



# **Spiorad na Mara Offshore Wind Farm**

## **Offshore Project**

### **Environmental Impact Assessment Report**

#### **Appendix 3.1: Percussive Piling Installation Approach, Volume 1c**

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# 1 INTRODUCTION

## 1.1 OVERVIEW

- 1.1.1.1 This appendix of the Environmental Impact Assessment Report (EIAR) presents the percussive piling installation approach for the proposed Spiorad na Mara Offshore Wind Farm (hereafter referred to as the 'Offshore Project'). The approach defines the maximum design scenario, within the Project Design Envelope (PDE), that has informed the relevant environmental assessments presented in **Chapter 6: Socio-Economics** to **Chapter 23: Offshore Human Health, Volume 2a** and the **Offshore Report to Inform Appropriate Assessment (Offshore RIAA)**.
- 1.1.1.2 This appendix should be read in conjunction with the project description provided in **Chapter 3: Offshore Project Description, Volume 1a**.

## 1.2 PROJECT BACKGROUND

- 1.2.1.1 Spiorad na Mara Limited (hereafter referred to as 'the Applicant') is proposing to develop the Project. The Project is an offshore wind farm (OWF) that will consist of up to 60 fixed-bottom wind turbine generators (WTGs).
- 1.2.1.2 The Project will include both offshore and onshore infrastructure. This Offshore EIAR supports the application for the offshore components of the Project as outlined in **Chapter 1: Introduction, Volume 1a**. The offshore components of the Project (the Offshore Project) include all infrastructure and activities located seaward of Mean High Water Springs (MHWS) within the Array Area and Offshore Cable Area of Search (OCAS) (**Figure 1.2: Offshore Project Location, Volume 1b**). Further detailed information is provided in **Chapter 3, Volume 1a**.
- 1.2.1.3 The Offshore Project is situated off the northwest coast of Isle of Lewis/*Eilean Leòdhais* and the Array Area is located approximately 5-13 km offshore and is approximately 161 km<sup>2</sup> in size. It will comprise WTGs, foundations, Offshore Cables, Offshore Substation Platform (OSP) (if required), and Landfall. The Array Area combined with the OCAS is defined as the Offshore Project Boundary. The water depths across the Turbine Area range from 37 m - 67 m with the southwest corner of the Array Area reaching 72 m. The proposed WTGs and fixed foundations will be located within a Turbine Area of approximately 140 km<sup>2</sup>, within the Array Area.

## 1.3 PURPOSE OF THIS APPENDIX

- 1.3.1.1 This appendix outlines the approach and detail around piling activities associated with the driven percussive piles for the WTGs and OSP (if required). The broad objectives of this appendix are to provide details of:

- The installation methodology;
- Key percussive pile installation parameters;
- The anticipated duration of pile driving and maximum hammer energies to be used;
- The mitigation strategy to be implemented during pile installation.

1.3.1.2 The information provided in this appendix will be further refined after consent is granted, once the final design and construction methods have been determined. These details will be formalised in a Piling Strategy, which will be reviewed and discussed with key stakeholders in relation to monitoring compliance with the specific requirements of the relevant consent conditions.

## **1.4 STRUCTURE OF THIS APPENDIX**

1.4.1.1 This appendix is structured as follows:

- Section 2: Overview of percussive piling installation;
- Section 3: Design envelope for percussive piling installation;
- Section 4: Glossary of terms and abbreviations.

## 2 OVERVIEW OF PERCUSSIVE PILING INSTALLATION

### 2.1 INTRODUCTION

- 2.1.1.1 The Offshore Project will utilise fixed foundations to secure infrastructure (WTG and the OSP) to the seabed and includes for percussive piling installation, drilling & grouting, or vibratory driving for the WTG and OSP foundations within the PDE.
- 2.1.1.2 This section provides an overview of the WTG layout, relevant design parameters and percussive piling methodology that have informed the use of percussive piling and the PDE, presented in Section 3.
- 2.1.1.3 Further details of the WTGs and the OSP parameters are provided in **Chapter 3, Volume 1a**.

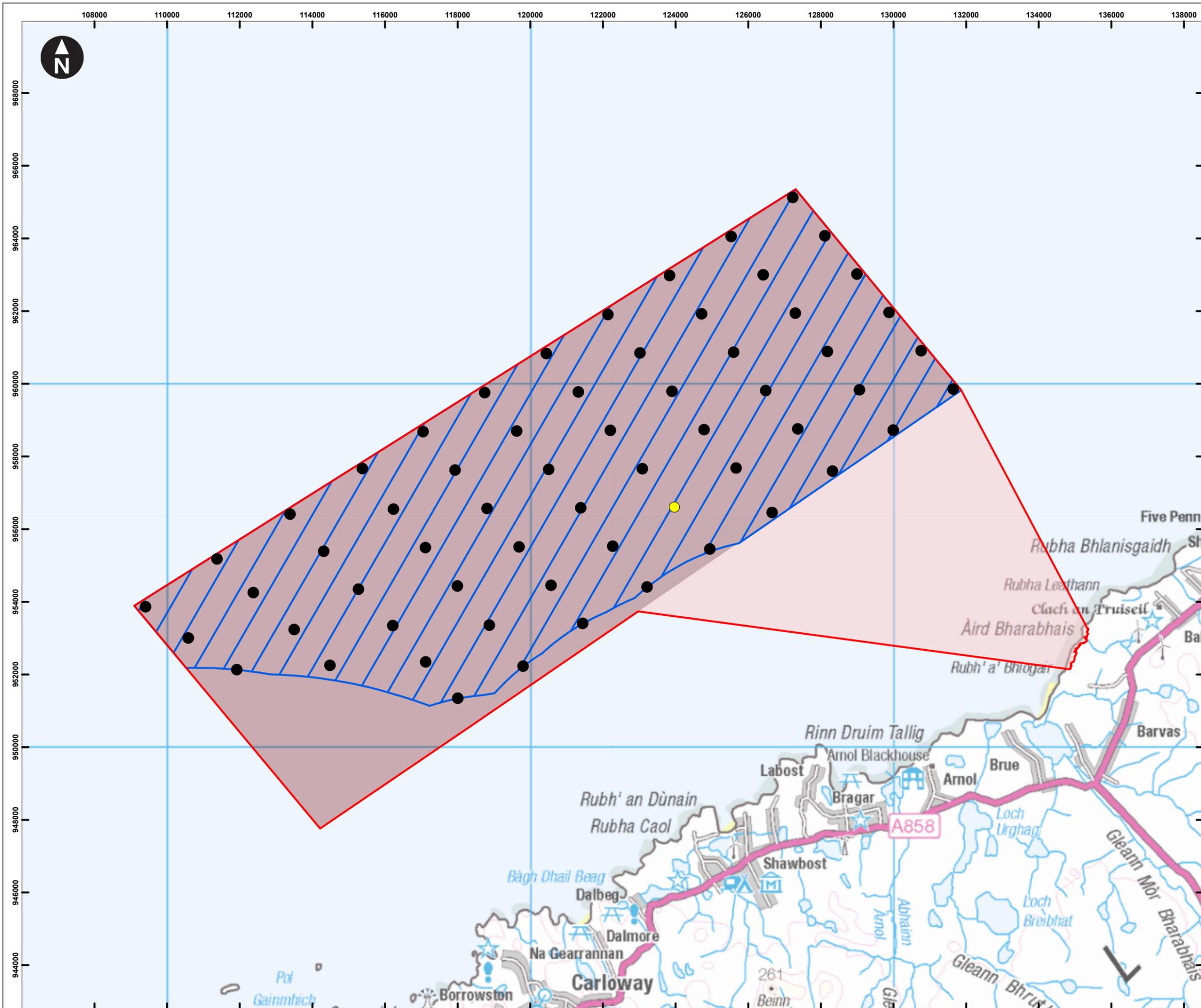
### 2.2 WIND TURBINE GENERATOR LAYOUT

- 2.2.1.1 Within the Array Area, the Turbine Area has been defined through multidisciplinary workshops, which considered baseline conditions, engineering and environmental factors along with stakeholder feedback, as outlined further in **Chapter 4: Consideration of Alternatives, Volume 1a**.
- 2.2.1.2 All surface piercing infrastructure, including WTGs and OSP (if required), will be located in the Turbine Area to reduce environmental and human impacts. The potential proportions and bounding turbine scenarios of the PDE are outlined in **Chapter 3, Volume 1a**.
- 2.2.1.3 At this stage, taking into account known constraints and opportunities, an indicative perpendicular layout for the wind farm is shown in **Plate 2-1** (see **Chapter 4, Volume 1a** for further details). The final wind farm layout and position of the WTGs and OSP will be refined post-consent, informed by detailed geophysical and geotechnical investigations to confirm seabed conditions, identify hazards and determine the suitability of the seabed for foundation installation. These assessments, alongside key safety, technical, commercial and environmental considerations, will inform the final design, including the confirmed locations of the WTG and OSP (if required) and the selected foundation installation methods.
- 2.2.1.4 Following final design, micrositing of infrastructure may be required to accommodate unexpected on-site conditions or avoid potential sensitive receptors identified as part of the EIAR, for example unknown archaeology. This is a standard approach in the construction of offshore wind farms and is considered as part of this EIAR.

The final design and capacity of the WTGs/OSP for the Offshore Project will be determined during the final design stage, adhering to the parameters set out in **Chapter 3, Volume 1a**. As is typical for OWFs, the final selection of WTGs and the overall capacity of the wind farm will be determined through the post-consent procurement process.

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Plate 2-1 Indicative turbine layout Option 1

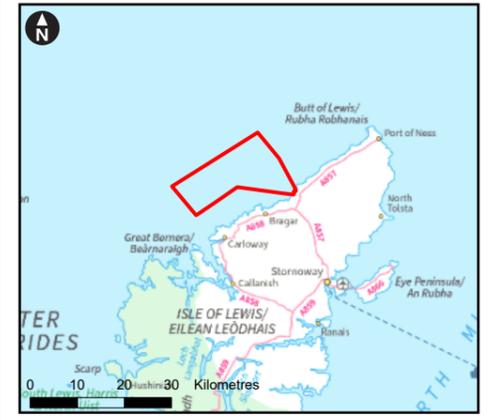


**Key**

- Offshore Project Boundary
- Offshore Cable Area of Search
- Array Area
- Turbine Area

**Option 1: Wind Turbine Generator 60 (WTG)**

- Turbine
- Offshore Substation Platform (OSP)



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Drawn: SS Checked: MS Approved: DA

Spiorad na Mara Offshore Wind Farm

**Plate 2-1**  
**Indicative Turbine Layout (Option 1)**

|                 |                                     |            |
|-----------------|-------------------------------------|------------|
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## 2.3 WIND TURBINE GENERATORS

2.3.1.1 The WTG will use a multi-leg jacket foundations design, these are a type of WTG foundation that consists of a steel lattice framework structure. The jacket structure will have either 3 or 4 legs. At this stage, 2 fixed foundation design options are under consideration for WTGs:

- **Multi-leg jacket foundations with pin piles** – to be secured to the seabed via percussive piling, drilling & grouting, or vibratory driving;
- **Hybrid multi-leg jacket with Gravity Base Structure (GBS)** – to be secured to the seabed predominantly by its weight and connections (i.e. grouted or similar material) to the prepared stable gravel bed or seabed.

## 2.4 OFFSHORE SUBSTATION PLATFORM

2.4.1.1 As outlined in **Chapter 3, Volume 1a**, the Offshore Project may include an OSP (Scenario 1). The OSP would serve as a centralised connection point for the Array Cables to OSP, which deliver electricity to the OSP, where the voltage is increased before being transmitted to landfall via Export Cables.

2.4.1.2 The installation of the OSP involves installing the foundation then lifting the topside into place. The OSP will use a fixed foundation design with up to 8 legs. Each leg will be secured to the seabed via 1 or 2 piles (up to 16 piles in total).

## 2.5 PERCUSSIVE PILING INSTALLATION METHODOLOGY

2.5.1.1 The percussive piling methodology is set out in Section 3.5.5, **Chapter 3, Volume 1a** will proceed the required seabed preparation activities. The methodology provides an outline of the activity which will be refined post-consent following further survey work, detailed design, and understanding of the construction technologies and vessels available.

## 3 DESIGN ENVELOPE FOR PERCUSSIVE PILING INSTALLATION

### 3.1 INTRODUCTION

- 3.1.1.1 The Offshore Project design has been refined over time and the resultant maximum parameters proposed for the percussive piling installation have been defined through multidisciplinary workshops and taken consideration of baseline conditions, engineering and environmental factors along with stakeholder feedback.
- 3.1.1.2 The refinement of percussive piling installation has been primarily driven by environmental considerations, such as geological baseline conditions and potential underwater noise impacts on sensitive receptors, such as migratory fish and marine mammals. Further detail on how the evolution and refinement of the percussive piling installation approach has been developed and refined through the design process is outlined in **Chapter 4, Volume 1a**.
- 3.1.1.3 This section outlines the resultant maximum parameters proposed for the percussive piling installation and includes details on percussive piling spatial and duration restrictions; variable hammer energy, programme, installation specific parameters and maximum hammer energy parameters; and noise abatement measures.
- 3.1.1.4 The maximum parameters and relevant commitments have been used to inform the relevant environmental assessments presented in **Chapter 6 to Chapter 23, Volume 2a**. Additional secondary mitigation has been considered within the Environmental Impact Assessment (EIA) and RIAA to reduce the potential impact of the percussive piling installation, as required. This is outlined within the relevant technical EIAR chapters (see **Chapter 12: Fish Ecology, Volume 2a, Appendix 12.3: Overview of Percussive Piling Fish Ecology Mitigation, Volume 2c, Chapter 13: Marine Mammals, Volume 2a** and **Chapter 19: Offshore Airborne Noise, Volume 2a**) and Section 7 of the **Offshore RIAA**.

### 3.2 PERCUSSIVE PILING RESTRICTIONS

- 3.2.1.1 The following parameters inform the EIA. However, the conclusions of pre-construction surveys, and/or technological advances in both hammer design and mitigation measures may ultimately mean that a higher hammer energy could be deployed but it is envisaged that this will be regulated through the imposition of conditions which will ensure that the resulting effects will be no greater than what has been concluded in this EIAR and the **Offshore RIAA**.

#### Percussive piling spatial restriction

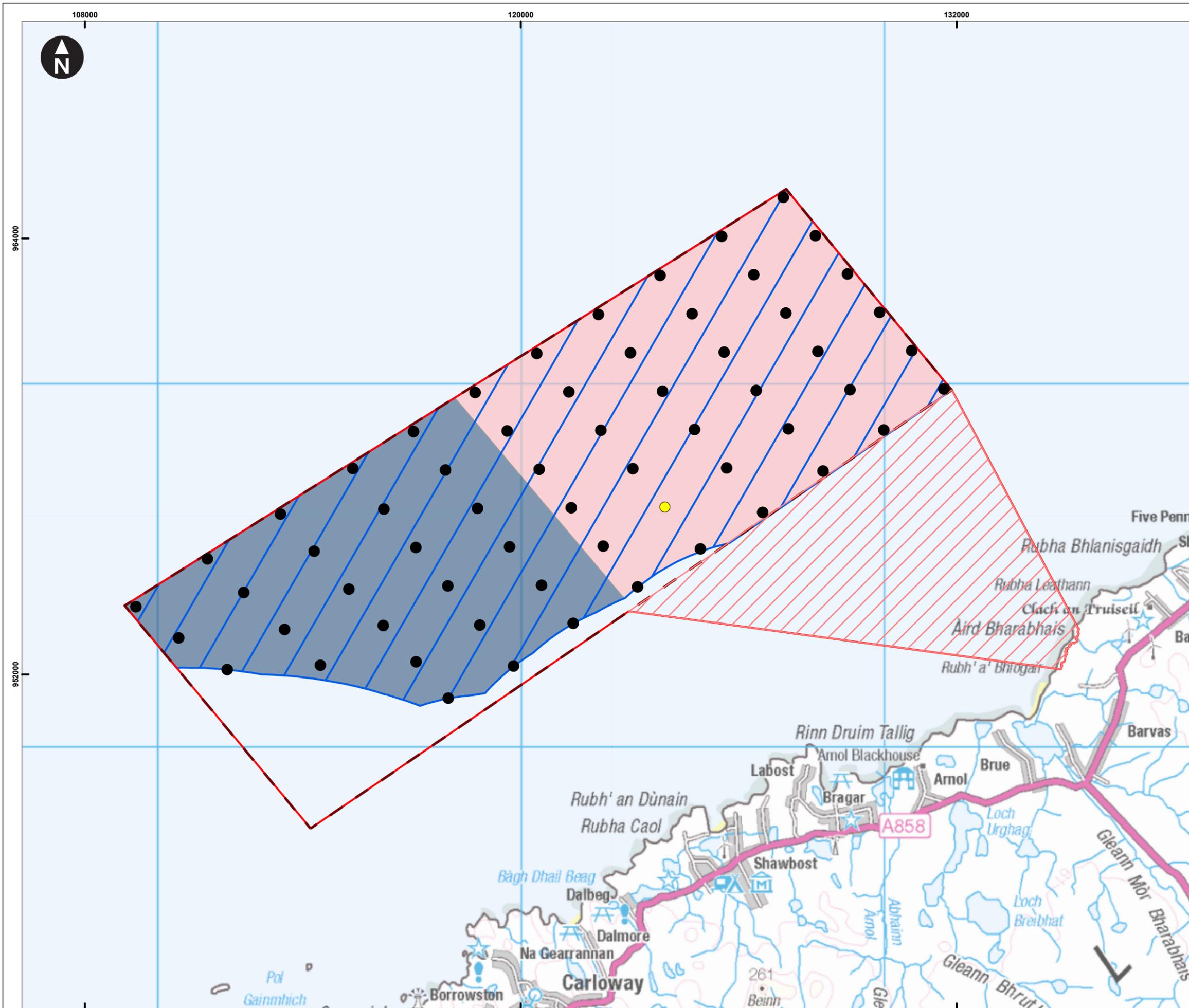
- 3.2.1.2 In the southwest of the Turbine Area a Percussive Piling Exclusion Area has been defined in which only drill and grout pin pile installation can be used (see **Plate 3-1**). This area has been defined

with the purpose of reducing the extent of potential underwater noise impact to migrating fish from Loch Roag/*Loch Ròg*.

- 3.2.1.3 The maximum design scenario for foundation installation is for the smallest WTG type as a greater number of piles will need to be installed. **Chapter 3, Volume 1a** states that for the smallest WTG type, a maximum of 60 turbines will be installed.
- 3.2.1.4 Based on the indicative layout for the smallest WTG (see **Plate 3-1**) a maximum of 35 WTGs and the OSP are located within the northeast portion of the Turbine Area in which percussive piling installation can be undertaken (hereafter referred to as 'Percussive Piling Area'). The remaining maximum of 25 WTGs are located within the Percussive Piling Exclusion Area, where only drill and grout installation of pin piles are permitted.
- 3.2.1.5 Although percussive piling is constrained to the Percussive Piling Area for pin pile installation, within the PDE drill and grout multi-leg jacket foundation installation is an option for the entire Turbine Area (see **Chapter 3, Volume 1a** and **Chapter 9: Physical and Coastal Processes, Volume 2a**).

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Plate 3-1 Location of Percussive Piling Area and Percussive Piling Exclusion Area within the Turbine Area

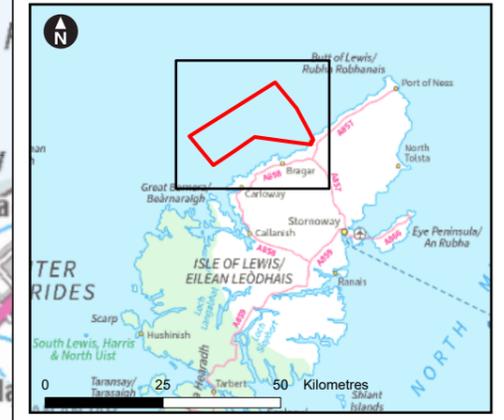


**Key**

- Offshore Project Boundary
- Offshore Cable Area of Search
- Turbine Area
- Percussive Piling Area
- Percussive Piling Exclusion Area

**Option 1: Wind Turbine Generator 60 (WTG)**

- Turbine
- Offshore Substation Platform (OSP)



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Spiorad na Mara Offshore Wind farm

**Plate 3-1**  
**Location of Percussive Piling Area and Percussive Piling Exclusion Area within the Turbine Area**

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### Percussive piling daily duration restriction

3.2.1.6 The Offshore Project has limited the length of percussive piling installation to 5.5 hours for piles / 4.5 hours for casings per 24-hour period. This is inclusive of soft start and ramp up procedures, for further detail on these procedures see **Appendix 13.3: Underwater Noise Modelling Assessment, Volume 2c**. In principle, multiple piles could be installed within a 24-hour period, provided that the 5.5 hour maximum is not exceeded.

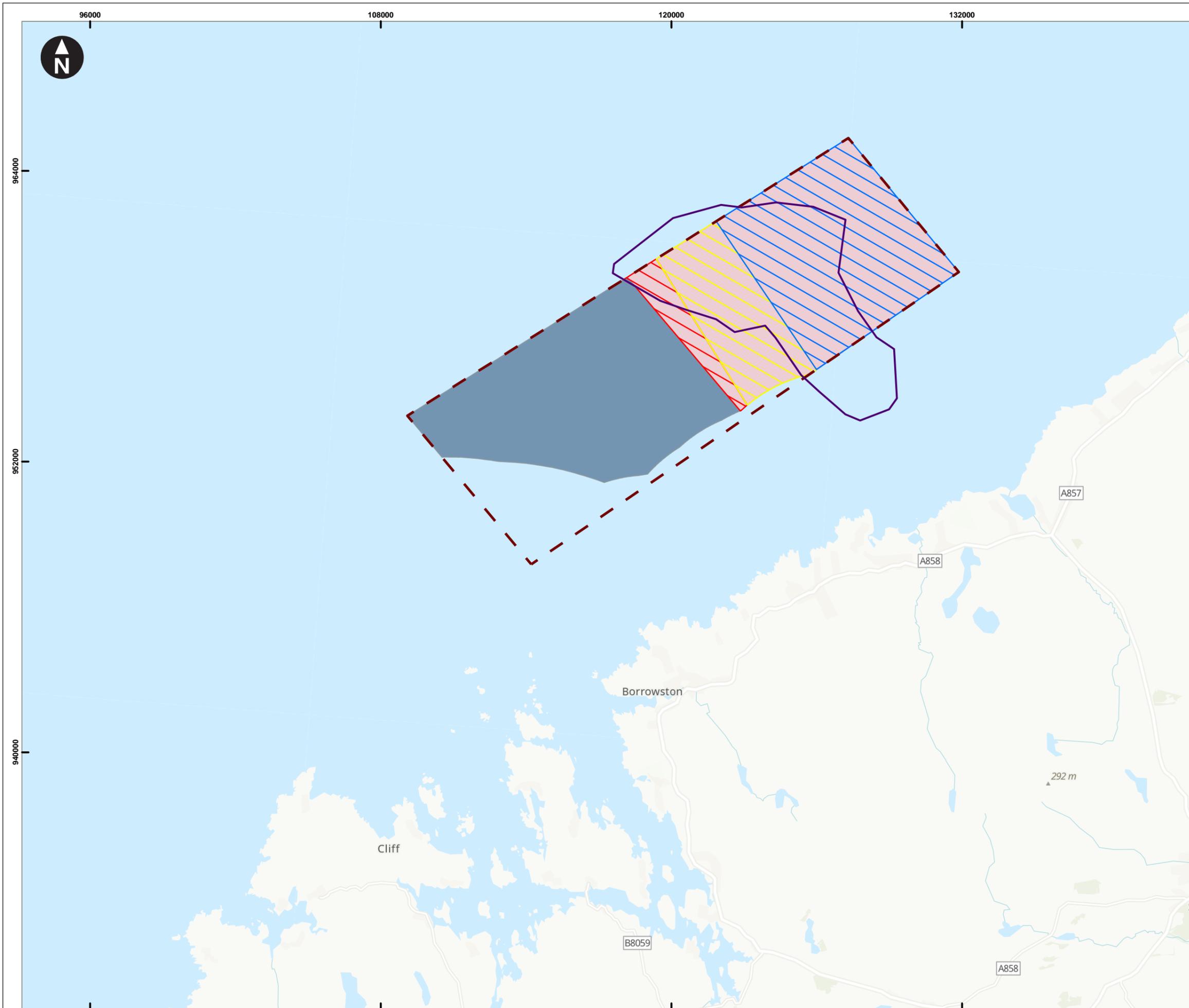
### Variable hammer energy

3.2.1.7 The Percussive Piling Area has been split into 3 zones (2,500 kJ Max; 3,500 kJ Max; 5,000 kJ Max) to limit the maximum hammer energy (see **Plate 3-2**). The hammer energy reduces towards the southeast of the Percussive Piling Area that is closest to the mouth of Loch Roag/*Loch Ròg* to reduce the zone of impact for migrating fish (see **Chapter 12, Volume 2a** and Section 7 of the **Offshore RIAA**).

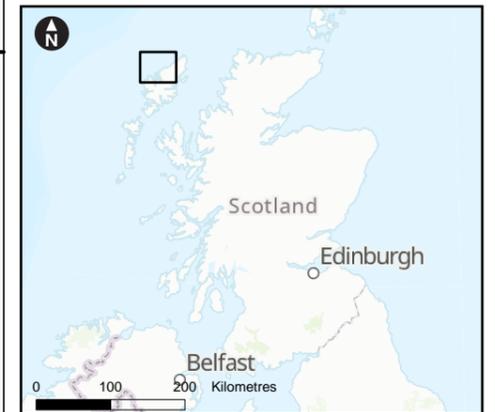
3.2.1.8 Further details of the hammer energy parameters are presented in Section 3.4 and **Table 3-3**.

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Plate 3-2 Variable hammer energy zones within the Turbine Area



- Key
- Array Area
  - Buried Channel
  - Percussive Piling Area
  - Percussive Piling Exclusion Area
- Piling Energy Zones**
- Red 2,500 kJ
  - Yellow 3,500 kJ
  - Blue 5,000 kJ



0 1.5 3 4.5 6 Kilometres

Scale at A3:1:150,000

World Topographic Map: Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community



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Spiorad na Mara Offshore Wind farm

**Plate 3-2**  
**Variable hammer energy zones**  
**within the Turbine Area**

|                                     |            |
|-------------------------------------|------------|
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### Concurrent piling

3.2.1.9 The Offshore Project will not undertake any concurrent piling operations for percussive piling installation.

## 3.3 PROGRAMME

3.3.1.1 An indicative construction programme for the Offshore Project is provided in Section 3.7 of **Chapter 3, Volume 1a**. It is anticipated that the offshore construction works will commence in 2028/2029 and be completed within 5 years. Due to construction feasibility (weather conditions), the Applicant will undertake percussive piling between late spring and early autumn months. Foundation installation operations (including percussive piling) will take place between April to October over a 2 year period (April to October 2030/2031).

3.3.1.2 In order to understand the maximum design scenario of the percussive piling installation, the Offshore Project has outlined the maximum number of piles to be installed throughout the programme to inform the EIAR.

3.3.1.3 This is based upon a maximum of 35 WTGs (up to 4 piles per WTG) and the OSP (up to 16 piles) being located within the Percussive Piling Area. Therefore, a total of up to 156 piles will be installed by percussive piling. On average, it is anticipated that 1 pile will be installed every 2.7 days between April to October over a 2-year period during the percussive piling installation.

## 3.4 PERCUSSIVE PILING INSTALLATION MAXIMUM DESIGN SCENARIO

3.4.1.1 Based on the PDE described in Section 2 and in **Chapter 3, Volume 1a**, the percussive piling installation parameters for WTGs are outlined in **Table 3-1** and parameters for the OSP are in **Table 3-2**. The estimated maximum hammer energy parameters for percussive piling installation are outlined in **Table 3-3**.

Table 3-1 WTG percussive piling installation parameters

| Parameter                                 | Maximum Design Parameter |
|---|--------------------------|
| Number of WTG requiring percussive piling | 35                       |
| Maximum number of pin piles per WTG       | 4                        |
| Total number of pin piles                 | 140                      |
| Maximum pin pile diameter                 | 5 m                      |
| Embedment depth (below seabed)            | 15 – 120 m               |
| Maximum seabed footprint per pile         | 30 m <sup>2</sup>        |

Table 3-2 OSP percussive piling installation parameters

| Parameter                                 | Maximum Design Parameter                           |
|---|--|
| Number of WTG requiring percussive piling | 1  |
| Total number of pin piles                 | 16 (up to 8 legs and each leg may require 2 piles) |
| Maximum pin pile diameter                 | 5 m  |
| Embedment depth (below seabed)            | 20 -120 m  |
| Maximum seabed footprint per pile         | 30 m <sup>2</sup>                                  |

Table 3-3 Hammer energy parameters

| Parameter   | Maximum Design Parameter                    |
|---|---|
| Maximum percussive piling duration per 24 hour period | 5.5 hours for piles / 4.5 hours for casings |
| Maximum hammer strikes per 24 hour period             | 10,635                                      |
| Strike rate   | 34 blows per minute                         |
| Soft start strike rate                                | 1 – 6 blows per minute for 5 minutes        |
| Ramp up strike rate                                   | 6 – 34 blows per minute for 15 minutes      |
| Maximum hammer energy                                 | 2,500 – 5,000 kJ                            |
| Initial hammer energy                                 | 550 kJ                                      |
| 2,500 kJ zone – number of pin piles*                  | 20 (for 5 WTGs)                             |
| 2,500 kJ zone – total energy delivered                | 25,280,250 kJ                               |
| 3,500 kJ zone – number of pin piles*                  | 40 (for 6 WTGs + 1 OSP)                     |
| 3,500 kJ zone – total energy delivered                | 35,038,250 kJ                               |
| 5,000 kJ zone – number of pin piles*                  | 96 (for 24 WTGs)                            |
| 5,000 kJ zone – total energy delivered                | 49,692,250 kJ                               |
| Noise abatement                                       | 12dB reduction at source                    |

\*Indicative number of pin piles based on the indicative layout presented in **Plate 2-1**.

## 3.5 NOISE ABATEMENT

3.5.1.1 Any piling undertaken for the Offshore Project will include a system for noise abatement, which will provide a reduction in the noise that can spread to the surrounding water. A specific system for noise abatement will be confirmed during detailed design, but a noise reduction of 12 dB will be achieved, and has been included in the modelling results used to inform the relevant environmental assessments (see **Appendix 13.3, Volume 2c**).

## 3.6 PERCUSSIVE PILING MITIGATION MEASURES

3.6.1.1 As part of the Offshore Project design process, a number of embedded mitigation measures have been adopted to reduce the potential for impacts from percussive piling installation. These

embedded mitigation measures have evolved as the EIA has progressed and in response to consultation (see **Appendix 5.4: Stakeholder Consultation and Engagement, Volume 1c**).

- 3.6.1.2 The embedded mitigation measures also include established good or standard practice and include actions that are required to meet existing legislative obligations. As these measures will be secured through Section 36 and marine licence conditions, and align with recognised sectoral practices, they are considered an inherent part of the Offshore Project design and are set out in this EIAR.

## 4 GLOSSARY OF TERMS AND ABBREVIATIONS

4.1.1.1 A list of key terms and acronyms used in this appendix are provided in **Table 4-1** and **Table 4-2**.

Table 4-1 Acronyms and abbreviations

| Term   | Definition                                     |
|--------|--|
| EIA    | Environmental Impact Assessment                |
| EIAR   | Environmental Impact Assessment Report         |
| GBS    | Gravity Base Structure                         |
| kJ     | Kilojoules                                     |
| MD-LOT | Marine Directorate – Licensing Operations Team |
| MMMP   | Marine Mammal Mitigation Protocol              |
| OCAS   | Offshore Cable Area of Search                  |
| OSP    | Offshore Substation Platform                   |
| PDE    | Project Design Envelope                        |
| RIAA   | Report to Inform Appropriate Assessment        |
| SAC    | Special Area of Conservation                   |
| WTG    | Wind Turbine Generator                         |

Table 4-2 Glossary

| Term  | Meaning   |
|---|---|
| the Applicant                                 | Spiorad na Mara Limited (the Project owner)   |
| Array Area                                    | The offshore area within which the offshore wind turbine generators (WTGs), associated foundations, Offshore Cables, and Offshore Substation Platform (OSP) (if required), will be located. This area encompasses the Turbine Area that will contain all above water surface infrastructure (WTGs / OSP) and an additional area within which further below water infrastructure (foundations and cables) may also be located. |
| Environmental Impact Assessment Report (EIAR) | The Environmental Impact Assessment Report (EIAR) prepared to assess the likely significant effects of the Project on the environment.  |
| Embedded or 'Designed-in' Mitigation          | Mitigation measures to avoid or reduce environmental effects that are directly incorporated into the preferred design for the Project. This can include standard practice in accordance with or without guidance. Embedded mitigation is considered as part of the impact assessment, before effect significance is identified.   |
| Impact  | Change that is caused by an action; for example, foundation installation (action) during construction which results in habitat loss (impact)  |
| Jacket Foundation                             | A steel lattice framework structure with 3 or 4 legs used as a foundation for WTGs, secured to the seabed with pin piles or by gravity base.  |

| <b>Term</b>                          | <b>Meaning</b>  |
|--------------------------------------|---|
| Offshore Cable Area of Search (OCAS) | The area within which the offshore electrical and communication cables between the Array Area and Landfall up to Mean High Water Springs (MHWS) will be located.  |
| Offshore Project                     | The offshore components of the Spiorad na Mara offshore wind farm (the Project) located seaward of Mean High Water Springs (MHWS).  |
| Offshore Substation Platform (OSP)   | The optional offshore substation located within the Array Area. Includes the platform and associated components which allows the voltage to be increased to meet onward transmission requirements.  |
| Percussive Piling                    | <p>A method of installing piles and pile casings into the seabed using an impact hammer. This form of piling can be solely used if ground conditions are suitable. If pile depth cannot be achieved through percussive piling alone, a pile-drill-pile technique can be used to reach desired depths.</p> <p>The percussive piling technique can be used for the installation of the Wind Turbine Generators (WTGs) and the Offshore Substation Platform (OSP) (if required) located within the Percussive Piling Area.</p> |
| Percussive Piling Area               | The area within the Turbine Area where both percussive piling, and drill and grout construction methods can be used for the installation of the wind turbine generators (WTGs) and the Offshore Substation Platform (OSP) (if required) fixed foundations.  |
| Percussive Piling Exclusion Area     | An area in the southwest of the Turbine Area where there will be no percussive piling. Other methods including drill and grout or vibratory methods can be used in this area.   |
| Project Design Envelope              | A description of the range of possible components that make up the Project design options under consideration when the exact engineering parameters are not yet known.  |
| Pin Pile                             | A long, slender steel pile installed into the seabed to anchor offshore structures such as WTGs and OSPs  |
| Scoping Opinion                      | A report presenting the written opinion of the Scottish Ministers, with input from Comhairle nan Eilean Siar (CnES) for the Onshore Transmission Works, as to the scope and level of detail of information to be provided in the Environmental Impact Assessment (EIA) for the Project.   |
| Soft Start / Ramp Up                 | Procedures to gradually increase hammer energy and strike rate at the start of piling to mitigate impacts on marine life.   |
| Turbine Area                         | A reduced area within the Array Area where above water surface infrastructure would be located i.e. wind turbine generators (WTG) and Offshore Substation Platform (OSP) (if required). This area has been developed and refined through stakeholder engagement and environmental assessment.   |
| Wind Turbine Generator (WTG)         | The wind turbines that generate electricity consisting of tubular towers and blades attached to a nacelle housing mechanical and electrical generating equipment  |

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