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Best Practicable Environmental Option Assessment: Ground preparation works

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Contents

1. Introduction

Seagreen Wind Energy Ltd (SWEL, hereafter Seagreen) is constructing the Seagreen Alpha and Seagreen Bravo offshore wind farms off the east coast of Scotland in the outer Firth of Forth and Firth of Tay area (Figure 1). The projects received consent under Section 36 of the Electricity Act 1989 from the Scottish Ministers in 2014 (the S.36 Consents). Marine Licences were also awarded by the Scottish Ministers in 2014 (one for Seagreen Alpha (licence no. 04676/18/0, as amended), one for Seagreen Bravo (04677/18/0, as amended), and one for the Offshore Transmission Asset (OTA) (MS-0010078, as amended)). Together Seagreen Alpha and Seagreen Bravo and the OTA collectively comprise ‘the Seagreen Project’.

The Onshore Transmission Asset (the onshore export cable from landfall at Carnoustie to a new substation at Tealing) was subject to a separate planning application under the Town and Country Planning (Scotland) Act 1997 and was granted Planning Permission in principle by Angus Council in January 2013. This was extended by Angus Council in December 2016, following re-application by Seagreen.

The existing OWF Marine Licence permits the installation of up to 150 wind turbine generators (WTGs) with associated foundations, inter-array cables, offshore substation platforms (OSPs) and meteorological masts. Offshore works commenced in October 2021 with the installation of the first three-legged, WTG suction caisson jacket. At the time of writing the OSP, the export cables, approximately 75% of the suction caisson jackets and 60% of the WTGs have been installed.

Extensive pre-construction ground investigation works took place to support the wind farm WTG array design. As installation of the suction caisson jackets has progressed, a greater understanding of ground conditions at the wind farm site has been obtained. At some WTG locations micro-siting and/or use of sandbags has been used to help generate the required seal and enable foundation installation to complete. However, at this point in the construction programme there are a number of locations where suction caisson installation has not been possible due to particular ground conditions which have prevented sufficient seal being generated at the base of the caisson in order to allow the required suction for full penetration. The locations where suction caisson jacket refusal has occurred are shown in Figure 2. This has been mitigated in some cases by use of spare locations, but for some locations a suitable may not be available.

Seagreen therefore proposes further ground preparations works at up to five of the refusal locations where a shallow layer of boulders or firm clay is considered to prevent initial self-weight penetration of the suction caissons to generate the required seal. Dredging will enable removal of the obstructing shallow sediment layer to expose less firm sub-layers to enable installation to complete at these locations.

This document provides a BPEO assessment in support of a marine licence application to permit dredging and disposal at the required locations. Details are provided of the proposed dredging method and the disposal of dredge arisings which are considered in the BPEO assessment. An assessment of potential impacts on environmental, human and other receptors is also provided.

This report is structured as follows:

- Section 1 – Introduction (this section)
- Section 2 – Description of proposed dredging

- Section 3 – Sediment quality at dredge locations
- Section 4 – Scoping of potential dredged material disposal options
- Section 5 – Assessment of feasible disposal options
- Section 6 – Conclusion

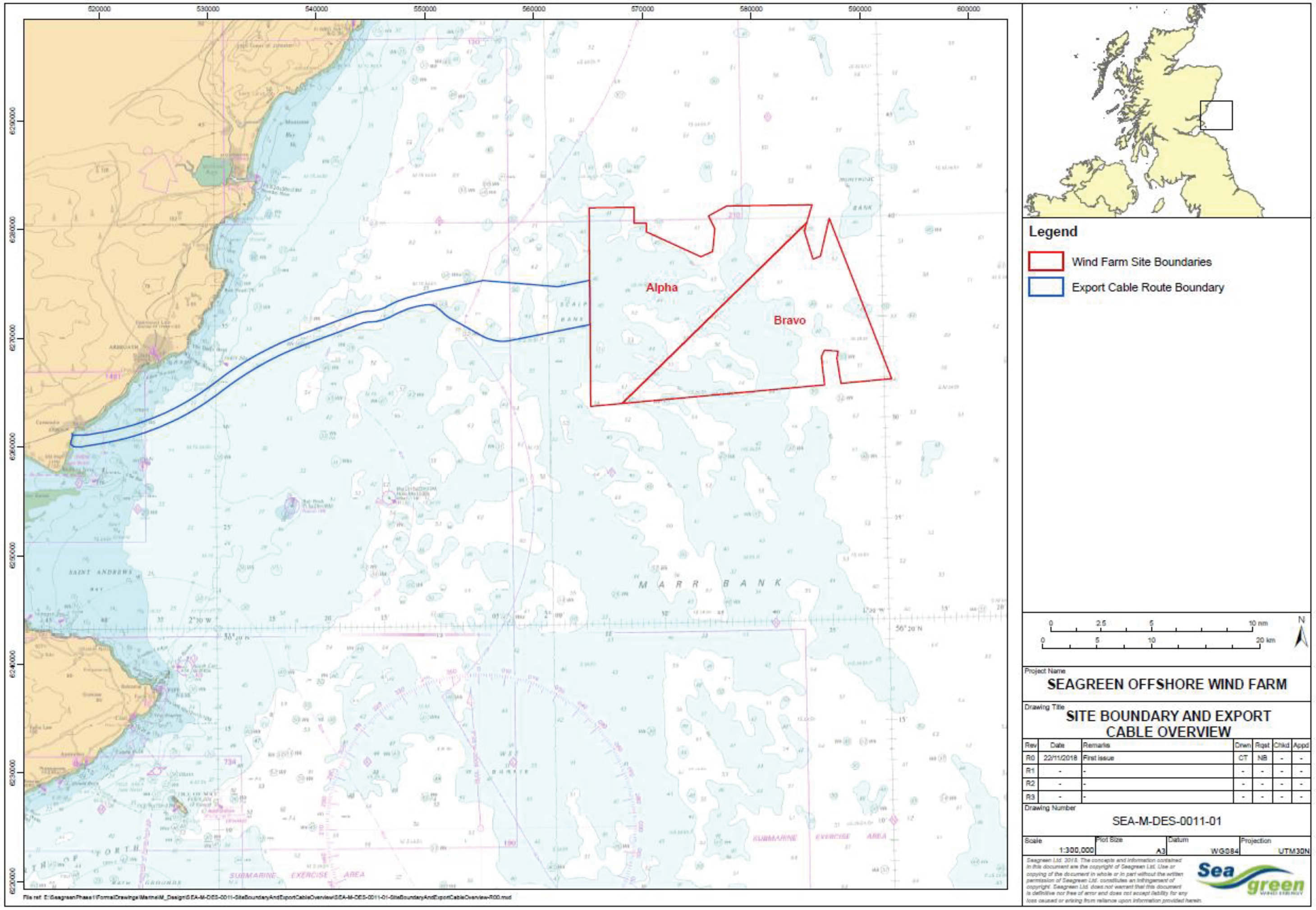

Figure 1 – The Seagreen wind farm project location.

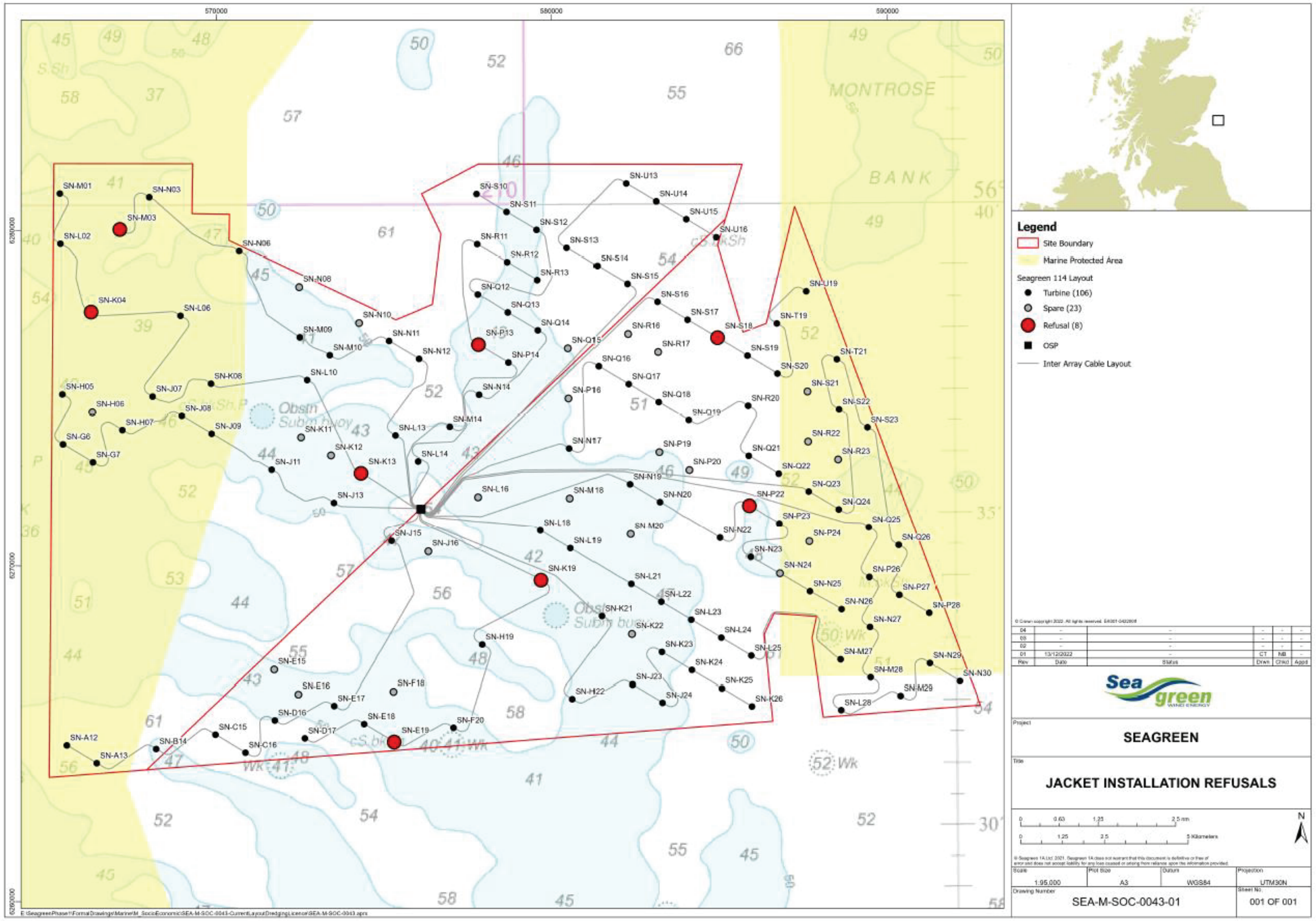

Figure 2 – WTG array layout showing locations where suction caisson refusal has occurred and MPA areas overlap with the Seagreen wind farm site

2. Description of proposed dredging

2.1 Seabed material to be dredged

Detailed surveys have been undertaken across the Seagreen wind farm site throughout the development and pre-construction phases. The ground conditions across the site generally consist of a layer of sands and gravels suitable for suction caisson installation. In some areas there are cobble and boulder fields present.

At the locations where jacket installation refusals have occurred and where dredging is proposed, a detailed review of ground conditions data has been undertaken. This indicated that particularly stiff sands and clays with embedded cobbles and gravels was present in a shallow surface layer, overlying less firm material. Dredging is proposed to remove the stiff surface layer to expose sediments that are suitable for suction caisson installation.

2.2 Dredging Method

The WTG suction caisson jacket is a three-legged design, with a caisson at the base of each leg. For each of the up to five WTG locations under consideration, excavation at each caisson position is proposed.

The WTG installation contractor has undertaken a review of potential dredging approaches to achieve the required removal of material at the WTG location, and the following summarises the proposed approach:

- 20m diameter excavation for each caisson (to allow for caisson diameter and positional / heading tolerances)
- 1m depth of excavation and 1:2 side slope
- Estimated excavation volume per WTG location (3 caissons) = 1,400m^3
- Total estimated excavation volume for up to five WTG locations = 7,000m^3

The above volume estimates include a 20% overage to allow for dredge control accuracy.

A number of approaches, such as diver or ROV operated tools, ploughing and air-lift dredging were ruled out as being insufficiently precise or not appropriate for the anticipated ground conditions or the volumes required. Controlled Flow Excavation (CFE) and subsea excavation methods were considered best suited to the requirements and were investigated in more detail in Section 2.3 and 2.4 respectively.

2.3 Controlled Flow Excavation (CFE)

Two configurations of CFE system were investigated. These use a low pressure, high volume jet to remove material from the required locations. Such systems are very controllable and can be adjusted to suit different soil types and to control the excavations rate and depth. The excavated material is expelled from the site and spreads over the surrounding area. However, the CFE approach is not appropriate for large cobbles and boulders and can result in a layer of gravels/cobbles/boulders at the bottom of the excavation, or even further embedded into the seabed. Some stiff clay conditions are not suited to this approach. Both CFE systems investigated would be suspended above the seabed by crane with similar wave height limitations for safe operation.

2.4 Subsea excavation

The subsea excavation approach involves the application of a well-understood mechanical excavation technique using a 40T excavator converted for subsea use. This approach can be adapted for different soil conditions through the use of different excavator arm attachments and allows accurate control of excavation as well as the direct placement of spoil material. Additionally the excavator is self-propelled and can be remotely operated from a surface vessel. Real-time sonar provides monitoring of excavation progress and the placement of dredged material. This approach is less weather limited than CFE for safe deployment and recovery of the excavator, however a dedicated vessel is required due to its size.

Potential use of a subsea grab excavator in parallel with the mechanical excavator was also considered. The grab would be deployed from a crane, with power and positioning delivered through ROV control. Material would be lifted and side cast from the grab away from the excavation site. The grab excavator is less controllable than the excavator and may not be suited to stiff seabed conditions but could enable more efficient use of vessel and technician time during dredging operations in some circumstances.

2.5 Preferred dredging approach

The preferred dredging approach is subsea excavation due to the capability to achieve more precise excavation in all seabed types and the positive displacement of excavated material. The CFE approach was considered not suitable to firm clays and likely to result in coarse sediments (gravel, cobbles, boulders) remaining at the bottom of the dredged area, resulting in a risk to any subsequent suction caisson installation.

The subsea excavator is likely to require a dedicated vessel, however, as the excavator is self-propelled, the vessel can also perform simultaneous operations such as seabed grab excavation at another location. This would increase the efficiency of operations.

2.6 Dredge volumes and estimated duration with the preferred approach

It is assumed that excavation is required for all three caissons at each of up to five WTG locations. For each WTG location the estimated dredge volume will be 1,400m^3 (1m depth, 20m diameter (1:2 side slope), 3 caissons). The total estimated dredge volume for five WTG locations is therefore 7,000m^3. From Seagreen pre-construction survey data, the average bulk density in the upper 2m of sediment within the wind farm site is in the range of 1.80 to 2.20 tonnes/m^3. Assuming an average value of 2.0 tonnes/m^3 (2000kg/m^3) the sediment mass for excavation at each WTG location is up to 2,800 tonnes, with a total of 14,000 tonnes for five WTG locations.

The assumed excavation rate based on available soils data is 37.5m^3/hr for the preferred mechanical excavation approach. Allowing for weather, approximately three days dredging is estimated at each location, a total of 15 days for up to five locations.

3. Sediment quality at dredge locations

3.1 Seagreen 2012 Offshore Environmental Statement

A sediment quality survey was undertaken in 2011 to inform the Environmental Impact Assessment (EIA) for the Seagreen Project, reported in the 2012 Offshore Environmental Statement (ES) (SWEL, 2012). The survey comprised the recovery of sediment samples from 50 samples stations, 25 of which were prioritised and analysed (see Figure 3). The samples were analysed for heavy metals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAH), organotins and particle size analysis (PSA).

In summary, arsenic was the only contaminant found at elevated levels in the sediments (although still below Cefas Action Level 1), however this metal is known to be present naturally in Firth of Forth sediments. The EIA concluded that there is no evidence to suggest that the sediments within the Seagreen Project area contain PCBs or PAHs (or metals) in concentrations that would be of concern and that baseline sediment quality was good and generally below levels at which any benthic impacts would be observed.

From a physical perspective, the 2011 survey identified that sediments within the Project Alpha and Project Bravo sites were dominated by sandy sediments containing varying degrees of gravel. Large boulders were occasionally recorded in sandy areas.

There are no known contamination incidents or events which have occurred subsequent to the 2011 survey which would have materially changed the chemical or physical composition of the sediment within the Seagreen Project area. The wind farm site is offshore and is undisturbed compared to some near shore or estuarine environments.

From the PSA results for the grab samples that were collected within the Seagreen wind farm site boundary during the 2011 survey, the average surface sediment composition size was 11.4% gravel, 86.8% sand and 1.8% mud.

The 2012 Offshore ES assessed a worst case of resuspension of 1.4million m^3 of seabed material over the duration of construction, associated with ground preparation for gravity base structures (GBS), with up to 21,475m^3 of seabed material excavated at each GBS location. The assessment concluded that the impact of the resuspension of any contamination associated with sediments was negligible and not significant. The amount of material to be dredged and the extent and duration of the dredging activities for the planned works considered in this BPEO are significantly less than was assessed in the 2012 Offshore ES.

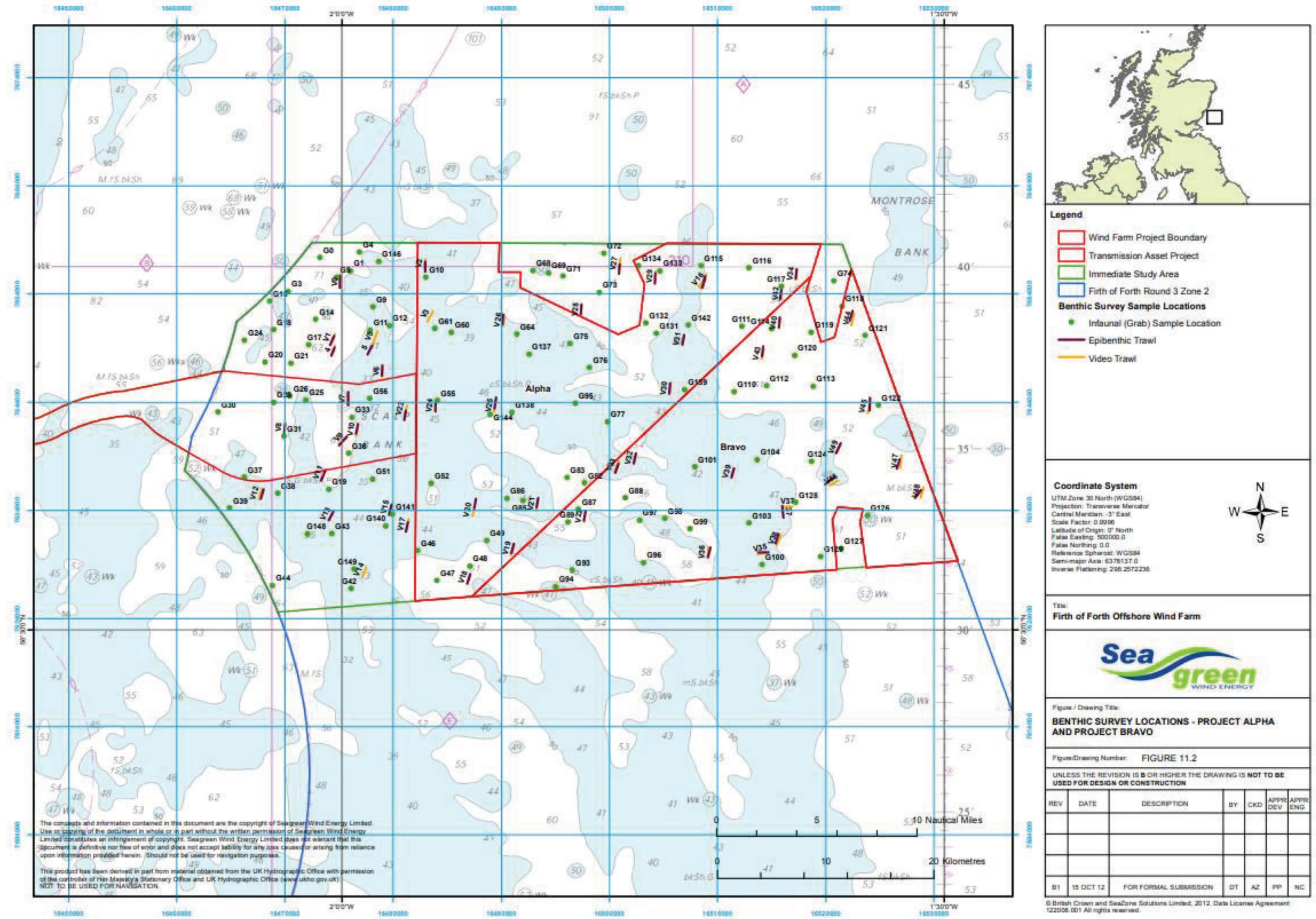

Figure 3 – 2010 benthic survey sample locations in the Seagreen wind farm area (copied from Figure 11.2 in SWEL (2012))

3.2 Exemption from requirement for sediment quality sampling

Consultation with Marine Scotland in November 2022 (A. Alexander email, 15/11/2022) set out the requirements for Seagreen to demonstrate that exemption from the requirement for sediment sampling was appropriate. This is provided in section 5.2 of the OSPAR Guidelines for the Management of Dredged Materials at Sea (OSPAR, 1998), which states that one or more of the following criteria must be met (for sediment quality sampling to not be required). The dredged material must be;

a) composed of previously undisturbed geological material; or;

b) composed almost exclusively of sand, gravel or rock; or

c) in the absence of appreciable past and present pollution sources, the quantity of dredged material from operations does not exceed 10,000 tonnes per year.

Based on the information presented in Sections 2.1 and 3.1, both criteria a) and b) are met and it is therefore concluded that there is no requirement for additional sediment quality sampling to support a marine licence application for the proposed dredge and disposal activity.

4. Scoping of potential disposal options (long list of options)

This section of the report describes the long list of options for the disposal of dredged material. This section concludes by identifying those options that are short-listed for further consideration in the BPEO process.

Possible options for the disposal of dredged arisings are considered to be:

- Do nothing
- Side cast at dredge location
- Reuse of dredged material during wind farm construction
- At sea disposal at licensed site
- Onshore disposal (landfill)

4.1 Disposal Option 0: Do nothing (leave in situ)

As noted in Section 1, further ground preparations works in the form of dredging is required to remove the obstructing shallow sediment layer to expose less hard sub-layers to enable installation to complete at various locations. It is therefore not possible to leave the material in situ and therefore Option 0 (Do Nothing) has not been considered further.

4.2 Disposal Option 1: Side cast at dredge location

As set out in Section 3, the excavated sediment will have low or undetectable levels of contamination due to its undisturbed offshore location. The depth of excavation is relatively shallow and the sediment removed will have a similar composition to adjacent, undisturbed sediments. Side casting using the excavator arm or the grab will enable the excavated material to be distributed adjacent to the dredge location, limiting the movement of material and the extent and duration of any disturbance caused by the works to the local area and minimising the generation and transport of any sediment plume to the site of the works and the local area. The material deposited adjacent to the dredged location will be reworked on the seabed over time by wave and current action allowing recovery from any benthic impact.

Option 1 is a viable solution to the management of dredged material and has been considered further in Section 5.

4.3 Disposal Option 2: Reuse of dredged material during wind farm construction

Reuse of the excavated material during construction would require it to be recovered to a surface vessel or barge prior to reuse at another location. The preferred dredge approach of mechanical excavation does not readily lend itself to recovery of excavated material. However, if used, the grab excavator would be suitable for recovery of dredged material to a surface vessel or barge. For both methods, recovery of dredge material to the surface would be likely to significantly increase the duration of the dredging operation and would result in greater transport and dispersal of fine sediments beyond the immediate excavation area. It would also increase the complexity of the operation, requiring additional vessel presence and introducing further health and safety risks.

Scour protection is placed around the suction caissons following installation to protect from any risk of seabed erosion during the lifetime of the project. Rock protection will also be installed where array cables cannot be sufficiently buried. Both applications require tightly specified rock sizes in order to achieve the desired protection. The excavated material is likely to consist of sands, gravels, cobbles and some boulders of greatly varying sizes at each location.

Given the small volume to be dredged, as well as its composition, the excavated material is not suitable for reuse as scour protection at suction caissons or for rock berms to protect cables. This option does not provide any advantages compared to Option 1 and has not been considered further.

4.4 Disposal Option 3: At sea disposal at a licensed site

Disposal at a licensed sea disposal site would require recovery of the dredge spoil to surface, as described for Option 2. The material would then have to be transported to the selected site for release and disposal. There are a number of disposal sites within the Forth and Tay area licenced for the disposal of dredged material, including sites off Lunan Bay, Arbroath and in the Firth of Forth. These are identified based on various characteristics, including economic and operational feasibility and their physical, chemical and biological characteristics.

The release of the dredged material at the selected disposal site would result in additional spread of fine sediments at this location. While the volume of material to be deposited is small and contaminant levels are considered to be low, this represents additional environmental disturbance relative to Option 1.

The nature of the material to be dredged and the availability of suitably licensed disposal sites makes Option 3 (at-sea disposal) a viable option however, which has been considered further in Section 5.

4.5 Disposal Option 4: Onshore disposal

Disposal at an onshore location would require the recovery of the dredged material to surface and then transfer at port for road transport by licensed carrier to the selected onshore disposal site. The dredged material would also require de-watering (and subsequent disposal of water) prior to transport by road to the landfill site. This would significantly increase the complexity and duration of the dredge and disposal operation. Waste classification for the de-watered dredged material would be required in order to ensure an appropriate disposal facility was used.

Although there are a number of potential landfill sites in the Tayside and Angus area or more widely in central Scotland, disposal of material into landfill sites is generally considered to be an undesirable solution from a waste hierarchy perspective.

Based on the above, Option 4 (onshore disposal) has been discounted and has not been considered in Section 5.

4.6 Summary of options scoping

Based on the information in Section 4.1 to 4.4, Option 2 (re-use of dredged material during construction) and Option 4 (onshore disposal) have been ruled out for the management of dredged material because they do not offer any environmental or technical advantages over the retained options. Option 1 (side cast at the dredge site) and Option 3 (disposal at sea) are however considered to be feasible options and have been subject to further consideration in Section 5.

5. Assessment of short-listed disposal options

This section of the report provides an assessment of the feasible options for the management of dredged material. The assessment, detailed in Table 5.1, considers the following aspects:

- Strategic aspects
  - Operational aspects, including handling and transport
  - Availability of suitable sites / facilities
  - General public / local acceptability
  - Legislative implications
  - Consultation with third parties
- Environmental aspects
  - Safety implications
  - Public health implications
  - Pollution / contamination implications
  - General ecological implications
  - Potential interference with other third party uses e.g. fishing
  - Amenity / aesthetic implications
- Financial aspects
  - Operating costs
  - Capital costs e.g. transport, equipment hire

Table 5.1 Assessment of feasible options for the disposal of dredged material

Criteria	Option 1 (side cast at dredge location)	Option 3 (at-sea disposal at a licensed site)
Strategic aspects		
Operational aspects, including handling and transport	There would be no double handling of material – it would simply be side cast onto the seabed adjacent to the dredge area, minimising the disturbance footprint and removing the requirement to transport it elsewhere. The option is therefore very straightforward from an operational perspective.	The dredged material would need to be transported from the dredge site to one of the licensed disposal sites in the Forth and Tay area where it would be subsequently deposited. This option would therefore result in a greater amount of handling and transport compared to Option 1, with a greater chance of interacting with other vessels / users of the sea.
Availability of suitable sites / facilities	The material would be side cast onto the seabed adjacent to the dredge area in a controlled manner – an available site therefore does exist for the dredged material. The dredged material would be well distributed from the location of the excavator, within the reach of the excavator arm.	There are a number of disposal sites within the Forth and Tay area licenced for the disposal of dredged material, including sites off Lunan Bay, Arbroath and in the Firth of Forth. The closest is approximately 32km from the nearest dredge location. Disposal would likely be through surface release resulting in a spread of sediment as it fall to the seabed within the disposal area.
General public / local acceptability	Side casting of the dredged material is not anticipated to result in any concerns from the general public from an acceptability perspective (in light of the fact that the material is expected to be chemically suitable for such a purpose and the location for side casting is greater than 30km offshore).	The disposal of dredged material into licensed offshore disposal sites is a traditionally accepted route for dredged material with limited public impact.
Legislative implications	Side-casting of dredged material is a licensable activity by Marine Scotland. No further licencing requirements apply as the activities are wholly within the wind farm site boundary.	Disposal of dredged material at sea is a licensable activity by Marine Scotland. A Marine Works licence from Crown Estate Scotland may also be required.
Summary of outcome of consultation with third parties	No consultation has been undertaken with any 3rd parties. The dredging works would take place wholly within the Seagreen offshore wind farm site which is an active construction site with carefully controlled access.	No consultation has been undertaken with any 3rd parties.
Environmental		
Safety implications	The material would be side cast onto the seabed adjacent to the dredge area; such an approach has minimal safety implications as the material would not be brought to the surface.	The dredged material would need to be transported from the dredge site to one of the licensed disposal sites in the Forth and Tay area. Disposal into licensed disposal sites is not generally considered to be a high-risk activity from a safety perspective; however, the requirement for double-handling of the material and transporting it from the dredge area to the disposal site generates additional health and safety risks when compared to Option 1.
Public health implications	The material would not be brought to the surface therefore there is no mechanism for human contact / public health implications during dredging and disposal operations.	Although the material would need to be brought to the surface prior to disposal into a licensed site, there would be very low potential for human contact with the dredged material.
Pollution / contamination implications	The dredged material is expected to be free from contamination and therefore side casting is unlikely to result in any significant reduction in water quality (from a chemical perspective), based on the results of the 2012 Offshore ES which are still considered to be valid.	The dredged material is expected to be free from contamination and therefore disposal into a licensed offshore disposal site is unlikely to result in any significant reduction in water quality (from a chemical perspective), based on the results of the 2012 Offshore ES, which are still considered to be valid.

Criteria	Option 1 (side cast at dredge location)	Option 3 (at-sea disposal at a licensed site)
	Side casting will enable the excavated material to be distributed adjacent to the dredge location, limiting the movement of material and the extent and duration of any disturbance caused by the works to the local area and minimising the generation and transport of any sediment plume to the site of the works and the local area.	The disposal into a licensed disposal site is likely to result in the creation of a sediment plume, with impacts likely experienced over a larger area compared to Option 1.
Generical ecological implications	The total volume of material to be side cast is small at approximately 8,140m^3 (16,280 tonnes) across up to 5 locations. It is inevitable that the side casting will have a localised impact on the habitat within the footprint of the works, however, the material will be reworked on the seabed over time by wave and current action allowing recovery from any benthic impact out with the installed footprint of the WTG foundation. The dredging and sidecasting of material would be taking place at a location that will subsequently be subject to further disturbance through the installation of the suction jacket caisson and subsequent scour protection installation. The conclusions of the benthic ecology impact assessment reported in the 2012 Offshore ES are considered still to be relevant. No significant impact was predicted due to release of a significantly greater volume of sediment, for the worst case GBS foundation, over the full duration of installation. Up to two WTG locations where dredging will take place lies within the boundary of the Firth of Forth Banks Complex MPA. The extent of the MPA overlapped by the Seagreen wind farm site is 123.8km^2 which is 5.8% of the total MPA area The total area to be dredged for two locations is 2,700m^2. Assuming the dredged material is sidecast adjacent to the dredge site and distributed over a similar area the total footprint of disturbance will be 5400m^2. This represents less than 0.01% of the wind farm site overlap with the MPA area. The additional area of the MPA that is disturbed as a result of this activity will therefore be a very small fraction of the total MPA area, and which would be expected to recover in time out with the area of permanent impact from the suction caisson foundation. There are no other designated sites overlapping the dredge locations. Side casting the material would also minimise greenhouse gas emissions as well as potential impacts to wider environmental receptors from the movement of dredge and disposal vessels.	The deposition of dredged material would be within a licensed offshore disposal site which is intended to accept dredged material. No significant impacts are predicted given the material is expected to be suitable for disposal from a chemical and physical perspective and the volume of material to be disposed of is small. The movement of dredge / disposal vessels from the source site to a disposal site would generate greater amounts of greenhouse gas emissions, and result in additional mechanisms for impact to wider ecological receptors compared to Option 1. As the disposal site is licensed it is assumed that benthic impacts have been assessed and are already considered acceptable.
Interference with other legitimate activities	The dredging is required to enable the installation of the WTGs. No significant impact to other activities in the area is predicted from the side casting.	The disposal would be into a licensed offshore disposal site; there would therefore be potential for short term impact to other users of the disposal site should other dredging and disposal activities be taking place elsewhere. There are also potential impacts to other marine users through a further increase in vessel activity transporting material from the dredged locations to the disposal site.

Criteria	Option 1 (side cast at dredge location)	Option 3 (at-sea disposal at a licensed site)
Amenity / aesthetic implications	Given the location of the proposed dredge (i.e. greater than 30km offshore), no significant impacts on amenity / aesthetic value are predicted.	Given the location of the nearest offshore disposal sites (i.e. approximately 3km from the shore), no impacts on amenity / aesthetic value are predicted, although the vessel undertaking disposal is likely to be clearly visible from shore.
Costs		
Operating costs	No operating costs are anticipated following completion of the dredging activities.	No operating costs are anticipated following completion of the dredging activities.
Capital costs	The side casting approach would avoid the requirement for bringing the material to the surface and transporting elsewhere for disposal. This option would therefore be comparatively cheaper than Option 3.	The requirement to bring the sediment to the surface and transport to the offshore disposal site would result in additional cost compared to Option 1.

6. Conclusion

Highly localised and small-scale dredging is required within the footprint of the Seagreen Project to enable the installation of up to five WTG suction caisson foundations. A review of options for the management of the dredged material has been undertaken to identify the BPEO. A long-list of options was initially developed (Section 4) and screened into a short list which was subject to further assessment (Section 5). The short-listed options which have been subject to further assessment comprise side casting at the dredge location (Option 1) and at sea-disposal at a licensed site (Option 3).

Based on the information presented in Section 5, both Option 1 and Option 3 are considered to be environmentally acceptable with limited risks associated with both options, however Option 1 (side casting at the dredge location) is considered to be the BPEO (based on a comparatively reduced scope of work and consequently reduced potential for environmental impact, cost and wider strategic impacts).

7. References

OSPAR, 1998; Guidelines for the Management of Dredged Material (Reference Number: 1998-20)

Seagreen Wind Energy Limited (SWEL), 2012. Offshore Environmental Statement