Offshore Wind Power Limited

West of Orkney Windfarm Offshore EIA Report

Volume 1, Chapter 4 - Site Selection and Alternatives

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West of Orkney Windfarm

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4 SITE SELECTION AND ALTERNATIVES

4.1 Introduction

This chapter outlines the site selection process that has been undertaken by Offshore Wind Power Limited (OWPL) when defining the West of Orkney Windfarm ('the Project'). It also outlines the alternatives to the Project that have been considered, both in terms of the different design options throughout the development process as well as the consideration of not developing the Project at all (the 'do nothing' option).

As defined in chapter 3: Planning policy and legislative context, the Environmental Impact Assessment (EIA) Regulations require that the Project's EIA Report includes 'a description of the reasonable alternatives (for example in terms of Project design, technology, location, size and scale) studied by the Developer, which are relevant to the proposed works and its specific characteristics and an indication of the main reasons for selecting the chosen option, including a comparison of the environmental effects'.

4.2 The 'do nothing' option

The English courts[1] have cast doubt on whether the 'do nothing' option is a true alternative, however for completeness, and given reference to it in pre-existing guidance, the 'do nothing' option is considered here. The 'do nothing' option is consideration of what would happen if the Project did not go ahead.

As presented in the Offshore EIA Report chapter 2: Need for the Project, the Project will aim to achieve the following:

- Supply electricity generated from wind energy to meet energy demand;
- Support the transition to a net zero economy;
- Contribute to Government commitments to climate change;
- Provide a secure source of energy; and
- Deliver sustainable low-carbon economic growth.

A 'do nothing' scenario would not meet any of the above Project aims.

The 'do nothing' option would result in no Offshore Wind Farm (OWF) development within the N1 Plan Option (PO) and loss of over 2 gigawatts (GW) of offshore wind capacity.

The Project location has been strategically identified through the Scottish Government Sectoral Marine Plan (SMP) process and has been subject to Strategic Environmental Assessment (SEA), Habitats Regulations Appraisal (HRA), Socio-Economic Impact Assessment (SEIA) and an Island Communities Impact Assessment. If the Project does not proceed, a significant area of seabed identified by the Scottish Government's SMP as suitable and made available for

[1] *Humber Sea Terminal Ltd v Secretary of State for Transport and another [2005] EWHC 1289 (Admin), comments at paragraph 84.*

large-scale offshore wind development would not be developed in the near-term, if at all. This could result in ramifications for all future ScotWind applications.

In support of climate change legislation, the Draft Scottish Energy Strategy and Just Transition Plan was published in January 2023 and provides a roadmap of how net zero emissions by 2045 can be accomplished. A key ambition for Scotland as outlined in the draft plan is the production of more than 20 GW of additional renewable electricity by 2030. The Offshore Wind Policy Statement (OWPS) sets ambitions for offshore wind development, initially as much as 11 GW of offshore wind capacity in Scottish waters by 2030. The Project is the most advanced ScotWind Project, with a grid connection date before 2030 (first power planned 2029). In the 'do nothing' scenario there would be a gap between Scottish AR3 OWFs (coming online in the next few years) and future ScotWind developments (likely to mostly come online from 2033). Scotland cannot be expected to meet its target for offshore wind capacity if the Project does not go ahead. It is not compatible with a climate emergency to 'do nothing'.

The Scottish Government is committed to ensuring secure, reliable and affordable energy supplies (i.e. social and economic benefits), within the context of long-term decarbonisation of energy generation (i.e. environmental benefits). The continued growth of the renewable energy sector in Scotland is an essential feature of the future clean energy system and a key driver of economic growth (Scottish Government, 2020a). Development of the Project will be an important step in the continued growth of renewable energy in Scotland and for meeting the current energy demand. Thus, 'doing nothing' (no West of Orkney Windfarm) would substantially hinder decarbonisation and security of supply efforts during the critical 2020s and would ignore the clear need for rapid OWF deployment at scale. The importance of the decarbonisation, energy security and related affordability challenges mean that no viable OWF projects should be passed over in the development process.

As part of the ScotWind application, the Project produced a Supply Chain Development Statement (SCDS), which included commitments to the Scottish and United Kingdom (UK) supply chains. If the Project was not to go ahead, these local and national supply chain opportunities would be missed.

For all the above reasons, the "do nothing" option was discounted.

4.3 Site selection process

The site selection process for the West of Orkney Windfarm has been guided and informed by key events in the Project's development timeline:

- Development of the Scottish Government's Sectoral Marine Plan (SMP) for Offshore Wind Energy;
- The selection and award of the West of Orkney Option Agreement Area (OAA) through the ScotWind leasing processes;
- The securing of the grid connection agreement with National Grid; and
- Consultation, and environmental and technical investigations which have enabled refinements to be made to the Project design and areas within which Project infrastructure will be located.

An overview of the key events in the Project's development timeline are shown below in Figure 4-1.

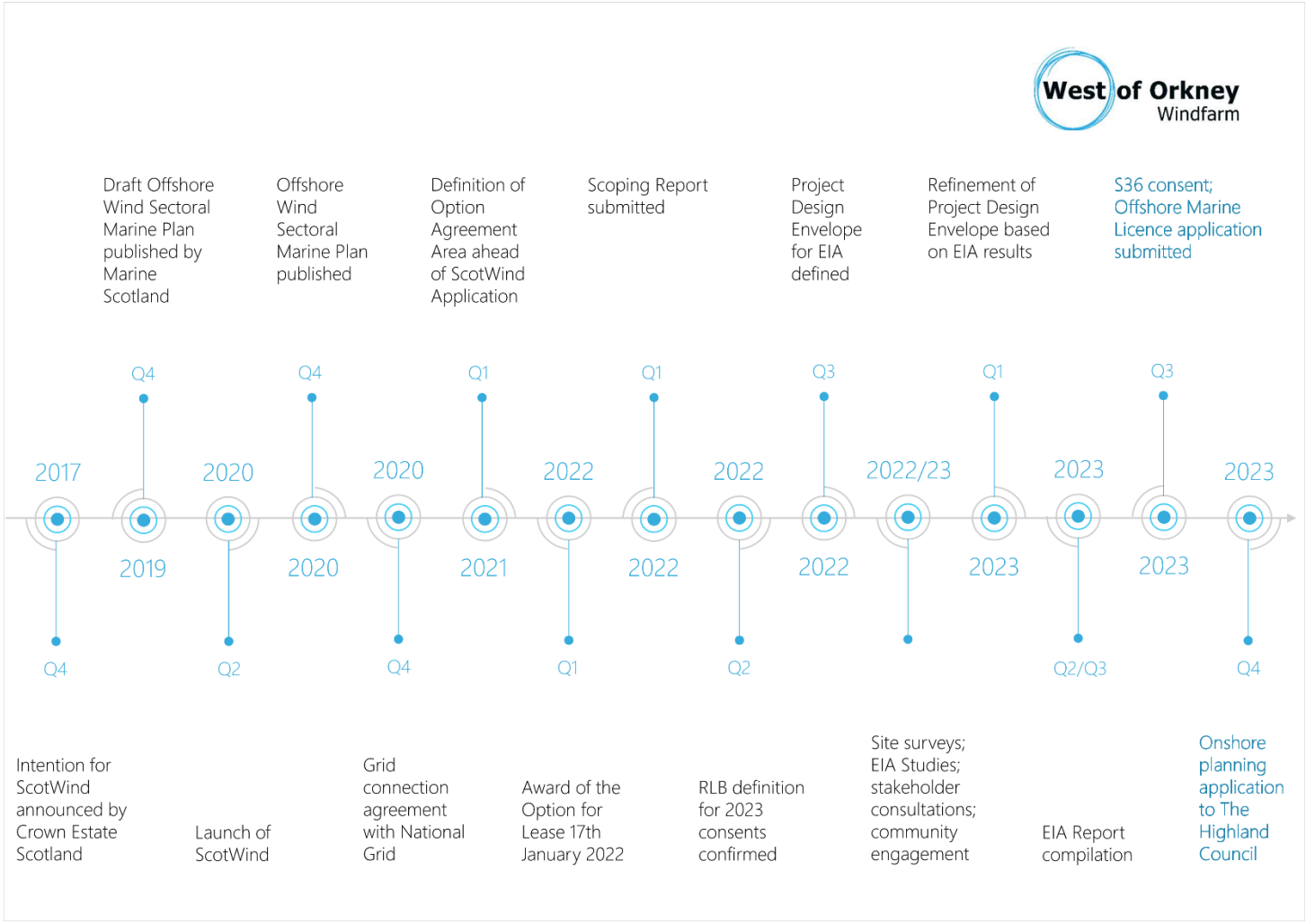


Figure 4-1 The Project site selection process and refinement of Project design

4.4 Sectoral Marine Plan and ScotWind

In November 2017, Crown Estate Scotland (CES) announced their intention to run a leasing round for commercial scale offshore wind energy projects in Scottish Waters. This round became known as ScotWind and was the first offshore wind leasing round in Scotland for over a decade. This initiative was consistent with the Scottish Energy Strategy which envisaged further offshore wind developments playing a key role in Scotland's future energy mix. To inform the spatial development of this leasing round, Marine Scotland[2], as Planning Authority for Scotland's Seas was required to undertake a planning exercise, in accordance with relevant European Union (EU), UK and Scottish legislation (CES, 2022).

As identified by the Scottish Government, offshore wind has the potential to play a pivotal role in Scotland's energy system over the coming decades. This resulted in the SMP being developed to identify areas suitable for the future development of commercial-scale offshore wind energy in Scotland (Scottish Government, 2020b). The Draft SMP was published in December 2019 and identified 17 Draft Plan Option (DPO) areas. The final plan was published in October 2020 and identified 15 Plan Option (PO) areas split across four regions around Scotland, (two of the DPO areas were not progressed).

The SMP process was iterative, informed through stakeholder engagement and evidence from the related social, economic and environmental assessments. Information and consultation feedback was gathered throughout the process and used to support the Scottish Ministers in identifying the POs and policies included in the SMP. The key steps to the SMP are detailed in Table 4-1.

Table 4-1 Draft PO Identification: Key Stages (Scottish Government, 2020b)

STAGE	DETAILS
Opportunity and Constraint Analysis – Iteration 1 –	Areas of Search (AoS) identified using an Opportunity and Constraint (O&C) analysis – built upon work carried out by Marine Scotland Science (MSS) in 2011 and production of draft regional locational guidance for potential deep water floating offshore wind test sites in 2014. The O&C analysis sought to identify areas of opportunity for the future development of offshore wind, whilst also identifying areas that minimised potential negative impacts to the environment, other sectors and users of the sea.
Opportunity and Constraint Analysis – Iteration 2 - Single Issue Constraint Analysis	AoS were then refined, considering specific spatial issues and sectoral engagement workshop feedback. No commercial or technology specific information was used in this refinement process.

[2] *Now the Marine Directorate.*

STAGE	DETAILS
Scoping Consultation	Scottish Ministers consulted on the screening and scoping stages of the Plan during June and July 2018. Screening and Scoping Reports were prepared and published online for the SEA, HRA and SEIA alongside the AoS scoping study.
Opportunity and Constraint Analysis – Iteration 3	Following consultation, the AoS were refined. Areas of seabed for offshore wind development proposed by stakeholders during scoping consultation were also considered at this stage.
Identification of Draft Plan Options	22 revised AoS were made available to the SMP Project Board and two Project Steering Groups for consideration and comment. Responses from the Project Board and Steering Groups, together with outputs from the initial assessments, were presented to Scottish Ministers to inform their decision on which AoS should progress to the Sustainability Appraisal for more detailed assessment. 17 AoS were selected as DPOs.
Assessment of Draft Plan Options	The DPOs identified were subject to SEA, HRA and SEIA with reports produced to summarise these.
Consultation on Draft Plan Options	Statutory consultation was held on the draft SMP Plan and Sustainability Appraisal for a period of 14 weeks between 18th December 2019 and 25th March 2020. In support of this, a total of 17 consultation events were held in coastal communities across Scotland during February and March 2020. 443 responses were received.
Finalisation and adoption of the Plan	Consultation responses were used to inform the Scottish Ministers' decision on the final POs which would be offered in the ScotWind leasing round.

Some of the key opportunities and constraints which influenced selection of the N1 PO are summarised below:

- Bathymetry: the N1 PO is one of only four areas identified during the SMP process that included substantial areas of seabed with water depths of below 70 m, and therefore a prime location for the delivery of large scale, competitive fixed bottom offshore wind;
- Wind resource: the N1 PO was identified as having wind resource suitable for at least 2 GW of installed capacity;
- Power export: The north of Scotland offered grid connection options and planned reinforcement offered increased capacity;
- Interferences with other users: the PO does not overlap sites of significant exploration or development potential for the oil and gas industry (in the foreseeable future); there are no sites identified for carbon capture and storage within the PO; the N1 PO does not overlap with any radar surveillance for any airports and the PO is offset to the north of the main shipping route around the north of Scotland;
- Defence: although there is significant defence activity to the north of Scotland, the N1 PO avoids designated exercise areas;
- Commercial fisheries: areas within the N1 PO are less intensely fished that other areas in Scottish waters, although not devoid of fishing activity;

- Environmental considerations: the N1 PO does not overlap any designated sites and there are no scheduled monuments in the N1 PO, however some environmental sensitivities were identified which would need to be investigated further as part of the Project EIA, including fish ecology, ornithology, marine mammals and seascape and landscape; and
- Supply chain: the SMP identified locations that could be developed to support all phases of OWF development in the north of Scotland.

4.5 Offshore site selection

Having identified the N1 PO as their preferred development site, OWPL commenced work to identify the preferred development area, i.e. proposed OAA, within the N1 PO. Selection of the OAA and proposed offshore Export Cable Corridor (ECC) route options were an important step in the preparation of the ScotWind bid application and considerable work was done ahead of the bid application to define these areas. The Project Geographic Information System (GIS) database which contains over 1,000 layers of technical and environmental data, consultation with local stakeholders, desk-based studies and Project specific surveys informed refinement of the Project areas.

4.5.1 Option agreement area

The OAA is the area in which the generating infrastructure including Wind Turbine Generators (WTGs) and associated foundations, inter-array cables, Offshore Substation Platforms (OSPs) and interconnector cables will be located.

Key technical parameters assessed to inform the selection of the OAA (within the N1 PO), included wind resource, bathymetry, ground and metocean conditions, WTGs sizing, foundation technology options as well as WTG layout flexibility. Marine operations during installation and operations were also considered using a 10-year multiple metocean buoy dataset sourced from the European Marine Energy Centre (EMEC).

Over 80 meetings with 25 stakeholders (2020 – 2021), including regular engagement with statutory advisors (including NatureScot, Historic Environment Scotland (HES), the Maritime and Coastguard Agency (MCA) and Northern Lighthouse Board (NLB)), and other interested stakeholders such as fisheries organisations, and representatives, Space Hub Sutherland and other sea users has helped form a detailed understanding of the key sensitivities which were considered in the selection of the OAA.

A Desktop Preliminary Feasibility Study (DPFS) undertaken in 2021 as part of the ScotWind application identified the 657 km^2 OAA (reduced from the 1,163 km^2 total area of the PO). The OAA selection was influenced by a combination of technical, environmental and other user constraints. These are summarised below and key constraints illustrated in Figure 4-2.

Technical considerations included:

- Wind resource assessment: analysis of data from several established sources provided a high level of confidence in the modelled wind speed (10.72 m per second (classed as a 'fresh breeze' on the Beaufort wind force scale) at 146 m above Mean Sea Level (MSL), with low spatial variability;
- Physical characteristics and existing infrastructure: several established, publicly available data sources were used to assess the physical characteristics for the OAA covering bathymetry, ground and metocean conditions. These were enhanced by EMEC's proprietary metocean dataset. The analysis concluded that:

  - Bathymetry and ground conditions were expected to be within the envelope of current offshore wind experience, with very similar physical characteristics present on several other offshore windfarm sites, meaning that the Project is able to draw from industry knowledge;
  - The metocean conditions were identified as potentially more challenging than those found on other OWF sites. However, due to available solutions for a range of metocean conditions, the conditions at the site were not considered to adversely affect the Project's viability when technically and economically evaluated; and
  - Proximity checks identified no existing conflicts;
- Foundation types: a screening of potential foundation types and conceptual designs concluded that there were a range of feasible foundations available for the N1 PO, and further industry development and optimisation may increase these options over time; and
- Electrical architecture and related infrastructure: the electrical architecture was heavily influenced by the distance to the onshore grid connection and Project capacity. These inputs were determined by the power offtake options and OWPL developed the following solutions:
  - A firm post-signature Construction and Infrastructure Operation Note (CION) connection agreement with National Grid, confirmed at or near Spittal substation on Caithness; and
  - The proposed Flotta Hydrogen Hub (Flotta, Orkney) which provides a second power export opportunity for the Project. OWPL are currently negotiating the terms of this private wire export option through a 'Power Purchase Agreement' (PPA). These negotiations will provide clarity on the timing for the availability of this power export option and will determine the timing of a subsequent separate Marine Licence application and onshore planning application for the transmission infrastructure from the Project to the Flotta Hydrogen Hub.

Key environmental considerations and other sea user constraints included:

- Shipping and navigation: analysis of Automatic Identification System (AIS) vessel data from 2015 and 2017, together with consultation with shipping organisations highlighted the importance of the direct yachting route between the west coast of Scotland and Stromness, Orkney, due to tidal restrictions in the approach to Stromness through Hoy Sound. In order to retain a direct yachting route, the southeastern corner of the N1 PO was removed from consideration for the OAA (see Figure 4-2);
- Visual impact: pre-application advice from The Highland Council (THC) highlighted the need to maintain key sightlines between key landscape/seascape designations in Sutherland and Orkney. The OAA selected mitigates this concern (see Figure 4-2) and also goes some way in avoiding higher sensitivity areas identified in the NatureScot (at the time Scottish Natural Heritage (SNH)) Landscape and Visual Impact Assessment and Design Guidance (2020) produced as part of the SMP;
- Aviation: The Yankee Helicopter Main Route (HMR) intersects the eastern boundary of the PO. The OAA was selected to avoid any overlap with the HMR and, in line with Civil Aviation Authority (CAA) guidelines, allowed for a buffer of 4 km (2 nautical miles) either side of the HMR (see Figure 4-2). In addition, consultation with Space Hub Sutherland highlighted a potential Launch Exclusion Zone (LEZ), not identified in the SMP which could overlap the western extents of the N1 PO; and
- Commercial fisheries: Fishing data from the Scottish Fishermen's Federation (SFF) and the Scottish White Fish Producer's Association (SWFPA), indicated the need to avoid development activities east of the 4-degree line.

The technical and environmental constraints considered above resulted in a 657 km^2 OAA being selected which was a 44% reduction of the N1 PO. Due to this considerable reduction, no further boundary changes are considered necessary ahead of the Section 36 Consent and Marine Licence application submission.

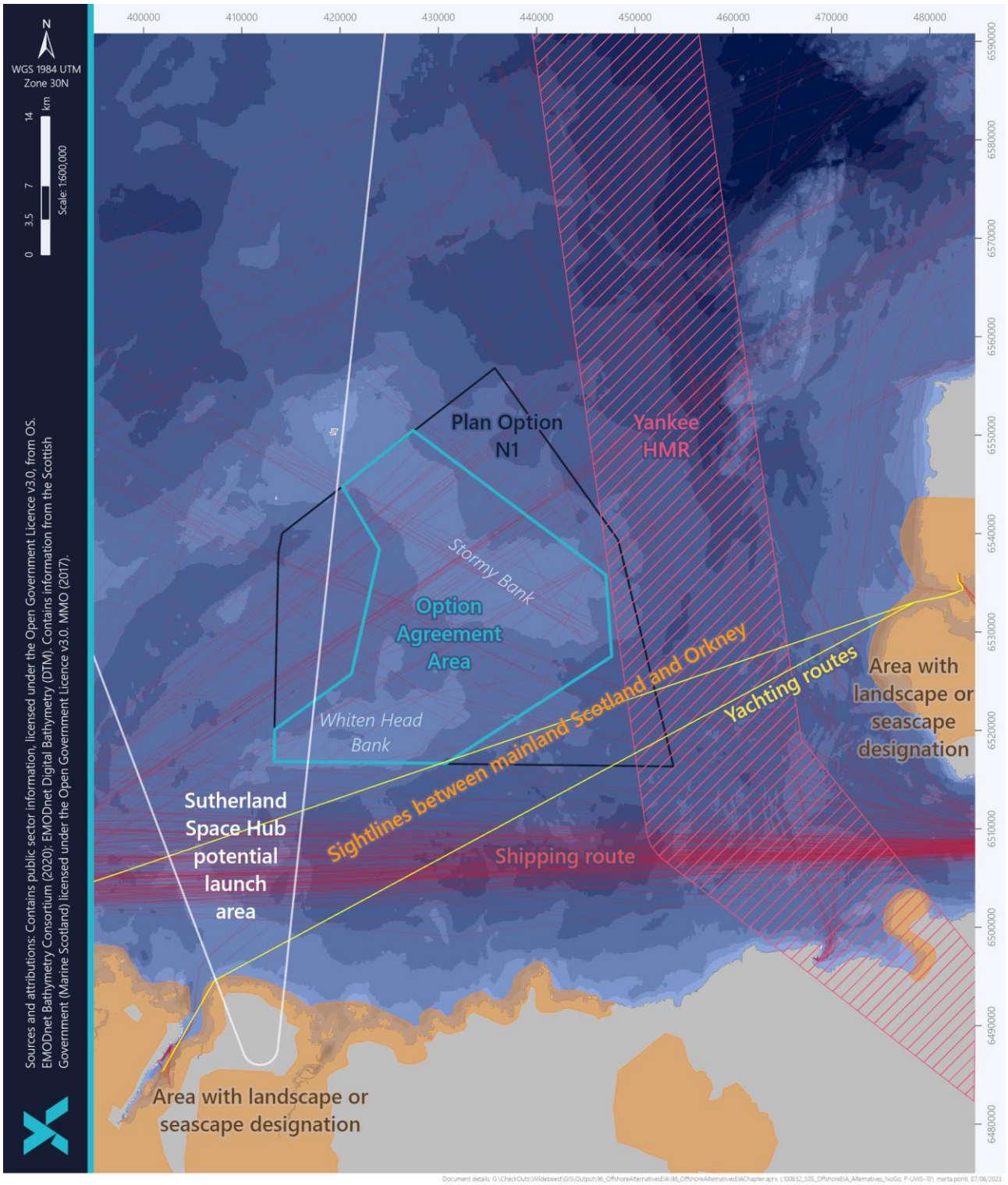


Figure 4-2 Key Constraints and bathymetry of the OAA

4.5.2 Offshore export cable corridor and landfall

The offshore ECC is the area within which the offshore export cables will be installed from an Offshore Substation Platform (OSP) within the OAA to landfall. The main driver for the route selection of the offshore ECC was the end point – the location at which the Project will connect to the Grid.

In August 2019, OWPL received a grid connection offer from the National Grid, with a potential connection in Caithness on mainland Scotland. This was the main driver for the selection of the offshore ECC route options. In November 2020, this offer was refined as National Grid indicated the grid connection would be "at or near Spittal". An initial cable routing study was commissioned (OWC, 2021), which identified six cable landfall options along the north coast of Caithness and a number of associated offshore routes between the OAA and the potential landfall options. These offshore cable route and landfall options (some landfalls with multiple options), together with key technical and environmental constraints associated with each route are summarised in Figure 4-3 and detailed in the following tables. The criteria used to inform the assessment are summarised below:

The environmental constraints analysis criteria:

- Low - Lowest / most preferred option;
- Low to moderate - No significant consenting risk – with the use of best practice approaches;
- Moderate - Potential for consenting risk, but mitigation measures anticipated to reduce risk appropriately;
- High – High chance of consenting risk, potential to require design changes and mitigation; risk of stakeholder objection; and
- Very High – Very high chance the Project will not be consented.

The technical criteria used a scored risk assessment matrix. Consequences to personnel, programme, assets and reputation were assigned a score from 1 – 5 based on the severity of the potential impact from the technical criteria (ranging from slight (1), minor (2), moderate (3), major (4) and severe (5)). In a similar manner, the probability of the consequence occurring ranged from remote (1), very unlikely (2), unlikely (3), likely (4) and very likely (5). When considering each technical aspect, the potential consequence score and the probability score were multiplied to give the overall ranking. Colours have been assigned to the respective technical criteria rankings based on:

- Low risk – a score of 1 -5
- Medium risk - a score of 5 – 15; and
- High risk – a score of 15 – 25.

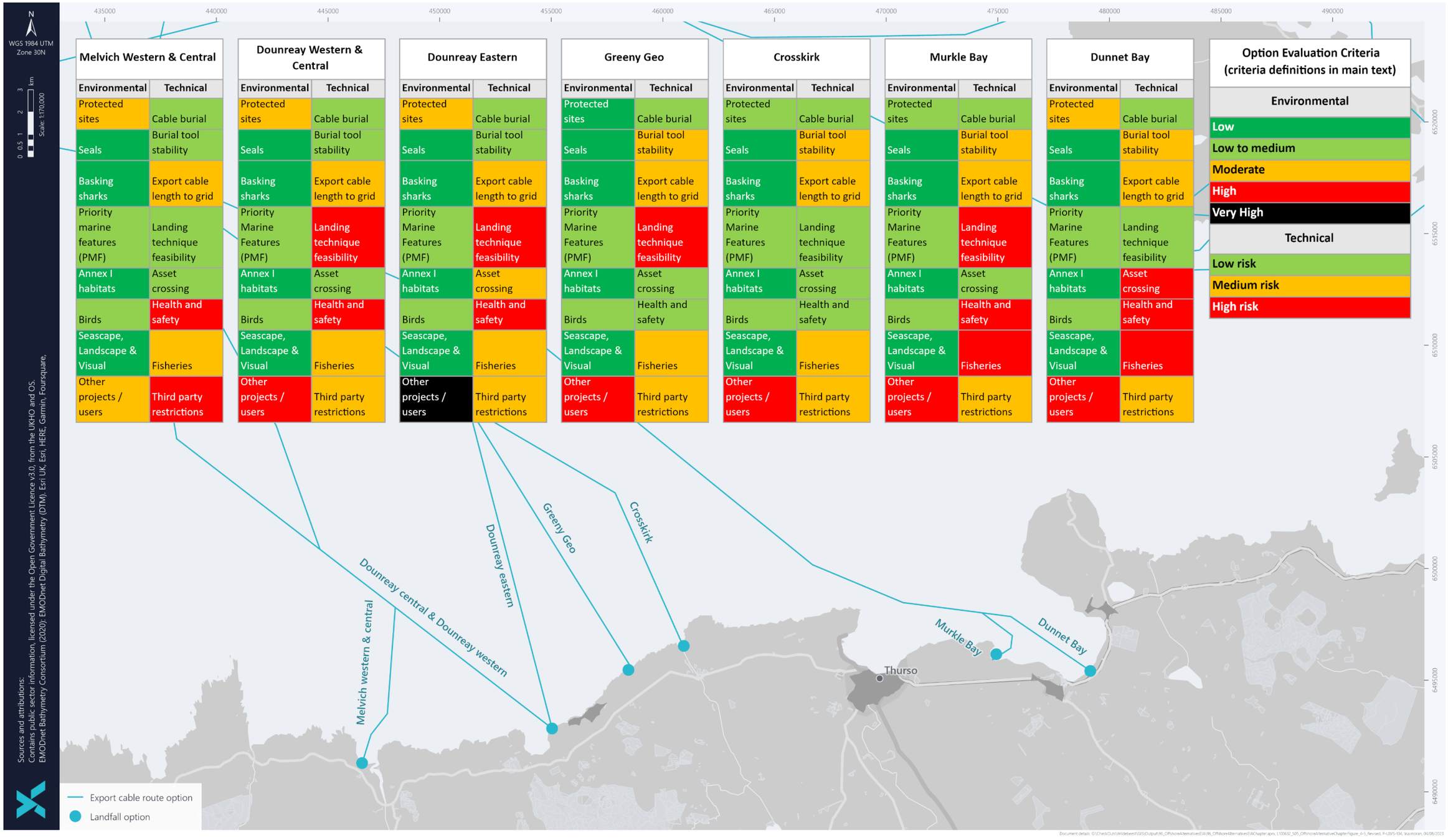
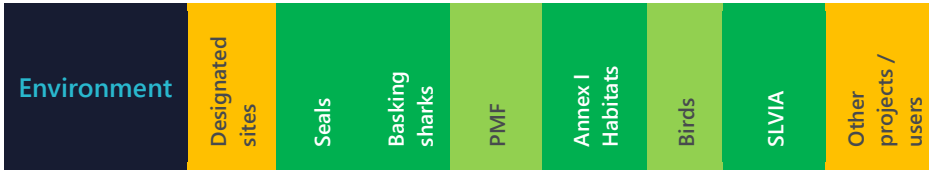


Figure 4-3 Technical and environmental constraints associated with the offshore cable routes and landfall options – details behind ranking for each constraint and route in following tables

Key Technical Risks

- Potential presence of ammunitions from the Caithness Firing Range;
- Mostly feasible for cable burial and burial tool suitability, possible risk of reduced performance of burial tool due to dense sand and gravelly sediments;
- Shortest offshore export cable to landfall (32.3 km); the longest onshore cable to grid connection (30 km);
- Moderate to high density of fishing activity along the cable route; and
- No third-party cable crossings.



Key Environmental Constraints

- This landfall is in close proximity to the North Caithness Cliffs Special Protection Area (SPA) and Strathy Point Site of Special Scientific Interest (SSSI). Designated features of these sites include bird and sensitive habitats which could be disturbed or damaged as a result of cable installation activities;
- The landfall overlaps a Special Landscape Area, however the visual impacts of the cable installation will be temporary and not considered to be a significant risk;
- Close proximity to the Pentland Floating Offshore Windfarm (PFOWF). Due to this proximity, there is potential for cumulative impacts to arise from this landfall location; and
- Based on the information available at the time of the routing desk study, there were no significant distinguishing characteristics with respect to the following constraints: seals, basking sharks, Priority Marine Features (PMFs), Annex I habitats, and birds.

Key Technical Risks

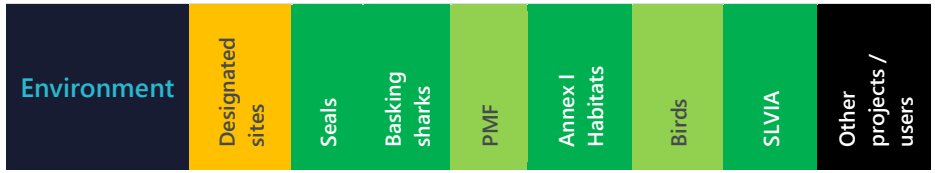
- Installation in a contaminated area approaching Dounreay landfall;
- Mostly feasible for cable burial and burial tool suitability, possible risk of reduced performance of burial tool due to gravelly sand, sand and dense sand;
- Slightly longer offshore export cable to landfall (32.5 km central; 33.9 km western route); and slightly longer onshore export cable to grid connection (25 km);
- No third-party cable crossings required. However, cable route coincides with PFOWF export corridor; and
- Moderate to high density of fishing activity along the cable route.

Key Environmental Constraints

- Landfall in close proximity to the North Caithness Cliffs SPA and Strathy Point SSSI. Designated features of these sites include bird and sensitive habitats which could be disturbed or damaged as a result of cable installation activities;
- Projects in the vicinity of this landfall include: PFOWF (overlaps) and the proposed SHET-L Caithness to Orkney HVAC Link (overlap). Due to this proximity, there is potential for cumulative impacts;
- High number of other Projects in this area also presents lack of space for development immediately adjacent to this landfall; and
- Based on the information available at the time of the routing desk study, there were no significant distinguishing characteristics with respect to the following constraints: seals, basking sharks, PMFs, Annex I habitats, birds and SLVIA.

Key Technical Risks

- Installation in a contaminated area approaching Dounreay landfall;
- Mostly feasible for cable burial and burial tool suitability;
- Slightly longer offshore export cable to landfall (33.5 km); slightly longer onshore export cable to achieve grid connection (25 km);
- Moderate to high density of fishing activity along the cable route; and
- One potential future third-party cable crossing will be required. Route coincides with the PFOWF export corridor.



Key Environmental Constraints

- Landfall in close proximity to the North Caithness Cliffs SPA and Strathy Point SSSI. Designated features of these sites include bird and sensitive habitats which could be disturbed or damaged as a result of cable installation activities;
- Projects in the vicinity of this landfall include: PFOWF (large portion of this project overlaps) and the proposed SHET-L Caithness to Orkney HVAC Link (significant overlap). Due to this proximity, there is potential for cumulative impacts;
- Number of other Projects presents lack of space for development at this landfall; and
- Based on the information available at the time of the routing desk study, no significant distinguishing characteristics with respect to the following constraints: seals, basking sharks, PMFs, Annex I habitats, birds and SLVIA.

Key Technical Risks

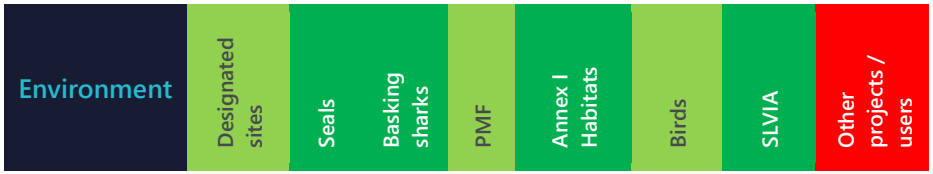
- No health and safety risks identified in the installation corridor;
- Mostly feasible route, possible complexities in rock area approaching landfall;
- Likely feasible for most of route, potential difficulties penetrating gravelly sediments;
- Slightly longer offshore export cable to landfall (32.3 km) and reasonable onshore export cable length to grid connection (22 km);
- Horizontal Directional Drilling (HDD) only feasible option;
- One potential future third-party cable crossing will be required;
- Moderate to high density of fishing activity along the cable route; and
- Cable route will cross the SHET-L Caithness to Orkney HVAC Link.

Key Environmental Constraints

- Landfall located approximately 3.6 km from North Caithness Cliffs SPA and 2.6 km from Ushat Head SSSI. Due to these separation distances, impacts from cable laying activities will be absent/minimal compared to other landfall options;
- Projects in the vicinity of this landfall include: PFOWF and the proposed SHET-L Caithness to Orkney HVAC Link (overlaps). Due to this proximity, there is potential for cumulative impacts;
- Developments at this landfall will require a crossing agreement; and
- Based on the information available at the time of the routing desk study, no significant distinguishing characteristics with respect to the following constraints: seals, basking sharks, PMFs, Annex I Habitats, Birds and SLVIA.

Key Technical Risks

- No health and safety risks identified in the installation corridor;
- Mostly feasible for burial, possible complexities in rock area approaching the landfall;
- Likely feasible for most of route, potential difficulties penetrating gravelly sediments;
- Slightly longer offshore export cable to landfall (34.2 km) and reasonable onshore export cable length to achieve grid connection (20 km);
- Potential to employ more than one cable landing technique;
- One potential future third-party cable crossing will be required;
- Moderate to high density of fishing activity along the cable route; and
- Cable route will cross the SHET-L Caithness to Orkney HVAC Link.

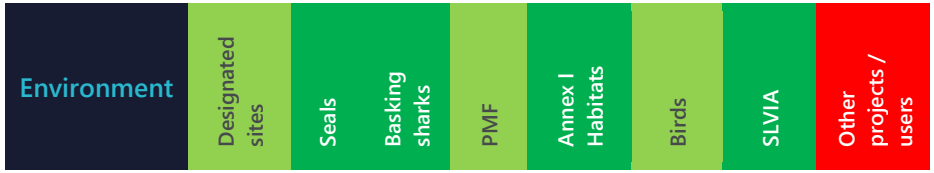


Key Environmental Constraints

- This landfall is directly adjacent to Ushat Head SSSI. Protected features of this site may be disturbed as a result of installation activities;
- Projects in the vicinity of this landfall include: PFOWF and the proposed SHET-L Caithness to Orkney HVAC Link (overlaps). Due to this proximity, there is potential for cumulative impacts;
- Developments at this landfall will require a crossing agreement; and
- Based on the information available at the time of the routing desk study, no significant distinguishing characteristics with respect to the following constraints: seals, basking sharks, PMFs, Annex I Habitats, Birds and SLVIA.

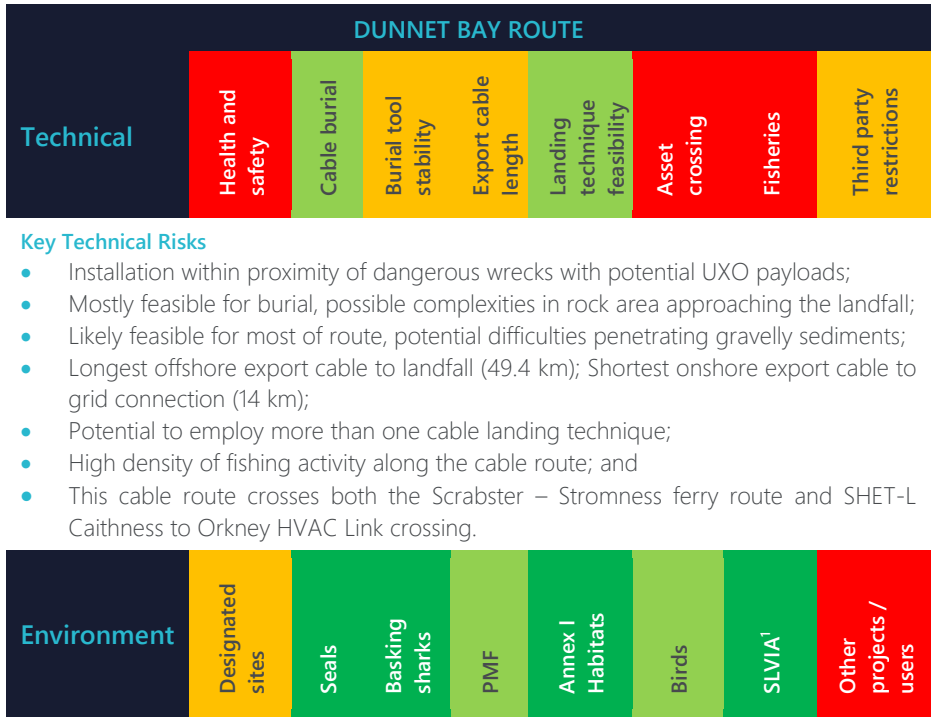
Key Technical Risks

- Installation within proximity of dangerous wrecks with potential Unexploded Ordnance (UXO) payloads;
- Mostly feasible for burial, possible complexities in rock area approaching landfall;
- Likely feasible for most of route, potential difficulties penetrating gravelly sediments;
- Second longest offshore export cable to landfall (46.8 km); Shortest onshore export cable to achieve grid connection (14 km);
- Only one landing technique feasible at Murkle Bay;
- High density of fishing activity along the cable route; and
- This cable route crosses both the Scrabster – Stromness ferry route and SHET-L Caithness to Orkney HVAC Link crossing.



Key Environmental Constraints

- Landfalls route approach passes through the North Caithness Cliffs SPA. While there might be some disturbance to protected species, it is expected to be of a lesser scale;
- Projects in the vicinity of this landfall include: three in-service and one out of service cables served by these routes and the proposed SHET-L Caithness to Orkney HVAC Link. Due to this proximity, there is potential for cumulative impacts dependant on Project timing;
- Developments at this landfall will require a crossing agreement; and
- Based on the information available at the time of the routing desk study, no significant distinguishing characteristics with respect to the following constraints: seals, basking sharks, PMFs, Annex I habitats, birds and SLVIA.



Key Technical Risks

- Installation within proximity of dangerous wrecks with potential UXO payloads;
- Mostly feasible for burial, possible complexities in rock area approaching the landfall;
- Likely feasible for most of route, potential difficulties penetrating gravelly sediments;
- Longest offshore export cable to landfall (49.4 km); Shortest onshore export cable to grid connection (14 km);
- Potential to employ more than one cable landing technique;
- High density of fishing activity along the cable route; and
- This cable route crosses both the Scrabster – Stromness ferry route and SHET-L Caithness to Orkney HVAC Link crossing.

Key Environmental Constraints

- Landfall within close proximity of the North Caithness Cliffs SPA and Strathy Point SSSI. Designated features include birds and sensitive habitats which could be disturbed or damaged as a result of cable laying activities;
- Dunnet Bay overlaps with a Special Landscape Area, however the visual impacts of the cable installation will be temporary and not considered a significant risk;
- Projects in the vicinity of this landfall: 3 in service and 1 out of service cable and the proposed SHET-L Caithness to Orkney HVAC Link. Due to proximity, potential for cumulative impacts dependant on Project timing;
- Developments at this landfall will require a crossing agreement; and
- Based on the information available at the time of the routing desk study, no significant distinguishing characteristics with respect to the following constraints: seals, basking sharks, PMFs, Annex I habitats, and birds.

Ahead of the ScotWind bid application and following the desk-based study presented above, the Murkle Bay and Dunnet Bay landfalls and associated offshore routes were discounted. These routes posed a high technical risk, as both landfall locations:

- Required additional cable length;
- Required a number of cable crossing agreements with third parties;
- Had natural geohazards present; and
- Required mitigation due to the proximity to ferry routes.

The routes were also found to pose a moderate to high consenting risk due to:

- Commercial fisheries – higher density of fishing recorded along the offshore route, compared to the other route options;
- Shipping and navigation – shipping in the vicinity of the route due to a high number of shipping and navigation features; high levels of vessel tracks and the Orkney-Scrabster passenger ferry; and
- Other projects and cables – due to other nearby projects and cables, there was a potential for cumulative impacts as a result of installation activities and cable crossing agreements would have needed to be agreed.

Following the removal of Dunnet Bay and Murkle Bay options, at the point of ScotWind award the following landfall options remained, and were considered in the EIA Scoping Report:

- Melvich;
- Dounreay;
- Greeny Geo; and
- Crosskirk.

Following scoping, there was further consideration of the technical and environmental constraints associated with the onshore cable route options, including the engagement of a land agent. This work led to the Melvich and Dounreay landfall options to be dropped from consideration for the following reasons:

- Melvich – This was the longest proposed onshore route between cable landfall and connection to the grid at or near Spittal. There are also some very constrained areas along the route e.g., around the Reay village and golf course, which were considered too high risk for the Project; and
- Dounreay – This landfall is very constrained due to a number of future consented and potential projects in and around Dounreay including:
  - The Pentland Offshore Floating Windfarm, its offshore export cables and associated onshore infrastructure;
  - The consented Scottish Hydro Electric Transmission Limited (SHET-L) Caithness to Orkney High Voltage Alternating Current (HVAC) Link and associated onshore infrastructure; and
  - Other potential future developments at the landfall.

Following the elimination of the above landfall options, Crosskirk and Greeny Geo were retained as the final two potential landfall options for export cables.

At this time, there will be no further refinement of the landfall locations ahead of the Section 36 Consent and Marine Licence applications. It is currently anticipated that the five offshore export cables may landfall into a single location

at either Crosskirk or Greeny Geo. However, if constrained, the offshore export cables will be split across the two landfall options.

4.5.3 Red Line Boundary for offshore consent applications

At the point of Red Line Boundary (RLB) definition for the Environmental Impact Assessment (EIA), full analysis of the geotechnical data was not yet (and still isn't) available, therefore, the OAA has been retained, along with offshore ECC route options to Caithness and two landfall options for consideration in the EIA.

Once the geotechnical and further geophysical data become available further refinement of the WTG layout and offshore ECC route(s) will be undertaken. These will inform post consent requirements, including the production of post-consent document and management plans such as the Project Development Specification and Layout Plan (DSLP) and Cable plans.

4.6 Project design alternatives

At the time of production of the Scoping Report (March 2022) the Project had retained a number of options associated with different aspects of the offshore Project design, including fixed and floating foundation options, electrical architecture and cable landfall installation techniques. Since the submission of the EIA Scoping Report, a number of key decisions have been taken which have removed certain design concepts from the Project design envelope, these being:

- Floating sub-structures;
- Gravity Based Structures as an option for fixed foundations;
- Use of High Voltage Direct Current (HVDC) export cables; and
- Open Cut Trench (OCT) and rock pinning as landfall installation techniques.

The rationale behind these design decisions is provided in the sections below.

4.6.1 Floating sub-structures

Given the bathymetry within the OAA, the presence of two banks with water depths of <60 m presents an opportunity for the installation of fixed foundations. Floating foundations are only suitable for installation across 50% of the OAA, thus reducing the ability of the Project to deliver the agreed capacity. As the vast majority of the OAA is suitable for fixed foundations from a bathymetric and environmental condition perspective, and this is considered to be the more effective foundation option within the Project timeline, floating WTGs have been removed from the Project Design Envelope for the current application.

4.6.2 Gravity-based structures

Gravity based structures, generally with a concrete caisson, have a track record in shallower water depths. Deployment of these foundation types in water depths >50m and in the metocean conditions experienced at the site, will require an exceptionally large base to ensure the stability of the structure. This would lead to an economically prohibitive design (potentially 4 to 5 times the cost of a jacket in comparable water depths).

Additional downside risks include the large environmental footprint requiring several thousand cubic meters of seabed cleared to create a suitable flat surface on competent soils, supply chain (requirements for yard space for serial production) and installation abilities (weather window sensitivity). In addition, there are very limited lifting facilities that would be able to economically install a weighted gravity-based structure at the required size.

Compared to other fixed foundation options retained in the Project Design Envelope, the decommissioning of gravity-based structures is expected to be more challenging due to the ballast removal operation required and lifting the foundation from the seabed to the vessel deck.

Driven primarily by the size of the base that would be required for the offshore Project, gravity-based structures have been removed from the Project Design Envelope.

4.6.3 High voltage direct current export

The use of HVDC can offer an efficient means of transmitting a large amount of power over long distances and offers an alternate solution for connecting power to the grid. HVDC is becoming more important in the energy landscape and is supported by the need for decarbonisation. The use of HVDC can result in a smaller infrastructure footprint for a given amount of power transmitted compared to HVAC. However, HVDC is a much more capitally intensive system when compared to HVAC over shorter distances. In other words, relative losses from HVDC are smaller and HVAC costs (including losses) rise significantly over long distances.

The distance of the offshore Project from shore is at the 'breakeven point' from the tipping point (where HVDC would be advantageous), with regards to operational expenditure losses, and therefore, HVAC is considered the more efficient system overall for the Project. HVAC also offers greater flexibility to incorporate an additional circuit for a future potential connection to Flotta.

The current experience with HVAC solutions is extensive in the UK and the lead time for supply of HVAC solutions is considerably shorter than for HVDC. Based on this, and together with the distance of the Project location offshore, HVAC has been selected as the preferred option.

4.6.4 Landfall installation techniques

Following identification of the preferred landfall locations, the suitability of rock pinning, OCT and HDD cable installation techniques were considered:

- Rock pinning is the process by which cables are stabilised in areas where the seabed can maintain lateral loads. Rock bolts are used to stabilise subsea cables in rocky areas where trenching is not an option. They are typically installed using divers to ensure that the bolts are drilled into the ground and grouted;
- The OCT method requires the excavation of a trench prior to installation of the cable, and, once installation is complete, the trench is back-filled. The offshore cable can be installed from the cable lay vessel or barge by pulling from a land-based winch assisted by buoyancy aids if necessary; and
- HDD involves drilling a bore hole between two points at a specified depth through which the cable will be installed. These points are called the HDD entry and exit points respectively with the drill rig positioned at the entry point typically located above the high-water mark at a distance back from the coastline.

A landfall methodology conceptual assessment (OWPL, 2022) indicated rock pinning was an unsuitable technique at both Crosskirk and Greeny Geo, due to the technical difficulties presented by the size of the proposed cables and presence of steep rocky shelves and cliffs in the area. Similarly, OCT was not considered a feasible option for landing locations to the east and west of Crosskirk, or at Greeny Geo, due to low to medium scale cliffs and slumping dunes with an inter-tidal zone of rocky wave-cut platforms which would require significant rock removal. The central part of the Crosskirk landfall would potentially be suitable for OCT. However, large amounts of clearance would be required in terms of parallel cable separation and would result in a significant footprint which was unlikely to be achievable.

HDD installation is technically feasible at both the eastern and western areas of Crosskirk and could also be possible in the central part of Crosskirk, although less preferrable due to potential impacts to St. Mary's chapel and other possible archaeological sites. Similarly, HDD is the preferred method of installation at Greeny Geo with sufficient space available for equipment and access routes.

Due to the geographical features and associated technical risk and spatial requirement, OCT and rock pinning were removed from the Project Design Envelope and HDD installation only, for both landfalls retained in the Project Design Envelope.

4.6.5 Project design process

The Project's technical team has a structured process for technical decisions, the aims of which are:

- To provide clear justification and documentation of decisions;
- To provide clarity on the timing of decisions;
- To make clear the different options and pros and cons relating to all decisions;
- To ensure all relevant parties are consulted and informed on decisions;
- To ensure decisions consider the full range of aspects (environmental, health and safety etc.) and are not made purely on a technical or cost basis;
- To ensure decisions are made holistically across engineering packages and the wider Project considerations; and
- To ensure the decision-making process is transparent, objective and fair, without room for biases (hence the use of multi-criteria assessment and Levelised Cost of Energy (LCoE) metric).

Two tools are used to inform decision making: (i) a techno-economic model focusing on the LCoE metric which provides a method to assess overall benefits across a Project life and across all design aspects in tandem and (ii) a Strengths, Weaknesses, Opportunities, Threats (SWOT) multi-criteria assessment that captures considerations from a qualitative perspective and includes technical, commercial, environmental, health and safety and other key criteria which are weighted and scored to provide an indication of the relative merits of different options. The SWOT assessment results and the LCoE analysis are then combined to guide decision making towards a balanced solution.

Past and future technical decisions for the Project are documented and approved using a structured Design Decision Log (DDL) which incorporates Construction, Design and Management (CDM) requirements. The following are considered for each engineering design decision:

- Implications for other engineering packages;
- Cost;

- Schedule;
- Supply chain/procurement;
- Environmental;
- Health and safety; and
- Lifecycle (including decommissioning).

The DDL details the personnel involved or required to be involved in the decision (to ensure cross-package interactions are factored), any missing information and any residual risks. Each decision has a tangible document for review and approval through the Project's document control system that summarises the key considerations relating to the decision and sets out the evidence and justification for the decision made, along with any additional supporting documents or drawings.

For decisions made around the time of the Project Design Envelope development, a higher-level optioneering style process was employed based on the higher uncertainty and lower availability of data and information. This enabled early screening such as the removal of floating foundation types and HVDC transmission. These decisions did not require a fully holistic optioneering process to be employed due to the strong logic already available to justify the screening process. However, the screening process made use of multi-criteria assessments along with cost considerations. The process undertaken for the Project Design Envelope was an initial screening to rule out non feasible options for the Project in order to provide feasible potential options for consideration within the EIA. All of these decisions are documented in the DDL.

4.7 Summary

Overall, during the site selection and consideration of alternatives for the West of Orkney Windfarm, the Project has endeavoured, where possible to reduce environmental effects through the Project's design and the Project alternatives that have been considered. To date, the Project has:

- Assessed other site alternatives as presented in the SMP produced by Marine Scotland using plan level SEA, HRA and socio-economic impact assessments and consultation to guide PO areas;
- Reduced the site boundary (44% reduction between N1 PO and OAA) in order to reduce impacts to shipping, seascape, landscape and visual, aviation and commercial fisheries receptors;
- Reduced the Project Design Envelope by the removal of floating foundations, removal of gravity-based structures, the use of HVAC and the selection of HDD as a landfall installation technique. In addition, several Project parameters have since been refined, including reduction in hub height, increased lower blade tip clearance and reduction in length of inter-array cables (see chapter 5: Project description);
- Developed a strategic method to capture all decisions (past and future) to ensure all possible options are considered and the decision process clearly recorded; and
- The overall aim to provide a secure, low-carbon source of energy to meet the energy demand and support the transition to net zero while meeting the Scottish Government's climate change and renewable energy targets.

4.8 References

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4.9 Abbreviations

ACRONYM	DEFINITION
AIS	Automatic Identification System
AoS	Areas of Search
CAA	Civil Aviation Authority
CDM	Construction, Design and Management
CES	Crown Estate Scotland
CION	Construction and Infrastructure Operation Note
DDL	Design Decision Log
DPFS	Desktop Preliminary Feasibility Study
DPO	Draft Plan Option
DSLP	Development Specification and Layout Plan
ECC	Export Cable Corridor
EIA	Environmental Impact Assessment
EMEC	European Marine Energy Centre
EU	European Union
GIS	Geographic Information System
GW	Gigawatts
HDD	Horizontal Directional Drilling
HES	Historic Environment Scotland

ACRONYM	DEFINITION
HMR	Helicopter Main Route
HRA	Habitats Regulation Appraisal
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
IPCC	The Intergovernmental Panel on Climate Change
Km^2	Square kilometres
LCoE	Levelised Cost of Energy
LEZ	Launch Exclusion Zone
m	meters
MCA	Maritime and Coastguard Agency
MSL	Mean Sea Level
NLB	Northern Lighthouse Board
O&C	Opportunity and Constraint
OAA	Optional Agreement Area
OCT	Open Cut Trenching
OSP	Offshore Substation Platforms
OWF	Offshore Wind Farm
OWPS	Offshore Wind Policy Statement
PFOWF	Pentland Floating Offshore Wind Farm

ACRONYM	DEFINITION
PMF	Priority Marine Features
PO	Plan Option
PPA	Power Purchase Agreement
SCDS	Supply Chain Development Statement
SEA	Strategic Environmental Assessment
SEIA	Socio-Economic Impact Assessment
SFF	Scottish Fishermen's Federation
SHET-L	Scottish Hydro Electric Transmission Limited
SLVIA	Seascape, Landscape and Visual Impact Assessment
SMP	Sectoral Marine Plan
SNH	Scottish Natural Heritage
SPA	Special Protection Area
SSSI	Sites of Special Scientific Interest
SWFPA	Scottish White Fish Producer's Association
SWOT	Strengths, Weaknesses, Opportunities, Threats
THC	The Highland Council
UK	United Kingdom
UXO	Unexploded Ordinance
WTG	Wind Turbine Generator