CHAPTER 3: SITE SELECTION AND ALTERNATIVES

INTRODUCTION

3.1. This chapter of the ES presents a summary of the site selection and evaluation of design alternatives process. It describes The Crown Estate's R3 Zone identification process and the UK Strategic Environmental Assessment (SEA) for offshore wind. This chapter also describes Seagreen's approach to Zone Appraisal and Planning (ZAP) and the final selection of the sites for the Seagreen Project. The chapter then goes on to describe the design evolution process for the Project Alpha and Project Bravo OWFs and the Transmission Asset Project, including an explanation of the derivation of the design parameters defined for assessment by Seagreen through this process.

3.2. All figures referred to in this chapter can be found in ES Volume II: Figures. This chapter should be read in conjunction with Appendix A1: Landfall Site Selection Report, which can be found in ES Volume III: Appendices.

OFFSHORE WIND ROUND 3 ZONAL APPROACH

3.3. In previous offshore wind leasing rounds, individual project sites were awarded to developers by The Crown Estate. However, for R3, a zonal approach was adopted whereby exclusive development rights over wider areas of seabed were granted to individual development companies or consortia. The zonal approach was intended to enable developers to assess the potential for OWF projects across wider areas of seabed such that, in the larger zones, multiple OWF projects can be developed in a more planned and coordinated manner (The Crown Estate, 2012).

3.4. This approach was considered to provide two key benefits. It provided flexibility to choose the most appropriate project locations which assists in the minimisation of environmental impacts and, by providing the ability to plan the development of multiple OWF projects, the zonal approach allowed visibility of an ongoing pipeline of projects across the R3 programme. The latter was intended to help support investment confidence for the supply chain and financiers, to encourage the required scale of transmission grid improvements, and enables economies of scale to develop within the industry to drive down costs.

3.5. The zonal approach was also intended to avoid some of the site-level problems encountered by developers in Rounds 1 and 2, in particular in relation to cumulative effects.

3.6. The R3 offshore wind development programme instigated by The Crown Estate in 2008 was designed to facilitate delivery of a larger scale of OWF development than has previously occurred in the UK. Strategic national planning for R3 was undertaken jointly by the DECC and The Crown Estate in 2008/ 2009. Suitable areas for the development of offshore wind were assessed through the statutory process of SEA which was undertaken by DECC (DECC, 2009a). This ensured that the R3 zones were carefully selected and consulted upon to identify most suitable areas for large scale wind energy development in UK waters, meeting DECC objectives.

3.7. Through the process led by The Crown Estate nine OWF development zones (the R3 zones) were identified and tendered within the area covered by the SEA. The total target generation capacity for the R3 programme is 32.2GW, with a target of 25GW operating or in construction by 2020.

3.8. In response to the call for bids by The Crown Estate in 2009, Seagreen submitted a tender and was awarded the exclusive developments rights to the R3 Zone 2 (named the 'Firth of Forth Zone'). Seagreen and the Crown Estate then entered into a ZDA in January 2010 with a target Zone generation capacity of circa 3.5GW.

STRATEGIC ENVIRONMENTAL ASSESSMENT

Offshore Energy SEA 1 (OESEA 1)

3.9. The first Offshore Energy Strategic Environmental Assessment (OESEA 1) (DECC, 2009a), carried out in 2008/ 2009, covered plans for creating additional offshore wind and oil and gas capacity, to be developed in the UK's REZ. The specific offshore wind plan assessed within OESEA 1 was:

3.10. *"to enable further rounds of offshore wind farm leasing in the UK Renewable Energy Zone and the territorial waters of England and Wales with the objective of achieving some 25GW of additional generation capacity by 2020. This part of the plan/programme does not include the territorial waters of Scotland and Northern Ireland...The UK Renewable Energy Zone includes an area outside territorial waters where Scottish Ministers have functions in relation to renewable energy installations."* (DECC, 2009a) [1]

3.11. OESEA1 also included a reference to the indicative R3 development zones which were then under consideration by The Crown Estate. Following completion of the SEA and publication of the Environmental Report, and having regard to the consultation responses received (and other available information), the UK Government adopted the offshore wind plan, subject to the recommendations which were set out in the SEA post-public consultation report (DECC, 2009b).

Offshore Energy SEA 2 (OESEA 2)

3.12. OESEA 1 formed the basis of the R3 programme. DECC has also completed OESEA 2 (DECC, 2011). The plan for offshore wind capacity and the SEA study area was as for OESEA 1. OESEA 2 also included reference to the nine R3 zones (which had been tendered and were already under development when the SEA was compiled).

3.13. A full public consultation was also undertaken for OESEA 2 and the plan was adopted by UK Government in October 2011. The offshore wind recommendations reiterated those which had been made in OESEA 1, and enhanced them in some cases, as well as adding requirements to increase the evidence base for impacts on marine mammals and fish. The spatial considerations are not prohibitions on development in areas, but recommendations that offshore wind is developed in such a way to reduce impacts on other users of the sea, on nature conservation areas, and on environmentally sensitive coastal areas. In each case, the potential impacts should be assessed (and mitigated) at project level (The Crown Estate, 2012).

IDENTIFICATION OF THE ROUND 3 ZONES

3.14. Using available data within its Marine Resource System (MaRS) Geographical Information System (GIS), The Crown Estate identified zones of seabed within the area assessed by OESEA 1, which had good potential for OWF development and within which individual projects could be identified at a later date with more detailed knowledge of the constraints.

3.15. To delineate the R3 zones, a three-stage approach was adopted as follows (The Crown Estate, 2012):

i. Areas unsuitable for OWF development due to the presence of one or more exclusions to development were removed. Exclusions are defined as areas of seabed which:

1 OESEA1 did not include Scottish Territorial Waters (STW). A separate SEA was undertaken by the Scottish Government in 2010 (Marine Scotland, 2010) for offshore wind development in STW.

- are already leased or licensed for another purpose or activity that would preclude OWF development (e.g. a site licensed for aggregate dredging);
- have been granted future permission for another purpose or activity (e.g. an Agreement for Lease area for a OWF); or
- are unsuitable for development because of technical reasons or external interests (e.g. excessive water depth, or International Maritime Organization (IMO) Shipping Lane).

ii. The suitability of the remaining areas of seabed was then evaluated on the basis of restrictions that were present. Restrictions were defined as activities, developments or interests which may not preclude development, but which should be considered when planning the proposed activity or development. Restrictions were weighted according to the perceived severity of the constraint that they may impose on the development of an OWF.

iii. The outputs from this national scale modelling were then reviewed against a number of detailed review datasets to check for consistency. Review datasets consisted of information and data which were unsuitable for national analysis and modelling but which could be used to inform decisions about the individual zones.

3.16. Three iterations of this process were undertaken during 2008/ 2009 involving stakeholder consultation, refinement of modelling and use of spatial data. This resulted in reduction of the number of zones from eleven to nine and the refinement of zone boundaries to those offered for tender. It is the role of offshore wind developers to evaluate further the opportunity within the zones, and address technical and environmental considerations on a project level before bringing forward projects for consenting within the statutory planning system.

ZONE AND SITE DEVELOPMENT

3.17. As stated above, Seagreen entered into a ZDA with The Crown Estate in January 2010 for the Firth of Forth Zone following the R3 bidding stage. The ZDA grants Seagreen certain rights over the seabed within the Zone, including the right to identify specific areas for the development of OWFs. Seagreen does not have these rights outside the area described within the ZDA, and the ability to select alternative OWF sites has therefore been constrained by the work which was done at national level in selecting zones which were suitable for offshore wind development. However, the Zone covers sufficient area to allow Seagreen a degree of flexibility in identifying the most appropriate areas to develop based on the potential constraints within the Zone.

3.18. The main considerations for selection of preferred sites for OWF development are environmental or technical factors (environmental or engineering) and economic factors. A developer cannot build an OWF in areas which are unsuitable (for example as a result of seabed geology) or in areas where the project would not be economically viable (for example where the wind resource is insufficient).

3.19. For the larger R3 zones, where multiple projects could be developed, developers have typically adopted a form of spatial planning. This approach is referred to as ZAP, which involves the consideration of the zone as a whole in order to identify the areas most suitable for development. ZAP is a discretionary, non-statutory tool to aid developers in managing development risks within their zones (The Crown Estate, 2010).

FIRTH OF FORTH ZONE ZAP

The Seagreen ZAP Approach

3.20. Seagreen has adopted the ZAP approach and used it to provide a clear rationale for, and confidence in, the decision process evaluating potential constraints and culminating in the identification of the offshore phase and site boundaries. The focus and objectives of Seagreen's approach to ZAP is to:

- present an overview of the offshore baseline data and information relevant to the Zone and its OWF projects;
- define the most suitable areas for development in the Zone;
- document key decisions;
- consider potential cumulative and in-combination effects at a zonal level; and
- engage with key consultees early in the development process about Zone planning and site selection.

3.21. Part of the Seagreen ZAP includes the preparation and issue of reports to inform key stakeholders about this process at key points during the Zone development process to present changes to, and improvements in, understanding of conditions and constraints across the Zone. An initial ZAP report was issued in June 2010 (Seagreen, 2010a) to The Crown Estate, Marine Scotland and other interested parties, and the first ZAP update report was subsequently issued to the same consultees in December 2011 (Seagreen, 2011a).

3.22. The Seagreen ZAP will be an ongoing process throughout the development and consenting of all project phases in the Zone and the project specific EIA process.

Firth of Forth Zone Characterisation

3.23. The first ZAP report (Seagreen, 2010a) took the form of a Zone Characterisation desk study. It set out Seagreen's rationale and methodology for conducting ZAP and described the constraints mapping process by which potential development areas had been initially identified at the R3 bid stage. The report was issued to a range of key stakeholders for their information. Though no formal feedback was requested, comments indicated that the first ZAP report was well received and was viewed by statutory bodies as key to shaping development within the Zone. There were clear indications that there would be value in continuing to provide stakeholders with updates on the ZAP process.

3.24. While the boundary of the Zone is fixed, phase and project boundaries remain flexible within the Zone. Seagreen considered that for project financing and supply chain availability reasons there was a sensible upper limit to individual projects of a nominal 500 MW capacity. Therefore at the R3 bid stage the larger potential development areas identified within the Zone were split into smaller indicative project areas with potential capacities of this scale. A phased approach to delivery of these projects was then defined to achieve the target zone capacity. This was based around prioritising those areas with the least potential constraints and considering the practicalities of resourcing delivery of the target capacity for the Zone.

3.25. The first ZAP report described the initial site identification process. This comprised a detailed, desk based assessment of constraints to development using data compiled from a

number of primary sources, including SeaZone2 , UKDEAL3 , Kingfisher4 , The Crown Estate, and a number of additional third party reports from industry experts commissioned by Seagreen to address specific environmental and/ or technical issues. The technical studies carried out at this stage covered:

- grid connection;
- navigation and shipping;
- commercial fisheries;
- aviation and military;
- wind resource;
- construction and ports; and
- support structures.

3.26. The site identification process described in the first ZAP report considered 'hard' and 'soft' constraints to OWF development. Hard constraints are parameters for which there is no feasible or practicable way of incorporating mitigation into the design. Soft constraints are those which, through further survey and / or consultation and the application of appropriate mitigation or management measures, may not represent an absolute constraint to development.

3.27. Hard constraints considered were:

- Water depth - Significant areas in the Zone where water depths exceed 50 metres (m) were excluded, although in the interests of optimising development areas and of simplifying OWF site boundaries, some sites included areas of water deeper than 50m.
- Decommissioned oil and gas wells – There is one decommissioned well within the Zone; a 500m buffer was applied around this and it has been excluded from consideration for development.

3.28. Although no designated Traffic Separation Schemes (TSS) are located within the Zone, detailed consultation was required to confirm whether recognised shipping routes would represent a hard constraint. Similarly, although the Zone overlaps military exercise areas and a submarine exercise area detailed consultation was required to identify the level of constraint this represents. Both these issues were therefore identified as soft constraints.

3.29. The following soft constraints were considered:

- Currently undeveloped but awarded Oil and Gas Licence Blocks.
- Fishing effort.
- Bathymetry.
- Civil and military aviation.

2 SeaZone is a consultancy which provides hydrographic and marine GIS data.

3 DEAL is a web-based gateway to information on the UK Offshore Oil & Gas Industry.

4 Kingfisher provides information on marine industries primarily for the use of the fishing industry to provide awareness of surface and subsea hazards.

- Shipping.
- Nationally designated landscape/ seascape within 35 kilometres (km).
- Internationally designated sites (Natura 2000) and proposed sites/ extensions to sites.
- Annex 1 Habitats (not part of a designated site).
- Ornithology, marine mammals and features of marine ecological interest.
- Sensitive fish spawning areas considered for hearing specialists (herring, sprat) and sandeel.

3.30. Using the acquired environmental and technical data a GIS based constraints map was developed which enabled layering of relevant spatial constraints information. The map was used to:

- confirm areas that were not subject to hard constraints;
- confirm areas with fewer soft constraints and less environmental sensitive;
- inform the choice of potential OWF site boundaries within the Zone; and
- inform the Zone Consenting Strategy (Seagreen, 2010b) by ranking sites based on the level of constraint and the ability to construct.

3.31. The constraints mapping exercise informed the strategy to develop seven OWF within the three phases. The phase boundaries were designed to permit maximum flexibility for each OWF site within it. Phase 1, consisting of Project Alpha and Project Bravo, the survey area for the Seagreen Project assessed in this ES, was considered to be the least constrained for development. The boundaries of each phase within the Zone identified during at this stage can be seen in Figure 3.1.

ZAP Update 2011

3.32. Following completion of the first ZAP report significant additional environmental baseline data was gathered through specialist surveys and studies to inform the EIA for the Seagreen Project. Seagreen therefore issued a ZAP Update Report in December 2011 (Seagreen, 2011a) which presented the following:

- current data availability and Seagreen survey results;
- revisions to proposed site boundaries for Project Alpha and Project Bravo; and
- potential changes to project boundaries for Phase 2 and Phase 3.

Data Updates

3.33. Table 3.1 summarises the data updates presented in ZAP Update Report.

Table 3.1 Zone Environmental Data to Inform ZAP Update Report, 2011

Parameter	Data Update Summary
Physical environment	Geophysical survey of Phase 1 and ECR corridor area (2010) - bathymetry, seabed sediment features and sub-bottom profiles. Preliminary geotechnical survey of Phase 1 area (2011) comprising borehole samples and core penetration tests. UK Hydrographic Office (UKHO) multibeam bathymetry data of the Zone (~90% coverage). Metocean survey outputs. Met Office 10-year wind dataset.
Water and sediment quality	Analysis of contaminants in a number (~50) of grab samples collected (150) as part of the benthic ecology survey within the Phase 1 and ECR corridor area.
Ornithology	24 months of boat-based survey sightings data covering the entire Zone, with analysis and reporting of initial 12 months bird survey data in 2011. Sightings data gathered during aerial surveys commissioned by The Crown Estate (2009/ 2010). Bird tracking studies of Special Protected Areas (SPA) species undertaken in 2010.
Benthic ecology and intertidal ecology	Phase 1 and ECR corridor area benthic survey (benthic grabs, drop down video survey, epibenthic trawls) completed in 2011. Phase 1 and ECR corridor area benthic habitat map.
Natural fish and shellfish resources	Updated fish and shellfish spawning and nursery ground maps produced by Centre for Environment, Fisheries and Aquaculture Science (Cefas). Phase 1 and ECR corridor area benthic survey epibenthic trawl data. Multiple datasets relating to fish ecology and life cycle, fishing activity from Marine Scotland.
Marine mammals	18 months of boat-based survey sightings data covering the entire Zone Incidental sightings data gathered during aerial surveys commissioned by The Crown Estate and an aerial survey of the Zone commissioned by Seagreen in 2011. Analysis of existing seal telemetry data.
Commercial fisheries	Fisheries activity charts issued by Marine Scotland.
Shipping and navigation	Updated vessel tracking data resulting from Automated Identification System (AIS) survey. Summer and winter radar surveys (2010 – 2011) carried out for the Forth and Tay Offshore Wind Developers Group (FTOWDG)
Archaeology and cultural heritage	Geophysical seabed anomalies within Phase 1 and ECR corridor area identified in survey.
Military and civil aviation	Desk-based assessment of potential aviation issues to be taken into account in Zone development. Closure of a military Practice and Exercise Area (PEXA) within the Zone.

Boundary Refinement

3.34. Through the design evolution process (see sub-sections below), and based on the data updates summarised in Table 3.2, Seagreen further considered the environmental (consent) and the engineering (buildability) constraints to development. Revised boundaries were established to provide a balance between the environmental constraints considered significant and the requirement to maintain design flexibility and economic viability. These were presented in the ZAP update report.

3.35. Consideration of the boundary implications arising from the key environmental constraints identified is given in Table 3.2. Potential mitigation was achieved by limiting development within environmentally constrained parts of the Zone influencing site boundaries across all phases.

Table 3.2 Summary of Constraint Implications for Phase 1 Boundaries

Topic	Phase 1 Constraint within Original Phase 1 Boundary	Identified Response to Constraint
Ornithology	Recommendation that the original Phase 1 boundary may have a significant impact due to predicted level of collision for key protected species based on 2010 data.	Relocate the Project Alpha and Project Bravo site boundaries to the east to reduce collision risk
Marine mammals	Potential for effects upon passage of bottlenose dolphins due to piling noise. Potential auditory injury and behavioural impacts due to piling noise on harbour seals foraging within or in close proximity to the Zone.	Relocate the Project Alpha and Project Bravo site boundaries to the east to reduce potential effects
Commercial fisheries	Potential conflict with fishing activity, principally scallop dredging, with higher intensity in western part of Phase 1.	Relocate the Project Alpha and Project Bravo site boundaries to the east to reduce potential conflict with fishing activity
Natural fish and shellfish resources	Potential for effects upon migratory fish due to piling noise.	Relocate the Project Alpha and Project Bravo site boundaries to the east to reduce potential impact upon migratory fish.

3.36. The shallowest water depths within the initial Phase 1 area identified occur in the immediate area over the Scalp Bank. Initial surveys suggested that the Scalp Bank area is of higher importance to ornithology, marine mammal and fishing interests. To reduce the potential impact on these interests, Seagreen delimited waters of 40m depth or less as representing the Scalp Bank and excluded this area from consideration for development in this phase of applications. The initial Phase 1 boundary and the refined Project Alpha and Project Bravo boundaries are shown in Figure 3.1. This is the overall boundary for both projects that is assessed in this ES. At this stage an indicative north to south boundary was used to distinguish between the two projects. Further decisions regarding the location of Project Alpha and Project Bravo within this boundary are described in sub-section 'Offshore Wind Farm Design'.

3.37. In specifically developing away from a location of apparent ecological sensitivity Seagreen is proactively seeking to minimise adverse impacts upon features of environmental sensitivity. The flexibility to adjust site boundaries with the Zone extents to mitigate potential impacts while maintaining site capacity was a key element of The Crown Estate's zonal approach for R3. This flexibility is not available for sites identified in other leasing rounds.

3.38. The environmental and physical justification presented above in respect of the new Phase 1 area also holds for the repositioning of the future Phase 2 and 3 project boundaries. This is an ongoing process which will be applied to further define the boundaries during the future development of Phases 2 and 3 as more survey data for these areas is collected.

PROJECT ALPHA AND PROJECT BRAVO DESIGN EVOLUTION

3.39. Throughout the development process for the Seagreen Project there has been a dynamic relationship between environmental constraints and engineering requirements in order to retain design flexibility whilst seeking to minimise and mitigate potential environmental impacts. This section briefly describes the process through which the OWFs design parameters have been evaluated and selected.

Rochdale Envelope Parameters

3.40. As discussed in Chapter 6: EIA Process of this ES, a parameter based approach to defining the design, known as the 'Rochdale Envelope' principle, has been adopted for assessment purposes. The detailed design of the Seagreen Project will not be finalised until after the consent applications are submitted. There are therefore fixed minimum and maximum parameter ranges, described as the Rochdale Envelope, within which the project design will ultimately be finalised and which have been assessed in this ES.

3.41. The Rochdale Envelope will form the basis of the project procurement process post consent in order for the EIA to consider the likely significant environmental impact of the Seagreen Project as accurately as possible. The envelope, defining the range of parameters for the OWFs and transmission asset, has been developed based on a series of design decisions taken by Seagreen. As a result, a range of minimum and maximum values for the key parameters are defined and assessed within the EIA.

3.42. Should the Seagreen Project be consented, although the final WTG generating capacity and the detailed foundation and substructure design are unknown at this point, the final specifications will be within the range set out in the project description parameters as detailed in Chapter 5: Project Description of this ES. Seagreen has therefore sought to ensure the EIA assesses the likely significant environmental impacts arising from the project which is eventually constructed. Where there is certainty in design regarding an engineering parameter this is stated in Chapter 5: Project Description. Where there is uncertainty regarding the final design of an engineering parameter, the parameter range has been identified and described. The extent and scope of the subsequent impact assessments within this ES identify, on a receptor by receptor basis, the realistic worst case parameter chosen for the assessment within the engineering parameter ranges presented in this chapter.

3.43. Chapter 5: Project Description also defines the approach to OWF construction, installation and decommissioning for assessment. This is based on the parameter ranges for the design options described and is drawn from recent experience of other similar OWF construction projects.

Offshore Wind Farm Design

3.44. The initial OWF design basis was drawn from a market assessment of WTG models currently available and in development and reviews of publicly available information on seabed topography and ground conditions. The desktop information was then confirmed by the geophysical survey and preliminary geotechnical survey (GEMS, 2010 and Osiris Projects, 2011). These informed initial engineering concept designs for foundations and substructures and established the initial ranges for the Rochdale Envelope parameters described in the following paragraphs.

Preliminary (Skeleton) Assessment – Parameter Revisions

3.45. During the EIA process for the Seagreen Project, environmental studies and engineering design studies have been progressed in parallel since commencement of the first surveys in December 2009. A key stage in the evolution of the OWF design parameters was the preliminary (skeleton) assessment of impacts undertaken with the first iteration of the Rochdale Envelope. This was presented to the Seagreen EIA team (as detailed in Chapter 1: Introduction of this ES) in September 2011 following completion of the baseline data gathering phase of the programme.

3.46. This approach was adopted in order that any potentially significant adverse impacts could be fed back into the subsequent evolution of design parameters to enable mitigation of these impacts by design refinement. As a result of the preliminary assessment further work was undertaken to address concerns, particularly over collision risk impacts to birds (see Chapter 10: Ornithology of this ES) and piling noise impacts to marine mammals (see Chapter 13: Marine Mammals of this ES). The following sections describe how these concerns were addressed and describe further design revisions that have taken place in establishing the final parameter ranges for the OWFs defined in Chapter 5: Project Description.

3.47. In addition, parallel studies of the options for design of the transmission grid connection and investigations into the preferred export cable landfall option were completed. The selection of the resulting options and parameters for assessment is also described in the following 'Transmission Design Evolution' section.

Project Boundaries

3.48. As described above, concerning the Seagreen ZAP reports, the initial Phase 1 boundary established at the bid stage was revised to exclude the Scalp Bank feature following the initial modelling of collision risk for birds (see Figure 3.1).

3.49. Subsequent to this, and based on a further review of consenting strategy options, Seagreen finalised the Project Alpha and Project Bravo site areas taken forward in the EIA and consent applications (see Figure 1.1). The basis for this decision was to achieve two comparable OWF assets with broadly equal site area, wind resource and capacity that could be constructed and operated separately, if this strategy for delivery was adopted by Seagreen.

3.50. At this time Seagreen also finalised the site capacities and WTG parameter ranges described as follows.

Offshore Wind Farm Capacity and Array Layout

3.51. The initial, combined capacity for Projects Alpha and Bravo was derived from a uniform distribution of regularly 'standardised' spaced WTGs across the project areas identified at desk study stage, based on a nominal 5MW WTG capacity. The 1,075MW connection agreement with National Grid established on this basis then formed the upper capacity limit.

3.52. Evaluation of WTG options by Seagreen was based on parameters for a WTG capacity range of between 3.6MW to 7MW, representative the extent of existing proven WTG technology as well as likely available WTG technology at the time of construction (Seagreen, 2012). Achieving the target capacity across both sites therefore implied installation of up to 299 WTGs

3.53. Following initial collision risk modelling for birds (see Chapter 10: Ornithology of this ES), Seagreen took a decision to remove parameters associated with the lower capacity WTG options from consideration. This had the beneficial effect of limiting the total WTG numbers in each site, thus significantly reducing the risk of collisions. The final minimum and maximum range of WTG parameters, including rotor diameter, nacelle dimensions, hub height and blade tip height are presented in Chapter 5: Project Description. Notwithstanding the technical uncertainty and the eventual WTG selected for installation, Seagreen has set an upper limit of 75 WTGs each for Project Alpha and Project Bravo, giving an upper limit of 150 WTGs for both.

3.54. Initial OWF capacity estimates were based on an indicative standard array layout where WTGs are positioned on a standardised grid (see Figure 5.1). Recent investigations into reducing wake losses at downwind WTGs have led to the development of optimised grid layouts (see Figure 5.2) to increase overall array efficiency. To allow the flexibility for innovative WTG array design to optimise array efficiency, no preferred layout is defined at this stage. Notwithstanding this a minimum WTG spacing of five rotor diameters has been defined based on manufacturer recommendations and will be applied to any preferred layout.

3.55. Array cable lengths are determined by the WTG layout. An array cable options study (Seagreen, 2011b) was completed using a number of potential layout configurations, including an unconventional layout that may require a greater total extent of array cabling in comparison to a standardised grid array.

3.56. The array cable options study has informed the upper limit on array cable lengths for both Project Alpha and Project Bravo, which are presented in the Rochdale Envelope (Chapter 5: Project Description).

3.57. Following consultation with the fishing industry (Chapter 14: Commercial Fisheries of this ES), as well as the consultation associated with the Navigational Risk Assessment (NRA) (Chapter 15: Shipping and Navigation of this ES), the decision was made to bury the array cables wherever feasible in order to provide protection to vessels from snagging and also to protect the cables against damage. Based on currently available information it is considered possible that up to 90% burial could be achieved and where cable burial cannot be achieved protection measures will be installed such as rock armouring or placement of concrete mattresses.

Offshore Wind Farm Structures

3.58. Engineering studies (Garrad Hassan, 2011a and 2011b) were undertaken to evaluate the range of substructure and foundation types available for the WTG model options under consideration. The feasibility of each substructure/ foundation type was considered, based on a number of technical and financial criteria, including proven experience of installation and Safety, Health and the Environment (SHE) issues. Suitability to the Project Alpha and Project Bravo sites was addressed, based on existing understanding of bathymetry and ground conditions.

3.59. The preferred options taken to the concept evaluation stage were a piled steel jacket structure, a steel jacket with suction piles and a concrete gravity base structure (GBS). These are described in more detail in Chapter 5: Project Description.

3.60. Initial modelling of underwater noise due to worst case piling operations, based on the concept design stage outputs for piled jackets, indicated potentially significant impacts on marine mammals (see Chapter 13: Marine Mammals of this ES). Seagreen then undertook further model sensitivity analysis and engineering studies of ground conditions and pile

driveability to refine the understanding of piling operation requirements and develop a more realistic piling scenario for the detailed assessment of potential impacts. This resulted in a reduced piling hammer force and piling duration and a revision of the overall programme for installation of piled foundations to restrict simultaneous operations across Projects Alpha and Bravo to one per site at any time.

3.61. The GBS concept design outputs were based on structural requirements, water depth and assumed soil conditions. If applied across both sites the seabed preparation requirements for the largest structure size, for the greatest water depth and weakest soils, resulted in a worst case impact on that was unrealistic. Therefore the final parameters for assessment included an upper limit for the number of GBS structures of this size, as stated in Chapter 5: Project Description.

TRANSMISSION ASSET DESIGN EVOLUTION

3.62. This section briefly describes the process through which the transmission asset design parameters and the Transmission Asset Project boundary have been evaluated and selected.

Electrical Connection Design

3.63. At the initial desk study stage, Seagreen considered a HVDC design for the grid connection option at Project Alpha and Project Bravo. Subsequent electrical engineering design studies undertaken for Seagreen also included HVAC options (Xero Energy, 2011). Due to the current uncertainty as to which technology will be the most suitable and cost effective, both HVDC and HVAC grid connection options are included within the Rochdale Envelope (Chapter 5: Project Description).

3.64. Four HVDC and one HVAC connection options were initially proposed. These initial options were then further developed through input from major suppliers of the electrical transmission infrastructure to determine the connection options giving the final range of parameters for assessment described in Chapter 5: Project Description. These provide the numbers and size of the OSPs, details on the high voltage (HV) transmission cable length required for Project Alpha and Project Bravo. The OSP foundation and substructure parameter ranges for assessment were based on those developed for the WTGs described above. The design of the electrical transmission infrastructure must be sufficiently flexible to accommodate the regulatory regime that applies to the OFTO who will ultimately own and operator the infrastructure.

Cable Route and Landfall Location

3.65. Seagreen submitted grid connection applications for Project Alpha and Project Bravo to National Grid Electricity Transmission (NGET) in early 2010. NGET assessed the most suitable grid connection point and selected the existing 275kV substation at Tealing for connecting both projects to the grid. Seagreen accepted the grid connection offer in late 2010.

3.66. Following this, Seagreen commenced a consideration of route options for the export cables, with the aim of determining a landfall location for the cable, the most suitable cable route and a site for the connection to the grid. This process has sought to identify and overcome environmental constraints and address stakeholder concerns, landowner issues and potential construction issues.

3.67. The selection process was informed by a series of offshore and onshore studies and workshops undertaken which involved a number of specialists brought together to represent the following concerns:

- environmental constraints onshore and offshore;
- electrical engineering feasibility onshore and offshore;
- construction feasibility;
- geotechnical feasibility; and
- land use and availability.

3.68. This preliminary landfall/ route planning process was aided further through the application of criteria developed to ensure that, as far as is practicable, the ECR:

- avoids environmentally sensitive/ designated sites;
- avoids underground or subsea rock/ solid substrates;
- minimises access issues;
- minimises disruption to existing users of adjacent coastal waters;
- ensures sufficient land area for the transition pit;
- ensures construction feasibility;
- minimises the crossing of linear natural features and infrastructure, e.g. watercourses, rail lines, roads and utilities;
- avoids areas of tree cover, standing water or undesignated areas likely to have nature conservation interest;
- minimises take of prime quality agricultural land;
- avoids existing dwellings;
- avoids important recreation areas; and
- avoids steep gradients/ banked verges.

3.69. The cable landfall location is a critical element of the route which directly relates to the subsequent landward route to the grid connection point. From an engineering perspective the landfall must be feasible and ideally include a gently sloping sandy beach with good access, sufficient space for construction and a suitable area behind the beach for a cable transition pit. The landfall locations selected for consideration all comprised a suitable beach with potential for other key requirements to be met. The ability to achieve suitable cable protection within the foreshore and intertidal area, ideally by means of cable burial, is also important. As such installation conditions are a key consideration which influence the site selection process. Where initial assessment confirmed potential to meet the key requirements further assessment of installation conditions has been carried out.

3.70. Following desk based reviews of a number of potential locations on the Angus coastline to identify preferred options for further detailed assessment locations at Arbroath and Carnoustie were taken forward for further investigation. A 1km wide ECR corridor from the offshore western Phase 1 boundary to both of these locations was identified. Following ECR corridor surveys and detailed studies of the options for inshore cable installation and the construction requirements at landfall, Carnoustie was selected as the preferred option. A summary of the cable landfall and cable route planning process with details of the options, constraints and decisions can be seen in Appendix A1.

3.71. Further consideration of the ECR following boundary refinement, led to a widening of the ECR corridor into Phase 1 and adjacent to Project Alpha's western boundary. This was to enable optimisation of the ECR to avoid known areas of unsuitable ground conditions including the presence of a historical wreck, and provide greater flexibility the ultimate selection of OSP locations and design of the final ECR. The final transmission asset project boundary can be seen in Figure 1.1

Final Rochdale Envelope Parameters for Assessment

3.72. The final parameters for assessment established through the iterative process described above are described in detail in Chapter 5: Project Description in this ES. Further design details will be determined during Front End Engineering Development (FEED) following further offshore geotechnical studies and detailed analysis of ground conditions to inform OWF engineering design decisions. FEED will not proceed until the Seagreen Project has been consented.

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