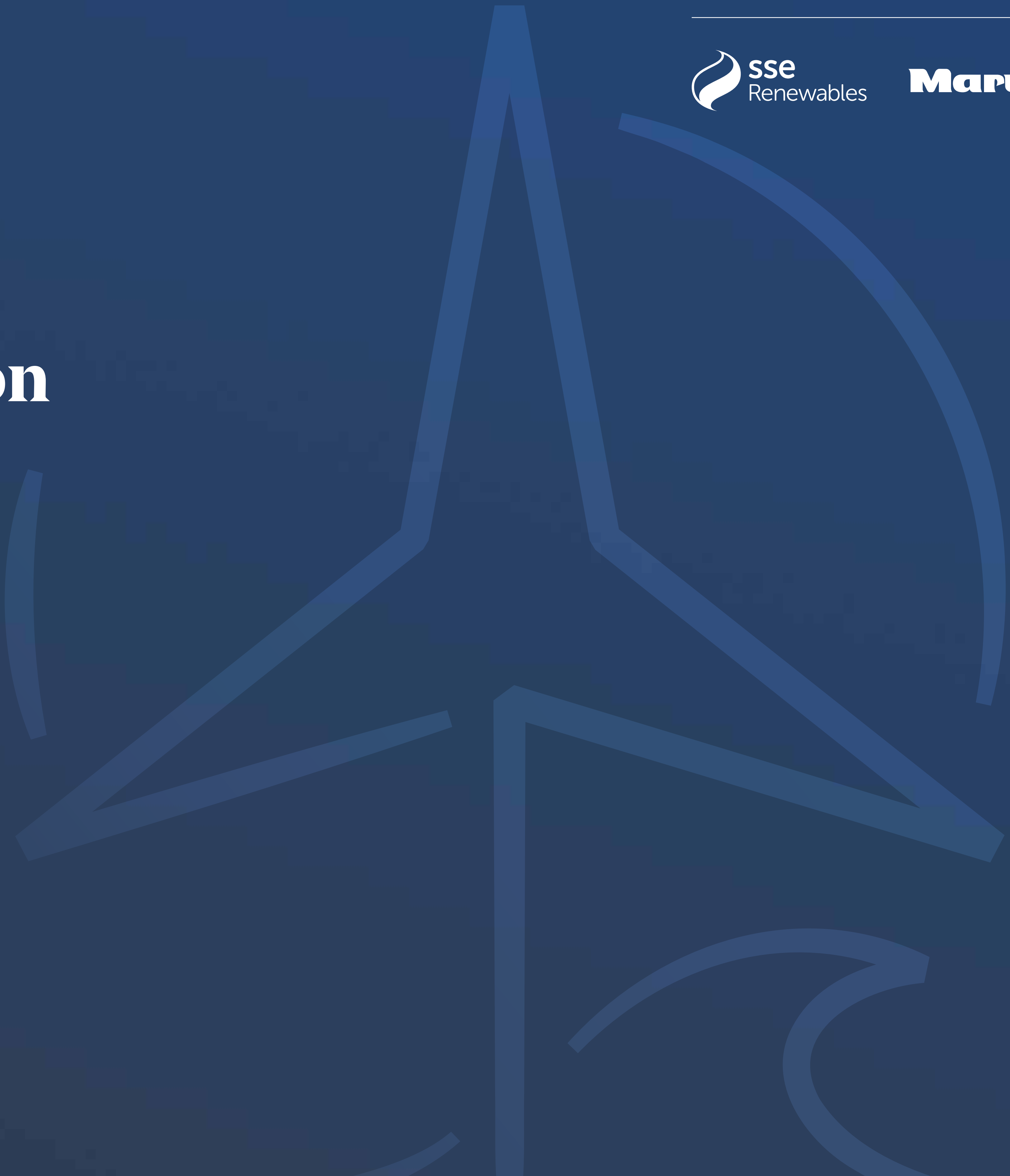
Chapter 3: Project Description

Array EIA Report

2024



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3. PROJECT DESCRIPTION

3.1. INTRODUCTION

3.1.1. OVERVIEW

1. This chapter of the Array Environmental Impact Assessment (EIA) Report provides a description of the infrastructure including all construction, operation and maintenance, and decommissioning activities associated with the Array. This chapter is informed by design work undertaken to date and current understanding of the environment associated with the Array from site-specific survey work undertaken by Ossian Offshore Wind Farm Limited (OWFL) (hereafter referred to as the 'Applicant').

2. As noted in volume 1, chapter 1, this EIA Report has been prepared for the Array only; the Proposed offshore export cable corridor(s) and Proposed onshore transmission infrastructure (comprising the Proposed onshore export cable corridor(s), Proposed onshore converter station and the Proposed landfall location(s)) associated with Ossian will be subject to a separate EIA Scoping Report(s), EIA Report(s) and consent application(s) in the future.

3. The specific conditions and environmental factors within the Array have influence on the design and engineering options available. The Applicant has carried out several studies in the early development stage to address existing unknowns and to refine design parameters. Further studies are expected to be completed beyond the planning phase and into procurement and contracting to gain further site-specific information to inform the final Array design. This includes final wind turbine number and size, floating foundation design (including mooring and anchoring systems), Array layout, and the exact locations, numbers, and types of Offshore Substation Platforms (OSPs). The detailed design will be confirmed post-consent, subject to further site investigation.

4. The Project Design Envelope (PDE) approach (also known as the 'Rochdale Envelope') (Scottish Government, 2022a) has been followed by the Applicant, meaning that parameters for the Array included in this chapter present the maximum extents of the design in order to assess the likely significant adverse effects of the Array. It should be noted that for some technical topics the Maximum Design Scenario (MDS) might be a combination of parameters, not just the maximum parameter, as explained and assessed in volume 2, chapters 7 to 20. The 'maximum design envelope' presented in this chapter defines the maximum range of design parameters. Within the EIA, the Applicant has determined the maximum impacts that could occur for given receptor groups, selecting these from within the range of the 'maximum design envelope' to define the MDS for that receptor group. As a result, for each topic-specific assessment, the predicted effects for any alternative parameter within the range will be no greater than those assessed.

5. The final detailed design will be further developed as additional information becomes available from site investigations and on the commercial availability of technologies. It should be noted that the final detailed design for the Array will be within the PDE parameters presented in this chapter. This is a standard approach for large scale energy projects such as the Array.

3.1.2. PURPOSE OF CHAPTER

6. The purpose of this Project Description chapter is:

- to provide the maximum PDE for the Array, comprising information on the site, design, size and other relevant features of the Array, based on preliminary conceptual design principles (section 3.1.4) and current understanding of the environment;
- to set out the individual components of the Array, as well as the main activities associated with the construction, operation and maintenance and decommissioning phases; and
- to provide the basis for the assessment of effects included in volume 2, chapters 7 to 20.

3.1.3. PROJECT DESIGN ENVELOPE

7. The PDE approach allows for flexibility in the final Array design to account for supply chain constraints, and selection of the most appropriate technology for the site and conditions, while ensuring all likely significant effects (LSE[1]) (beneficial or adverse) are assessed and reported within the Array EIA Report. The PDE presents a range of potential parameter values up to and including the maximum Array design parameters.

8. The Array's PDE has been designed to allow for sufficient flexibility in the final project design options and further refinement during the final design stage, where the full details of a project are not known at the point of Application submission. For each of the impacts assessed within the technical assessments (volume 2, chapters 7 to 20), the PDE has been reviewed and the MDS has been identified from the range of potential options for each parameter. The MDS approach allows the Applicant to retain some flexibility in the final design of the Array and associated offshore infrastructure, but certain maximum parameters are set and are assessed in this Array EIA Report. The maximum scenario, as per the PDE, is presented within this chapter. Anything less than that set out within this chapter and assessed within the technical assessments (volume 2, chapters 7 to 20) will have a lesser impact.

9. This approach aligns with Scottish Government (2013) guidance, which states that "*by applying the principles of an approach commonly known as the 'Rochdale Envelope' it is possible to undertake an environmental assessment which takes account of the need for flexibility in the future evolution of the detailed Project proposal, within clearly defined parameters. In such cases, the level of detail of the proposals must be sufficient to enable a proper assessment of the likely significant environmental effects, and any resultant mitigation measures - if necessary, considering a range of possibilities*". The approach also complies with the guidance prepared by Marine Scotland and the Energy Consents Unit in June 2022 for applicants using the design envelope for applications under section 36 of the Electricity Act 1989 (Scottish Government, 2022a). Further information on the Rochdale Envelope approach and the site selection process for the Array is detailed in volume 1, chapter 4.

10. The PDE describes a range of parameters that apply to a Project technology design scenario (e.g. largest wind turbine option). In this example, wind turbine size and wind turbine number are inherently correlated so if larger wind turbines are selected, fewer wind turbines are likely to be required. Therefore, each design parameter set out in this chapter is not considered independently. The PDE has been used to develop the MDS for each impact pathway in order to determine the parameters (or combination of parameters) which are likely to result in the maximum effect (e.g. the maximum design scenario) on a particular receptor, while adhering to the Project technology design scenarios (e.g. infrastructure parameters associated with the largest wind turbine size). It should be noted, however, that the largest parameters set out in this chapter will not necessarily comprise the MDS for any given receptor group and each of the impacts assessed within the technical assessments (volume 2, chapters 7 to 20).

11. Since the submission of the Array EIA Scoping Report (Ossian OWFL, 2023), the Applicant has developed and refined the PDE for the Array EIA Report using the results of early engineering studies and information gained through consultation with stakeholders. A full description of PDE refinements for the Array is provided within volume 1, chapter 4, however, in summary, the following parameters have changed:

- reduction in the number of floating wind turbines from 270 to 265;
- refinement of floating wind turbine foundation anchoring options – piled anchor solutions, suction anchors, and drag embedment anchors retained in the PDE as these are considered to be suitable anchor solutions for the seabed conditions identified within the Array and with the most mature supply chain. Innovative technologies described under paragraphs 41 to 43 will be considered where commercially available and if there is opportunity to further reduce environmental impacts;
- removal of floating OSP foundation option;
- additional option for OSPs – either up to six large OSPs, or up to three large OSPs and 12 small OSPs;
- refinement of piling parameters for floating wind turbine foundations and OSPs; and
- refinement of inter-array and interconnector cable lengths – changed from 1,515 km (total inter-array and interconnector cable length) to 1,497 km (total inter-array and interconnector cable length).

12. The Habitats Regulations Appraisal (HRA) process includes derogation provisions which may require the Applicant to provide compensatory measures to compensate for the potential adverse effects on the integrity of European sites resulting from the Array, either alone, or in combination with other plans and projects. The Applicant has undertaken an appraisal of the potential impacts of the compensatory measures proposed (without prejudice to the HRA to be conducted by the competent authority). An EIA and HRA has been undertaken on the proposed compensation measures for the Array and are provided as part of the Application.

3.1.4. LOCATION AND SITE INFORMATION

13. The Array will be located within the site boundary, located off the east coast of Scotland, approximately 80 km south-east of Aberdeen from the nearest point, and comprising an area of approximately 859 km^2 (Figure 3.1).

14. In January 2022, as part of the ScotWind Leasing Round, the Applicant was awarded an Option to Lease Agreement to develop Ossian, an offshore wind farm project within the E1 Plan Option (PO) Area (please see volume 1, chapter 4 for further information on the site selection process). Figure 3.1 presents the location of the Array.

Water depths and seabed within the Array

15. A geophysical survey covering the area within the site boundary was conducted between March 2022 and July 2022 to collect geophysical and bathymetric data. Across the site boundary, the maximum water depth was recorded at 88.7 m lowest astronomical tide (LAT), and the shallowest area was recorded at 63.8 m LAT. The seabed across the site boundary slopes gently downwards in an approximately north-west to south-east direction (Ocean Infinity, 2022).

16. Seabed sediments within the site boundary are significantly dominated by deep circalittoral sand, with one area of limited extent comprised of deep circalittoral coarse sediment within the northern part of the site (EUSeaMap, 2021). The geophysical survey indicated that the seabed comprises mainly of sand, with areas of gravel in the west of the site boundary (Ocean Infinity, 2022). The seabed within the site boundary is generally flat, with mega-ripples and sand waves observed in the north-west of the site. Furrows were observed occasionally across the site boundary, more commonly in the west (Ocean Infinity, 2022).

17. Further details of the bathymetry and seabed composition are presented within volume 2, chapters 7 and 8.

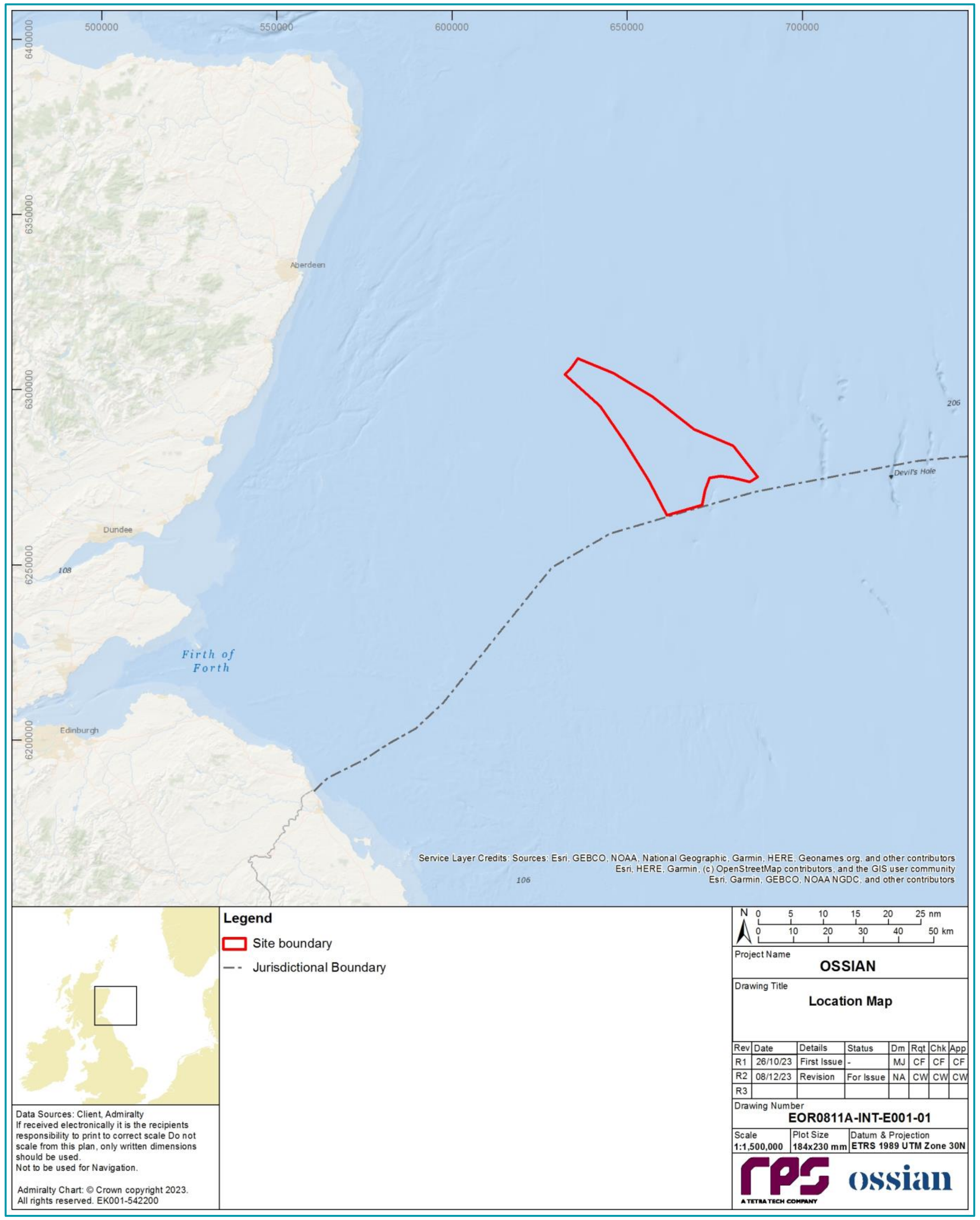

Figure 3.1: Location of the Array

3.2. ARRAY INFRASTRUCTURE

3.2.1. OVERVIEW

18. The main components of the Array will include:

- up to 265 floating wind turbines (each comprising a tower section, nacelle, hub and three rotor blades) and associated floating foundations;
- mooring and anchoring systems for each floating foundation;
- connectors and ancillaries for mooring and anchoring systems, including buoyancy elements and clump weights;
- up to six large OSPs, or up to three large OSPs and up to 12 small OSPs with fixed jacket foundations;
- scour protection for wind turbine anchoring systems;
- scour protection for small and large OSP fixed foundations as required;
- a network of dynamic/static inter-array cabling linking the individual floating wind turbines to OSPs, and interconnector cables between OSPs (approximately 1,261 km of inter-array cabling and 236 km of interconnector cabling); and
- discrete condition monitoring equipment (such as sensors, cameras, dataloggers, etc.), as required for safe and efficient operation of the Array infrastructure.

19. Table 3.1 presents the coordinates of the Array in which the infrastructure will be located.

Table 3.1: Array Coordinates

Array Coordinate No.	Easting (m) (ETRS89 UTM30N)	Northing (m) (ETRS89 UTM30N)
1	686879.95	6275506.95
2	687195.73	6275098.64
3	685058.75	6273806.32
4	685005.4	6273773.99
5	684810.31	6273817.26
6	684232.32	6273945.32
7	680220.4	6274836.53
8	676705.99	6275365.01
9	673521.08	6274870.83
10	672490.61	6272137.3
11	672487.56	6272129.27
12	672258.14	6271521.23
13	671382.07	6267118.91
14	669407.11	6266547.79
15	666739.99	6265778.42
16	661310.94	6264218.21
17	656536.02	6273476.16
18	655807.82	6274655.15
19	655611	6274973.99
20	650627.29	6283017.84
21	649285.03	6285190.21
22	642220.6	6295339.72
23	638532.13	6298677.31
24	634777.9	6302083.16
25	632742.59	6303933.32
26	632228.62	6304400.88
27	632708.66	6304916.62
28	634077.21	6306387.94
29	634108.92	6306422.16
30	635897.77	6308945.92
31	635917.04	6308937.97
32	642630.9	6306178.13
33	646106.44	6304755.18
34	653283.35	6300410.15
35	657265.23	6298008.62
36	660745.4	6295269.97
37	664781.56	6292101.84
38	667469.07	6289997.1
39	667469.07	6289997.1
40	669066.41	6288747.93
41	673603.43	6286851.55
42	680271.65	6284076.35
43	686478.89	6276025.77

3.2.2. FLOATING WIND TURBINES

20. The Array will comprise up to 265 floating wind turbines, however, the final number of wind turbines will be dependent on the capacity of individual wind turbines used, as well as the environmental and engineering survey results.

21. A range of wind turbine parameters are provided which account for varying generating capacities of wind turbines considered within the PDE. This allows a degree of flexibility to account for anticipated technological developments in the future whilst allowing the MDS to be defined for each potential impact within the technical assessments (volume 2, chapters 7 to 20). Therefore, the wind turbine parameters presented in this section, and for which consent is being sought, represent the maximum wind turbine parameters as presented in the PDE, such as maximum rotor blade diameter and maximum blade tip height.

22. Table 3.2 presents the range of parameters considered for the wind turbines and considers both the maximum number of wind turbines and the largest wind turbines described within the PDE. Therefore, the parameters in combination do not represent a realistic design scenario, rather they represent the most adverse parameters of a range of wind turbine models that may be available post-consent/at the time of the Array construction.

23. Floating wind turbines will comprise a tower section, nacelle, hub and three rotor blades, and will be attached to a floating foundation (further described in section 3.2.3). A schematic of a typical floating wind turbine is presented in Figure 3.2.

24. The maximum rotor blade diameter will be no greater than 350 m, with a maximum blade tip height of up to 399 m above LAT and minimum blade clearance of 36 m above LAT. The hub height will be no greater than 224 m above LAT. The Applicant will develop and agree a scheme for wind turbine lighting and navigation marking with the relevant consultees post-consent decision for approval by Scottish Ministers after consultation with appropriate consultees.

25. The wind turbine layout will be developed to effectively make use of the available wind resource and suitability of seabed conditions, whilst ensuring that the environmental effects and potential impacts on other marine users (e.g. fisheries and shipping routes) are reduced. If required by consent conditions, confirmation of the final layout of the wind turbines will occur at the final design stage (post-consent) in consultation with relevant stakeholders and submitted to the Marine Directorate – Licensing and Operations Team (MD-LOT) for approval. Indicative array layouts are presented in Figure 3.3 and Figure 3.4 for 265 wind turbine locations plus 15 OSP locations, and 130 wind turbine locations plus 15 OSP locations, respectively. The OSPs could be sited at any of the locations shown in the figures and will be determined at the final design stage (post-consent). Further information on OSPs is provided in section 3.2.4.

Table 3.2: Maximum Design Envelope: Floating Wind Turbines

Parameter	Maximum Design Envelope
Maximum number of floating wind turbines	Up to 265
Minimum blade clearance above LAT (m)	36
Maximum blade tip height above LAT (m)	399
Maximum hub height above LAT (m)	224
Maximum rotor diameter for smallest wind turbine option in PDE (m)	236
Maximum rotor diameter for largest wind turbine option in PDE (m)	350
Maximum number of blades	3
Minimum wind turbine spacing (m)[1]	1,000 in all directions
Maximum wind turbine spacing (m)[2]	4,200 in all directions

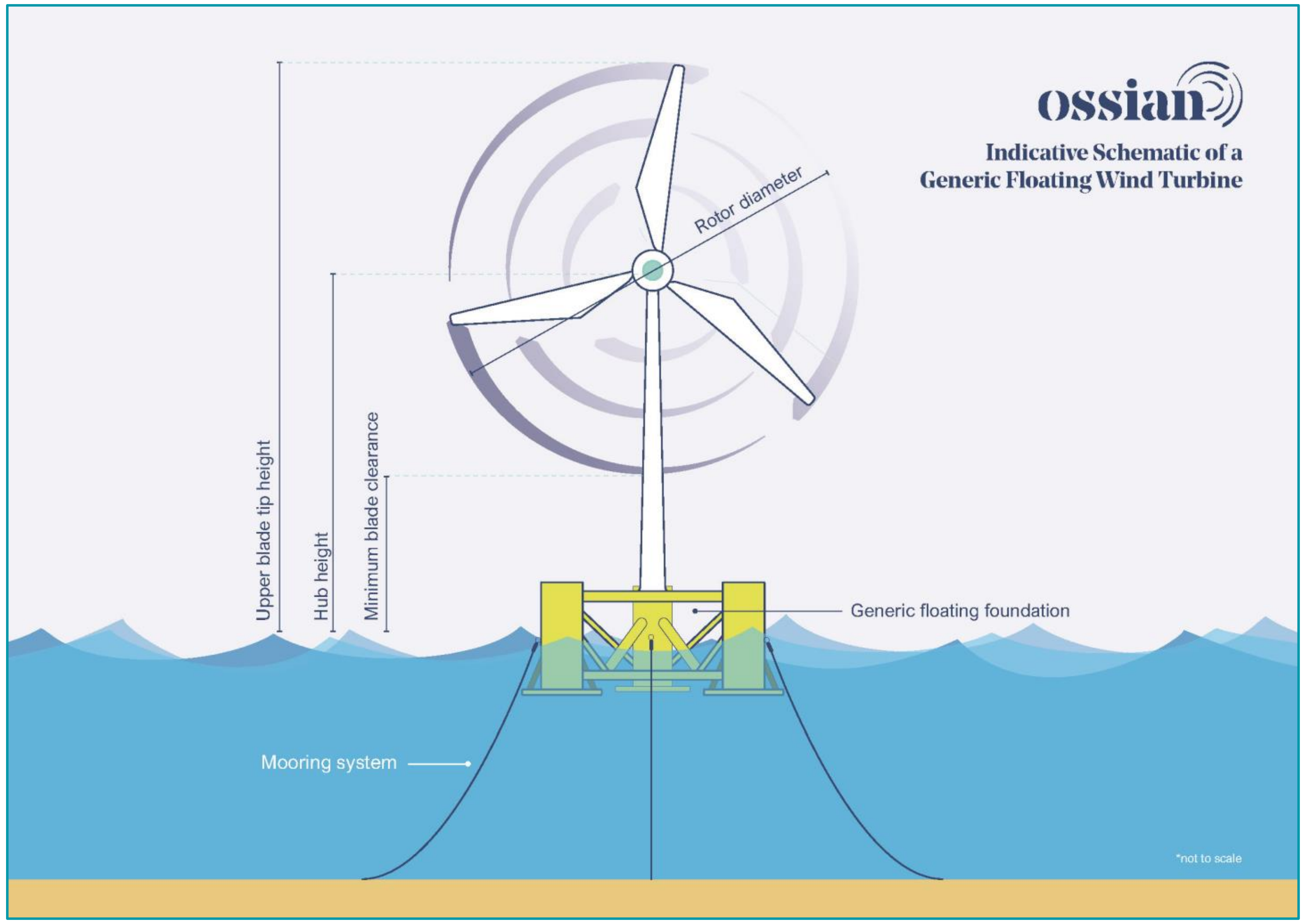

Figure 3.2: Indicative Schematic of a Generic Floating Wind Turbine

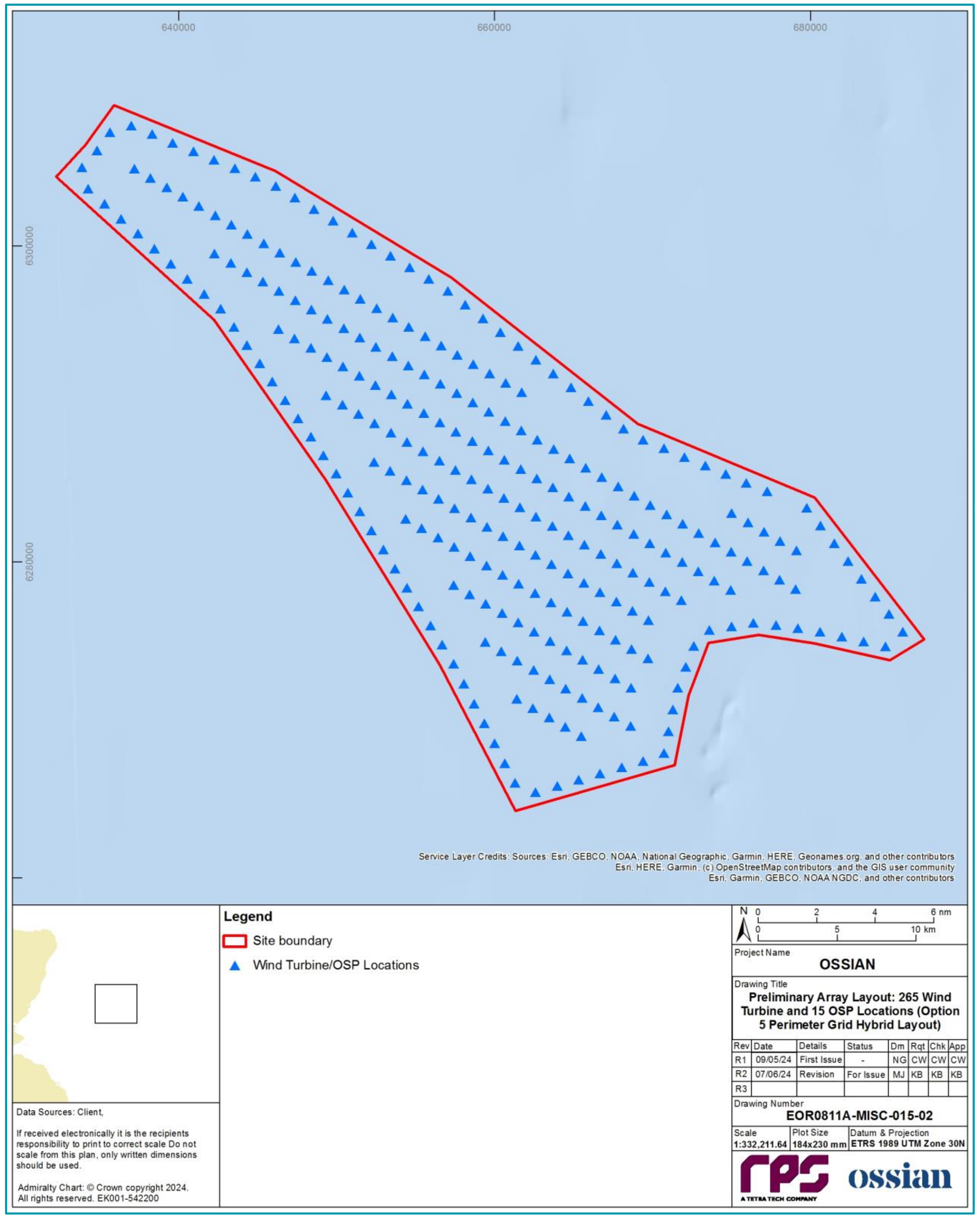

Figure 3.3: Preliminary Array Layout Comprising up to 265 Wind Turbines and up to 15 OSP Locations

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[1] Minimum distance measured from rotors of one wind turbine to the rotors of another wind turbine.

[2] Maximum distance measured from rotors of one wind turbine to the rotors of another wind turbine.

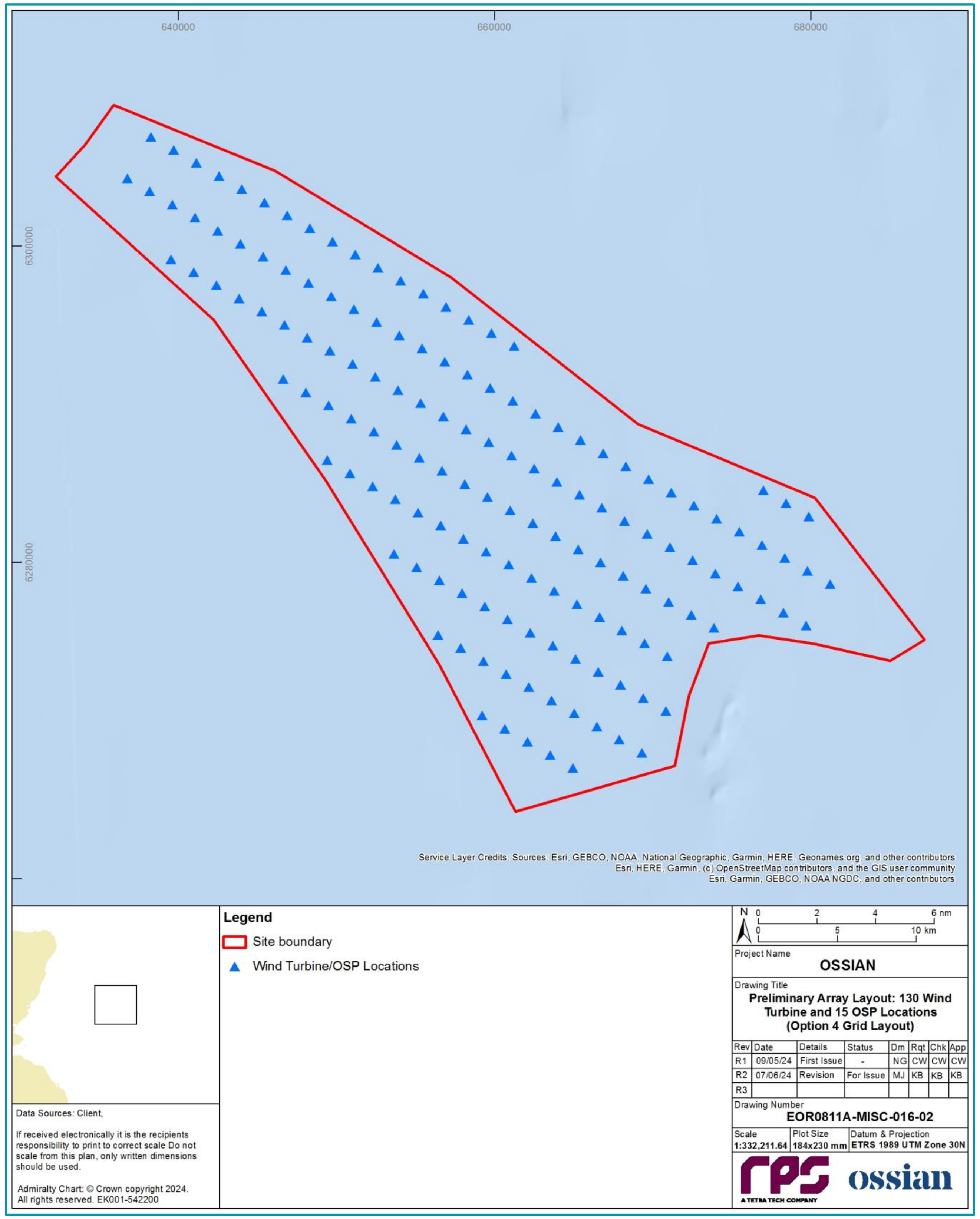

Figure 3.4: Preliminary Array Layout Comprising up to 130 Wind Turbines and up to 15 OSP Locations

26. A number of consumables will be required throughout the Array's lifecycle to improve operation, productivity and reduce wear on parts of wind turbines. These may include:
    - grease;
    - synthetic oil;
    - hydraulic oil;
    - gear oil;
    - lubricants;
    - nitrogen;
    - water/glycerol;
    - transformer silicon/ester oil;
    - diesel fuel;
    - Sulphur Hexafluoride; and
    - glycol/coolants.

27. Required quantities of each consumable will be dependent upon the final design of the wind turbine selected. Potential release of any chemicals into the marine environment via an accidental pollution event during the construction, operation and maintenance and decommissioning phases will be reduced as far as reasonably practicable through implementation of appropriate controls and mitigation as set out in an Environmental Management Plan (EMP), including a Marine Pollution Contingency Plan (MPCP), and the Decommissioning Programme (DP[2]). An outline EMP, including an outline MPCP, is presented in volume 4, appendix 21.

3.2.3. FLOATING WIND TURBINE FOUNDATIONS AND SUPPORT STRUCTURES

28. The Array will comprise floating wind turbines supported by floating foundations which require mooring and anchoring systems to maintain station. The following subsections describe the MDS for the floating foundations, mooring systems, and anchoring systems.

Floating foundations

29. An overview of the floating foundation options considered for the Array is provided in Figure 3.5. Each floating technology has varying dimensions as a result of the differing approach to meeting the unique engineering challenges associated with floating wind turbines, floating structure site specific design, wind turbine sizes and project specific requirements. The final floating foundation design may look different to those pictured but will follow the same design principles. The following floating foundation solutions are being considered for the Array:
    - Semi-submersible: A buoyancy stabilised platform which floats semi-submerged on the sea surface whilst anchored to the seabed. The structure gains its stability through the buoyancy force associated with its large footprint (relative to the spar solution) and geometry, which ensures the wind loadings on the floating foundation and wind turbine are countered/dampened by the equivalent buoyancy force on the opposite side of the structure. Other configurations, similar to semi-submersibles with regards to footprint, draft and mooring arrangement, like buoy floaters, are also being considered. It should be noted that semi-submersible foundations are applicable for use with catenary, semi-taut and taut mooring systems, as described in paragraph 34.
    - Tension Leg Platform (TLP): A TLP is a semi-submerged buoyant structure, anchored to the seabed with tensioned mooring lines (tendons; please see paragraph 34 for further information). The combination of the structure buoyancy and tension in the anchor and mooring system provides the platform stability. This system stability (as opposed to the stability coming from the floating foundation itself) allows for a smaller and lighter floating foundation.

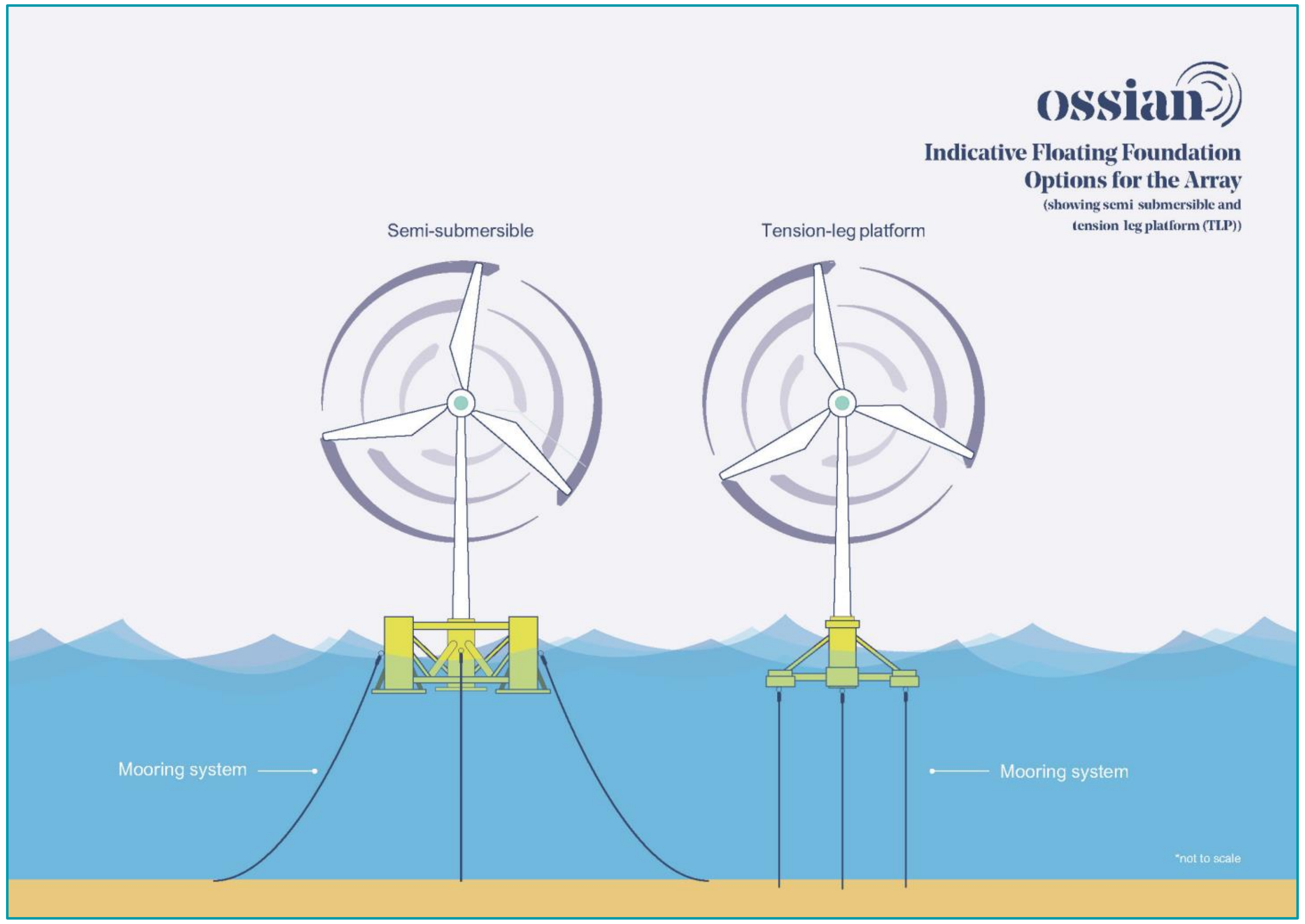

Figure 3.5: Indicative Floating Foundation Options for the Array

Table 3.3: Maximum Design Envelope: Floating Foundations

Parameter	Maximum Design Envelope
Foundation type considered	• Steel or concrete floating semi-submersible substructure • Steel or concrete floating TLP
Maximum number of floating foundations	265
Maximum floating foundation surface dimensions (m)	140 x 140
Maximum depth of structure (draft) in the water column (m)	40
Maximum excursion limit of foundations horizontally across sea surface (m)	140
Shape of foundation	Polygonal

Mooring systems

30. The floating foundations are connected to the seabed via mooring and anchoring systems. Mooring lines run from the floating foundations, through the water column, to an anchoring system which maintains station of the floating foundation. The mooring line will connect to the floating foundation at a point below the splash zone, nominally set at 5 m below the sea surface. The point at which the mooring line reaches the seabed is referred to as the touchdown point.

31. Four mooring system options are currently being considered within the PDE, namely:

- catenary - catenary mooring lines typically comprise free hanging chains, secured to the seabed using anchors. Some designs may include the addition of clump weights to enhance the stiffness and restoring capacity;
- semi-taut – semi-taut mooring lines typically use mixed materials, for example, chain and synthetic rope, secured to the seabed with anchors. Ancillary components like buoyancy modules may be required to achieve desired configuration;
- taut - taut mooring lines use mostly synthetic ropes connected to small sections of chain at the seabed and at the top section, to prevent abrasion damage to the fibre ropes. Taut mooring lines are usually kept under tension and have a narrower mooring footprint; and
- tendons - tendons may also be used, which are tensioned mooring lines running vertically from the floating foundation to the seabed and are only applicable for use with TLP floating foundations.

32. For catenary and semi-taut mooring systems sections of the mooring lines will lie on the seabed. During normal operations systems will be designed to reduce the excursion of floating foundations as far as practicable. However, during stronger winds and heavy sea states when floating foundations move to the edge of the excursion limits mooring lines on the windward side of the turbine will experience increased tension and may lift from the seabed. Mooring lines on the leeward side of the turbine would slacken and drop to the seabed (Figure 3.6). The greatest changes would be anticipated with the catenary mooring system followed by the semi-taut mooring systems.

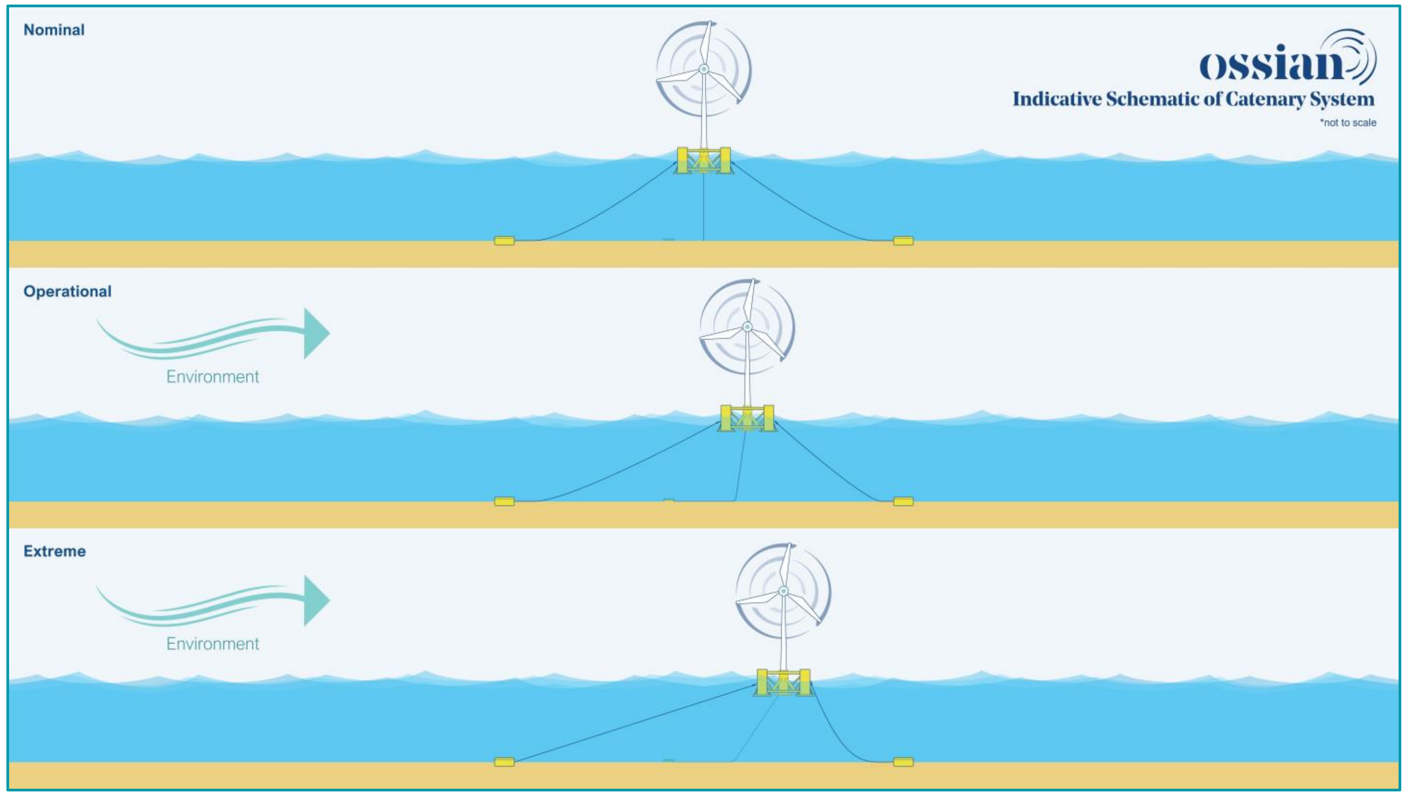

Figure 3.6: Indicative Schematic of Example Semi-Submersible Floating Foundation with Catenary Mooring System Option During Normal Operations and Extreme Conditions

33. For the taut system it is anticipated that mooring lines would only interact with the seabed during extreme weather conditions. For the tendons option, mooring lines are tensioned, meaning that they run vertically from the floating foundation straight to the seabed, therefore, the mooring lines would not interact with the seabed and would not extend horizontally beyond the floating foundation footprint, unlike the catenary, semi-taut and taut options (Figure 3.7, Figure 3.8 and Figure 3.9, respectively).

34. It should be noted that the final mooring line solution selected may vary across the site and will be dependent upon the anchoring solution chosen (see paragraph 36). A schematic of the different mooring systems is provided in Figure 3.7, Figure 3.8 and Figure 3.9, respectively.

35. The mooring system will be limited to a maximum of six and nine mooring lines per wind turbine for the 265 and 130 turbine scenarios respectively. Mooring line radius is not expected to exceed 700 m, and maximum length of mooring line per foundation will be up to 750 m. A maximum of 680 m of mooring line per foundation will rest on the seabed during normal operations. The maximum design envelope for the mooring system options is presented in Table 3.4.

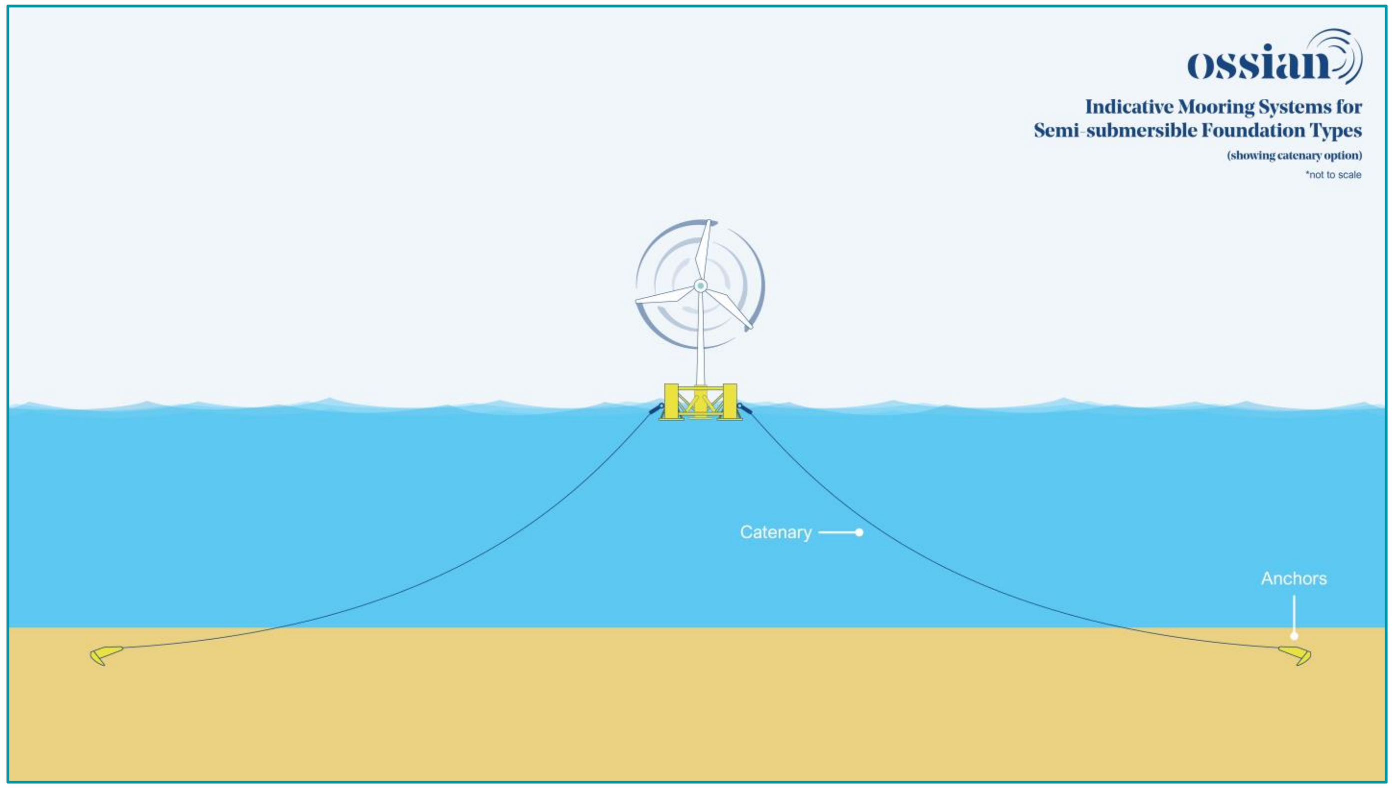

Figure 3.7: Indicative Schematic of Catenary Mooring System Option for Floating Wind Turbines on Example Semi-Submersible Floating Foundation

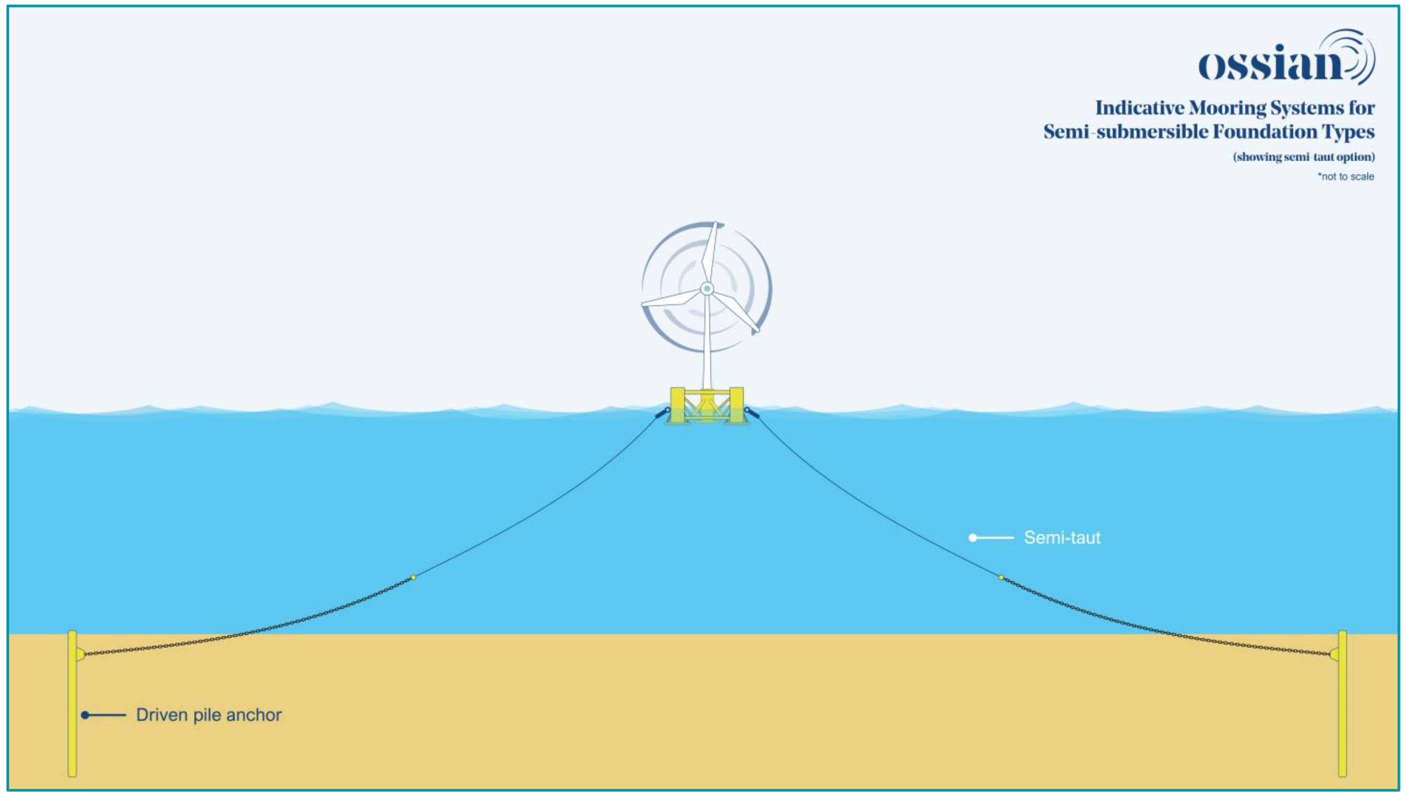

Figure 3.8: Indicative Schematic of a Semi-Taut Mooring System Options for Floating Wind Turbines on Example Semi-Submersible Floating Foundation

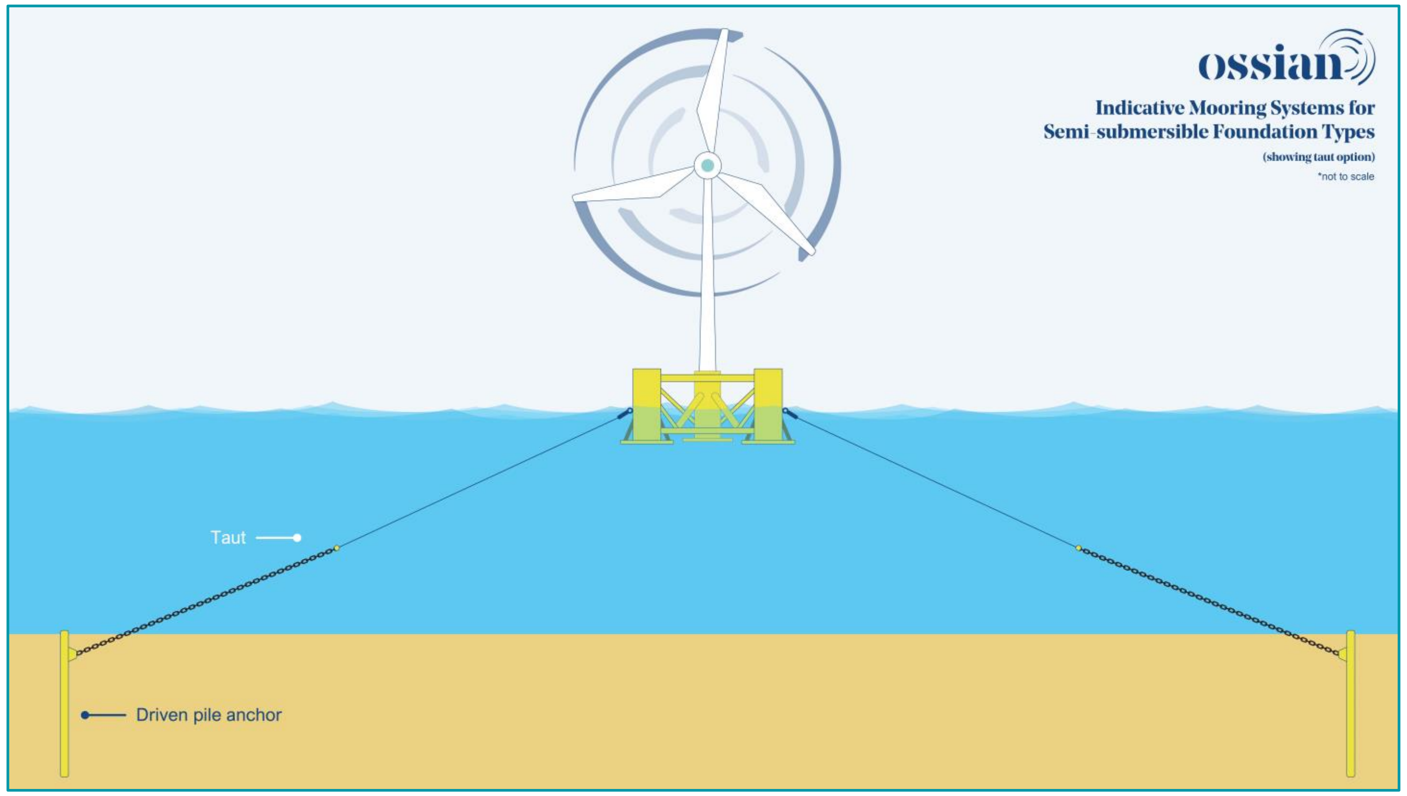

Figure 3.9: Indicative Schematic of Taut Mooring System Options for Floating Wind Turbines on Example Semi-Submersible Floating Foundation

Table 3.4: Maximum Design Envelope: Mooring Systems

Parameter	Maximum Design Envelope			
	Catenary Option	Semi-Taut Option	Taut Option	Tendons Option
Foundation type	Semi-submersible	Semi-submersible	Semi-submersible	TLP
Maximum mooring line radius (m)[3]	700	700	600	0
Minimum mooring touchdown distance from foundation (m)	25	100	300	0
Maximum mooring touchdown distance from foundation (m)	150	500	600	0
Mooring line point of attachment to foundation below sea surface (m)	5 - 20	5 - 20	5 - 20	5 - 20
Maximum length of each mooring line within the water column during normal operation (m)	200	500	650	95
Maximum length of each mooring line on the seabed during normal operation (m)	680	250	100	0
Potential range of mooring line angles from foundation (°)	30 - 50	60 - 80	75 - 82	0

Anchoring systems

36. Anchoring systems fix the mooring lines to the seabed and may include various solutions, such as driven piles, or embedded anchor types such as suction anchors and Drag Embedment Anchors (DEA). A brief description of the various anchoring types that are considered are presented in Table 3.5.

Table 3.5: Description of Anchoring Options Considered in the Maximum Design Envelope

Anchor Type	Description
Driven Piles	These are foundations which are driven into the seabed using a pile-driving hammer. Various factors influence the time and number of hammer strikes required to achieve the required penetration depth, including the type and size of hammer, pile size, and soil properties of the seabed. Note, vibropiling may be used as an alternative to percussive piling if feasible.
Suction Anchors	These anchors are installed by pumping water out of a capped steel cylinder, resulting in this being sucked into the seabed. The use of these piles is best suited to sand and clay soils.
DEA	These anchors are dragged across the seabed until required depth and holding capacity is reached. These anchors are best suited for cohesive sediments and function best when they are fully submerged into the seabed.

37. The Applicant is considering installation of a maximum of six or nine anchors per floating foundation within the PDE for the 265 and 130 wind turbine scenarios respectively. The final anchoring solution selected may vary across the site and will take account of the seabed conditions, detailed analysis of geotechnical data to inform engineering design, and environmental impacts. A range of scenarios has been identified based on preliminary analysis of geophysical and geotechnical data to identify possible anchoring solutions arrangements which could be installed for the purposes of undertaking a robust EIA. The Applicant has undertaken preliminary geotechnical surveys to determine feasibility of the proposed scenarios. Geotechnical samples were not taken at every turbine location therefore flexibility is retained within the PDE to ensure there will be feasible anchoring solutions across the Array. This will be informed by detailed geotechnical surveys and engineering design to identify the most appropriate anchor technology.

38. The final design may vary from the specific scenarios outlined but the environmental impacts will be no greater than the most adverse impacts resulting from these scenarios and will be confirmed post-consent within the suite of consent plans. The scenarios assessed within this Array EIA Report are as follows:

- Anchoring Option 1 - use of driven piles to anchor all floating foundations;
- Anchoring Option 2 - use of DEAs to anchor all floating foundations;
- Anchoring Option 3 – use of a mix of driven piles and DEAs to anchor up to 65% and 35% of the floating foundations, respectively;
- Anchoring Option 4 – use of a mix of driven piles and suction anchors to anchor up to 65% and 35% of the floating foundations, respectively; and
- Anchoring Option 5 - use of driven piles, shared between the floating foundations (equating to up to 70% of the total number of piles required for Anchoring Option 1).

39. Anchoring Option 1 is considered the most likely anchoring solution for the project at this stage, with Anchoring Options 2 to 5 considered as alternative options which may be used depending upon the results of engineering and environmental studies. A description of the maximum design envelope for each Anchoring Option is presented in Table 3.6 to Table 3.10. Images of the anchoring solutions are presented in Figure 3.10. Shared anchors will be considered by the project subject to appropriate layout design. This has the potential to reduce the overall number of anchors required within the Array. The maximum length

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[3] Mooring line radius is the horizontal distance from the top connector at the floating foundation to a point in line with the bottom connector at the seabed anchor.

of mooring line detailed within Table 3.4 may be exceeded for the shared anchor solution, however, the overall length of anchor chain required across the Array, including length of chain on the seabed, would be reduced by utilising shared anchors.

40. Considering all Anchoring Options, the maximum seabed footprint per foundation is 900 m^2 and maximum seabed footprint for the Array is 159,000 m^2. Scour protection may be required for the anchoring systems with up to 8,511 m^2 of scour protection to be installed per foundation, and up to 1,503,612 m^2 of scour protection to be installed across the Array.

Table 3.6: Maximum Design Envelope: Anchoring Option 1

Parameter	Maximum Design Envelope
Maximum number of foundation substructures	265
Mooring line types considered	Catenary, semi-taut, taut or tendons options (see Table 3.4)
Anchor type	Driven pile only
Maximum anchor dimension (diameter x length) (m)	4.5 x 40
Maximum number of driven piles per foundation	9
Maximum number of driven piles across the Array	2,385
Maximum driven pile diameter (m)	4.5
Maximum pile penetration depth (m)	40
Maximum dimensions of mud mats (m)	15 x 15
Maximum seabed footprint per foundation (m^2)	144
Maximum seabed footprint for the Array (m^2)	25,288
Maximum hammer energy (kJ)	3,000

Table 3.7: Maximum Design Envelope: Anchoring Option 2

Parameter	Maximum Design Envelope
Maximum number of foundation substructures	265
Mooring line types considered	Catenary or semi-taut options (see Table 3.4)
Anchor type	DEAs only
Maximum anchor dimension (length x width x height) (m)	10 x 10 x 5
Maximum number of DEAs per foundation	9
Maximum seabed footprint per foundation (m^2)	900
Maximum seabed footprint for the Array (m^2)	159,000

Table 3.8: Maximum Design Envelope: Anchoring Option 3

Parameter	Maximum Design Envelope
Maximum number of foundation substructures	265
Mooring line types considered	Catenary, semi-taut or taut options (see Table 3.4)
Anchor type	Driven piles and DEAs
Maximum anchor dimension (m)	Driven piles: 4.5 x 40 (diameter x length) DEAs: 10 x 10 x 5 (length x width x height)
Maximum percentage of driven piles within the Array (%)	65
Maximum percentage of DEAs within the Array (%)	35
Maximum number of anchors per foundation	9
Maximum number of driven piles across the Array	1,032
Maximum number of DEAs across the Array	558
Maximum driven pile diameter (m)	4.5
Maximum driven pile penetration depth (m)	40
Maximum seabed footprint per foundation (m^2)	408
Maximum seabed footprint for the Array (m^2)	72,088
Maximum number of driven piles requiring piling per foundation	5.85
Maximum hammer energy (kJ)	3,000

Table 3.9: Maximum Design Envelope: Anchoring Option 4

Parameter	Maximum Design Envelope
Maximum number of foundation substructures	265
Mooring line types considered	Catenary, semi-taut or taut options (see Table 3.4)
Anchor type	Driven piles and suction anchors
Maximum anchor dimension (diameter x length) (m)	Driven piles: 4.5 x 40 Suction anchors: 10 x 15
Maximum percentage of driven piles within the Array (%)	65
Maximum percentage of suction piles within the Array (%)	35
Maximum number of anchors per foundation	9
Maximum number of driven piles across the Array	1,032
Maximum number of suction piles across the Array	558
Maximum driven pile diameter (m)	4.5
Maximum driven pile penetration depth (m)	40
Maximum suction pile diameter (m)	10
Maximum suction pile penetration depth (m)	15
Maximum seabed footprint per foundation (m^2)	340
Maximum seabed footprint for the Array (m^2)	60,144
Maximum number of driven piles requiring piling per foundation	5.85
Maximum hammer energy (kJ)	3,000

Table 3.10: Maximum Design Envelope: Anchoring Option 5

Parameter	Maximum Design Envelope
Maximum number of foundation substructures	265
Mooring line types considered	Catenary, semi-taut or taut options (see Table 3.4)
Anchor type	Driven piles only, shared anchoring between floating foundations
Maximum anchor dimension (diameter x length) (m)	4.5 x 40
Maximum driven pile diameter (m)	4.5
Maximum driven pile penetration depth (m)	40
Maximum percentage of shared driven piles within the Array (%)	70
Average number of shared driven piles across the Array	1,113
Maximum seabed footprint per foundation (m^2)	101
Maximum seabed footprint for the Array (m^2)	17,702
Maximum number of driven piles requiring piling per foundation	6.3
Maximum hammer energy (kJ)	3,000

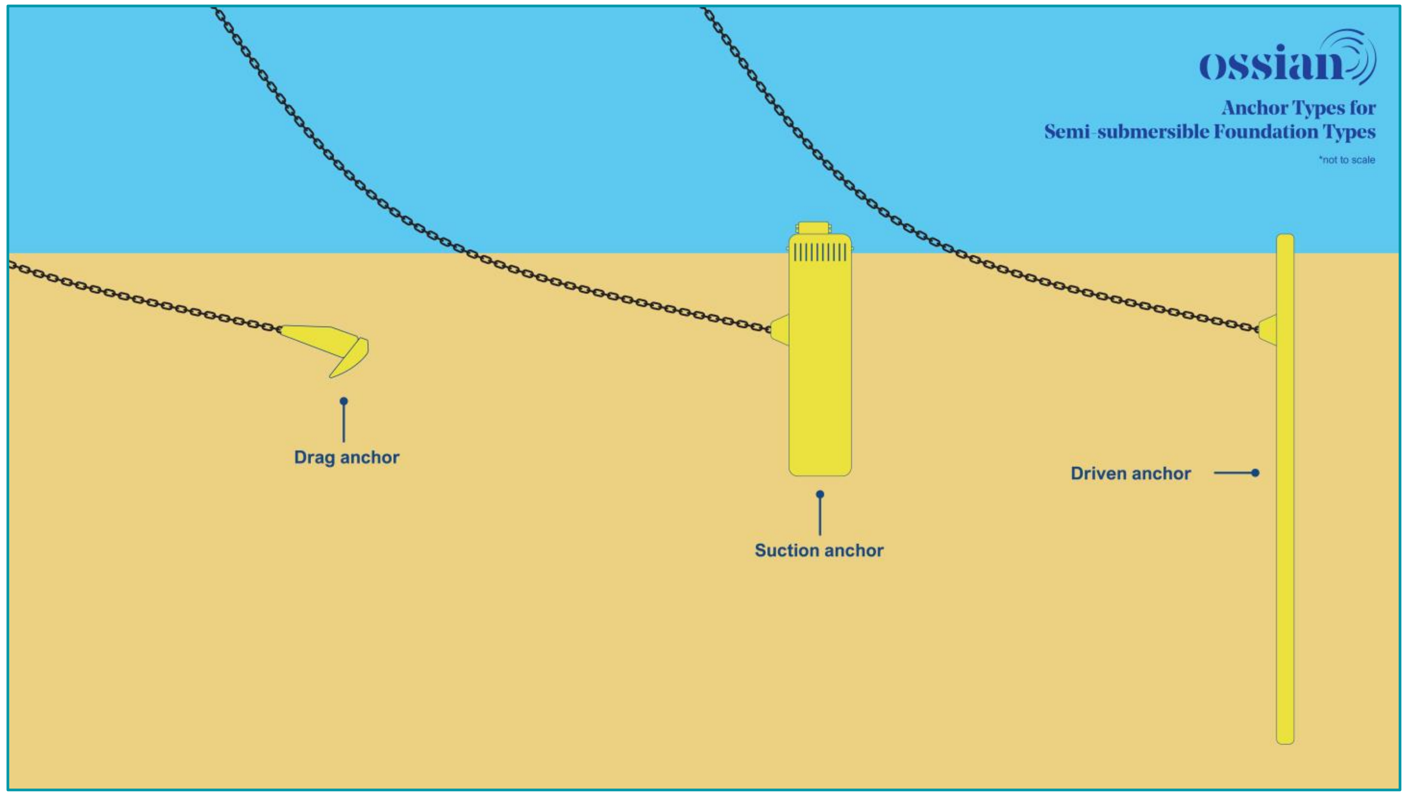

Figure 3.10: **Schematic of Anchoring Options**

Emerging anchor technologies

41. The Applicant is engaging with a number of suppliers who are developing innovative solutions to address some of the challenges associated with anchoring of floating offshore wind turbines. A number of emerging anchoring technologies are being considered by the Applicant.

42. These anchor technologies have the potential to increase efficiency by using less materials to achieve similar or higher loading capacities, reduce installation times and transportation requirements, mitigate supply chain constraints and further mitigate environmental effects. Innovative solutions currently being considered include using micro piles to fix an anchor plate to the seabed. These include helical piles that are installed through a bespoke installation tool, or drilled and grouted micro piles installed using a drilling template.

43. The Applicant will aim to use these technologies where they are feasible (depending on availability, certification, ground conditions and design performance) and where there are opportunities to reduce environmental impacts. These technologies will be presented in post-consent plans outlining how the construction and deployment falls within parameters assessed within the Array EIA Report.

Connectors and ancillaries

44. The use of a number of different connectors and ancillaries may be required for the mooring and anchoring systems which alter the mooring system behaviour, for example, to reduce dynamic loads, and to reduce mooring line radius which limits movement of the floating foundation. The following connectors and ancillaries may be used:

- Long Term Mooring (LTM) connectors (shackles or H-links): these are used to securely connect different mooring line sections and the mooring lines to the anchoring systems.
- Clump weights: these may be added near the touchdown point of the mooring line to reduce the mooring line radius and provide additional weight. These are commonly used with catenary mooring lines and are usually installed over the chain links.
- Buoys or buoyancy modules: commonly used with semi-taut mooring lines, these are used to suspend portions of the mooring line within the water column. The depth of these buoyancy modules within the water column can be altered, which allows the correct tension to be obtained.
- In-line tensioners: these may be added to the mooring line in order to install mooring lines with the correct tension.

45. The maximum design envelope for mooring line connectors and ancillaries is presented in Table 3.11, and schematics are presented in Figure 3.11 and Figure 3.12.

Table 3.11: **Maximum Design Envelope: Connectors and Ancillaries**

Parameter	Maximum Design Envelope
Maximum size of clump weights (diameter x length) (m)	1.5 x 1.5
Maximum dimensions of eccentric buoyancy modules (diameter x length) (m)	5 x 7
Maximum dimensions of in-line buoyancy modules (diameter x length) (m)	5 x 7

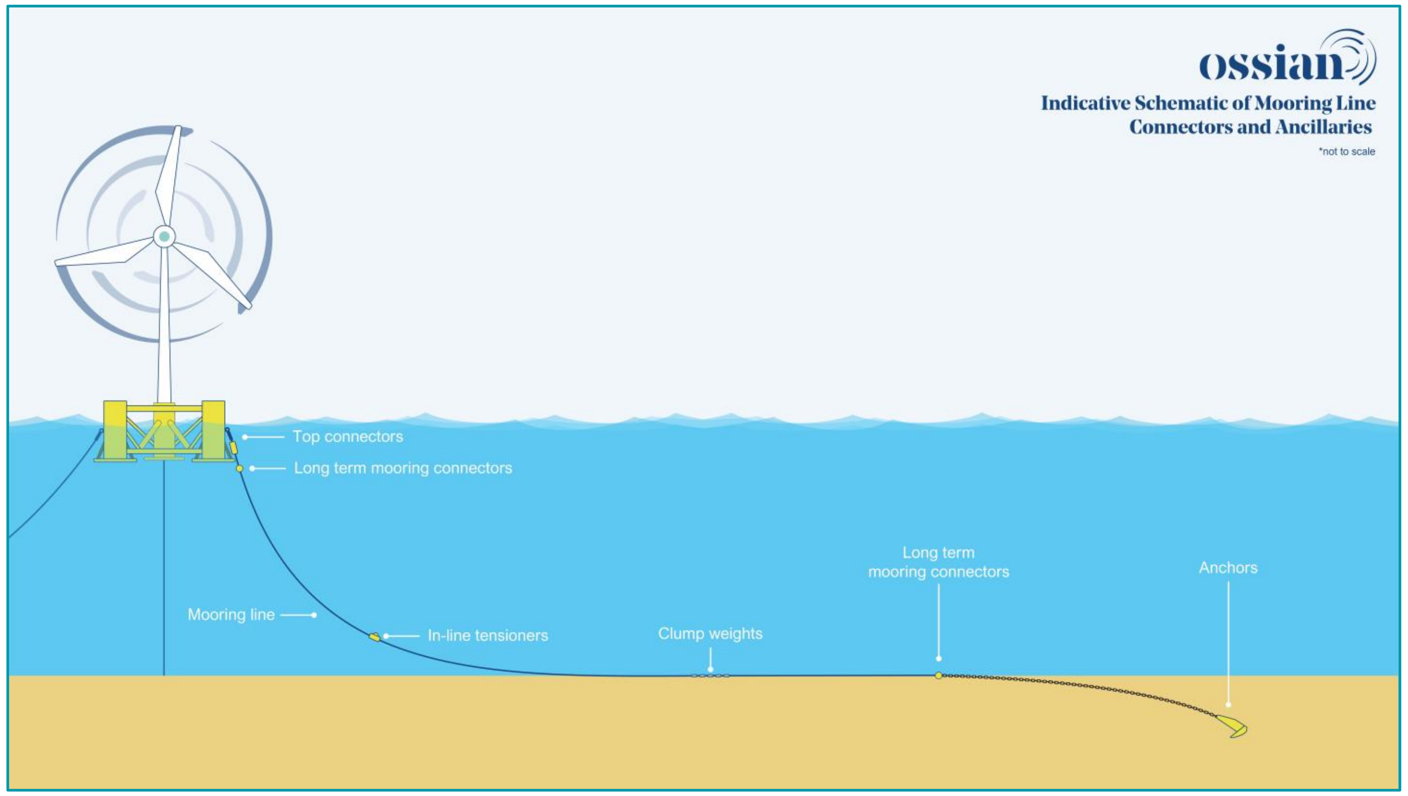

Figure 3.11: **Indicative Schematic of Mooring Line Connectors and Ancillaries Showing LTM Connectors, Clump Weights and In-Line Tensioners**

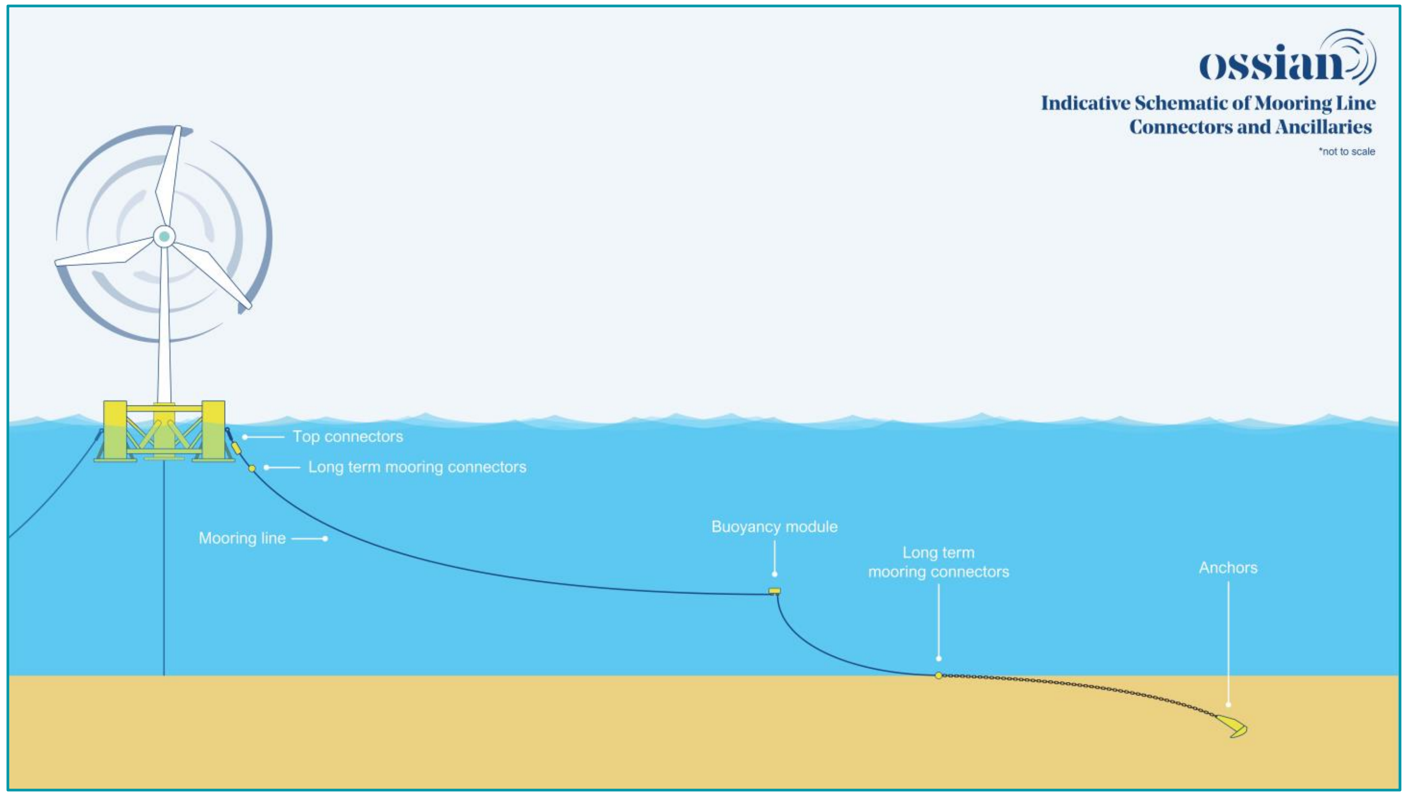

Figure 3.12: Indicative Schematic of Mooring Line Connectors and Ancillaries Showing LTM Connectors and Buoyancy Modules

3.2.4. OFFSHORE SUBSTATION PLATFORMS

46. The OSPs will transform the electricity generated by the wind turbines to a higher voltage and/or to direct current allowing the power to be efficiently transmitted directly to shore or to a wider offshore grid network.

47. The Applicant has defined two options for OSP arrangements to be considered within the Array EIA Report. The exact number and size of OSPs will be subject to National Grid (NG) Electricity System Operator Limited (ESO) final design recommendations and detailed design, however, the overall size, footprint, piling parameters and key design features will remain within the representative OSP design scenarios considered within the Array EIA Report. The following OSP arrangement scenarios have been considered within this Array EIA Report:

- OSP Option 1: up to six large High Voltage Alternating Current (HVAC)/High Voltage Direct Current (HVDC) OSPs; or
- OSP Option 2: a combined option comprising:
  - up to three large HVAC/HVDC OSPs; and
  - up to 12 small HVAC OSPs.

48. The following subsections describe the maximum design envelope for the topsides and foundations for these options.

Offshore platform topsides

49. Up to six large OSP topsides will be installed with maximum dimensions of up to 121 m (length) by 89 m (width), and will be approximately 93 m in height (above LAT), excluding the helideck, lightning protection and antenna structure (Table 3.12).

50. Should OSP Option 2 be selected at the final design stage, up to 12 small OSPs will be installed (alongside three large OSPs with same dimensions as mentioned previously), up to 41 m in length, 37 m in width and 50 m in height, excluding helideck, lightning protection and antenna structure (Table 3.13). The final solution chosen, and the topside sizes, will be dependent on the final electrical setup for the Array.

Table 3.12: Maximum Design Envelope: OSP Option 1 Topsides

Parameter	Maximum Design Envelope
Maximum number of OSPs	6 (HVDC or HVAC)
Maximum length of topside (m)	121
Maximum width of topside (m)	89
Maximum height of main structure above LAT (excluding helideck or lighting protection) (m)	93
Maximum weight of topside (t)	33,000
Maximum height of lightning protection above LAT (m)	104
Maximum height of helideck above LAT (m)	97
Maximum height of crane above LAT (m)	100
Maximum height of top of antenna structure above LAT (m)	109

Table 3.13: Maximum Design Envelope: OSP Option 2 Topsides

Parameter	Maximum Design Envelope	
	Large OSPs	Small OSPs
Maximum number of OSPs	3 (HVDC or HVAC)	12 (HVAC)
Maximum length of topside (m)	121	41
Maximum width of topside (m)	89	37
Maximum height of main structure above LAT (excluding helideck or lighting protection) (m)	93	50
Maximum weight of topside (t)	33,000	3,700
Maximum height of lightning protection above LAT (m)	104	60
Maximum height of helideck above LAT (m)	97	53
Maximum height of crane above LAT (m)	100	71
Maximum height of top of antenna structure above LAT (m)	109	71

Offshore platform foundations

51. The OSPs will be installed on fixed jacket foundations and will be located within the Array. For large OSPs, the fixed jacket foundations will have up to 12 legs, whereas fixed jacket foundations for small OSPs will have up to six legs. Up to two piles will be required per leg for both large and small OSPs.

52. For OSP Option 1, this results in a maximum of 24 piles required per foundation. Up to 144 piles will require piling for up to six large OSPs (Table 3.14). For OSP Option 2, a maximum of 24 piles will be required per foundation for three large OSPs and a maximum of 12 piles will be required per foundation for 12 small OSPs, resulting in a total number of up to 216 piles requiring piling (Table 3.15). It should be noted that diameter of piles required for large OSP fixed jacket foundations are 4.5 m, whereas small OSP fixed jacket foundations will require piles with diameter of 3 m.

53. Table 3.14 and Table 3.15 describe the maximum design envelope for OSP Option 1 and OSP Option 2, respectively.

Table 3.14: Maximum Design Envelope: OSP Option 1 Fixed Jacket Foundations

Parameter	Maximum Design Envelope
Maximum number of platforms	6
Maximum number of legs per foundation	12
Maximum leg diameter (m)	5
Maximum number of driven piles per leg	2
Maximum number of driven piles per platform foundation	24
Maximum jacket leg spacing (at seabed) (m)	100
Maximum jacket leg spacing (at surface) (m)	100
Maximum driven pile diameter (m)	4.5
Maximum driven pile length (m)	85
Maximum driven pile penetration depth (m)	70
Maximum dimensions of mud mats (if used) (m)	20 x 20
Maximum seabed footprint per jacket foundation (m^2)	382
Maximum seabed footprint for the Array (m^2)	2,290
Maximum number of driven piles requiring piling (all platforms)	144
Maximum hammer energy (kJ)	4,400

Table 3.15: Maximum Design Envelope: OSP Option 2 Fixed Jacket Foundations

Parameter	Maximum Design Envelope	
	Large OSPs	**Small OSPs**
Maximum number of platforms	3	12
Maximum number of legs per foundation	12	6
Maximum leg diameter (m)	5	3.5
Maximum number of driven piles per leg	2	2
Maximum number of driven piles per platform foundation	24	12
Maximum jacket leg spacing (at seabed) (m)	100	50
Maximum jacket leg spacing (at surface) (m)	100	40
Maximum driven pile diameter (m)	4.5	3
Maximum driven pile length (m)	85	85
Maximum driven pile penetration depth (m)	70	70
Maximum dimensions of mud mats (if used) (m)	20 x 20	15 x 15
Maximum seabed footprint per jacket foundation (m^2)	382	85
Maximum seabed footprint for the Array (m^2)	1,145	1,018
Maximum number of driven piles requiring piling (all platforms)	72	144
Maximum hammer energy (kJ)	4,400	4,400

3.2.5. SCOUR PROTECTION FOR FOUNDATIONS

54. Natural hydrodynamic and sedimentary processes can lead to seabed erosion and 'scour hole' formation around anchor and mooring systems, and foundation structures. Scour hole development is influenced by the shape of the foundation structure, seabed sedimentology and site-specific metocean conditions such as waves, currents, and storms. Employing scour protection can mitigate scour around foundations. Commonly used scour protection types include:

- concrete mattresses: cast of articulated concrete blocks, several metres wide and long and linked by a polypropylene rope lattice, which are placed on and/or around structures to stabilise the seabed and inhibit erosion; or
- rock: the most frequently used scour protection method. Layers of graded stones placed on and/or around structures (e.g. foundation structures) to inhibit erosion, or rock filled mesh fibre bags which adapt to the shape of the seabed/structure as they are lowered on to it.

55. The type and volume of scour protection required will vary depending on the various wind turbine anchoring options and offshore platform options considered, and the final parameters will be decided once the design of these is finalised. This decision will consider a range of aspects including geotechnical data, meteorological and oceanographical data, water depth, foundation type, maintenance strategy and cost.

56. Table 3.16 presents the maximum design envelope for scour protection required for the Anchoring Options described in section 3.2.3. It should be noted that Anchoring Option 2 is not included within Table 3.16 as there is no requirement for scour protection for this option. DEAs are fully embedded within the seabed (see Table 3.5) and, therefore, erosion around the structure is unlikely to occur, minimising the need for scour protection.

57. Table 3.17 presents the maximum design envelope for the OSP Options described in section 3.2.4.

Table 3.16: Maximum Design Envelope: Scour Protection for Anchoring Options[4]

Parameter	Maximum Design Envelope			
	Anchoring Option 1	**Anchoring Option 3**	**Anchoring Option 4**	**Anchoring Option 5**
Anchor type	Driven piles	Driven piles and DEAs	Driven piles and suction anchors	Shared driven piles
Scour protection type	Rock or mattress			
Maximum height of scour protection (m)	1.5	1.5	1.5	1.5
Maximum diameter of scour protection per pile / anchor (including pile/anchor) (m)	22.5	22.5	50	22.5
Maximum area of scour protection per foundation (excluding pile/anchor area) (m^2)	3,436	1,918	8,171	2,405
Maximum volume of scour protection per foundation (m^3)	5,368	3,489	12,767	3,757
Maximum volume of scour protection for Array (m^3)	948,295	616,392	2,225,420	663,807

Table 3.17: Maximum Design Envelope: Scour Protection for OSP Options

Parameter	Maximum Design Envelope		
	OSP Option 1	**OSP Option 2**	
Platform type	Large OSP	Large OSP	Small OSP
Maximum number of platforms	6	3	12
Scour protection type	Rock or mattress	Rock or mattress	
Maximum height of scour protection (m)	1.5	1.5	
Maximum diameter of scour protection (including pile) (m)	22.5	22.5	15
Maximum area of scour protection per foundation (excluding pile area) (m^2)	14,516	14,516	4,092
Maximum volume of scour protection per foundation (m^3)	22,346	22,346	6,265

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[4] Anchoring Option 2 (DEAs only) does not require scour protection, therefore, this option has been omitted from this table.

Parameter	Maximum Design Envelope	
	OSP Option 1	OSP Option 2
Maximum volume of scour protection for Array (m^3)	134,078	142,220

3.2.6. SUBSEA CABLES

Inter-array cables

58. Inter-array cables carry the electrical current produced by wind turbines to an OSP. So as not to hinder the movement of the floating foundations, it is proposed that dynamic inter-array cables will be used. There are several cable designs which may be used, however, the most likely to be used for the Array is a 'lazy-S' configuration which allows extension of the cables in response to the floating foundation movements. Buoyancy modules are attached to the dynamic inter-array cable to support the weight of the cable and provide the 'lazy-S' configuration in the water column (as demonstrated in Figure 3.13). Bend stiffeners help to reduce the fatigue in the inter-array cables, and are typically used where the cable exits the floating foundation and at touch down points of the cable on the seabed.

59. Where the dynamic cable transitions to static, the transition length (dynamic touch down) would typically have protection around the cable to protect the cable from abrasion and fatigue. Tether clamps and weighted anchors may also be required (Figure 3.13) to limit the movement at the touch down area. A tether clamp is designed to secure subsea lines to an anchor on the seabed and usually comprises a steel housing that is bolted over the cable with a padeye to secure a chain to a weighted anchor on the seabed. Where the static cable is laid on the seabed it will be protected in line with the outputs of the Cable Burial Risk Assessment (CBRA). It is anticipated that cable burial methods will be used to protect cables, with external cable protection employed where target burial depths cannot be achieved. Further detail is provided in paragraph 61. A schematic of the dynamic/static inter-array cabling system is presented in Figure 3.13.

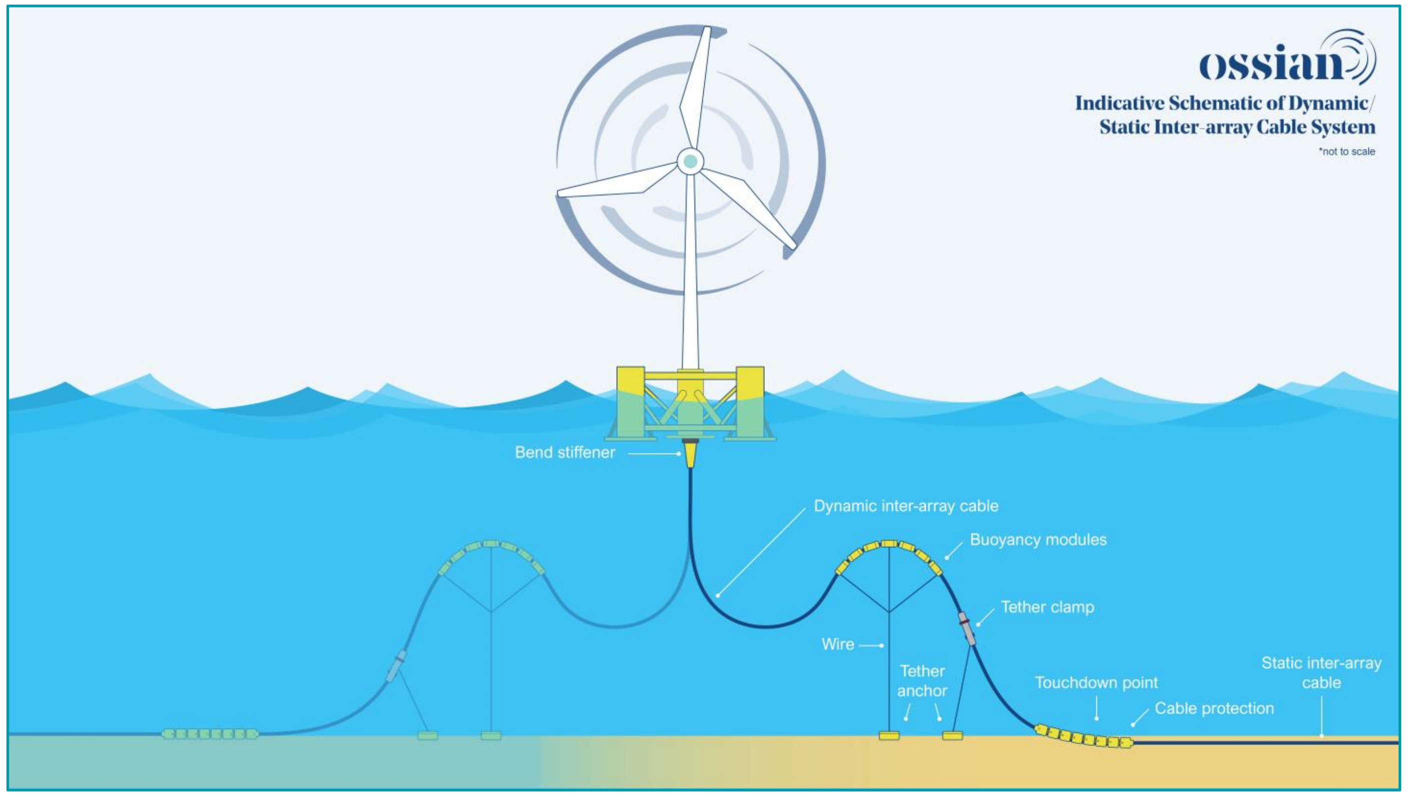

Figure 3.13: Indicative Schematic of the Dynamic/Static Inter-array Cable System (Subject to Detailed Design Configuration)

60. Different approaches and techniques are available for burial of the inter-array cables laid on the seabed. The final choice of burial or external cable protection methods will be subject to a review of the seabed conditions and the CBRA. Equipment which will be used to achieve cable burial is described in paragraph 110.

61. External cable protection methods will be required in areas where cable burial is unachievable, for example, where there are pre-existing cables or pipelines, or areas of exposed bedrock. A hard protective layer, such as rock or concrete mattresses, may be used to protect exposed cables. The need for this additional external protection will be subject to whether minimum target cable burial depths recommended for protection from the external threats can be achieved. Factors such as seabed conditions and sedimentology, naturally occurring physical processes and any potential interactions with human activities such as vessel anchoring and bottom-trawl fishing gear, will influence the requirement for additional protection. Site preparation activities may be required to provide relatively flat seabed surface for installation of cables and enable burial of inter-array cables to target burial depths. These are discussed in section 3.3.

62. The cable burial methodology and potential external cable protection will be identified at the final design stage (post-consent). The maximum design envelope for inter-array cables is presented in Table 3.18. Figure 3.14 presents a schematic of the dimensional characteristics set out in Table 3.18.

Table 3.18: Maximum Design Envelope: Inter-Array Cables

Parameter	Maximum Design Envelope
Maximum voltage (kV)	132
Maximum total cable length (km)	1,261

Parameter	Maximum Design Envelope
Maximum external cable diameter (mm)	300
Minimum external cable diameter (mm)	100
Maximum length of cable on the seabed (km)	1,222
Maximum length of cable in the water column (km)	116
Cable burial methodology	Cable plough Jet trencher Mass flow excavator Mechanical cutter
Minimum target burial depth (m)	0.4 (subject to CBRA)
Maximum width of cable trench (m)	2
Maximum width of seabed affected from installation tool per cable (m)	20

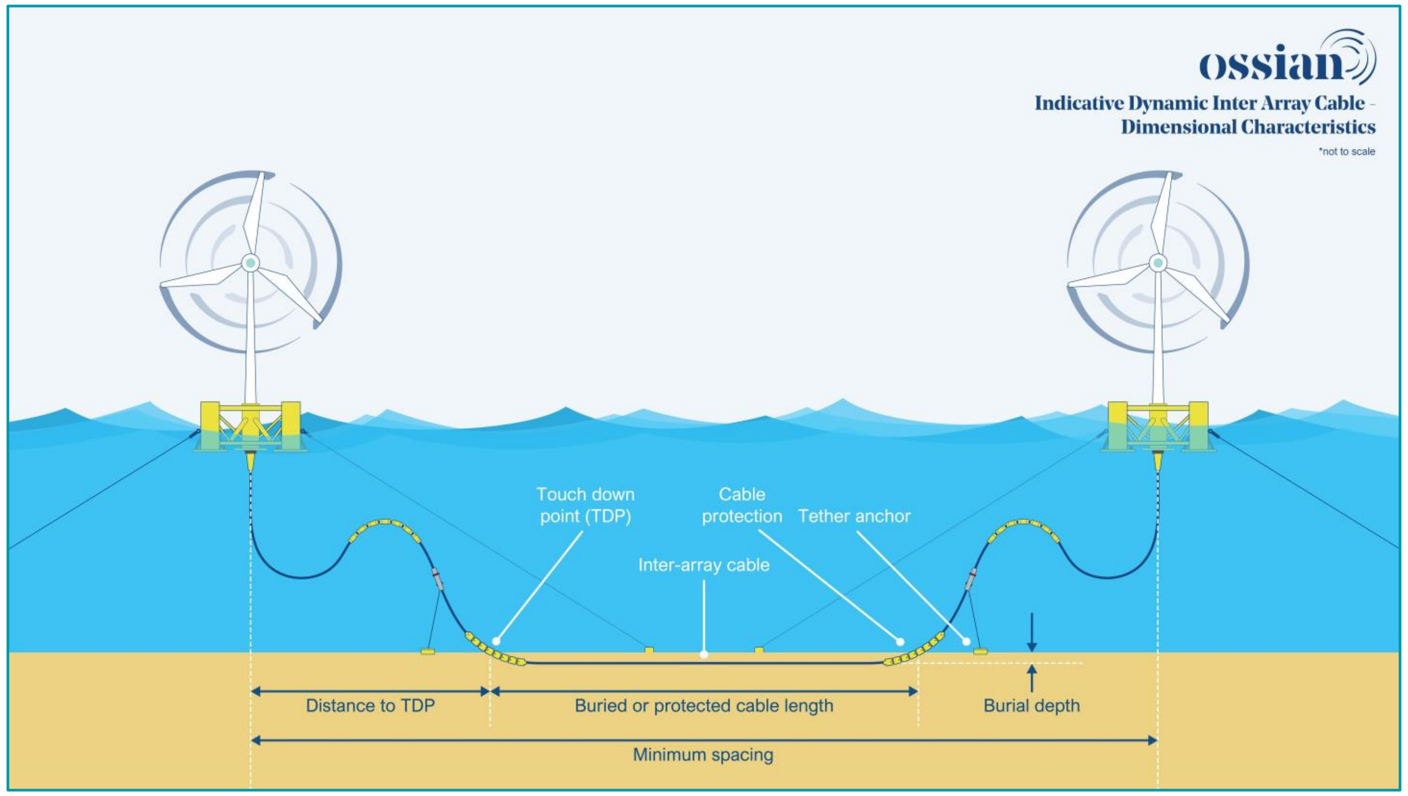

Figure 3.14: **Indicative Inter-Array Cable Dimensional Characteristics**

Subsea junction boxes

63. Subsea junction boxes may be installed on the seabed which serve as a single connection point for inter-array cables from several wind turbines. There are several configurations which may be used to connect inter-array cables into the subsea junction boxes as depicted in Figure 3.15. These comprise the following:

- Daisy-chain – two inter-array cables are required per wind turbine, which connect wind turbines together in sequence. The wind turbines located at either end of the grouping are connected to a single subsea junction box via the second inter-array cable exiting each of the two wind turbines. Once reaching the subsea junction box, a single static inter-array cable exits, to connect into the OSP.
- Fishbone – each wind turbine is connected to a single subsea junction box via one inter-array cable. Lengths of static inter-array cable connect the subsea junction boxes together in sequence and then a single static inter-array cable exits the final subsea junction box in the sequence to connect into the OSP.
- Star – several wind turbines are connected to a single subsea junction box via one inter-array cable per wind turbine. A single static inter-array cable exits the subsea junction box, to connect into the OSP.
- Fishbone and star hybrid – several wind turbines are connected to a single subsea junction box via one inter-array cable per wind turbine. Lengths of static inter-array cable then connect multiple subsea junction boxes together in sequence. A single static inter-array cable exits the final subsea junction box in the sequence to connect into the OSP.

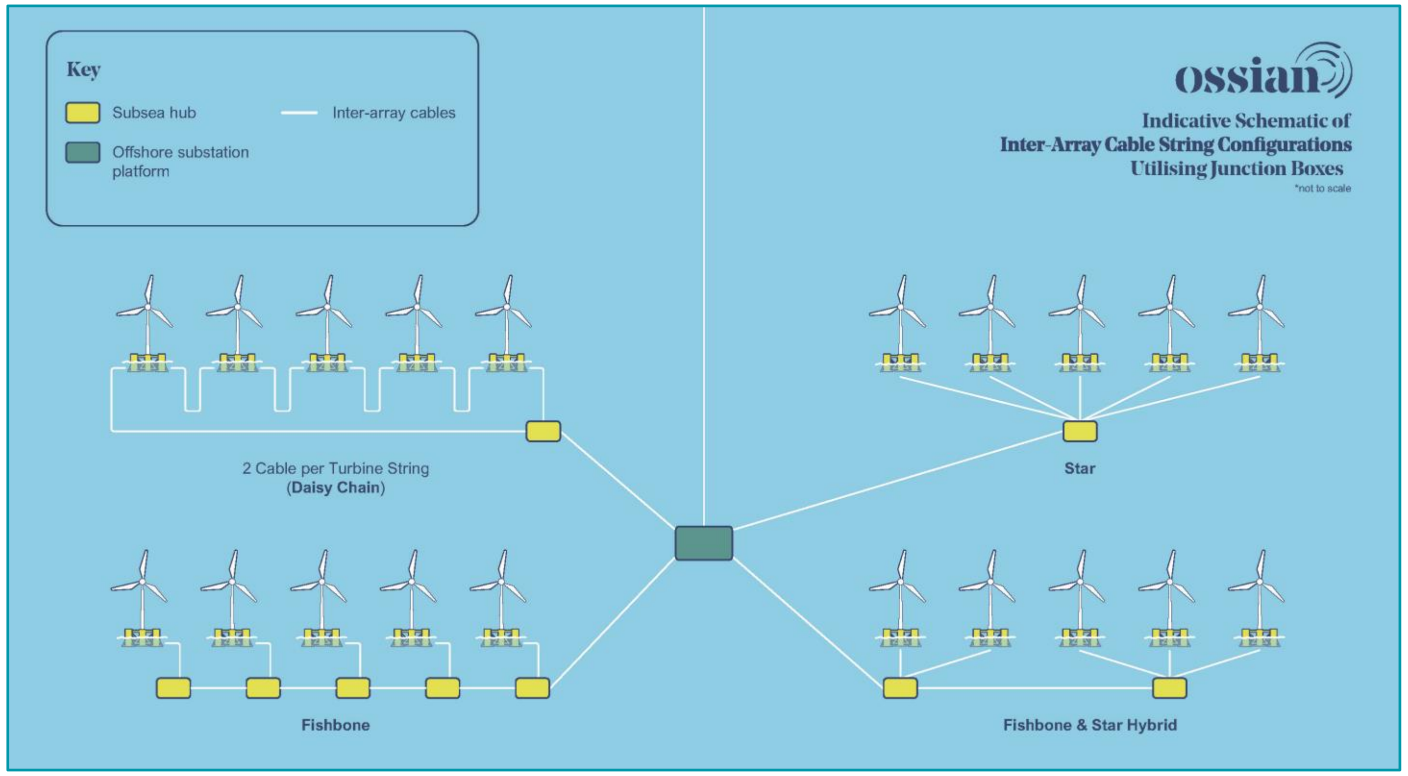

Figure 3.15: **Schematic of Indicative Inter-Array Cable String Configurations Utilising Junction Boxes (Subject to Detailed Design Configuration)**

64. The maximum design envelope for inter-array cables, presented in Table 3.18, takes into account these potential configurations and, therefore, allows flexibility in design should any of these configurations be employed alongside the subsea junction boxes.

65. The maximum design envelope for the subsea junction boxes is presented in Table 3.19. At this stage, the design of the subsea junction boxes is conceptual, therefore, some parameters included are estimated; this is indicated in Table 3.19 as appropriate. In addition, the parameters presented in Table 3.19 take into account the junction boxes associated with the various inter-array cable configurations, therefore, the parameters represent a conservative estimate which is considered to be the maximum design scenario. The parameters included within the maximum design envelope for the subsea junction boxes account for ongoing development of this technology and allows flexibility in the future.

Table 3.19: Maximum Design Envelope: Subsea Junction Boxes

Parameter	Maximum Design Envelope
Maximum number of subsea junction boxes	228
Maximum length of subsea junction boxes on seabed (m)	18
Maximum width of subsea junction boxes on seabed (m)	10
Maximum height of subsea junction boxes (m)	6
Material type	Steel (assumed)
Scour protection	
Maximum area of scour protection per subsea junction box (m^2)	884
Maximum height of scour protection per subsea junction box (m)	1.5
Maximum volume of scour protection per subsea junction box (m^3)	1,326
Maximum area of seabed preparation per subsea junction box (m^2)	884
Anchoring	
Anchoring method	• Ballasting where the design and weight of the junction box base stabilises the structure on the seabed. • Suction anchors (using similar technology as described in Table 3.5)

Interconnector cables

66. Interconnector cables connect OSPs to one another and provide redundancy should there be any failures within the electrical transmission system. It is expected that these cables will be a combination of HVAC and HVDC. The maximum design envelope is presented in Table 3.20.

67. Up to 236 km of interconnector cables will be installed within the Array. It is anticipated that cables will be protected via burial methods and will be buried at a minimum target depth of 0.4 m (subject to CBRA). External cable protection will be used in areas where minimum target burial depth cannot be achieved, as described in paragraph 61. Site preparation activities may also be required to provide relatively flat seabed surface for installation of cables and enable burial of interconnector cables to target depths. These are discussed in section 3.3.

Table 3.20: Maximum Design Envelope: Interconnector Cables

Parameter	Maximum Design Envelope
Maximum total cable length (km)	236
Maximum external cable diameter (mm)	300
Cable burial methodology	• Cable plough • Jet trencher • Mass flow excavator • Mechanical cutter
Minimum target burial depth (m)	0.4 (subject to CBRA)
Maximum width of cable trench (m)	2
Maximum width of seabed affected from installation tool per cable (m)	20

External cable protection

68. Where minimum target cable burial depth cannot be achieved, external cable protection methods will be employed to restrict movement and prevent exposure over the lifetime of the Array. This will protect cables from activities such as fishing, anchor placement or dropped objects, and limit effect of heat and/or electromagnetic fields. External cable protection systems include concrete mattresses, rock placement, cast iron shells or polyurethane/polyethylene sleeving. The final solution(s) chosen at final design stage (post-consent) will be dependent upon seabed conditions and any potential interactions with human activities which may occur within the Array. Table 3.21 presents the maximum design envelope for external cable protection for inter-array cables and interconnector cables.

Table 3.21: Maximum Design Envelope: External Cable Protection Parameters

Parameter	Maximum Design Envelope	
	Inter-Array Cables	**Interconnector Cables**
Type	Concrete mattresses, rock, cast iron shells and polyurethane/polyethylene sleeving	Concrete mattresses, rock, cast iron shells and polyurethane/polyethylene sleeving
Maximum cable protection height (m)	3	3
Maximum cable protection width (m)	20	20
Maximum percentage of cables which may require cable protection (%)	20	30
Maximum length of cables which may require cable protection (m)	244,480	47,200
Maximum total cable protection footprint area for Array (m^2)	4,889,600	944,000
Maximum total cable protection volume for Array (m^3)	14,668,800	2,832,000

Concrete mattressing

69. Concrete mattresses comprising high strength concrete blocks and ultraviolet (UV) stabilised polypropylene rope may be used as a means of external cable protection for inter-array and interconnector cables and at cable crossings (paragraphs 68 and 74). The standard size of units is 6 m x 3 m x 0.3 m, however, size, density, and shape of units may be modified (within the parameters presented in Table 3.21), for example, by tapering edges of units for use in high current environments, or using denser concrete, so that they are engineered for and bespoke to the locality in which they are installed.

70. Concrete mattresses are installed above the cables using a Dynamic Positioning (DP[1]) vessel and free-swimming installation frame. The mattresses are lowered to the seabed and the installation frame is released in a controlled manner once in the correct position to deploy the mattress on the seabed. This installation process is repeated for each mattress along the length of cable that requires external protection. Dependant on expected scour, mattresses may be gradually layered in a stepped formation on top of each other.

Rock placement

71. Rock placement may also be utilised as a form of external cable protection for inter-array and interconnector cables and at cable crossings (paragraphs 68 and 74). Rock is placed on top of cables either by creating a berm or using rock bags (Figure 3.16).

72. Installation of rock placement in the form of berm creation will utilise a vessel with equipment such as a ‘fall pipe’ so that rock can be placed close to the seabed. Rock may be placed to a maximum height of 3 m

and 20 m width (see Table 3.21). The berm created via rock placement will be designed to provide protection from anchor strike and anchor dragging, and to reduce risk of snagging by towed fishing gear as far as practicable in line with best practice guidance. Depending on expected scour, the cross-section of the berm may vary, and the length of the berm will be dependent on the length of the cable which requires protection.

73. Alternatively, pre-filled rock bags may be used which will be placed above the inter-array and interconnector cables or cable crossings using installation beams. Rock bags consist of various sized rocks contained within a rope or wire net which are lowered to the seabed and deployed on to the seabed once in the correct position (similar to installation of concrete mattresses, see paragraph 70). Rock bags have typical dimensions of 0.7 m in height and 3 m diameter; the number of rock bags which may be required will be dependent on the length of cable which requires protection.

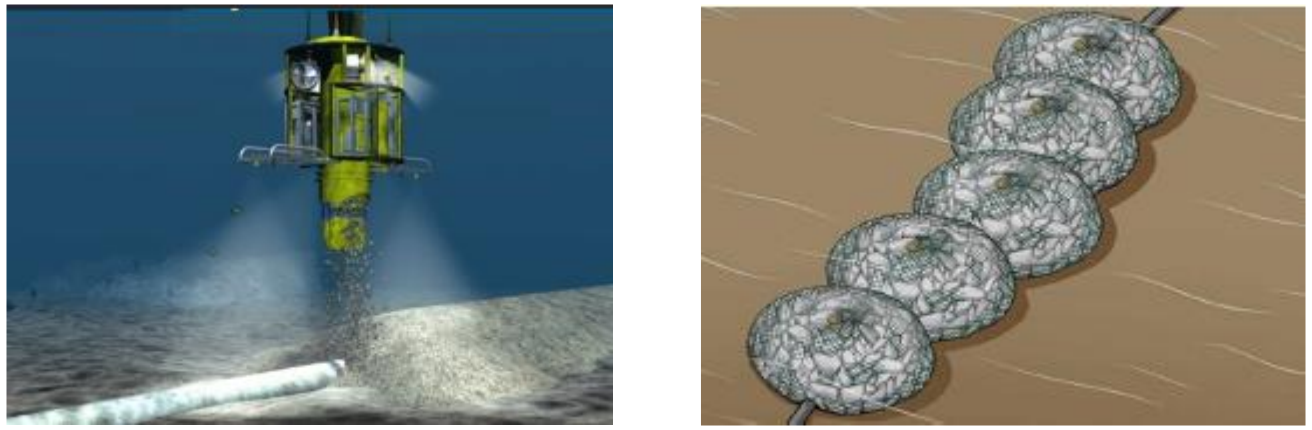

Figure 3.16: Rock Cable Protection Methods (Left: Rock Placement; Right: Rock Bags)

Cable crossings

74. Up to 12 inter-array cable crossings and up to 12 interconnector cable crossings may be installed across the Array. Cable crossings may comprise several different methods as demonstrated in Table 3.22, and additional cable protection will be installed at cable crossings. Table 3.22 presents the maximum design envelope for cable crossings, and accounts for additional protection required.

Table 3.22: Maximum Design Envelope: Cable Crossing Parameters

Parameter	Maximum Design Envelope	
	Inter-Array Cables	Interconnector Cables
Maximum number of crossings	12	12
Crossing material/method	Concrete mattresses, rock bags, rock, cast iron shells and polyurethane/polyethylene sleeving	Concrete mattresses, rock bags, rock, cast iron shells and polyurethane/polyethylene sleeving
Maximum height of crossing (m)	4	4
Maximum width of crossing (m)	20	20
Maximum length of each crossing (m)	50	50
Maximum length of crossings across the Array (m)	600	600
Maximum total area of crossings (m^2)	12,000	12,000
Maximum volume of protection material (per crossing) (m^3)	4,000	4,000
Maximum total volume of crossing protection across the Array (m^3)	48,000	48,000

3.3. SITE PREPARATION ACTIVITIES

75. Prior to the construction phase of the Array, a number of site preparation activities will be required to be undertaken. It is assumed that site preparation works will continue throughout the construction phase as required, therefore, these works may be undertaken at any point within the construction programme. A summary of site preparation activities is provided in sections 3.3.1 to 3.3.5.

3.3.1. PRE-CONSTRUCTION SURVEYS

76. Pre-construction surveys, including geophysical and geotechnical surveys, may be carried out to provide further information of:

- seabed conditions and morphology;
- soil conditions and properties;
- presence or absence of any potential obstructions or hazards; and
- to inform detailed design for the Array.

77. Geophysical surveys will be undertaken within the Array to provide further information of Unexploded Ordnance (UXO), bedforms and mapping of boulders, bathymetry, topography and sub-surface layers. Geophysical survey techniques to be employed include Multibeam Echosounder (MBES), magnetometer, Side-Scan Sonar (SSS), Sub-Bottom Profiler (SBP) and Ultra-High Resolution Seismic (UHRS).

78. Geotechnical surveys will be carried out at specific locations within the Array and will employ techniques such as Cone Penetration Tests (CPTs), vibrocores, box cores, piston cores and boreholes.

3.3.2. CLEARANCE OF UNEXPLODED ORDNANCE

79. The possibility exists for UXO originating from World War I or World War II to be present within the Array. Due to the health and safety risks posed by UXO and potential interactions with planned locations of installed infrastructure and vessel activities, it is necessary for UXO to be surveyed and managed carefully before the construction phase and installation of offshore infrastructure commences.

80. A desk-based study of the Array (Ordtek, 2022) reviewed the relevant military history in the vicinity of the Array and the likelihood of encountering UXO. Based on known military activity, the desk-based study concluded that there was a low background risk of UXO within the Array, and the likelihood of encountering different types of UXO within the Array was considered to be unlikely, meaning that it would be unusual for UXOs to be encountered within the Array. However, due to existing evidence of use in the wider area, potential for unrecorded activities such as munitions dumping, and potential for burial and migration of UXO due to natural seabed processes, the potential presence of UXOs cannot be discounted (Ordtek, 2022). Further assessment of UXOs has been undertaken within the relevant topic chapters (volume 2, chapters 7 to 20) on the basis of the desk-based study (Ordtek, 2022).

81. Methodologies considered within the PDE to avoid/clear UXOs are as follows:

- avoid and leave *in situ*;
- micrositing of offshore infrastructure to avoid UXO;
- relocation of UXO to avoid detonation;
- low order technique (e.g. deflagration); and

- high order detonation (with associated mitigation measures).

82. Due to the health and safety risks that UXOs pose, the Applicant would seek to either avoid UXOs entirely, avoid UXOs via micrositing, or relocate UXO where practicable. If methods cannot be employed to avoid UXOs, a specialist contractor will clear UXOs in advance of further site preparation and construction works taking place. The preferred clearance method for UXO is use of a low order technique with a single donor charge of 0.25 kg Net Explosive Quantity (NEQ) for each clearance event. Up to 0.5 kg NEQ clearance shot will be required for neutralisation of residual explosive material at each location. Detailed design work would be required to confirm planned locations of infrastructure, prior to conducting any UXO surveys. The Applicant has assumed that up to 15 UXOs may require clearance based upon the desk-based study (Ordtek, 2022) and experience from other offshore wind farms in the region such as the Seagreen 1 Offshore Wind Farm. As a risk remains that unintended high order detonation may occur, 10% of clearance events have been assumed to have the potential to result in high order detonation (see volume 2, chapter 10).

83. Table 3.23 presents the maximum design envelope for UXO clearance.

Table 3.23: Maximum Design Envelope: Unexploded Ordnance Parameters

Parameter	Maximum Design Envelope
Theoretical maximum weight anticipated to be encountered (kg)[5]	698
Maximum realistic charge weight (kg)[6]	227
Maximum estimated number of UXOs anticipated to be identified	15
Maximum estimated number of UXOs anticipated to be cleared	15
Maximum number of detonation activities occurring within 24 hours	2
Maximum total duration of UXO clearance activities (days)	8

3.3.3. SAND WAVE CLEARANCE

84. Existing sand waves may need to be cleared in some areas of the Array prior to the installation and burial of inter-array and interconnector cables. There are two main reasons for undertaking sand wave clearance:

- To provide a relatively flat seabed surface for cable installation and so that cable burial tools can work effectively: if cables are installed up or down a slope over a certain angle, or where the cable burial tool is working on a camber, the ability to meet target burial depths may be impacted.
- In order for cables to be buried at the target burial depth and remain buried for the operational lifetime of the Array (35 years): as sand waves are generally mobile in nature, the cable must be buried beneath the level where natural sand wave movement could uncover it. Therefore, for this to be achieved, mobile sediments may need to be removed before cables are installed and buried.

85. No large bed forms were observed as being prevalent across the site. It is expected based on geophysical data that if sand wave clearance is required it will be undertaken in specific discrete areas of the Array (e.g. along inter-array and interconnector cables) and could occur throughout the construction phase.

86. Sand wave clearance techniques could include pre-installation ploughing which flattens sand waves and pushes sediment from wave crests into adjacent troughs to level the seabed. It is not anticipated that large scale dredging would be required within the site boundary.

87. Table 3.24 presents the maximum design envelope for sand wave clearance. A geophysical survey campaign will be completed prior to construction which will allow the final parameters for sand wave clearance to be defined.

Table 3.24: Maximum Design Envelope: Sand Wave Clearance Parameters

Parameter	Maximum Design Envelope
Inter-Array Cables/Interconnector Cables	
Maximum width of sand wave clearance along inter-array/interconnector cables (m)	24
Maximum percentage of total length of inter-array/interconnector cable requiring sand wave clearance (%)	20
Maximum area of sand wave clearance along inter-array cables (m^2)	5,867,520
Maximum area of sand wave clearance along interconnector cables (m^2)	1,132.8
Maximum volume of sand wave clearance along inter-array cables (m^3)	5,867,520
Maximum volume of sand wave clearance along interconnector cables (m^3)	1,133
OSP	
Maximum area of sand wave clearance per large OSP for scour protection (m^2)	16,388
Maximum area of sand wave clearance per small OSP for scour protection (m^2)	4,595
Maximum area of sand wave clearance for OSP Option 1 (6 x large OSPs) for scour protection (m^2)	98,325
Maximum area of sand wave clearance for OSP Option 2 (3 x large OSPs, and 12 x small OSPs) for scour protection (m^2)	104,295
Maximum volume of sand wave clearance per large OSP for scour protection (m^3)	16,388
Maximum volume of sand wave clearance per small OSP for scour protection (m^3)	4,595
Maximum volume of sand wave clearance for OSP Option 1 (6 x large OSPs) for scour protection (m^3)	98,325
Maximum volume of sand wave clearance for OSP Option 2 (3 x large OSPs, and 12 x small OSPs) for scour protection (m^3)	104,295

3.3.4. BOULDER CLEARANCE

88. Boulder clearance may be required in some areas of the Array prior to installation of offshore infrastructure, in particular, along inter-array cables and interconnector cables. A boulder is defined as being over 256 mm

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[5] Based upon findings of the Ordtek (2022) desk-based study. This value is based upon German World War II ground mines; these have not been recorded as having been present within the vicinity of the Array, however, there is a background risk from unrecorded mine lays. The likelihood of encountering a UXO of this type and charge weight is considered very unlikely as these types of mines typically targeted ports and shallower waters than are recorded within the Array (Ordtek, 2022).

[6] Based upon findings of the Ordtek (2022) desk-based study. This value is based upon British World War II mines; a total of nine British World War II minefields are recorded as having been present within the vicinity of the Array, the closest of which was recorded as being located 23 km north of the Array. Although mine sweeping operations were undertaken within the vicinity, there is potential for migration and subsequent burial of UXO from their original lay position, therefore, there is potential that these may be encountered within the Array although this is considered unlikely (Ordtek, 2022).

(Wentworth Scale) in diameter and/or length. A DP[1] vessel is likely to be used to undertake the boulder clearance campaign.

89. Boulder clearance is required to aid cable installation and increase the success rate for achieving minimum target burial depth during cable burial, therefore, reducing the risk of further cables burial works and/or the need for cable protection. Boulder clearance also reduces the risk of cable damage during installation and subsequent burial. It may also be required in the vicinity of the OSP jacket foundation locations (including within the jack-up vessel zone around the OSP foundation locations), to avoid disruption to installation activities and to ensure stability for the jack-up vessel. The maximum design envelope for boulder clearance in the Array is presented in Table 3.25.

90. Boulders may be cleared using a plough or boulder grab, however, the geophysical and pre-construction surveys, and the parameters of any boulders present (e.g. size, density and location of boulders), will inform the methodology to be used. It is possible that more than one method of boulder clearance may be deployed across the Array. Cleared boulders will be relocated to an appropriate location within the site boundary.

Table 3.25: Maximum Design Envelope: Boulder Clearance Parameters

Parameter	Maximum Design Envelope
Maximum width of boulder clearance along inter-array/interconnector cables (m)	24
Maximum area of boulder clearance along inter-array cables (m^2)	7,334,400
Maximum area of boulder clearance along interconnector cables (m^2)	1,416,000

3.3.5. VESSELS FOR SITE PREPARATION ACTIVITIES

91. The maximum design envelope for vessels to be used during site preparation activities is presented in Table 3.26.

Table 3.26: Maximum Design Envelope: Vessels for Site Preparation Activities

Parameter	Maximum Design Envelope	
	Maximum Total Number of Vessels on Site at any One Time	Total Movements (Return Trips Across Site Preparation Activities)
Survey vessel	2	10
Boulder clearance vessel	3	42
Geophysical/geotechnical survey vessel	2	10
Sand wave clearance vessel	1	2
UXO clearance vessel	2	4
Total	**10**	**68**

3.4. CONSTRUCTION PHASE

3.4.1. METHODOLOGY

92. Construction of the Array is expected to occur over a period of eight years cumulatively aligning with the following indicative construction series:

- step 1 – anchoring and mooring installation;
- step 2 – OSP topsides and fixed jacket foundations installation/commissioning;
- step 3 – inter-array and interconnector cables installation, including cable burial and/or protection, where required; and
- step 4 – floating wind turbine and floating foundation installation/commissioning.

93. The following subsections summarise these steps.

Step 1 – Anchoring and mooring installation

94. Moorings and anchoring systems will be transported to the Array by vessel and pre-laid at the installation locations (exact locations to be confirmed at final design stage (post-consent)), prior to installation of all other infrastructure. Section 3.4.2 presents further details of vessels involved in installation activities within the Array. It should be noted that some components, such as anchors, mooring chains and clump weights may be wet stored within the Array and close to the final installation locations to optimise delivery schedules. These will not be wet stored for an extended period but they may be queued whilst installation of mooring and anchoring systems and other construction works are ongoing.

95. There are several anchoring options being considered as described in section 3.2.3, however, these will comprise either driven piles or DEAs alone, or a combination of driven piles and DEAs/suction anchors, depending on seabed conditions. Driven piles will be installed in the seabed using a vibro/hydraulic hammer until any hard ground is encountered. Drilling techniques may be used to install the remaining length of pile, if required.

96. Anchoring systems will be transported to site using an installation vessel(s) (e.g. heavy lift vessels, or alternative solution) and installed in the seabed using a crane and other equipment as appropriate. The mooring lines will then be connected to the anchoring system using LTM connectors, or similar (see paragraph 44). Once mooring and anchoring systems are installed, mooring lines will be left lying on the seabed until they are hooked up to the floating foundations (step 4; paragraph 115). Ancillaries such as clump weights may be used to temporarily anchor portions of the mooring lines to the seabed to restrict movement prior to hook up.

97. If DEAs are selected as an anchoring method for floating foundations (see Anchoring Option 2 and 3; Table 3.7 and Table 3.8), it is assumed that these will be lifted from the installation vessel using a crane and positioned on the seabed. The DEAs will then be pulled using an anchor handling tug or similar, in order to embed the anchor in the seabed. The anchor will likely be pulled 30 m to 60 m during the installation process, subject to further ground investigations and anchor design. This process will be undertaken in a controlled manner to ensure that DEAs are installed at the correct position and to appropriate depth.

98. If suction anchors are selected as an anchoring method for floating foundations (see Anchoring Option 4; Table 3.9), it is assumed that a crane will be used to lift the suction anchor from the installation vessel towards the seabed. Once the steel caisson reaches the seabed, water is sucked out of each bucket via a pipe which runs through the stem above each caisson. The resulting suction force allows the buckets to penetrate into the seabed. Once the bucket has penetrated the seabed to the desired depth, the pump is turned off. A thin layer of grout is then injected under the bucket to fill the air gap and ensure contact between the soil within the bucket, and the top of the bucket itself.

99. Table 3.27 presents the piling characteristics required for the installation of the anchoring and mooring systems, if driven piles are selected as an anchoring method (see Anchoring Option 1, 3, 4 and 5; Table 3.6, and Table 3.8 to Table 3.10). It is assumed that a crane will be used to lower the pile to the seabed and will be kept in position using a pile gripper. To enable pile placement, a pile installation frame may be temporarily placed on the seabed, which will be moved to the next location once the piles are installed. A hydraulic hammer will be positioned onto the pile, driving it to target depth. A hammer energy of 3,000 kJ has been considered as the MDS for the purposes of assessment.

100. Piling will commence with a lower hammer energy of approximately 450 kJ and will slowly ramp up energy up to a maximum 3,000 kJ, if required, over a period of 20 minutes. Detailed geotechnical data of the Array will be reviewed to inform a driveability assessment which will in turn inform maximum realistic hammer

energy required for piling. The findings of this study will allow the final hammer energies used to be optimised so that piling progress can be maintained whilst minimising required hammer energy. It is anticipated that the maximum hammer energy stated in Table 3.27 will only be required at some piling locations. Up to two piling events occurring simultaneously at wind turbines (or wind turbine and OSP locations) are considered within the PDE. No concurrent piling of OSP foundations is proposed. The maximum design envelope for the driven piles associated with the wind turbine anchoring is presented in Table 3.27.

101. If scour protection is required, this will be installed at a later stage following installation of the anchoring systems.

Table 3.27: Maximum Design Envelope: Wind Turbine Anchoring – Piling Characteristics

Parameter	Maximum Design Envelope
Maximum number of piles requiring piling	1,590[7]
Maximum hammer energy (kJ)	3,000
Soft start energy (% of maximum hammer energy)	15%
Duration	
Maximum soft start duration (minutes)	20
Maximum duration of piling per pile (hours)	8
Maximum number of piles installed over 24 hours	8
Estimated average number of piles installed over 24 hours	4
Maximum duration of piling per day over construction phase (hours)	24
Average duration of piling per day over construction phase (hours)	18
Maximum total number of days when piling may occur over construction phase	795
Concurrent piling	
Maximum number of concurrent piling events	2
Minimum distance between concurrent piling events (m)	950
Maximum distance between concurrent piling events (km)	41

102. If hard ground is encountered which makes pile driving unsuitable, drilling may be required. In this case, a sacrificial caisson may be installed to support surficial soils during the drilling activities; this would be driven into the seabed and left in place. The pile would then be lowered into the drilled bore and grouted in place, with the voids (annuli) between the pile and the rock, and between the pile and the caisson, filled with inert grout. The grout would be pumped from a vessel into the bottom of the drilled hole. The process would be subject to control measures and monitoring to ensure minimal spillage to the marine environment. Drilling characteristics are presented in Table 3.28.

103. Seabed material (drill arisings) will be released as a result of drilling activities. This material will be deposited adjacent to each drilled foundation location within the Array.

Table 3.28: Maximum Design Envelope: Wind Turbine Anchoring – Drilling Characteristics

Parameter	Maximum Design Envelope
Maximum number of piles requiring drilling over the Array	159
Maximum (%) of all piles requiring drilling over the Array	10
Minimum drilling rate (m/hour)	0.2
Maximum drilling rate (m/hour)	1.0
Maximum drilling depth (per pile) (m)	40
Maximum drilling duration (per pile) (hours)[8]	200
Maximum drilling duration for Array (days)[9]	442
Maximum volume of drill arisings per pile (m^3)[10]	1,178
Maximum volume of drill arisings for the Array (m^3)[11]	131,123
Maximum number of concurrent drilling events	1

Step 2 – OSP topsides and fixed jacket foundations installation/commissioning

104. The OSP jackets will be fixed to the seabed using driven piles. Driven piles will be transported to the Array by vessel from the fabrication site or port facility, and installed in the seabed at the installation locations (exact locations to be confirmed at final design stage (post-consent)), using methods described previously in paragraphs 95 to 100. Should drilling techniques be required, this will follow the same methodology as described in paragraphs 102 and 103.

105. Piling will commence with a lower hammer energy of 660 kJ, and will slowly ramp up energy up to a maximum 4,400 kJ over a period of 20 minutes. No concurrent piling is proposed across multiple OSPs. Concurrent piling may occur between an OSP and a turbine location.

106. Once the driven piles have been installed, the OSP jackets will be delivered to site by barge or delivery vessel, lowered to the seabed using a crane, and installed over the pre-installed driven piles. Once in place the jackets would be grouted onto the piles.

107. The maximum design envelope for the driven piles associated with the OSPs foundations is presented in Table 3.29. Drilling characteristics are presented in Table 3.30.

Table 3.29: Maximum Design Envelope: OSP Options – Piling Characteristics

Parameter	Maximum Design Envelope	
	OSP Option 1	**OSP Option 2**
Maximum number of piles requiring piling	144	216
Maximum hammer energy (kJ)	4,400	4,400
Soft start energy (% of maximum hammer energy)	15%	15%
Duration		
Maximum soft start duration (minutes)	20	20
Maximum duration of piling per pile (hours)	8	8
Maximum number of piles installed over 24 hours	8	8
Average number of piles installed over 24 hours	4	4
Maximum duration of piling per day over construction phase (hours)	20	20
Average duration of piling per day over construction phase (hours)	16	16
Maximum total number of days when piling may occur over construction phase	48	72
Concurrent piling (between OSP and Wind Tiurbine Anchors Only)		
Maximum number of concurrent piling events	2	2

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[7] Based upon Anchoring Option 1 (driven piles only) for 265 foundations.

[8] Based upon Anchoring Option 1 (driven piles only) for 265 foundations with minimum drilling rate of 0.2 m per hour.

[9] Based upon Anchoring Option 1 (driven piles only) for 265 foundations.

[10] Based upon Anchoring Option 5 (Driven piles only, shared anchoring between floating foundations) for 265 foundations.

[11] Based upon Anchoring Option 5 (Driven piles only, shared anchoring between floating foundations) for 265 foundations.

Parameter	Maximum Design Envelope	
	OSP Option 1	OSP Option 2
Minimum distance between concurrent piling events (m)	950	950
Maximum distance between concurrent piling events (km)	41	41

Table 3.30: Maximum Design Envelope: OSP Options – Drilling Characteristics

Parameter	Maximum Design Envelope	
	OSP Option 1	OSP Option 2
Maximum number of piles requiring drilling per foundation	24	36
Maximum (%) of all piles requiring drilling over the wind farm	100	100
Minimum drilling rate (m/hour)	0.2	0.2
Maximum drilling rate (m/hour)	1.0	1.0
Maximum drilling depth (m)	85	85
Maximum drilling duration (per pile) (hours)[12]	425	425
Maximum drilling duration for Array (days)	2,550	3,825
Average drilling duration for Array (days)	850	1,275
Maximum volume of drill arisings per pile (m^3)	300	300 for large OSPs and 200 for small OSPs
Maximum volume of drill arisings for Array (m^3)	43,260	50,470
Maximum number of concurrent drilling events	1	1 for large OSPs and up to 2 for small OSPs

108. Once the jacket foundations are installed, the OSP topsides will be transported to the Array via vessel either from the fabrication yard or the port facility. It is likely this will be transported by the installation vessel or on a barge towed by a tug. Once on site, the OSP topside will be rigged up, seafastening cut, lifted and installed onto the foundation. The topside and foundation will then be welded or bolted together. Rigging, welding and bolting equipment will be available on board the installation vessel.

109. It is expected that commissioning works will be carried out using a jack-up or DP[1] vessel. Assisting support and supply vessels will be used as required and Crew Transfer Vessels (CTVs) will be used for transfer of personnel to and from the installation vessel.

Step 3 – Inter-array and interconnector cables installation

110. A cable lay vessel will be used for installation (lay) of inter-array cables and interconnector cables (Figure 3.17) using various equipment such as a carousel or reels, tensioners and cable lay spread. Inter-array cables and interconnector cables are typically surface laid prior to cable burial or installation of external cable protection post lay. Cable lay and cable burial can also be performed simultaneously.

111. There are several options which may be used to bury cables to the minimum target burial depth. Equipment that may be used to bury the static portion of the inter-array and interconnector cables include:

- Jet trenchers or mass flow excavators which inject water at high pressure into the sediment surrounding the cable. Jet trenching tools use water jets to fluidise the seabed which allows the cable to sink into the seabed under its own weight.
- Mechanical trenchers, usually mounted on tracked vehicles, which use chain cutters or wheeled arms with teeth or chisels to cut a trench across the seabed.
- Cable ploughs are usually towed either from a vessel or vehicle on the seabed. There are two types of plough:
  - a displacement plough which creates a V shaped trench into which the cable can be laid; or
  - a non-displacement plough which simultaneously lifts a share of seabed whilst depressing the cable into the bottom of the trench. As the plough progresses, the share of the seabed is replaced on top of the cable.

112. Paragraph 74 describes cable crossings potentially required for the inter-array and interconnector cables.

113. Junction boxes will be installed from a construction support vessel (CSV) with adequate craneage and laid on the seabed. The junction boxes will then be secured by the structure's design (e.g. gravity anchors which are buried in the sediment with burial depth dependent upon various factors such as weight, geometry and soil characteristics) or through suction anchors, depending on ground conditions. Once in position the inter-array cables will be pulled into the junction boxes and secured by Remotely Operated Vehicles (ROVs).

114. The inter-array cables will run from the floating foundation to the junction box as described in paragraph 63.

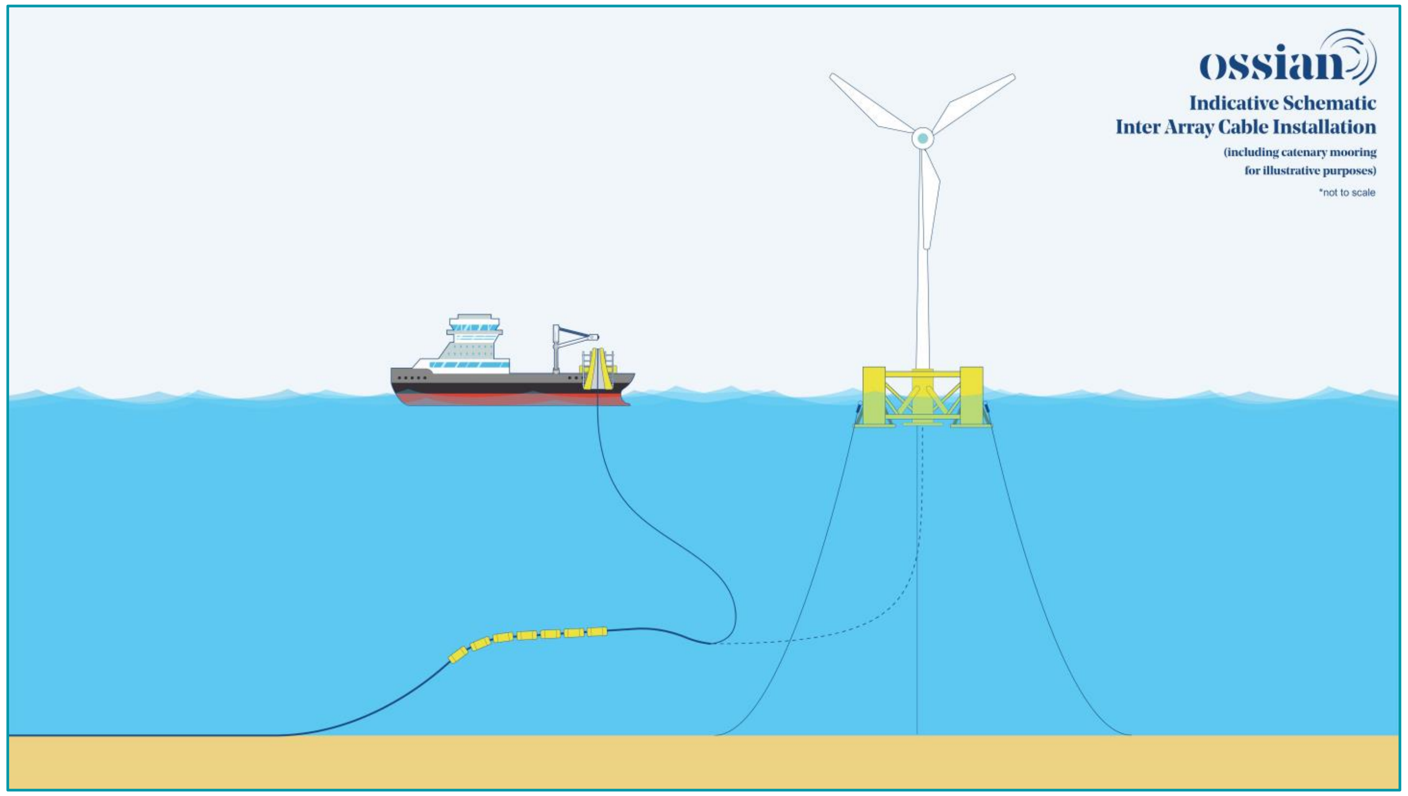

Figure 3.17: Indicative Schematic of Inter-Array Cable Installation from Vessel

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[12] Based upon the minimum drilling rate of 0.2 m per hour.

Step 4 – Floating wind turbine and floating foundation installation/commissioning

115. Floating foundations will be fabricated and assembled at a fabrication yard. The floating foundations will be wet stored within harbour limits of the fabrication yard / integration port. A supply of floating foundations will be assembled in advance of turbine delivery to optimise the integration programme. The floating foundations will then be towed or dry transported on a barge or delivery vessel to the final wind turbine assembly yard using anchor handling tugs (Figure 3.18, step 1). The wind turbines (comprising nacelle, rotor blades, hub and towers) will be assembled and integrated onto the floating foundations at the final wind turbine assembly yard (Figure 3.18, step 2). The schedule for integration of wind turbines with floating foundations will be optimised so that there is limited requirement for wet storage at this stage. It is not anticipated that integrated floating wind turbines will be queued at the wet storage area awaiting tow to the Array, instead, they will be towed to the installation location within the Array as soon as they are pre-commissioned, by up to two anchor handling tugs, or similar, (exact locations to be confirmed at final design stage (post-consent)) (Figure 3.18, step 3). Most floating substructures will employ a ballasting system to control their draft and level of submergence when transported or in operation. The ballasting methodology shall be dependent on the final substructure design and water depth of the final integration port. Some concepts allow the control of the ballast inside different compartments in the structure to modify the response of the floating wind turbine during operation, effectively applying an active control on the volume and mass of the ballast distribution. Active ballast will require special equipment hosted on board (e.g. pumps, pipes, valves). The ballasting material may vary across concepts but generally consists of sea water for the part of the ballast that will be changed for transportation or operation. Permanent ballast (i.e. ballast that won’t be modified during the design life of the foundation) is usually made of solid material (gravel, sand, iron ore etc.) and would be placed and sealed prior to load-out. At the installation location, the integrated floating wind turbines will be installed and hooked up to the pre-installed mooring system (Figure 3.18, step 4). Depending on the foundation concept, the final placement and positioning of the floating wind turbines prior to commissioning may require the adjustment of the ballast configuration.

116. Following hookup of the pre-existing mooring system to the integrated floating wind turbines, dynamic inter-array cables are ‘pulled-in’ to the integrated floating wind turbines using a cable laying vessel and connected to the wind turbine. Buoyancy modules, and tether clamps with clump weights, will be installed as required in order to maintain the dynamic inter-array cable configuration. Following connection to the necessary cabling, a process of testing and commissioning will be undertaken.

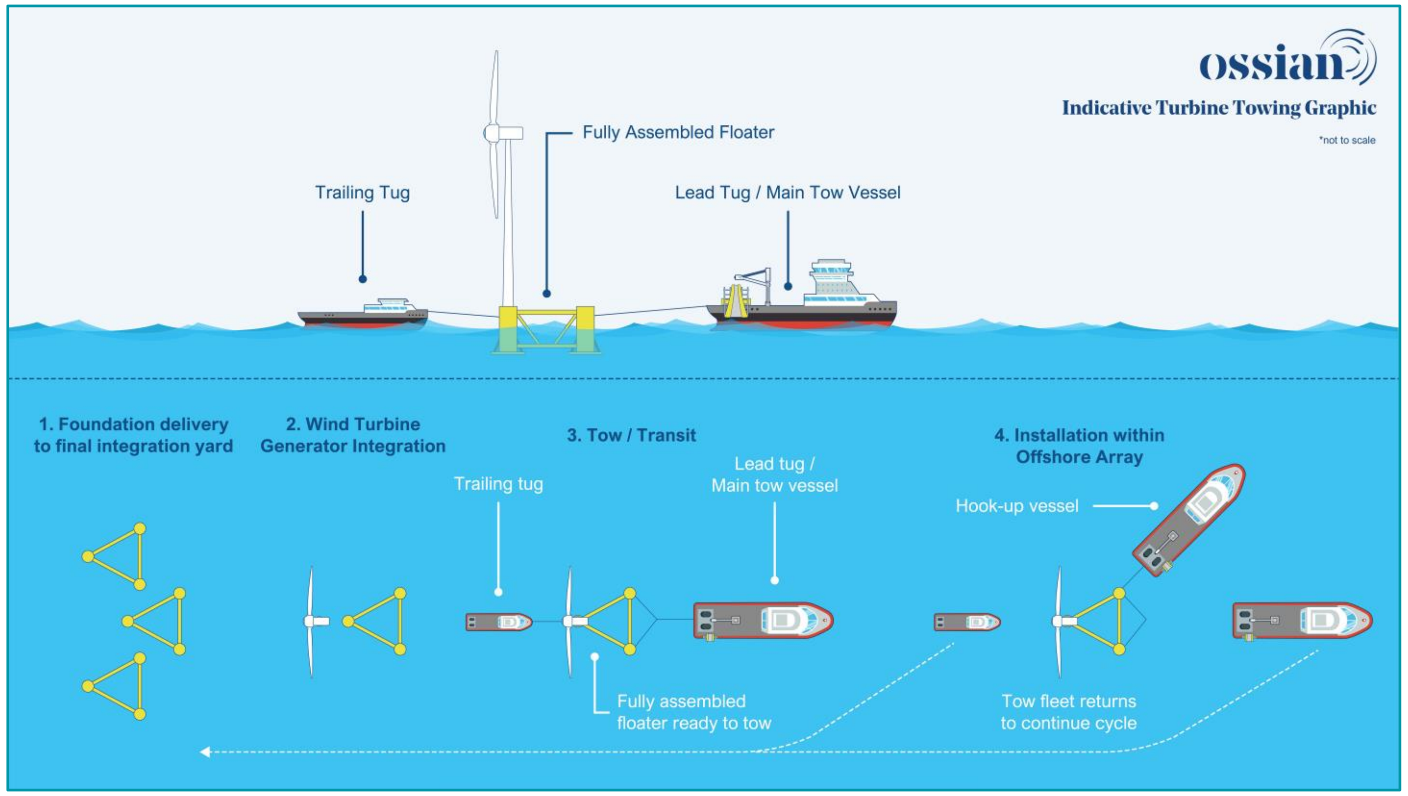

Figure 3.18: Indicative Schematic of Floating Wind Turbine and Floating Foundation Installation and Towing Operations During the Construction Phase

3.4.2. INSTALLATION VESSELS AND HELICOPTERS

117. A number of installation vessels will be used during the construction phase including main installation vessels (e.g. DP[1] vessels with heavy lifting equipment), support vessels (including Service Operation Vessels (SOVs)), tugs and anchor handlers, cable installation vessels, guard vessels, survey vessels, CTVs and scour/cable protection installation vessels. Helicopters may also be used for crew transfers.

118. Table 3.31 presents the maximum design envelope for vessels and helicopters used for the construction phase. The number of vessels/helicopters on site at any one time and the total vessel/helicopter movements (return trips) during the entire construction phase are presented in this table. The vessel numbers presented in Table 3.31 are an estimated maximum design scenario for the purposes of the assessment, and it is anticipated that vessel and helicopter numbers will be less than those presented in reality. The maximum number of vessels is 87 on site at any one time with up to 7,834 return trips.

Table 3.31: Maximum Design Envelope: Infrastructure Installation – Vessels and Helicopters

Parameter	Maximum Design Envelope	
	Maximum Total Number of Vessels on Site at any One Time	Total Movements (Return Trips Across Site Preparation Activities)
Main installation vessels (jack-up/DP[1] vessel)	6	220
Cargo barge/Heavy Transport Vessels (HTVs) (self-propelled)	9	421

Parameter	**Maximum Design Envelope**	
	Maximum Total Number of Vessels on Site at any One Time	**Total Movements (Return Trips Across Site Preparation Activities)**
Support vessels (including SOVs)	10	1,269
Tug/anchor handlers	27	2,059
CSVs	6	1,353
Cable installation vessels	3	236
Guard vessels	6	1,026
Survey vessels	3	70
CTVs	6	770
Trenching support vessels	3	189
Geophysical/geotechnical survey vessels	2	40
Sand wave clearance vessels	1	40
Pre-Lay Grapnel Run (PLGR) vessels	2	64
Rock dumping vessels	2	40
Dive Support Vessels (DSVs)	1	36
Helicopters	7	3,942
Total	**94**	**11,776**
Total (excluding helicopters)	**87**	**7,834**

119. Jack-up vessels or barges touch down on the seabed when their jack-up spud cans (base structure of each leg) are lowered into place. Jack-up vessel parameters are presented in Table 3.32.

Table 3.32: Maximum Design Envelope: Jack-up Vessels

Parameter	**Maximum Design Envelope**
Maximum number of legs per vessel	4
Maximum individual leg diameter (m)	22
Maximum area of spud cans (m^2)	360
Maximum seabed footprint (m^2)	1,440
Maximum number of jack-up positions per small/large OSP	2

3.4.3. CONSTRUCTION PORTS

120. Fabrication of components for the Array infrastructure is likely to occur at a number of manufacturing sites including those located within Scotland, the United Kingdom (UK), Europe, the Middle East and the Far East. It is likely that components will be transported to final assembly yards on the east coast of Scotland for final fabrication or integration before being towed to the Array.

121. It is anticipated that all components will be transported to the Array for installation via sea transport using vessels and associated equipment. It is not anticipated that large components (e.g. wind turbine blades) will be transported via road.

122. At time of writing this Array EIA Report, the Applicant is yet to determine which construction port(s) will be used for the storage, fabrication, pre-assembly and delivery of the Array infrastructure. The Applicant will determine suitable ports based on the facilities available to handle and process components for the Array. Port selection will take into account logistics to reduce towing distance of foundations and integrated turbines as far as practicable. The Applicant anticipates that established port licences and operational controls will cover all activities associated with the Array which are carried out within port. In order to assess a MDS, the assessments within this Array EIA Report consider a maximum number of vessels and vessel movements to/from site, where relevant from the east coast of Scotland or England.

123. Construction personnel will transit to the Array location on the installation vessels or other vessels listed in Table 3.31. CTVs, SOVs, or helicopters operating from a licenced airfield may be used to transfer crew between the port facility and the Array location during construction, operation and decommissioning.

3.4.4. CONSTRUCTION PROGRAMME

124. The indicative construction programme for the Array is provided below. This indicative construction programme, including the estimated commencement and completion dates, and estimated durations of activities, has been used within the technical chapter assessments of construction impacts.

125. As described at paragraph 116, there is no intention to wet store integrated turbines within the limits of the final integration and marshalling port. The location of the final integration and marshalling port is currently unknown. The Applicant are currently developing a fabrication, delivery and integration strategy and engaging with a number of port and harbour operators to identify an optimised approach. In the absence of an integration and marshalling yard it is not possible, at this stage, to consider the potential site-specific impacts on relevant receptors. The Ossian construction programme will be managed to reduce the requirement for storage of integrated pre-commissioned turbines within port. A stock of floating foundations will be accumulated, and mooring lines and cables would be installed within the array in advance of turbine integration. The Applicant aims to minimise any wet storage requirements by towing integrated turbines to their final location within the array as soon as they are ready, subject to suitable weather conditions for transfer. Enabling works, including integration, and marshalling activities, required within the final integration port to cover turbine pre-commissioning, testing and storage (if required) will be covered by the consenting requirements applying to them (including any requirements for environmental assessment) and will be managed by the port or harbour authority with support where appropriate from the Applicant.

126. The Array will be built out over a period of up to eight years including site preparation works. Separate campaigns will be undertaken for the relevant assets and are likely to occur concurrently across the eight year construction period. It should be noted that the activities listed below will not occur continuously throughout the eight year period, rather, the programme indicates the period within which these activities could occur. Increased construction activity is anticipated within the spring to autumn months, with limited works undertaken at site during the winter period.

127. The indicative construction programme is as follow

- Commencement of offshore construction phase (site preparation activities) expected Q2 2031;
- Completion of construction expected Q4 2038;
- Key construction activity and estimated durations:
  - Site preparation activities – estimated seven year duration between Q2 2031 and Q4 2037. These works will not be continuous;
  - Floating turbine mooring and anchoring installation – estimated seven year duration between Q2 2031 and Q4 2037. These works will not be continuous;
  - OSP topsides and fixed jacket foundations installation/commissioning – will occur for the duration of the construction period but will not be continuous;
  - inter-array and interconnector cables installation – will occur for the duration of the construction period but will not be continuous; and
  - floating wind turbine and floating foundation installation/commissioning – estimated seven year duration between Q2 2032 and Q4 2038. These works will not be continuous.

3.4.5. RECOMMENDED SAFE PASSING DISTANCES AND AIDS TO NAVIGATION

Safety zones, recommended safe passing distances and Notice to Mariners

128. The Applicant will communicate with other mariners of safe clearance distances around construction, installation, maintenance and decommissioning activities during the construction and operation of the Array as per standard practice and guidance.

Statutory safety zones

129. Volume 1, chapter 2 describes the legislation for establishment of statutory safety zones. The Applicant intends to apply for the following safety zones for the Array:

- temporary (or rolling) 500 m safety zones surrounding the location of all surface piercing structures where construction work is being undertaken by a construction vessel;
- 50 m safety zones around all partially completed or completed surface piercing structures which are not yet fully commissioned during the construction phase; and
- 500 m around any structure where major maintenance is ongoing (major maintenance works are defined within the Electricity (Offshore Generating Stations) (Safety Zones) (Application Procedures and Control of Access) Regulations 2007.

130. The Applicant will apply for statutory decommissioning safety zones during the decommissioning phase (as appropriate) which are not anticipated to exceed the standard 500 m safety zone.

Recommended safe passing distances

131. The Applicant may use recommended safe passing distances during the construction, operation and maintenance and decommissioning phases for the safety of third party vessels. Notice to Mariners (NtMs) will be used to communicate these to sea users during all phases of the Array.

Aids to navigation

132. The floating wind turbines and OSPs will be lit and marked to aid navigation. The Lighting and Marking Plan (LMP) for the Array will be defined post consent in consultation with the Northern Lighthouse Board (NLB), Maritime and Coastguard Agency (MCA), the Civil Aviation Authority (CAA) and the Ministry of Defence (MOD).

133. Marine aids to navigation will be provided throughout the lifetime of the Array in accordance with the requirements of the NLB, MCA and MOD, and in adherence to Civil Aviation Publication (CAP) 393 Article 223 (CAA, 2016 (as amended)), unless otherwise agreed. Monitoring and maintenance of all navigational aids associated with the Array will be undertaken so that the relevant CAA availability targets are met.

3.5. OPERATION AND MAINTENANCE PHASE

3.5.1. METHODOLOGY

134. The overall operation and maintenance strategy will be finalised once the operation and maintenance base location and technical specification of the Array are known, including wind turbine type, electrical export option and final project layout. Therefore, this section provides an overview of the potential scheduled and unscheduled operation and maintenance activities within the Array which are reasonably foreseeable.

135. Routine operation and maintenance works will be conducted using SOVs, CTVs, and/or ROVs. Divers and DSVs may be utilised if required, although it is anticipated that diverless operations will be utilised as far as practicable. For infrequent major operation and maintenance works, including major component replacements, wind turbines will be decoupled from their mooring and anchoring systems and towed to a suitable port facility. Jack-up vessels will be used for infrequent major maintenance campaigns associated with the OSPs. ROVs will be used to inspect foundations, mooring and anchoring systems, and cabling. A summary of the reasonably foreseeable operation and maintenance activities is provided in the following sections.

136. Offshore operation and maintenance will comprise of both preventative and corrective activities.

Floating foundations (including mooring and anchoring systems)

137. The following operation and maintenance activities are expected to occur in relation to the floating foundations:

- routine inspections;
- geophysical surveys;
- repairs or replacements of navigational equipment and other ancillary equipment including condition monitoring equipment;
- removal of marine growth;
- repairs or replacements of corrosion protection anodes;
- removal of fishing debris;
- painting;
- replacement of access ladders and boat landings;
- modifications to/replacement of ancillary structures;
- repairs or replacement of any buoyancy aids and/or clump weights; and
- replacement of scour protection.

138. It is assumed that the majority of these activities will be carried out using uncrewed surface vessels (USVs), SOVs, CTVs, ROVs, CSVs, DP[1] vessels, survey vessels, and tug vessels, with appropriate equipment for the activity to be undertaken. Divers and DSV may be required if necessary. Although it is assumed that the majority of these operation and maintenance activities will be routinely scheduled throughout the lifetime of the Array, repairs and replacements of navigational equipment, corrosion protection anodes and access ladders and boat landings, removal of marine growth and fishing debris, and painting are expected to be unscheduled. The frequency of these unscheduled activities will be dependent on the findings of routine inspections and will be carried out during other works as and when required.

Floating wind turbines

139. The following operation and maintenance activities are expected to occur in relation to the floating wind turbines:

- replacement of consumables;
- routine inspections;
- blade coatings/repairs;
- minor repairs and replacements within the wind turbines;
- major component replacement;
- painting or other coatings; and
- statutory inspections.

140. It is assumed that the majority of these activities will be carried out using SOVs and CTVs. ROVs, CSVs, tow vessels, cable vessels and anchor handler vessels may be used in the case of major component replacement which is anticipated to occur on an unscheduled basis (i.e. as and when required).

141. It is currently anticipated that any large operation and maintenance activities, including major component replacements will take place at a local operation and maintenance port or harbour facility. The process would follow a reverse of the installation approach. It is anticipated that the following indicative steps will be followed to undertake any major operation and maintenance works:

- Disconnect and unhook the inter-array cables, and wet store on the seabed.
- Deballast the floating foundation, if required.
- Disconnect the mooring lines from the floating foundation and wet store on the seabed.
- Tow the turbine to a suitable operation and maintenance facility using up to two anchor handling tugs, or similar. It is expected that a quay side mounted crane, or a suitable alternative, will be used to undertake any major component replacements. Ballasting and de-ballasting at the quayside may also be required.

142. Following completion of operation and maintenance works, the wind turbine will be towed back to the turbine location within the Array. Mooring lines would be reconnected, the turbine foundation would be reballasted (as required) and the inter-array cable will be pulled into the turbine and reconnected.

143. Other operation and maintenance strategies would be considered including novel solutions which do not require towing to port. Temporary floating structures may also be used to and connected to mooring lines and dynamic cables to reduce the need for lowering to and recovery from the seabed.

OSP jacket foundations

144. The following operation and maintenance activities are expected to occur in relation to the OSP jacket foundations:

- routine inspections;
- geophysical surveys;
- repairs and replacements of navigational equipment and other ancillary equipment including condition monitoring equipment;
- removal of marine growth;
- replacement of corrosion protection anodes;
- painting;
- replacement of access ladders and boat landings;
- modifications to/replacement of J/I-tubes; and
- replacement of scour protection.

145. It is assumed that the majority of these activities will be carried out using USVs, SOVs, CTVs, ROVs, CSVs, and DP[1] vessels, with appropriate equipment for the activity to be undertaken. Unscheduled maintenance activities as the same as described in paragraph 138 (with the exception of fishing debris removal which is not anticipated to be required for OSP jacket foundations), the frequency of which will be dependent on the findings of routine inspections and carried out during other works as and when required.

OSP topsides

146. The following operation and maintenance activities are expected to occur in relation to the OSP topsides:

- routine inspections;
- removal of marine growth;
- replacement of consumables and minor components;
- major component replacement; and
- painting or other coatings.

147. It is assumed that the majority of these activities will be carried out using SOVs and CTVs. Jack-up barges and/or heavy lift vessels may be required in the case of major component replacement. Although it is anticipated that the majority of these operation and maintenance activities will be routinely scheduled throughout the lifetime of the Array, replacement of consumables and minor components is an unscheduled activity which will occur as required, dependent upon the findings of routine inspections.

Inter-array and interconnector cables

148. The following operation and maintenance activities are expected to occur in relation to both the inter-array cables and interconnector cables:

- routine inspections;
- geophysical surveys;
- inter-array cable/interconnector cable repair;
- inter-array cable ancillary equipment repair;
- inter-array and interconnector cables reburial or installation of cable protection (if required);
- removal of marine growth and/or fishing debris;
- modifications to/replacement of J/I tubes;
- replacement of scour protection; and
- repairs or replacement of buoyancy modules and/or clump weights.

149. It is assumed that the majority of these activities will be carried out using USVs, SOVs, CTVs, ROVs, CSVs, DP[1] vessels, survey vessels, and cable vessels, with appropriate equipment for the activity to be undertaken (including burial equipment). Divers and DSV may be required if necessary. It is anticipated that the majority of these operation and maintenance activities will be routinely scheduled throughout the lifetime of the Array.

3.5.2. OPERATION AND MAINTENANCE VESSELS

150. Table 3.33 presents the maximum design envelope for vessels involved in operation and maintenance activities for the Array.

Table 3.33: Maximum Design Envelope: Vessels Required During the Operation and Maintenance Phase

Parameter	Maximum Design Envelope	
	Maximum Total Number of Vessels on Site at any One Time	**Maximum Total Movements (Return Trips Across Operation and Maintenance Phase)**
CTV/SOV/workboats	9	117
Tug (anchor handlers) vessels	6	200
Jack-up vessels	2	5
Cable repair vessels (including burial solution)	2	40
CSV	5	60
DSV	1	26
Other vessels	6	60
Helicopters	3	216
Total	**34**	**724**
Total (excluding helicopters)	**31**	**508**

3.6. HEALTH AND SAFETY

151. Risk assessments for all elements of the Array will be undertaken as per the relevant government guidance and the Applicant’s good practice procedures. The risk assessments will form the basis of the methods and safety mitigations put in place across the lifetime of the Array.

3.7. WASTE MANAGEMENT

152. The construction and decommissioning phases of the Array in particular will generate waste. A Site Waste Management Plan (SWMP) will be prepared and will describe the procedures for handling waste materials, the quantities of waste types generated as a result of the Array activities, and how these will be managed (e.g. disposal, reuse, recycle or recovery). Information on the management arrangements for the identified waste types and management facilities in the vicinity of the Array will also be provided within the SWMP.

153. The SWMP will be provided prior to construction when further detailed design information is available.

3.8. DECOMMISSIONING PHASE

154. In line with the requirements under Section 105 of the Energy Act 2004 (as amended), described fully in volume 1, chapter 2, the Applicant will prepare a DP^2 for approval by the Scottish Ministers which will include anticipated costs and financial securities, and consider good industry practice, guidance and legislation relating to decommissioning at the time.

155. At the end of the Array's operational lifetime, it is expected that all structures above the seabed (with the exception of driven piles and DEAs (depending upon anchor system used), scour protection and cable protection) will be fully removed where feasible. Driven piles and/or DEAs installed as part of the wind turbine anchoring system, static portions of inter-array cables, interconnector cables, scour protection and cable protection are either expected to remain *in situ* or method of decommissioning is yet to be determined. Legislation, guidance and good practice will be kept under review throughout the lifetime of the Array and will be followed at the time of decommissioning. Environmental conditions and sensitivities will also be considered since removal of structures may result in greater environmental impacts in comparison to leaving *in situ*.

156. The sequence of decommissioning is likely to be the reverse of the construction sequence, and similar types and numbers of vessels and equipment are expected to be involved. The Lease Agreement, which will be signed with CES, will require the Array to be decommissioned at the end of its lifetime.

3.8.1. OFFSHORE DECOMMISSIONING

Floating wind turbine components

157. The integrated floating wind turbines (i.e. floating wind turbine and floating foundation) will be removed from site by reversing the methods used to install them.

Wind turbine floating foundations – mooring and anchoring systems

158. Mooring lines will be fully removed from site where this be feasible and practicable. It may not be feasible to fully remove anchors where they are embedded in the seabed (e.g. DEAs or driven piles). These are expected to be left *in situ* and will follow good practice and consideration of environmental conditions and sensitivities This will be reviewed throughout the lifetime of the Array and the most up to date and good practice guidance at time of decommissioning will be followed. The most adverse scenario has been assessed for each topic within this Array EIA Report.

OSP topsides

159. OSP topsides will be fully removed from site by reversing the methods used to install them.

OSP fixed jacket foundations

160. Driven piles will be cut at seabed level and left *in situ*, depending on seabed mobility, to reduce further disruption of the seabed. This will be reviewed throughout the lifetime of the Array and the most up to date and good practice guidance at time of decommissioning will be followed. The most adverse scenario has been assessed for each topic within this Array EIA Report. Jackets will be fully removed from site.

Scour protection

161. It is currently proposed that scour protection will be left *in situ* subject to the final material used. Good practice guidance at time of decommissioning will be followed. The most adverse scenario has been assessed for each topic within this Array EIA Report.

Inter-array cables and interconnector cables

162. The dynamic portion of the inter-array cables within the water column will be fully removed. The approach for decommissioning the static portion of the inter-array cables and the interconnector cables on the seabed is yet to be determined, however, this will be reviewed throughout the lifetime of the Array and good practice guidance at time of decommissioning will be followed. Where cables remain buried these may be cut and left *in situ* taking account of environmental sensitivity at the time of decommissioning. The most adverse scenario has been assessed for each topic within this Array EIA Report.

Cable protection

163. The approach for decommissioning the cable protection systems is yet to be determined, however, this will be reviewed throughout the lifetime of the Array and good practice guidance at time of decommissioning will be followed. The most adverse scenario has been assessed for each topic within this Array EIA Report.

3.9. REPOWERING

164. Although it is standard procedure for sectors where a non-renewable resource is being exploited, such as oil and gas, for removal of all structures on the seabed as part of offshore decommissioning, the alternative option of repowering may be considered for offshore renewables – especially as, at the time of decommissioning, the need for the power generated will likely still exist.

165. The operational life of the Array is expected to be 35 years, during which there will be a requirement for upkeep and maintenance of the Array, as described in section 3.5.

166. 'Repowering' of the Array at or near the end of its design life may be considered suitable, for example, where new technology becomes available. In this example, wind turbines and/or foundations may be reconstructed and replaced with those of a different specification or design. If the specifications and designs of the new wind turbines and/or foundations fell outside of the MDS or if the impacts associated with the construction, operation and maintenance, and/or decommissioning of the wind turbines and/or foundations were to fall outside those considered by this Array EIA Report, further consent(s) (and potentially an EIA Report) would be required for repowering. Therefore, this is outside of the scope of this Array EIA Report.

3.10. DESIGNED IN MEASURES

167. A number of designed in measures have been considered as part of the PDE which the Applicant commits to deliver as part of the development of the Array. Table 3.34 presents the designed in measures for the Array. As these measures have been incorporated into the description of the Array, they have also been considered within the topic specific assessments within volume 2, chapters 7 to 20. Further details of the designed in measures, secondary mitigation and monitoring commitments are provided in volume 3, appendix 6.3.

Table 3.34: Designed In Measures for the Array

Designed In Measures	Justification
Spacing between wind turbines within the Array will be sufficiently distant (at least 1,000 m).	There is the potential for changes to the wave, wind and hydrodynamic regime due to the presence of the Array, should the wind turbines be situated closely together. The design adopted will ensure a sufficient spacing of at least 1,000 m between wind turbines, as discussed in section 3.2.2. Thus any wake effects, or changes to the wind and wave field or hydrodynamics will be reduced.
Undertake detailed wake loss modelling.	Undertaken to inform layout design by minimising wake loss across the Array.
Development of, and adherence to a CBRA.	The CBRA will consider relevant activities in the vicinity of inter-array and interconnector cables and confirm appropriate means of protection taking account of the final inter-array and interconnector cable. The CBRA will identify the appropriate target burial depth to ensure the cable remain buried, or appropriately protected, where target burial depths cannot be achieved, for the duration of the Array, to reduce the risk of interaction with other sea users or cable exposure.
Use of minimum target burial depths (0.4 m) or cable protection around inter-array and interconnector cables.	There is the potential for disturbance of seabed sediments to occur due to interactions between metocean regime (wave, sand and currents) and subsea cables. This can result in increased suspended sediments and affect the sediment transport regime. Therefore, the use of minimum burial depths and cable protection around inter-array and interconnector cables will be employed to ensure cables remain adequately protected for the duration of the operational phase of the project, as described in detail in section 3.2.6.
Development of, and adherence to, an Operation and Maintenance Programme (OMP).	The OMP will detail a programme of routine inspections, including for, but not limited to, of static inter-array and interconnector cables to confirm target burial depth is maintained. There is a potential for disturbance of seabed sediments to occur if the target burial depth is not maintained.
Development of, and adherence to a Scour Protection Management Plan (SPMP).	There is the potential for scouring of seabed sediments to occur due to interactions between metocean regime (wave, sand and currents) and wind turbine anchors or OSP foundations or other seabed structures. This scouring can develop into depressions around the structure, therefore the use of scour protection around offshore structures and foundations will be employed, where required, as described in detail in section 3.2.5.
Development and adherence to an EMP.	To ensure adequate environmental controls are in place across the project to manage and mitigate any potential risk to the environment. Measures will cover all aspects of environmental management including environmental awareness training, auditing, environmental reporting and waste management. It is anticipated that the MPCP and Invasive Non-Native Species Management Plan (INNSMP) will be appendices to the overarching EMP.
Development of, and adherence to a MPCP.	Measures will be adopted to ensure that the potential for release of pollutants from construction, operation and maintenance and decommissioning plant is reduced so far as reasonably practicable. These will likely include designated areas for refuelling where spillages can be easily contained, storage of chemicals in secure designated areas in line with appropriate regulations and guidelines, double skinning of pipes containing hazardous substances, and storage of these substances in impenetrable bunds. All vessels associated with the Array will be required to comply with the standards set out by International Convention for the Prevention of Pollution from Ships (MARPOL).
Development of, and adherence to an INNSMP.	To reduce the risk of introduction and spread of Invasive and Non-Native Species (INNS) during all phase of the Array as far as reasonably possible.
Development of, and adherence to, a DP[2].	The aim of this plan is to adhere to the existing UK and international legislation and guidance (at the time of writing) during the decommissioning phase. This will reduce the amount of long-term disturbance to the environment as far as reasonably practicable.
The development of, and adherence to a Piling Strategy (PS) (or equivalent) which will set out the following measures: Implementation of initiation stage and soft start during piling. This will involve the use of a low hammer energy with a low number of strikes used initially, followed by lower hammer energies at a higher strike rate at the beginning of the piling sequence before energy input is 'ramped up' (increased) over time to required higher levels.	These measures will reduce the likelihood of injury from elevated underwater noise to marine life in the immediate vicinity of piling operations as far as practicable, allowing individuals to move away from the area before sound levels reach a level at which injury may occur.
Undertake UXO clearance using low order disposal techniques where technically feasible.	Low order techniques will be adopted wherever practicable (e.g. deflagration and clearance shots) as mitigation to reduce noise levels and thereby injury and disturbance to sound-sensitive receptors during UXO clearance. There is a small risk that low order disposal could unintentionally result in a high order detonation and therefore this scenario has also been considered in the assessment of LSE[1].
Implementation of soft start measures for UXO clearance using a sequence of small explosive charges detonated over set time intervals.	These measures will reduce the likelihood of injury from elevated underwater noise to fish and shellfish receptors/marine mammals in the immediate vicinity of piling/UXO clearance operations as far as practicable, allowing individuals to move away from the area before sound levels reach a level at which injury may occur. This is in line with the most up to date guidance for piling/UXO clearance operations (Joint Nature Conservation Committee (JNCC), 2010a; JNCC, 2010b) and, in most cases, compliance with this guidance reduce the likelihood of injury to fish and shellfish/marine mammal receptors to negligible levels.
The development of, and adherence to a Marine Mammal Mitigation Protocol (MMMP).	The MMMP will: • mitigate for the risk of permanent auditory injury to marine mammals within a pre-defined 'mitigation zone' for each activity. The mitigation zone is determined considering the largest injury zone across all species for each relevant activity; • reduce the potential for collision risk, or potential injury to, marine mammals and other marine megafauna (e.g. basking shark and sea turtles) as far as practicable; and detail the visual and acoustic monitoring required as a minimum over the defined mitigation zones so that animals are clear before the activity commences. Additional measures to deter animals from injury risk zones may be applied in some instances (e.g. Acoustic Deterrent Devices (ADDs) or soft start charges). An outline MMMP has been developed on the basis of the most recent published statutory guidance (JNCC, 2010a, JNCC, 2010c, JNCC, 2017).
Routine inspections of the inter-array cables and mooring lines.	Mooring lines and dynamic inter-array cables in the water column will undergo regular inspections during the operation and maintenance phase with inspection frequency more frequent initially for the first two years and then decreasing to an annual schedule. The removal of marine debris from mooring lines and inter-array cables will be undertaken as necessary following monitoring and further relevant action taken if required, based on findings from the inspections. The removal of debris from mooring lines and cables further reduces the likelihood of secondary entanglement.
Fisheries liaison.	Appointment of a Fisheries Liaison Officer (FLO) and use of Offshore FLOs (OFLO) as required to enable ongoing liaison with fishing fleets to be maintained. Adherence to appropriate guidance with regards to fisheries liaison and mitigation procedures in the event of interactions between the proposed development and fishing activities, (i.e. Fishing Liaison with Offshore Wind and Wet Renewables Group (FLOWW) guidance).

Designed In Measures	Justification
Promulgation of information through timely and efficient posting of NtMs, Kingfisher Bulletins and navigational warnings, as appropriate. Information will include but not be limited to vessel routes, timings and locations, safety zones and advisory safe passing distances as required.	Maximises awareness of the Array allowing vessels to passage plan in advance.
Apply for and implement safety zones during major construction and operation and maintenance activities.	Application for safety zones up to 500 m around structures where vessels are undertaking construction work during construction and periods of major operation and maintenance and 50 m around partially completed or completed but not yet fully commissioned surface piercing structures during construction. Advisory temporary safe passing distances to be promulgated to mariners, including fishers, around installation/maintenance vessels actively engaged in works.
Preparation and implementation of a CaP.	This will include a refined cable laying plan, cable laying techniques and minimum burial depths (0.4 m) (for inter-array and interconnector cables).
Development of, and adherence to, a Fisheries Management and Mitigation Strategy (FMMS).	The FMMS will set out the means of ongoing fisheries liaison through the lifetime of the Array and detail any mitigation measures of relevance to commercial fisheries to be put in place. This will set out commitments to environmental monitoring in the pre, during and post-construction phases. A procedure for claims due to loss of, or damage to fishing gear, will be included in the FMMS.
Member of and engagement in a Regional Commercial Fisheries Working Group.	Provides a forum for information sharing and discussion of key issues with commercial fisheries stakeholders and other developers in the region. Will be detailed within the project FMMS which will be agreed with MD-LOT in consultation with key fishery stakeholders which will likely be a requirement of the S36 Consent and/or Marine Licence (ML) conditions.
Development of, and adherence to, a Navigational Safety and Vessel Management Plan (NSVMP).	The NSVMP will confirm the types and numbers of vessels that will be engaged in activities associated with the Array, and consider vessel coordination including indicative transit route planning (Marine Coordination). All contractors undertaking works to be contractually obliged to ensure compliance with standard offshore policies, including those that prohibit the discarding of objects or materials overboard and that require the rapid recovery of accidentally dropped objects where feasible. Development and issue of a Code of Conduct to all project vessel operators to advise on how to avoid impacts on marine megafauna and interference with fishing activities. The NSVMP will include measures to reduce disturbance to marine mammal receptors from transiting vessels, requiring them to: • not deliberately approach marine mammals as a minimum; and • avoid abrupt changes in course or speed should marine mammals approach the vessel to bow-ride. The NSVMP will be implemented as far as practicable and where it does not compromise the safety of vessels. Compliance of all project vessels with maritime regulations as adopted by the relevant flag state including the International Regulations for Preventing Collisions at Sea (COLREGs) (International Maritime Organization (IMO), 1974a) and the International Convention for the Safety of Life at Sea (SOLAS) (IMO, 1974b). Compliance with the Regulatory Expectations on Moorings for Floating Wind and Marine Devices (Health and Safety and Environment (HSE) and MCA, 2017),, in particular independent third party verification and monitoring/tracking.
Development of, and adherence to a LMP.	The LMP will confirm compliance with legal requirements including IALA G1162 (IALA, 2021), with regards to shipping, navigation and aviation marking and lighting to increases awareness of the Array in both day and night conditions for vessel and aviation operators including in restricted visibility and assists with SAR operations. Navigational aids and marine charting so that other marine users are made aware of the location of the Array. Consideration of UK Marine Guidance Note (MGN) 654 with respect to wind turbine design and construction, so that recognised safe standards are met with regards to navigational safety and emergency response (search and rescue, salvage and towing, counter pollution). Adherence with the provisions of the COLREGs for all contracted vessels, including the display of appropriate lights and shapes such as when vessels are restricted in their ability to manoeuvre. Array aviation lighting will conform to the following: • Red medium intensity aviation warning lights (of variable brightness between a maximum of 2,000 candela (cd)) to a minimum of 10% of the maximum which would be 200 cd) will be located on either side of the nacelle of significant peripheral wind turbines. These lights will flash simultaneously with a Morse W flash pattern and will also include an infra-red (IR) component. • All aviation warning lights will flash synchronously throughout the Array and be able to be switched on and off by means of twilight switches (which activate when ambient light falls below a pre-set level). • Aviation warning lights will allow for reduction in lighting intensity at and below the horizon when visibility from every wind turbine is more than 5 km (to a minimum of 10% of the maximum (i.e. 200 cd)). • SAR lighting of each of the non-periphery wind turbines will be combi IR/200 cd steady red aviation hazard lights, individually switchable from the control centre at the request of the MCA (i.e. when conducting SAR operations in or around the Array). All wind turbines will be fitted with a low intensity light for the purpose of helicopter winching (green hoist lamp). All wind turbines will also be fitted with suitable illumination (minimum one 5 cd light) for identification signs.

Designed In Measures	Justification
Appropriate marking of structures on UK Hydrographic Office (UKHO) Admiralty Charts and other electronic charts as appropriate.	Ensure the appropriate marking of structures on UKHO Admiralty Charts to maximise the awareness of the Array allowing vessels to plan their passage in advance.
Deployment of a buoyed construction area in agreement with the NLB.	Protects third-party vessels from project vessels involved in construction activities which may be Restricted in their Ability to Manoeuvre (RAM), and partially completed structures.
Compliance with MGN 654 and its annexes (in particular Search and Rescue (SAR) annex 5 and completion of a SAR checklist) where applicable.	Ensures the final Array layout is suitable for SAR operations and that reductions in underkeel clearance are acceptable.
Use of guard vessel(s) as required by risk assessment.	Maximises awareness of temporary hazards, and ensures vessel presence where necessary to alert passing mariners to a hazard.
Development of, and adherence to, a Development Specification and Layout Plan (DSLP) to confirm the final layout and design in consultation with the MCA and NLB.	Ensures the final Array layout is suitable for both surface and air based (for SAR purposes) navigation and is compliant with MGN 654. Will also confirm adherence to key project design conditions including ensuring a safe underkeel clearance is maintained around mooring line arrangements. The Applicant will consider MGN 654 (MCA, 2021), in addition to CAP 393 (CAA, 2016b as amended 2022), and CAP 764 (CAA, 2016a) where applicable. The Applicant has committed to a layout that will be compliant with MGN 654 which will incorporate at least one line of orientation.
Minimum blade tip clearance height of 36 m above LAT.	This reduces the risk of blade allision particularly for sailing vessels with a mast and surpasses the requirements set by the Royal Yachting Association (RYA) policy (RYA, 2019) and MGN 654 (MCA, 2021). As most seabirds tend to fly low, increased blade tip clearance leads to a reduction in collision mortality.
Development and implementation of an Emergency Response Co-operation Plan (ERCoP).	In line with MGN 654 (MCA, 2021) Annex 5 SAR requirements
Establishment of a Marine Coordinator and communication procedures to manage project vessel movements.	Ensure project vessels are suitably managed to reduce the likelihood of involvement in incidents and ensure the safe operation during all phases of project development. Increases the ability to assist in the event of a third-party incident.
Compliance with the Regulatory Expectations on Moorings for Floating Wind and Marine Devices (HSE and MCA, 2017).	Ensure that the final design is appropriately designed, constructed to an appropriate standard and structural integrity maintained during the operation and maintenance phase of the project.
Array infrastructure will be subject to third party verification where applicable.	Ensure that the final design is appropriately designed, constructed to an appropriate standard and structural integrity maintained during the operation and maintenance phase of the project.
Installation of remote discrete condition monitoring equipment.	Installation of appropriate system, such as sensors, cameras, dataloggers, etc. to ensure the safe and efficient operation of the Array infrastructure.
Construction Method Statement (CMS)	The CMS will confirm certain construction activities and how these will be managed. This will include plans on wet storage within the Array.
Notification to the Defence Geographic Centre (DGC) and NATS.	Information regarding construction will be passed to the DGC (at dvof@mod.gov.uk) at least 10 weeks in advance of the obstacle type(s) erection detailing position, height (tip of arc) and type of aviation lighting. Once reported, all will be included in the Digital Vertical Obstruction File (DVOF) database and all that meet aviation chart inclusion criteria will be published for broader awareness. Appropriate information about the site construction and any associated lighting (where applicable), for example the height and temporary location of construction cranes, should be provided to the NATS Aeronautical Information Service (AIS) (for promulgation in applicable aviation publications including the UK Integrated Aeronautical Information Package (IAIP)) (CAA, 2023a).
The identification and implementation of Archaeological Exclusion Zones (AEZs) around anomalies identified as having high and medium archaeological potential. Further details of AEZs are provided in the Written Scheme of Investigation (WSI) and Protocol for Archaeological Discoveries (PAD) (volume 3 appendix 19.2).	To reduce the potential for direct impacts on sites of identified archaeological significance.
The identification and implementation of Temporary Archaeological Exclusion Zones (TAEZs) based on all available information including the stated positional accuracy, the recorded size of the target and the potential archaeological significance around those records for wrecks and obstructions outside of the survey data coverage but within the Array site boundary. Further details of which are provided in the WSI and PAD (volume 3 appendix 19.2).	To reduce the potential for impacts on sites of archaeological importance.
Archaeologists engaged by the Applicant to be consulted in the preparation of any pre-construction ROV surveys and, if appropriate, in monitoring/checking of data. Further details of which are provided in the WSI and PAD (volume 3 appendix 19.2).	To identify any sites of archaeological importance that may require further investigation, avoidance or engagement with Historic Environment Scotland (HES).
Archaeological input into specifications for, and archaeological analysis of, any further site investigation. Further details of which are provided in the WSI and PAD (volume 3 appendix 19.2).	To identify any sites of archaeological importance that may require further investigation, avoidance or engagement with HES. To preserve by record on sediments of geoarchaeological/palaeoenvironmental importance and enhance knowledge of the offshore marine archaeological resource.
Mitigation of unavoidable direct impacts on known sites of archaeological significance through options which include i) preservation by record; ii) stabilisation; iii) detailed analysis and safeguarding of otherwise comparable sites elsewhere. Further details are provided in the WSI and PAD (volume 3 appendix 19.2).	To mitigate the effects of disturbance/destruction of irreplaceable archaeological remains.

Designed In Measures	Justification
Operational awareness of the location of those archaeological anomalies identified as having a low potential. Reporting through the protocol (PAD) will be undertaken should material of potential archaeological interest be encountered. Further details of which are provided in the WSI and PAD (volume 3 appendix 19.2).	To identify any sites of archaeological importance that may require further investigation, avoidance or engagement with HES.
Archaeologists to be consulted in the preparation of pre-construction clearance operations and, if appropriate, to carry out archaeological monitoring of such work. Further details of which are provided in the WSI and PAD (volume 3 appendix 19.2).	To record archaeological remains that may be affected by pre-construction clearance operations.
Commitment to preparation and implementation of an Offshore WSI and PAD prior to any post-consent works within the Array.	To set out and agree the mitigation measures required to reduce any potential effects on known and undocumented archaeological assets within the Array.
Engagement with oil and gas operators.	The Applicant will seek to engage early with oil and gas operators and, where possible and appropriate to do so, coordinate activities to facilitate coexistence.
Safety provisions within the wind turbine generator to include automatic shutdowns/lockdowns with to ensure turbines do not exceed maximum operational rotational speeds.	Enable the Array to be resilient to future climate change, in particular from the risk of overheating from temperature changes and increased frequency and intensity of extreme weather.
The OSP electrical plant will be located within an internal structure. Appropriate cooling plant will be designed to account for a range of temperature conditions.	Ensure appropriate, robust design and enable the OSP to be resilient to the known environmental conditions and potential future changes.
Application of anti-corrosion protective coatings, accounting for sea level rise.	Enable the Array to be resilient to future climate change, in particular from the risk of increased sea temperatures, ocean acidification and sea level rise.
Establishment of an online portal where potential suppliers can register interest, boosting the supply chain (implemented).	Measures to increase the capacity of the Scottish supply chain will support more companies to secure wind contracts and increase economic impact.
Signed memorandum of understanding with Scottish suppliers.	Engagement with Scottish and UK suppliers of offshore wind services will ensure that the appropriate capacity is in place.
Engaging with international companies to invest in Scottish manufacturing capacity.	Higher manufacturing potential in Scotland will result in higher Scottish content and more economic activity.
Establishing a £30 million Supply Chain Fund, which will enable local companies to invest in new facilities and equipment, and have confidence to invest.	Increased capacity will enable Scottish firms to secure more contracts and increase the Scottish economic impact.
Establish a £3 million Education, Research and Community Benefit Fund, which will promote offshore wind careers for young people, develop an apprenticeship programme and benefit local communities.	Will increase the capacity of the Scottish workforce, increasing the potential Scottish economic impact.

3.11. RESIDUES, EMISSIONS AND WASTE

168. A description of the anticipated residues and emissions and wastes arising from the Array and a description of the LSE[1] resulting from the emission of pollutants, noise, vibration, light, heat and radiation, the creation of nuisances, and the disposal and recovery of waste are required as per the EIA Regulations. These requirements, and where these are addressed in the Array EIA Report, are presented in Table 3.35.

Table 3.35: Residues and Emissions

EIA Report Requirement	How and Where Considered Within the Array EIA Report
Description of expected residues and emissions and the production of waste, where relevant; and a description of the LSE[1] of the project on the environment resulting from, the emission of pollutants, noise, vibration, light, heat and radiation, the creation of nuisances, and the disposal and recovery of waste	The following chapters assess the LSE[1] associated with the emission of noise and vibration and associated nuisances: • volume 2, chapter 8; • volume 2, chapter 9; • volume 2, chapter 10; • volume 2, chapter 20; and • volume 3, appendix 10.1. The following chapters assess LSE[1] associated with electromagnetic fields: • volume 2, chapter 8; • volume 2, chapter 9; and • volume 2, chapter 10. Disposal and recovery of waste is addressed in: • volume 4, appendix 21.

3.12. NATURAL RESOURCES

169. A description of the anticipated LSE[1] resulting from the use of natural resources is also required to be provided as per the EIA Regulations. These requirements, and where these are addressed in the Array EIA Report, are presented in Table 3.36.

Table 3.36: Natural Resources

EIA Report Requirement	How and Where Considered Within the Array EIA Report
A description of the LSE[1] of the project on the environment resulting from, the use of natural resources, in particular land, soil, water and biodiversity, considering as far as possible the sustainable availability of these resources	This chapter describes the use of natural resources. The following chapters assess seabed disturbance (land and soil): • volume 2, chapter 7; • volume 2, chapter 8; and • volume 2, chapter 9. The following chapters assess the use of rocks: • volume 2, chapter 8; • volume 2, chapter 12; and • volume 2; chapter 13.

3.13. RISK OF MAJOR ACCIDENTS AND DISASTERS

170. Volume 2, chapter 16 assesses the risk of major accidents and disasters which may arise from the Array.

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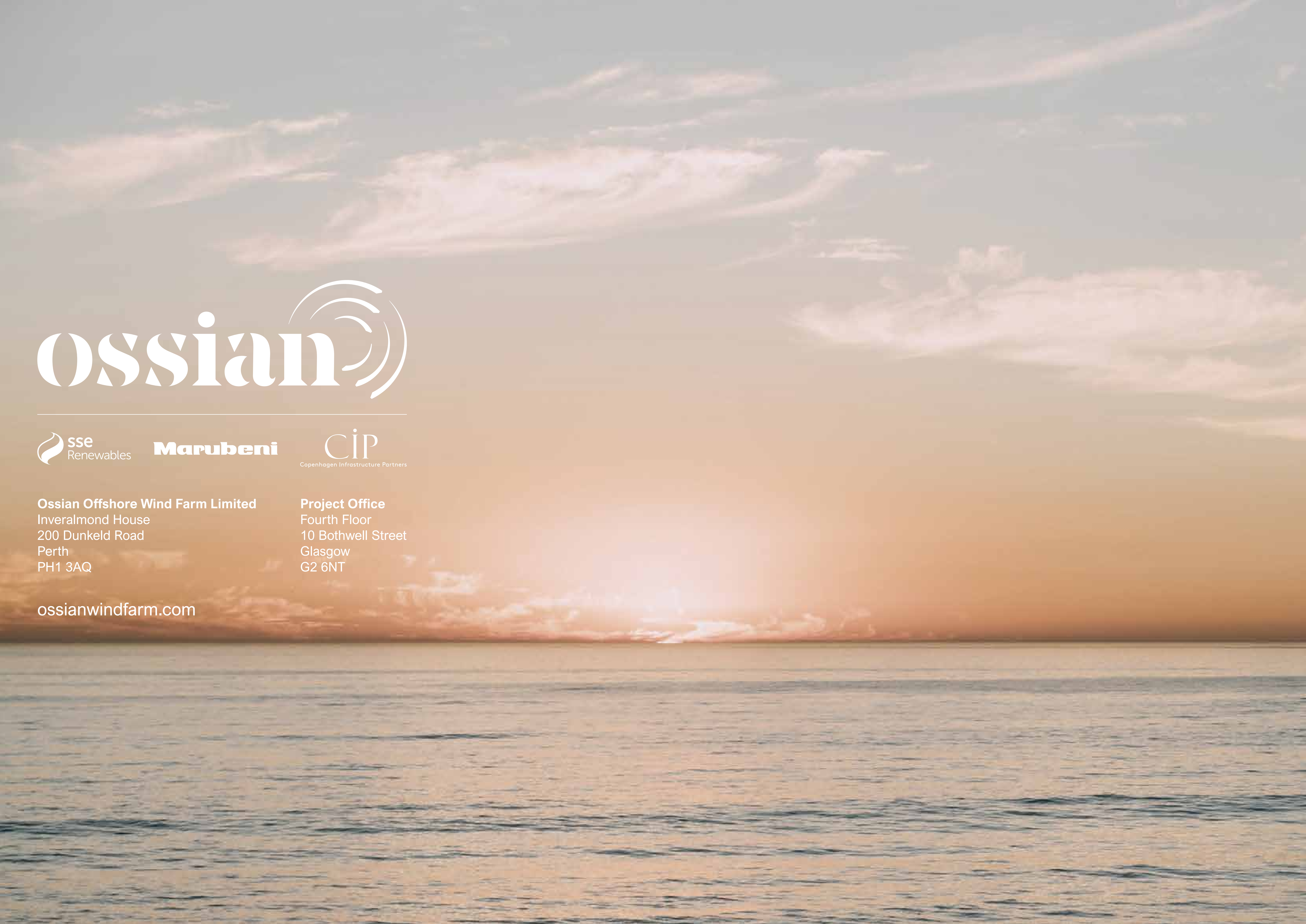

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