the potential release of suspended sediment and seabed level changes in the vicinity of each wind turbine. This could include rock or gravel placement, protective aprons or coverings, bagged solutions, concrete mattressing and / or flow energy dissipation devices. The volume and area of scour protection per turbine foundation will be included in the PEIR and ES, with impacts assessed accordingly.

2.2 Offshore Cabling

16. Array cables will connect the turbines to each other and to the offshore substation(s). The maximum length of the array cables for the Projects is estimated to be 610km. The location and length of the array cables will be determined post consent, subject to the final layout of the wind turbines.

17. Offshore export cables are likely to connect the offshore substation(s) to a transition joint bay at the possible landfall locations. The offshore export cables could be either HVAC or HVDC depending on the location of the onshore grid connection point(s). If HVAC is chosen there could be up to four HVAC cables per Project, with a diameter of approximately 240mm. For HVDC there could be up to two HVDC cables per Project, with a diameter of approximately 145mm.

2.3 Offshore Substations

18. Up to five offshore substation platforms and / or offshore converter platforms (OCP) may be required.

2.4 Construction Vessels

19. Vessel anchors and jack-up vessels required for construction also have the potential to impact marine physical processes at the seabed. The maximum number of anchors and / or jack-ups representing the worst case scenario would be defined in the PEIR and ES. Several types of construction vessel could work in parallel during the construction of the Projects. Wind turbine foundation installation vessels are expected to be a mixture of jack-up vessels and dynamically positioned vessels (the latter enabling installation without any direct contact with the seabed), depending upon the available water depth in the installation area. At present the most likely wind turbine installation vessel would be a jack-up vessel, although this activity may also be possible in the future with dynamically positioned vessels.

2.5 Possible Landfall Locations

20. There are currently three possible landfall zones where the offshore export cables could be brought onshore. Once National Grid ESO confirm the onshore grid connection point(s) it will be possible to select preferred landfall location(s) for the subsequent EIA through the detailed site selection process. For the purposes of this note the assumption has been made that landfall will occur along the Holderness coast, allowing a grid connection at Creyke Beck.

21. Trenchless solutions are currently being considered for the construction of the landfall(s). In this case, horizontal directional drilling (HDD) is likely to be used. The HDD will exit the seabed in an exit pit at a suitable location. The length of the HDD would depend on the landfall location(s) selected and may be influenced by factors such as shallow geology and soil conditions, environmental constraints, water depth, seabed topography and coastal erosion rates.

22. Should HDD not be possible due to cliff height or difficult drilling conditions alternative trenchless techniques would be considered such as microtunneling and / or using a tunnel boring machine to create a segmented tunnel system.

2.6 Construction Programme

23. Construction of the Projects is anticipated to begin no earlier than 2026. The programme for construction and operation of the Projects will depend on the outcome of the Holistic Network Design process. If the same onshore grid connection point is selected for both Projects, RWE Renewables may seek an integrated approach to installation of transmission assets. This approach could benefit the planning and construction of the electrical infrastructure and reduce the overall environmental impact.

2.7 Operation and Maintenance

24. Once commissioned, it is anticipated that the Projects' assets would have an operational life of 30 years. All offshore infrastructure including wind turbines, foundations, cables and offshore substations would be monitored and maintained during this period to maximise efficiency. As part of the Offshore Wind Leasing Round 4 the developers will enter into a seabed lease for up to 60 years, this allows sufficient time for two complete asset lifecycles.

2.8 Decommissioning

25. Decommissioning would most likely involve removal of the accessible installed components, such as:

- All the wind turbine components;
- The parts of the foundations above seabed level; and
- Sections of the array cables close to the offshore structures, as well as sections of the offshore export cables.

26. The process for removal of the installed components is generally the reverse of the installation process. Possible impacts associated with the decommissioning stage(s) will be further considered as part of the EIA. It is anticipated that a full EIA would be carried out ahead of any decommissioning works to be undertaken. A decommissioning plan and programme would be developed prior to construction and be updated during the Projects' lifespan to take account of changing best-practice and new technologies.

2.9 Cumulative Impact Scenarios

27. Cumulative impacts would be considered through awareness of the extent of influence of changes to marine physical processes arising from the Projects alone and those arising from the Projects cumulatively or in combination with other offshore wind farms and other nearby seabed activities, including marine aggregate extraction and marine disposal. The full list of ongoing plans or projects to be included in the PEIR and ES would be developed as part of on-going consultation with technical consultees.

2.10 Transboundary Impact Scenarios

28. Given that the likely physical and sedimentary impacts of the Projects would be restricted to near-field change only, transboundary impacts are unlikely to occur, or are unlikely to be significant. Therefore, transboundary impacts to marine physical processes are proposed to be scoped out of the EIA.

3 BASELINE ENVIRONMENT

3.1 Designated Sites

29. The principal receptors with respect to marine physical processes are those features with an inherent geological or geomorphological value or function which may potentially be affected by the Projects. Offshore these are the Dogger Bank Special Area of Conservation (SAC) and Southern North Sea SAC and along the east coast of England, the Greater Wash Special Protection Area (SPA), and various Sites of Special Scientific Interest (SSSIs), Marine Conservation Zones (MCZs), SACs, SPAs and National Nature Reserves (NNRs). The specific features defined within these receptors as requiring further assessment at the EIA stage for the Projects are listed in **Table 3-1**. It is important to note that some of these sites and features may be scoped out of the EIA once further details of the grid connection locations are available.

Table 3-1 - Marine Physical Processes Receptors

Receptor Group	Receptor	Distance from the Projects
Designated sites and features	Dogger Bank SAC	The array area is located in the SAC and the possible offshore export cable corridor(s) would pass through it
	Southern North Sea SAC	The array area is located in the SAC and the possible offshore export cable corridor(s) would pass through it
East coast of England	Greater Wash SPA	The possible offshore export cable corridor(s) may pass through the SPA
	Various SSSIs, MCZs, SACs, SPAs and NNRs	The possible offshore export cable corridor(s) making landfall on the Holderness coast

3.2 Main Existing Data Sources

30. The withdrawn EIA Scoping Report for the Projects (Royal HaskoningDHV, 2021) provides an overview of the baseline conditions in relation to marine physical processes based on available information. Considerable data and information exist relating to marine physical processes of the existing Dogger Bank offshore wind farms.

31. Numerous technical assessments have been completed for the original Dogger Bank Creyke Beck (now known as Dogger Bank A and B) and Dogger Bank Teesside A&B (now known as Sofia and Dogger Bank C) offshore wind farms in relation to physical processes, sediment transport and scour. For each project, initial geomorphological conceptual models were developed for the array sites, the export cable corridors and the landfall sites (Holderness and Redcar and Cleveland). These were followed by technical assessments of effects including numerical modelling of waves, tidal currents and sediment transport, and empirical assessments of scour. The conceptual models were then incorporated as the baseline and the technical assessments translated into environmental impacts / effects in the Environmental Statements.

32. **Table 3-2** identifies the main desk-based sources from the Dogger Bank A, B and C and Sofia offshore wind farms that will be accessed to inform the characterisation of the existing environments and support the EIA for the Projects. All the data collected for the adjacent offshore wind farms will be utilised for the assessment of the Projects.

Table 3-2 - Existing Data Sources related to Dogger Bank A, B and C and Sofia offshore wind farms that will be used in the EIA

Offshore Wind Farm	Data Source	Date	Data Content
Dogger Bank A and B	Array site conceptual model	March 2012	Described the existing physical and sedimentary processes operating across Dogger Bank and the changes in seabed geometry driven by these processes
	Export cable corridor conceptual model		Described the physical and sedimentary processes operating along the export cable corridor
	Landfall conceptual model		Provided a baseline understanding of the function and natural characteristics of the Holderness coast and in particular the location of the landfall
	Assessment of Effects technical report	August 2013	Assessment of effects focussed on numerical modelling assessments of tidal currents, waves and sediment transport, and their influence on morphological changes of the seabed and adjacent coasts, alongside empirical assessments of scour
	Environmental Statement		

Offshore Wind Farm	Data Source	Date	Data Content
Dogger Bank C and Sofia	Array site conceptual model	January 2014	Described the existing physical and sedimentary processes operating across Dogger Bank and the changes in seabed geometry driven by these processes
	Assessment of Effects technical report	March 2014	Assessment of effects focussed on numerical modelling assessments of tidal currents, waves and sediment transport, and their influence on morphological changes of the seabed and adjacent coasts, alongside empirical assessments of scour
	Environmental Statement		

33. The assessment of effects completed for both Dogger Bank A and B, and Dogger Bank C and Sofia offshore wind farms were exhaustive in their scope, using numerical modelling techniques (assessment of tidal currents, waves and sediment transport), empirical methods (scour) and expert geomorphological assessment (landfall). The modelling quantified the existing conditions and the changes caused by the installation and presence of the wind turbine foundations and associated structures and installation of connecting cables and export cables that connect the wind farms to the coast. Simulations were run for the baseline conditions and for the situation with the wind turbines and associated structures in place for the realistic worst case scenarios (Rochdale Envelope). The numerical modelling considered the three different phases of the offshore wind farms' life cycle: construction, operation and decommissioning.

34. In addition to drawing upon the above, the assessment of the Projects would also consider the most recent metocean data available that was collected for the adjacent offshore wind farms or any nearby metocean data collected for other purposes. The metocean data would be incorporated into the baseline characterisation and used to support the conceptual assessment of effects. Site-specific metocean data will also be used, where available.

3.3 Other Relevant Studies

35. Other data and information available to inform the EIA include:

- Marine Renewable Atlas;

- Wavenet (Cefas);
- United Kingdom Hydrographic Office (UKHO) tidal diamonds and historical charts;
- Met Office wind and wave time series;
- United Kingdom Climate Projections 2018 (UKCP18);
- Southern North Sea Sediment Transport Study;
- Futurecoast;
- Shoreline Management Plans;
- Humber Regional Environmental Characterisation;
- British Geological Survey geology and seabed sediment maps and regional reports; and
- Industry guidance.

3.4 Planned Data Collection

36. The data requirements for a baseline understanding of the marine physical processes at the proposed development locations that would underpin the assessment could be classified into two areas: material and process.

37. The material data includes knowledge of the geology of the seabed and sub-seabed, bathymetry, and the lithology and distribution of mobile and non-mobile sediments. The material information for the Projects would be obtained through planned geophysical surveys in Summer 2022. Data collected will include multibeam echosounder, side-scan sonar, and sub-bottom profiler data. Further material data (seabed sediments, particle size and seabed imagery) will be collected during the benthic survey planned from August 2022.

38. The details of the geophysical survey techniques that would be used are:

- Multibeam echosounder: to obtain high resolution bathymetry data to map the seabed and the seabed features across the full site area;
- Side-scan sonar: to provide information on the texture and nature of the seabed and identify bedforms and geological features; and
- Sub-bottom profiler: to map the geological units in the top 5m (as a minimum) below the seabed, including geo-hazards such as buried boulders, peat layers and shallow gas.

39. The process data includes knowledge of the forcing factors such as waves, tide-generated currents, their strengths, directions and variability with time, and sediment transport regime. The process data would be obtained from:

- Metocean buoys deployed at the array sites in March 2022;
- The results of existing metocean and numerical modelling campaigns carried out for Dogger Bank A and B, and Dogger Bank C and Sofia offshore wind farms; and
- Any nearby metocean data collected for other purposes.

4 USING THE EXISTING DOGGER BANK MODELLING TO SUPPORT THE CONCEPTUAL APPROACH

40. Numerical modelling was undertaken specifically for the development areas of Dogger Bank A and B, and Dogger Bank C and Sofia offshore wind farms to inform their environmental assessment. The Projects are located in close proximity to these previous wind farms within the Dogger Bank Zone and the results of the existing modelling will be used as part of the conceptual evidence-based assessment of potential effects or impacts of the Projects.

41. The assessment of effects for both Dogger Bank A and B, and Dogger Bank C and Sofia followed similar methodologies focussing on numerical modelling assessments of tidal currents, waves and sediment transport, and their influence on morphological changes of the seabed and adjacent coasts, alongside empirical assessments of scour. The modelling quantified the existing conditions and the changes caused by the installation and presence of the wind turbine foundations and associated structures and installation of connecting cables and export cables that connect the wind farms to the coast. Simulations were run for the baseline conditions and for the situation with the wind turbines and associated structures in place for the realistic worst case scenarios (Rochdale Envelope).

4.1 Physical Comparison of the Array Areas

42. The physical basis for using the previous modelling results is that the design of the Projects and the marine physical processes operating at the array area are like those at the previous Dogger Bank sites (Dogger Bank A, B and C and Sofia) and they therefore provide suitable evidence (and are suitable analogues) to support the assessment of effects or impacts caused by the Projects. There is an extensive and robust evidence base from the previous Dogger Bank wind farms work to negate the need for numerical modelling to support the assessment of the Projects.

43. Justification for using the modelling results from Dogger Bank A and B and Dogger Bank C and Sofia offshore wind farms as the principal evidence of potential effects or impacts at the Projects array area is provided below. This includes the similarities of the existing physical and sedimentary conditions (water depths, tidal currents, waves, seabed sediments, and suspended sediment) at each of the sites.

44. Water depths at Dogger Bank A and B and Dogger Bank C and Sofia are comparable to those at the Projects **(**

45. **Figure** 4-1). The maximum, minimum and average water depths across each wind farm are shown in **Table 4-1**.

Table 4-1 – Maximum, minimum and average water depths across the Dogger Bank wind farms

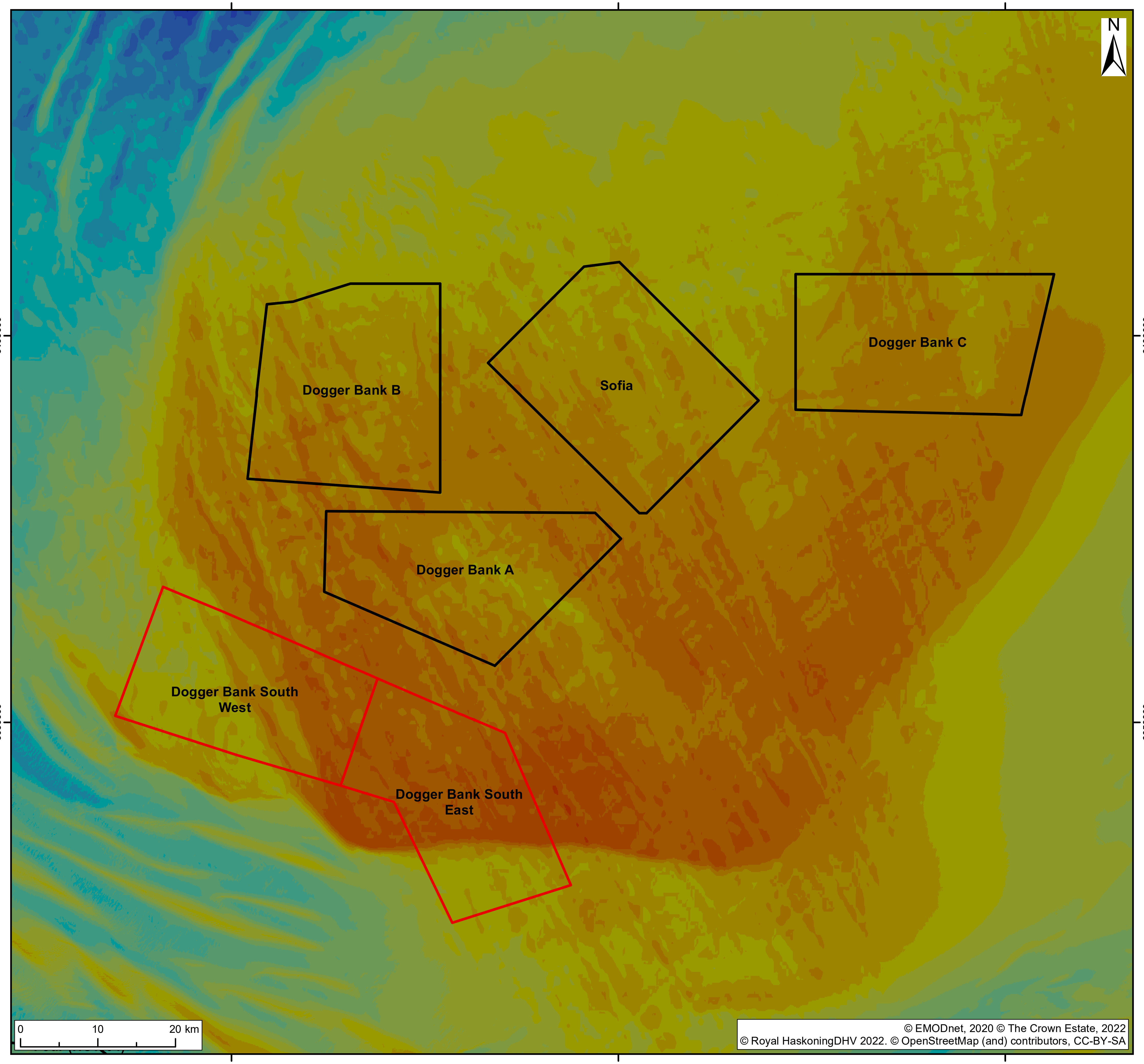
Wind Farm	Maximum (m LAT)	Minimum (m LAT)	Average (m LAT)
Dogger Bank South (West)	-38	-12.5	-26
Dogger Bank South (East)	-35	-10.5	-20
Dogger Bank A	-32	-13.5	-22.5
Dogger Bank B	-34	-14.5	-25.5
Dogger Bank C	-35	-19	-25
Dogger Bank Sofia	-35	-18	-26.5

46. Tidal currents flow in similar directions and at similar velocities on the flood tide and ebb tide. Spring tide peak current velocities lie between 0.2m/s and 0.4m/s across Dogger Bank A and B and Dogger Bank C and Sofia and 0.2m/s to 0.6m/s across the Projects (**Figure 4-2**).

47. Predominant waves approach all sites from similar directions (**Figure 4-3**). The whole area within which the offshore wind farms are located is exposed to wave conditions generated within the North Sea, with the most severe conditions arriving from the north due to long fetch lengths. Annual mean significant wave heights range from about 1.7m to 2.0m across all the sites.

48. Broad-scale sediment mapping by the British Geological Survey shows that the seabed sediments at all sites are similar (**Figure 4-4**). The seabed at Dogger Bank A and B and Dogger Bank C and Sofia offshore wind farms comprise mainly slightly gravelly sand, gravelly sand or sand. The seabed sediment across the Projects comprise mainly slightly gravelly sand or sand.

49. Regionally suspended sediment concentrations have been published by Cefas (2016) (**Figure 4-5**). Average concentrations across all sits between 1998 and 2015 were 2-3mg/l. Concentrations may increase significantly during storm events.



Legend:

- Dogger Bank South Offshore Wind Farms
- Other Offshore Wind Farms

Bathymetry (LAT)

- 0 - -9.9
- -10 - -14.9
- -15 - -19.9
- -20 - -24.9
- -25 - -29.9
- -30 - -34.9
- -35 - -39.9
- -40 - -44.9
- -45 - -49.9
- -50 - -54.9
- -55 - -59.9
- -60 - -64.9
- -65 - -69.9
- -70 - -74.9
- -75 - -79.9
- -80 - -84.9
- -85 - -89.9

S2	P01	17/02/2022	Suitable for Information	LB	CC	HC
SUI	REV	DATE	DESCRIPTION	DRW	CHK	APR

Title:

Bathymetry relationship between Dogger Bank A and B, Dogger Bank Sofia and C and the Projects

Figure: 4-1 Drawing No: PB2340-RHD-OF-DB-DR-Z-0125

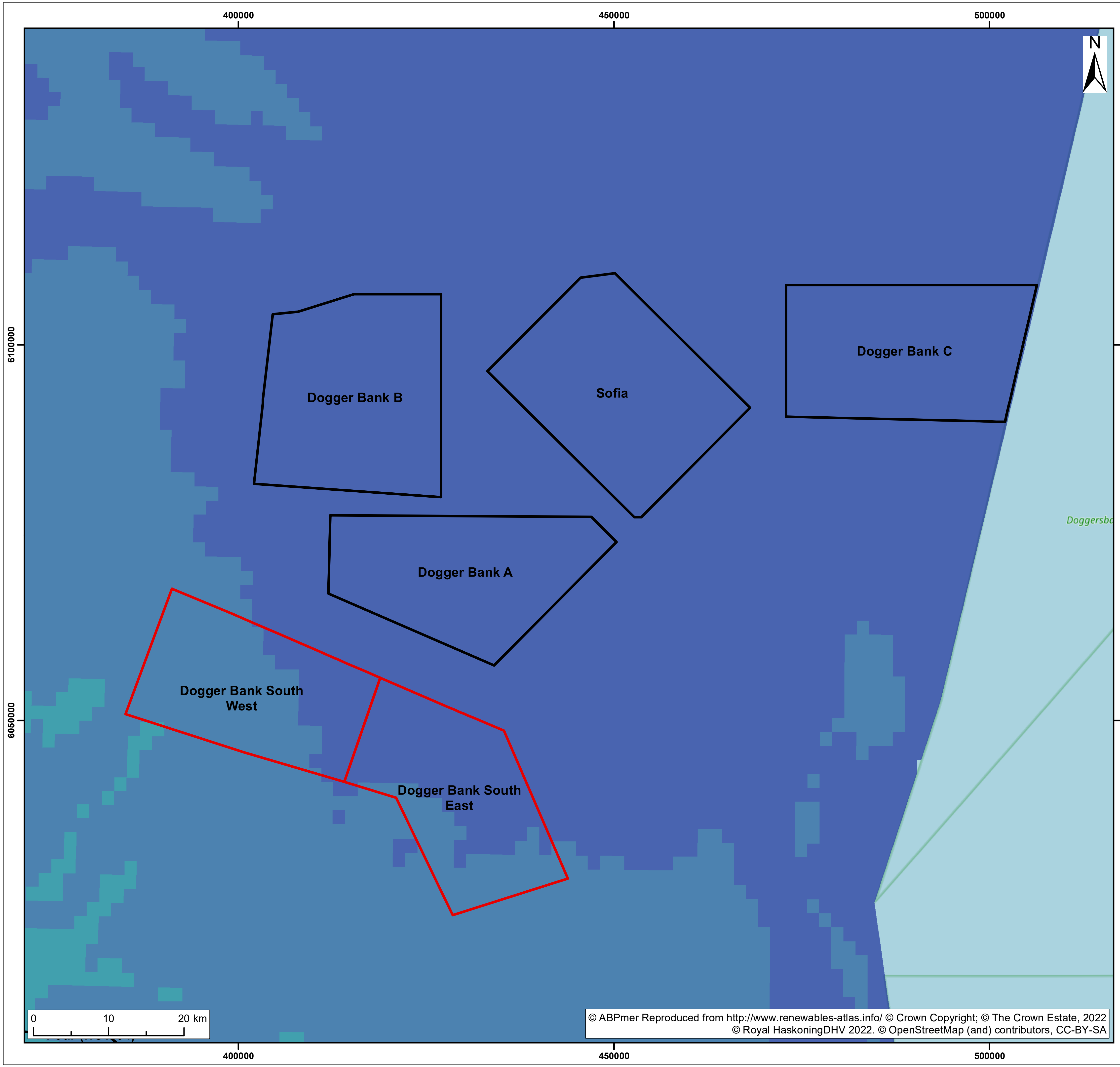
Co-ordinate system: WGS 1984 UTM Zone 31N | Page Size: A3 | Scale: 1:500,000

Project: Dogger Bank South Offshore Wind Farms

Report: Marine Physical Processes Method Statement

Royal HaskoningDHV
Enhancing Society Together

RWE



Legend:

- Dogger Bank South Offshore Wind Farms
- Other Offshore Wind Farms

Peak Flow of Mean Spring Tide (m/s)

- 0.21 - 0.40
- 0.41 - 0.60
- 0.61 - 0.80

SUI	REV	DATE	DESCRIPTION	DRW	CHK	APR
S2	P01	17/02/2022	Suitable for Information	LB	CC	HC

Title:

Modelled tidal flows across Dogger Bank

Figure: 4-2 | Drawing No: PB2340-RHD-OF-DB-DR-Z-0126

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WGS 1984 UTM Zone 31N	A3	1:500,000

Project:	Report:
Dogger Bank South Offshore Wind Farms	Marine Physical Processes Method Statement

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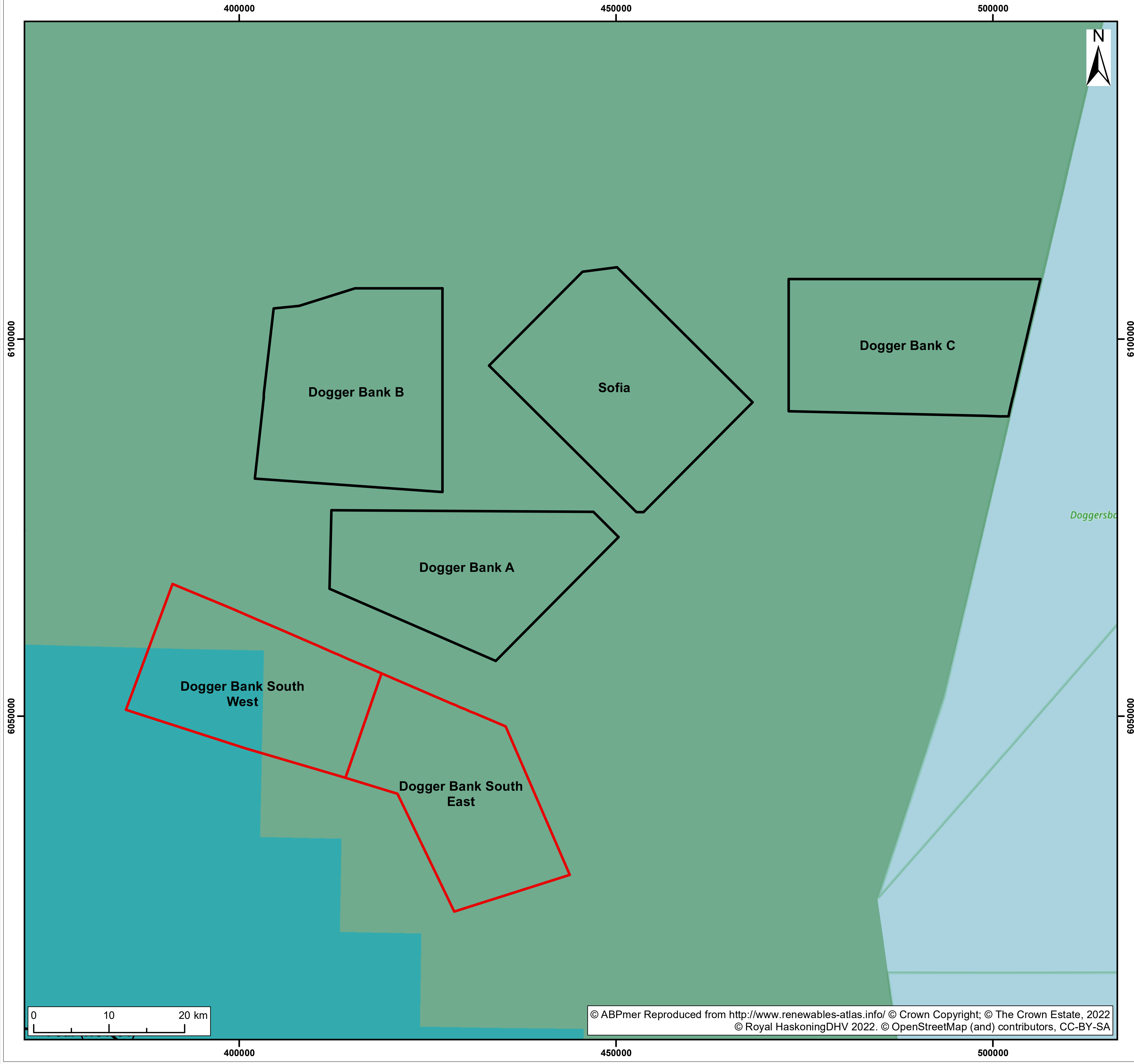


Legend:

- Dogger Bank South Offshore Wind Farms
- Other Offshore Wind Farms

Annual Mean Significant Wave Height (m)

- 1.51 - 1.75
- 1.76 - 2.00

S2	P01	17/02/2022	Suitable for Information	LB	CC	HC
SUI	REV	DATE	DESCRIPTION	DRW	CHK	APR

Title:

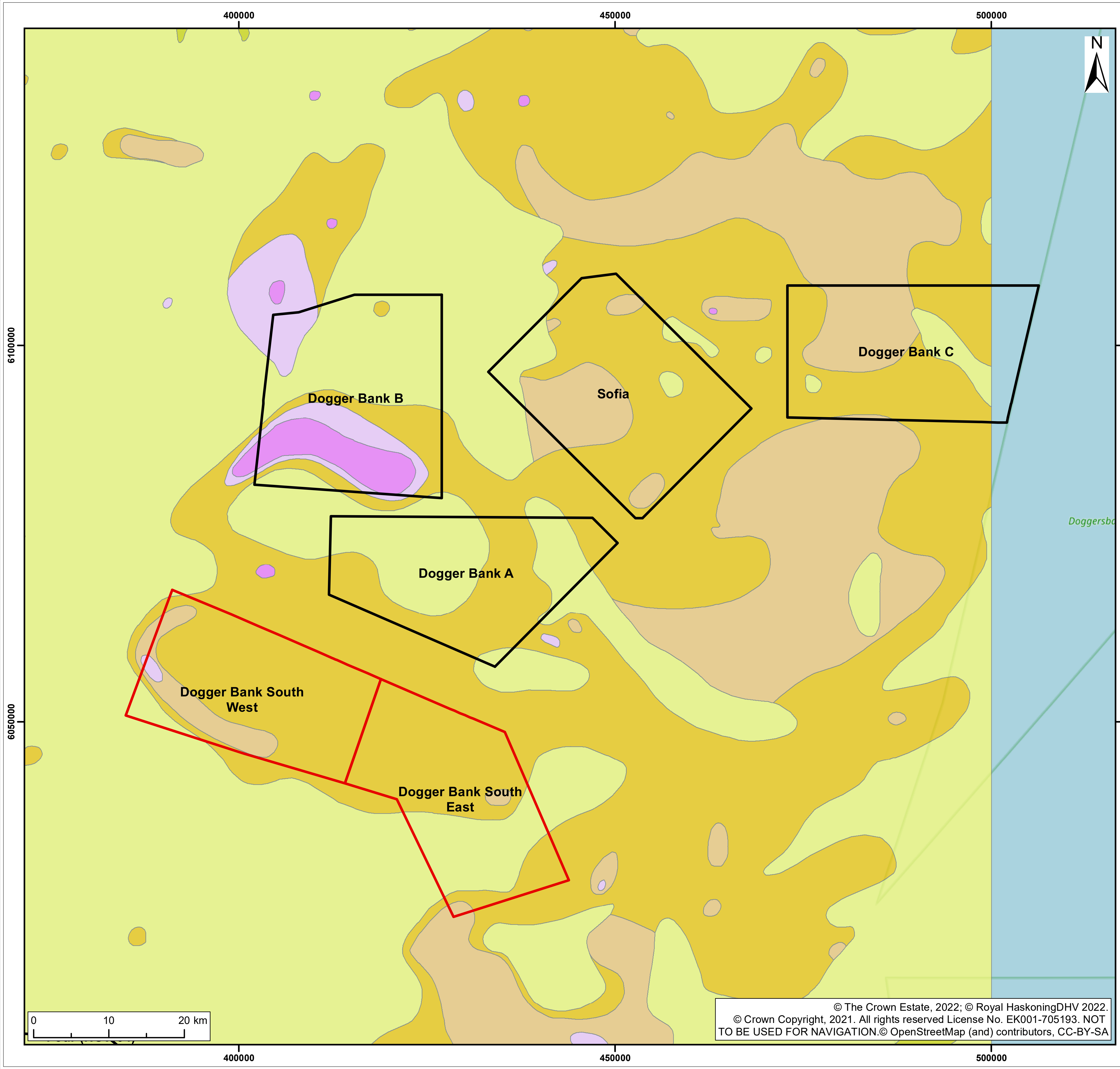
Modelled waves across Dogger Bank

Figure: 4-3 | Drawing No: PB2340-RHD-OF-DB-DR-Z-0127

Co-ordinate system:	Page Size:	Scale:
WGS 1984 UTM Zone 31N	A3	1:500,000

Project:	Report:
Dogger Bank South Offshore Wind Farms	Marine Physical Processes Method Statement

Royal HaskoningDHV
Enhancing Society Together
RWE



Legend:

- Dogger Bank South Offshore Wind Farms
- Other Offshore Wind Farms

Seabed Sediment

- GRAVEL
- GRAVELLY SAND
- MUDDY SAND
- SAND
- SANDY GRAVEL
- SLIGHTLY GRAVELLY SAND

SUI	REV	DATE	DESCRIPTION	DRW	CHK	APR
S2	P01	17/02/2022	Suitable for Information	LB	CC	HC

Title:

Seabed sediment relationship between Dogger Bank A and B, Dogger Bank Sofia and C and the Projects

Figure: 4-4 Drawing No: PB2340-RHD-OF-DB-DR-Z-0128

Co-ordinate system: WGS 1984 UTM Zone 31N
Page Size: A3
Scale: 1:500,000

Project: Dogger Bank South Offshore Wind Farms

Report: Marine Physical Processes Method Statement

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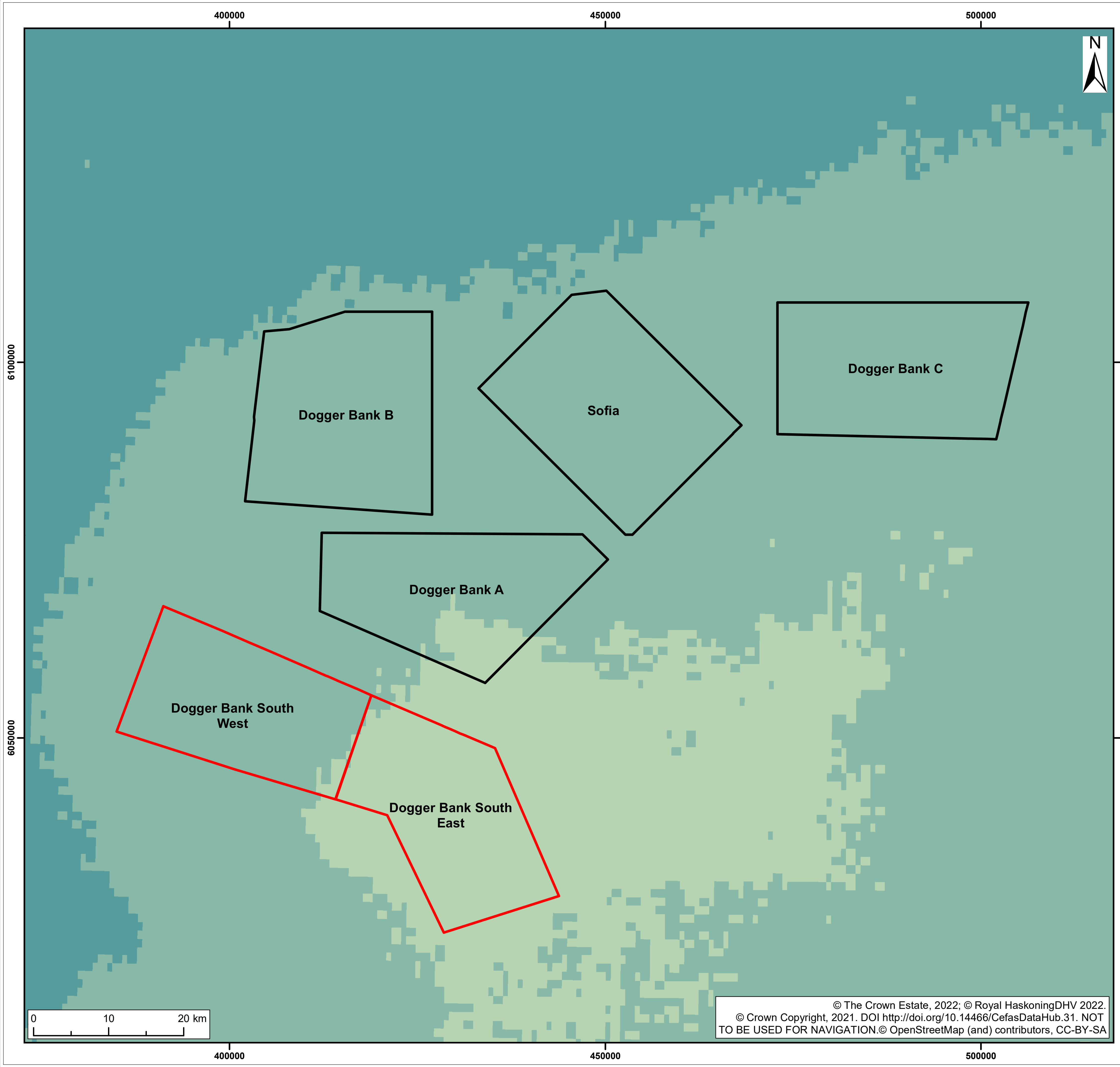

Legend:

Dogger Bank South Wind Farms

Other Offshore Wind Farms

SPM 1998-2015 (mg/l)

1

2

3

SUI	REV	DATE	DESCRIPTION	DRW	CHK	APR
S2	P01	17/03/2022	Suitable for Information	JR	LB	DB

Title:

Average Suspended Particulate Matter (SPM) 1998-2015

Figure: 4-5 Drawing No: PB2340-RHD-OF-DB-DR-Z-0131

Co-ordinate system:	Page Size:	Scale:
WGS 1984 UTM Zone 31N	A3	1:500,000

Project: Dogger Bank South Offshore Wind Farms

Report: Marine Physical Processes Method Statement

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RWE

50. The modelling for Dogger Bank A and B assessed 600 4MW gravity base foundations in a gridded layout at 700m spacings, each with a diameter of 47m (worst case scenario). The modelling for Dogger Bank C and Sofia assessed a perimeter of 6MW conical Gravity Based Solution (GBS) foundations at 750m spacings with a wider spaced grid of foundations across the rest of each site, totalling 400 foundations. Although indicative at this stage, the Projects will comprise between 200 15MW turbines and 126 23.81MW turbines with a worst-case of suction bucket jacket foundations. The larger number of wind turbines at smaller spacings assessed in the modelling of the previous Dogger Bank offshore wind farms provides a conservative proxy for the assessment of the Projects. Whilst it is recognised that there are small differences in physical and sedimentary conditions and project parameters between the sites, the conservative nature of the numerical modelling conducted for Dogger Bank A and B and Dogger Bank C and Sofia offshore wind farms allows for these differences in the effect that may arise due to these factors.

4.2 Physical Comparison of the Export Cable Corridors

51. The possible landfall locations between Bridlington and Spurn Point are similar to the previous landfalls and so the export cable corridors would cross areas of similarly composed seabed to those previously modelled. Hence, for these possible export cable corridor(s), the previous modelled results would provide suitable evidence (and are suitable analogues) to support the assessment of effects or impacts at the Projects.

4.3 Previous Assessment of Construction Effects

52. Over the construction period there is the likelihood of discrete and potentially instantaneous disturbances to the seabed as a consequence of installation of turbine foundations and cable laying. These activities have the potential to release suspended sediment into the water column forming sediment plumes. The magnitude of the disturbance would be a function of the type of seabed sediment, the method of construction and the prevailing hydrodynamic and wave conditions. Two main effects were identified that were addressed by the numerical modelling of Dogger Bank A and B, and Dogger Bank C and Sofia:

- Increase in suspended sediment concentrations as a result of foundation installation activities; and
- Increase in suspended sediment concentrations as a result of cable installation activities.

53. The simulations of the release and spreading of fine sediments (mud to fine sand) as a result of foundation and cable installation activities at both wind farms was modelled using the 3D model MIKE3-FM Mud Transport (MT). The overall effect on sediment transport of foundation and cable installation was modelled together over a 30-day installation period that included a one-year storm. As a very conservative worst-case scenario for both wind farms, a total of 24 foundations were assumed to be installed sequentially at the same time as the laying of a single export cable and a set of array cables. The foundations that were tested were located close to sensitive benthic habitat (faunal crusts and turfs) and fisheries (sandeel habitat). Two types of foundation installation were modelled to determine the worst case for plume dispersion. These were conical GBS foundations, where sediment is released through seabed preparation and scour and monopole foundations, where sediment is released through drill arisings and scour. The cable laying process and sequencing was the same for both types of foundation installation.

4.4 Previous Assessment of Operational Effects

54. During the operation of the wind farms, the effects of the built development are most likely through persistent and direct changes resulting from tide and wave interactions with the structures. An individual foundation can alter localised physical conditions, creating wakes, and has the potential to create localised scour where seabed sediments respond to increased shear stress. Several effects were addressed by the numerical modelling of Dogger Bank A and B, and Dogger Bank C and Sofia due to the presence of the foundation structures:

- Changes to the tidal current regime;
- Changes to the wave regime;
- Changes to the suspended sediment transport regime; and
- Introduction of scour effects.

55. The effect of operation on the tidal current and wave processes was modelled using a layout of foundations across each of the developable areas. For Dogger Bank A and B, the worst case scenario was determined to be a gridded layout of 4MW conical GBS foundations at 700m spacing (the foundation option that creates the greatest 'blocking' effect). For Dogger Bank C and Sofia, the worst case scenario was determined to be a perimeter of 6MW conical GBS foundations at their minimum 750m spacing with a wider spaced grid of foundations across the rest of the project. The MIKE3-FM HD (hydrodynamic) and MIKE21-SW (spectral wave) models were used to investigate tidal current flows and waves, respectively. The models were run over the same 30-day simulation period. No potential effects were considered for the export and array cables because, during operation, they would be buried or surface-laid and protrude (with armouring where present) only a small height above the seabed.

56. Over the period of operation, there is the potential for creation of sediment plumes caused by seabed scour around non-scour protected wind turbine foundations after they have been installed. In the assessment of Dogger Bank A and B, and Dogger Bank C and Sofia, the effect of scour on sediment transport was modelled using the gridded layouts that were used to model changes to tidal currents and waves. Two scenarios were tested as the worst case for plume dispersion using a minimum construction period of two years. These were a scenario after one year when half the foundations are operational and subject to a 30-day simulation including a one-year storm, and a scenario after two years when all the foundations are operational and subject to a 30-day simulation including a larger 50-year storm. The simulation of the release and spreading of fine sediments (mud to fine sand) as a result of foundation scour processes during the operation of the wind farm was modelled using the 3D model MIKE3-FM Mud Transport (MT).

57. Scour refers to the development of depressions in the seabed around the base of the foundations. It is the result of net sediment removal over time, due to the interaction between the foundation and the waves and tidal current flows. These interactions result in a local acceleration in mean flow velocity and locally elevated levels of turbulence that enhance sediment transport potential. The dimensions of a scour depression and its rate of development depend on the following characteristics:

- The dimensions, shape and orientation of the foundation;
- The depth, magnitude, orientation and variation in waves and/or tidal current flows; and
- The characteristics of the seabed sediment.

58. Based on existing literature and knowledge, an estimate of equilibrium scour volume for sand was derived empirically for each of the different foundation types to be used across Dogger Bank A and B, and Dogger Bank C and Sofia as a basis for comparison to establish which one would be the worst case.

59. In order to compare the predicted sediment volumes released by the scour process into the context of the scale of natural processes, empirical formulae were used to determine sediment volumes disturbed during one-year and 50-year storms across Dogger Bank A and B, and Dogger Bank C and Sofia without foundations in place. The scour volumes for different types and sizes of foundation were predicted using the following criteria:

- The equilibrium scour volume for sand was derived in various water depths defined by the location of the foundations;
- Calculated for the combined action of waves and tidal currents during a one-year storm event; and
- Conservatively assume maximum equilibrium scour depths created through an 'infinite' thickness of non-cohesive sandy sediments.

60. Also, the predicted sediment volumes released by the scour process were placed within the context of the scale of natural processes, through calculation of natural background suspended sediment concentrations that could be expected to arise during an extreme condition of waves and currents.

5 IMPACT ASSESSMENT METHODOLOGY

5.1 Defining Impact Significance

61. The assessment of effects on the marine physical processes will be predicated on a Source-Pathway-Receptor (S-P-R) conceptual model, whereby the source is the initiator event, the pathway is the link between the source and the receptor impacted by the effect, and the receptor is the receiving entity. An example of the S-P-R conceptual model is provided by cable installation which disturbs sediment on the seabed (source). This sediment is then transported by tidal currents until it settles back to the seabed (pathway). The deposited sediment could change the composition and elevation of the seabed (receptor). Numerical modelling of marine physical processes effects of the Projects is not being recommended because the existing Dogger Bank modelling is considered sufficiently robust and appropriate for an evidence-based assessment of the Dogger Bank South Offshore Wind Farms (Section 4).

62. Consideration of the potential effects of the Projects on the marine physical processes would be carried out over the following spatial scales:

- Near-field: the area within the immediate vicinity (tens or hundreds of metres) of the array area and along the possible offshore export cable corridor(s); and
- Far-field: the wider area that might also be affected indirectly by the project (e.g. due to disruption of waves, tidal currents or sediment pathways passing through the site).

63. There are three main phases of the Projects that will be considered, in conjunction with the present-day baseline, over the life cycle of the Projects. These are:

- Construction phase;
- O&M phase; and
- Decommissioning phase.

64. For the effects on marine physical processes, the assessment will follow two approaches. The first type of assessment would be impacts on marine physical processes whereby several discrete direct receptors could be identified. These include certain morphological features with ascribed inherent values, such as offshore sand banks, and beaches and sea cliffs at the coast.

65. The impact assessment will 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.

66. In addition to identifiable receptors, the second type of assessment would cover changes to marine physical processes which in themselves are not necessarily impacts to which significance could be ascribed. Rather, these changes (such as a change in the wave climate, a change in the tidal regime or a change in suspended sediment concentrations) represent effects which may manifest themselves as an impact upon other receptors, most notably marine water and sediment quality, benthic ecology, and fish and shellfish ecology (e.g. in terms of increased suspended sediment concentrations, or erosion or smothering of habitats on the seabed). Hence, the two approaches to the assessment of marine physical processes would be:

- Situations where potential impacts could be defined as directly affecting receptors which possess their own intrinsic morphological value. In this case, the significance of the impact is based on an assessment of the sensitivity of the receptor and magnitude of effect by means of an impact significance matrix.
- Situations where effects (or changes) in the baseline marine physical processes may occur which could manifest as impacts upon receptors other than marine physical processes. In this case, the magnitude of effect is determined in a similar manner to the first assessment method but the significance of impacts on other receptors is made within the relevant chapters of the PEIR and ES pertaining to those receptors.

67. Assessment of direct impacts on receptors with morphological value will be completed for the parts of the Projects inside Dogger Bank SAC, which is designated as an Annex I sandbank which is slightly covered by seawater all the time under the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2017.

68. The assessment would be undertaken in accordance with following standards and guidance:

- Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects (Cefas 2012);
- Guidance on Environmental Impact Assessment in Relation to Dredging Applications (Office of the Deputy Prime Minister 2001);

- Offshore Wind Farms: Guidance Note for Environmental Impact Assessment in respect of Food and Environmental Protection Act (FEPA) and Coast Protection Act (CPA) requirements: Version 2 (Cefas 2004); and
- Review of Cabling Techniques and Environmental Effects applicable to the Offshore Windfarm Industry (BERR 2008).

5.2 Sensitivity, Value and Magnitude

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

- Tolerance to an effect (i.e. the extent to which the receptor is adversely affected by an effect);
- Adaptability (i.e. the ability of the receptor to avoid adverse impacts that would otherwise arise from an 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).

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

71. 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).

72. The sensitivity and value of discrete morphological receptors and the magnitude of effect would be assessed using expert-based judgement and described with a standard semantic scale. Definitions for each term are provided in

73. **Table** 5-1, **Table 5-2** and **Table 5-3**. These expert-based judgements of receptor sensitivity, value and magnitude of effect would be closely guided by the conceptual understanding of baseline conditions.

Table 5-1 - Definitions of the different sensitivity levels for a morphological receptor

Sensitivity	Definition
High	**Tolerance**: Receptor has very limited tolerance of effect **Adaptability**: Receptor unable to adapt to effect **Recoverability**: Receptor unable to recover resulting in permanent or long-term (greater than ten years) change
Medium	**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 (five to ten years)
Low	**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 (one to five years)
Negligible	**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)

Table 5-2 - Definitions of the different value levels for a morphological receptor

Value	Definition
High	**Value**: Receptor is designated and / or of national or international importance for marine physical processes. Likely to be rare with minimal potential for substitution. May also be of significant wider-scale, functional or strategic importance
Medium	**Value**: Receptor is not designated but is of local to regional importance for marine physical processes
Low	**Value**: Receptor is not designated but is of local importance for marine physical processes
Negligible	**Value**: Receptor is not designated and is not deemed of importance for marine physical processes

Table 5-3 - Indicative criteria for assessing magnitude of effect

Magnitude	Definition
High	**Scale**: A change which would extend beyond the natural variations in background conditions **Duration**: Change persists for more than ten years **Frequency**: The effect would always occur **Reversibility**: The effect is irreversible
Medium	**Scale**: A change which would be noticeable from monitoring but remains within the range of natural variations in background conditions **Duration**: Change persists for five to ten years **Frequency**: The effect would occur regularly but not all the time **Reversibility**: The effect is very slowly reversible (five to ten years)
Low	**Scale**: A change which would barely be noticeable from monitoring and is small compared to natural variations in background conditions **Duration**: Change persists for one to five years **Frequency**: The effect would occur occasionally but not all the time **Reversibility**: The effect is slowly reversible (one to five years)
Negligible	**Scale**: A change which would not be noticeable from monitoring and is extremely small compared to natural variations in background conditions **Duration**: Change persists for less than one year **Frequency**: The effect would occur highly infrequently **Reversibility**: The effect is quickly reversible (less than one year)

5.3 Impact Significance

74. Following the identification of receptor sensitivity and value, and magnitude of the effect, it is possible to determine the significance of the impact. A matrix is presented in **Table 5-4** as a framework to guide how a judgement of the significance will be determined.

Table 5-4 - 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*

75. Through use of this matrix, an assessment of the significance of an impact will be made using expert-based judgement in accordance with the definitions in **Table 5-5**.

Table 5-5 - Indicative Impact Significance Categories

Impact Significance	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 is likely to be an important consideration at a local level
Minor	Small change in receptor condition, which may be raised as a local issue but is unlikely to be important in the decision-making process
Negligible	No discernible change in receptor condition

76. Note that for the purposes of the EIA, ‘major’ and ‘moderate’ impacts are deemed to be significant (in EIA terms). In addition, whilst minor impacts are not significant, it is important to distinguish these from other non-significant (negligible) impacts as they may contribute to significant impacts cumulatively. Following initial assessment, if the impact does not require additional mitigation (or none is possible) the residual impact will remain the same. If, however, additional mitigation is proposed there would be an assessment of the post-mitigation residual impact.

6 POTENTIAL IMPACTS DURING CONSTRUCTION

77. Impacts of construction on tidal currents and waves are scoped out of the EIA because the worst-case impacts relate to operation.

6.1 Changes in Suspended Sediment Concentrations and Seabed Levels due to Foundation Installation

78. Increases in suspended sediment concentration may result from disturbance arising from foundation construction activities. Deposition of this sediment may then lead to changes in bed levels and sediment type at the seabed.

79. The greatest effect on suspended sediment concentrations and subsequent deposition during the construction phase of the foundations depends on the installation methods used; different installation methods are required for different foundation types. Monopiles and pin piles are likely to be driven, drilled or drilled-driven into the seabed. Drilling has the potential to disturb seabed and sub-seabed sediments, which are raised to the sea surface from where they may be dispersed into the water column. For suction buckets, an area of seabed may need to be ploughed or dredged (seabed preparation) in order to provide a level surface upon which they are installed. Installation of scour protection would also disturb seabed sediments.

80. An expert-based assessment will draw from the results of the detailed sediment plume dispersion modelling previously undertaken for the existing Dogger Bank offshore wind farms, along with the project-specific survey data for the Projects. The proposed approach is considered proportionate to the likely risk of significant impact on seabed habitat. This is because the planned foundations and offshore export cables will be in predominantly sandy or coarser environments with very little fine sediment, and so the effects during construction on the surrounding environment are anticipated to be small. Any sediment plumes are expected to be limited and sediment would fall to the seabed in relatively close proximity to its point of release into the water column.

6.2 Changes in Suspended Sediment Concentrations and Seabed Levels due to Cable Installation

81. A variety of techniques could be used to excavate a trench for each offshore export cable (and array cables). These include jetting, ploughing, and trenching. Sand wave levelling may be required for some sections of the possible offshore cable corridor(s) prior to cable installation. During excavation or pre-sweeping (by whichever methods), sediment plumes will be formed by the release of sediment into the water column. The released sediment would become dispersed in the water column both vertically and laterally, resulting in increased suspended sediment concentration and sediment deposition in the environment at and surrounding the cable and, depending on the extent of sediment transport, in more remote environments.

82. There are currently three possible landfall zones where the offshore export cables could be brought onshore, and hence the area currently covered by the potential offshore export cable corridors is large. Until agreement is reached on the cable corridor that will be used, it is difficult to determine what level of assessment is required. If the chosen cable corridor is close to existing Dogger Bank cable routes, then it may be appropriate to use the results of existing models in an evidence-based assessment. However, if the chosen route is not close to an existing modelled cable corridor, then the approach will be revisited in consultation with stakeholders.

6.3 Indentations on the Seabed due to Installation Vessels

83. There is potential for certain vessels used during the installation of the foundations and offshore cable infrastructure to directly impact the seabed. This applies for those vessels that utilise jack-up legs or several anchors to hold station and to provide stability for a working platform. Where legs or anchors (and associated chains) have been inserted into the seabed and then removed, there is potential for an indentation proportional to the dimensions of the object to remain. The worst case is considered to correspond to the use of jack-up vessels since the depressions would be greater than the anchor scars.

84. An expert-based assessment of potential effects would be undertaken. This is because the effects would be minor and local, and the depressions are likely to re-fill with mobile sediment soon after the vessel is demobilised.

6.4 Changes in Bedload Sediment Transport at the Possible Landfall Locations

85. Possible landfall locations have been identified between Bridlington and Spurn Point. At these locations the offshore export cables must transit through the intertidal zone. It is presently envisaged that a HDD technique would be used to install cables at the landfall(s). Construction at the HDD exit point, either on the beach or below MLWS has the potential to interrupt bedload sediment transport along and across the coast. Also, the construction activities may release small amounts of suspended sediment into the coastal water.

86. The east coast has been the subject of numerous detailed investigations of coastal geomorphology and processes, including the Shoreline Management Plans, Southern North Sea Sediment Transport Study, and peer-reviewed publications. The existing studies in the possible landfall locations, and others identified through the course of the impact assessment, as well as stakeholder consultation through the Evidence Plan Process, would provide enough information to develop a detailed conceptual understanding of the coastal systems and their adjacent areas. Therefore, the proposed approach to assess the cable landfall(s) for the Projects is to review existing data and apply expert-based interpretation within the context of the construction programmes for the project.

7 POTENTIAL IMPACTS DURING OPERATION

7.1 Changes to Tidal and Wave Regimes due to the Presence of Foundation Structures

87. Over the operational lifetime of the Projects, the tidal regime effects are likely to be evident through persistent and direct changes, resulting from tidal current interactions with the foundation structures (and any scour protection). The effects on tidal currents of the foundations could be divided into two types:

- Local changes in the vicinity of each foundation created by interaction with the currents; and
- Regional changes, which are the overall changes created by the group of foundations in a layout pattern.

88. When waves coincide with a wind turbine foundation (and any scour protection), part of the energy is reflected and part of it is diffracted around the structure. This effect changes the wave climate in the vicinity of the structure and is referred to as the wave shadow effect. Potential effects on the wave regime associated with the presence of the foundations may include changes to the naturally occurring wave heights, periods and directions.

89. The approach that would be adopted for both tidal currents and waves is an expert-based assessment. This would involve delineation of indicative zones beyond which the effects on tidal currents and waves are likely to be diminished. Modelled evidence from the previous Dogger Bank offshore wind farm assessments would be used to identify potential tidal current and wave changes local to each foundation.

90. There is also a pre-existing scientific evidence base which demonstrates that changes in tidal currents due to the presence of foundation structures are both small in magnitude and localised in spatial extent. This is confirmed by existing guidance documents (ETSU, 2000, 2002; COWRIE, 2009) and numerous Environmental Statements for offshore wind farms.

91. There is also a strong scientific evidence base which demonstrates that changes in waves due to the presence of foundation structures, even under a worst case scenario of the largest diameter GBS, are both relatively small in magnitude and relatively local in spatial extent (ETSU, 2000, 2002; Ohl et al., 2001; Cefas, 2005; COWRIE, 2009). Changes are typically less than 10% of baseline wave heights near each wind turbine, reducing with greater distance from each one. Effects are relatively local in spatial extent, extending as a shadow zone typically up to kilometres from the site along the axis of wave approach, but with low magnitudes (only a few percent change across this wider area).

7.2 Changes to Seabed Morphology due to the Presence of Foundation Structures and Cable Protection

92. Seabed morphology directly impacted by the footprint of each foundation structure on the seabed within the array area, constitutes a loss in natural seabed area during the operational life of the Projects. Parts of the array cables and offshore export cables may require some form of protection on the seabed (rock or gravel placement, bagged solutions etc) which would also constitute a loss in seabed.

93. The assessment will quantify the construction footprint and the total loss of seabed habitat due to the foundations and compare that area to the total seabed area within the array area. A similar assessment will be completed for the footprint of the cable protection and any pressure exerted on designated features. These data will then be used to assess the likely scale and area of effect.

7.3 Changes to Sediment Transport due to Cable Protection Measures

94. Any cable protection on the seabed could potentially create a partial barrier to sediment transport. The key factors in determining the magnitude of the potential effect on bedload sediment transport of cable protection are the type and spatial extent of transport on the seabed. The two main drivers of transport in the nearshore zone are waves, and tidal currents further offshore. The spatial extent of transport depends on the size of the zone in which sediment is actively mobile and the magnitude of transport within this zone.

95. In order to understand these factors and assess the potential for significant interruption of bedload sediment transport, expert-based assessment will be used. The assessment will define the following transport processes as a baseline to assess the potential modes of change caused by the cable protection:

- Active offshore sediment transport: this transport mechanism occurs offshore and is primarily driven by tidal currents, although shallower offshore areas may have a wave-driven component;
- Active nearshore longshore sediment transport: this transport mechanism occurs along the nearshore seabed as a result of wave-driven processes; and
- Active nearshore cross-shore sediment transport: this transport mechanism also occurs along the nearshore seabed as a result of wave-driven processes. However, the sediment is generally transported offshore from the beach to the nearshore during storm events and returned to the beach during more constructive wave conditions. Cable protection will be unlikely to significantly affect cross-shore sediment transport since it would be laid broadly in alignment with the cross-shore transport direction, providing little obstruction to sediment movement.

8 POTENTIAL IMPACTS DURING DECOMMISSIONING

96. Decommissioning will most likely involve the accessible installed components comprising:

- All the wind turbine components;
- The parts of the foundations above seabed level; and
- Sections of the array cables close to the offshore structures, as well as sections of the offshore export cables.

97. The types of effect will be comparable to those identified for the construction phase, namely:

- Changes in suspended sediment concentrations and seabed levels due to foundation removal;
- Changes in suspended sediment concentrations and seabed levels due to removal of parts of the array cables and offshore export cables;
- Indentations on the seabed due to decommissioning vessels; and
- Changes in coastal sediment transport and suspended sediment concentrations due to removal of the landfall infrastructure.

98. The process for removal of foundations is generally the reverse of the installation process. Possible impacts associated with the decommissioning stage(s) will be further considered as part of the EIA. It is anticipated that a full EIA will be carried out ahead of any decommissioning works to be undertaken. Decommissioning is expected to be undertaken in reverse of the construction sequence, involving similar types and numbers of vessels and equipment (with the exception of no pile driving/drilling). The decommissioning plan and programme will be developed prior to construction and be updated during the lifespan of the Projects to take account of changing best-practice and new technologies.

9 POTENTIAL CUMULATIVE IMPACTS

99. Cumulative impacts will be considered through awareness of the extent of influence of changes to marine physical processes arising from the proposed wind farm alone and those arising from the Projects and other Dogger Bank offshore wind farms cumulatively or in combination with other nearby seabed activities, including marine aggregate extraction and marine disposal. The full list of ongoing plans or projects to be included in the ES will be developed as part of on-going consultation with technical consultees.

9.1 Construction Changes to Suspended Sediment Concentrations

100. Cumulative construction effects will be restricted to the interaction of sediment plumes and their deposition on the seabed. Cumulative effects may arise if the construction of foundations and cables at the Projects is synchronous with other offshore activities and the plumes that are created by the construction overlap. There is the potential for the respective plumes to interact, to create a larger overall plume, with higher suspended sediment concentration and, potentially, a greater depositional footprint on the seabed.

101. The potential interaction between plumes from different construction activities will be assessed using expert-based assessment. An initial screening exercise will identify where cumulative impacts are not anticipated with respect to overlapping plumes, thereby screening them out from further assessment. Where there is the potential for overlap of plumes, an expert view would be taken on the respective contributions from each and how they might combine to form enhanced suspended sediment concentrations.

9.2 Operational changes to Tidal Currents, Wave Regimes and Sediment Transport

102. The cumulative effect of the operation of the Projects with other offshore projects could occur for tidal currents, waves, and sediment transport. Based on modelling analyses for previous offshore wind farms and published guidance documents, changes to tidal current velocities, wave heights and sediment transport rates are expected to be greatest in the immediate vicinity of the foundation structures and reduce with increased distance away. Outside the array area, it was considered that changes in flow speed would be confined to within one peak spring tidal excursion of the array boundary. The largest changes to individual wave heights would occur within the Projects, with wave shadowing in a down-wave direction of each foundation. The changes to tidal currents and waves could potentially have a cumulative effect on the bedload sediment transport regime.

103. The potential interaction between tidal currents, waves and sediment transport will be assessed using expert-based assessment. An initial screening exercise will identify where cumulative impacts are not anticipated with respect to overlapping effects, thereby screening them out from further assessment. Where there is the potential for overlap of effects, an expert view will be taken on the respective contributions from each and how they might combine to change tidal currents velocities, wave heights and / or sediment transport within a ‘zone of potential cumulative influence’.

104. The zone of potential cumulative influence for tidal currents will be defined based on an understanding of the tidal ellipses, previous numerical modelling and knowledge that effects arising from wind turbine foundations are relatively small in magnitude and local. It is expected that changes to the tidal regime will have returned to background levels well within the excursion of one tidal ellipse, and this threshold will be used to produce the maximum ‘zone of potential influence’ on the tidal regime.

105. For the wave regime the zone of potential cumulative influence will be based on an understanding of the wave roses in the area, the use of expert-based assessment and an understanding that effects arising from wind turbine foundations on the wave regime would be local and relatively small in scale.

9.3 Potential Transboundary Impacts

106. Given that the likely physical and sedimentary impacts of the Projects will be restricted to near-field change only, transboundary impacts are unlikely to occur, or are unlikely to be significant. Therefore, transboundary impacts to marine physical processes are proposed to be scoped out of the EIA.

10 CONCLUSIONS

107. The purpose of this method statement is to outline the proposed approach to be taken in the assessment of marine physical processes effects of the Projects. It forms part of the Evidence Plan Process with a view to gaining agreement (through publication of an agreement log) on the proposed approach from all members of the Seabed ETG.

108. The main element of the approach is the use of the existing Dogger Bank numerical modelling results to support a conceptual evidence-based assessment (using a Source-Pathway-Receptor conceptual model) of the potential effects or impacts of the Projects. It is proposed that no new numerical modelling of the Projects will be completed because the results of the modelling of the existing sites are representative of the worst case for the Projects. They are therefore considered to be suitable analogies for how marine physical processes at the Projects will be affected.

109. The proposed use of the S-P-R conceptual model will be a key point of agreement with the ETG.

REFERENCES

BERR. 2008. Review of Cabling Techniques and Environmental Effects applicable to the Offshore Windfarm Industry.

Cefas. 2004. Offshore wind farms: guidance note for Environmental Impact Assessment in respect of FEPA and Coast Protection Act requirements.

Cefas. 2005. Assessment of the significance of changes to the inshore wave regime as a consequence of an offshore wind array. Defra R&D report.

Cefas. 2012. Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects.

CEFAS. 2016. Suspended Sediment Climatologies around the UK. Report for the UK Department for Business, Energy & Industrial Strategy offshore energy Strategic Environmental Assessment programme.

COWRIE. (Collaborative Offshore Wind Research into the Environment). 2009. Understanding the environmental impacts of offshore wind farms. ISBN- 978-0-9565843-8-0.

ETSU (Energy Technology Support Unit). 2000. An assessment of the environmental effects of offshore wind farms. Report No. ETSU W/35/00543/REP.

ETSU (Energy Technology Support Unit). 2002. Potential effects of offshore wind farms on coastal processes. Report No. ETSU W/35/00596/REP.

Office of the Deputy Prime Minister. 2001. Guidance on Environmental Impact Assessment in Relation to Dredging Applications.

Ohl, C.O.G., Taylor, P.H., Eatock Taylor, R. and Borthwick, A.G.L. 2001. Water wave diffraction by a cylinder array part II: irregular waves. Journal of Fluid Mechanics, 442, 33-66.

Royal HaskoningDHV. 2021. Dogger Bank South Offshore Wind Farms. Environmental Impact Assessment Scoping Report.