Offshore Wind Power Limited

West of Orkney Windfarm Offshore EIA Report

Volume 2, Supporting Study 1: Climate and Carbon Assessment

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1 INTRODUCTION

The Applicant, Offshore Wind Power Limited (OWPL) is proposing the development of the West of Orkney Windfarm ('the Project'), an Offshore Windfarm (OWF), located approximately 23 kilometres (km) from the north coast of Scotland and 28 km from the west coast of Hoy, Orkney. Crown Estate Scotland (CES) awarded OWPL the Option Agreement Area (OAA) in January 2022 for the development of the proposed Project following the ScotWind leasing round which launched in June 2020. The OAA lies wholly within the "N1" Plan Option (PO), which was one of 15 PO areas around Scotland that the Scottish Government considered suitable for the development of commercial scale OWFs according to the Sectoral Marine Plan. Of these 15 POs, following the ScotWind leasing round and subsequent clearing process, 20 developments have obtained Options for Lease agreements.

The climate change and carbon impact assessment for the Project is summarised in this supporting study and broadly utilises the Environmental Impact Assessment (EIA) methodology and approach which is presented in chapter 7: EIA methodology of the Onshore EIA Report and the Offshore EIA Report. This supporting study has been produced in accordance with relevant legislation, policy and guidance, as outlined in Section 2, and in line with feedback provided in the onshore and offshore Scoping Opinions for the Project, as outlined in Section 3.

This supporting study provides a detailed description of the future climate baseline over the lifetime of the offshore and onshore Project, focussing on key changes in climate variables that will affect the physical, biological and socio-economic environment. In the context of this future climate baseline and the offshore and onshore Project design, this supporting study provides an overarching assessment of all climate and carbon-related impacts for the Project, including:

- The vulnerability of the Project to climate change, focussing on the ability of the Project to withstand, respond to and recover from changes in climate - climate resilience review (Section 6);
- The combined effects of the Project, as assessed in the Onshore and Offshore EIA Reports, and climate change on the physical, biological and socio-economic environment - In-combination Climate Impact (ICCI) assessment (Section 7); and
- The effects of the Project on the climate, including:
  - The disturbance or loss of biological carbon stores (including blue carbon and onshore biological carbon stores) – biological carbon assessment (Section 8); and
  - The carbon life cycle emissions resulting from the Project and the carbon payback period - carbon assessment (Section 9).

Figure 1-1 shows the outline process for the assessments presented within this supporting study, including the key aspects that have informed the assessments.

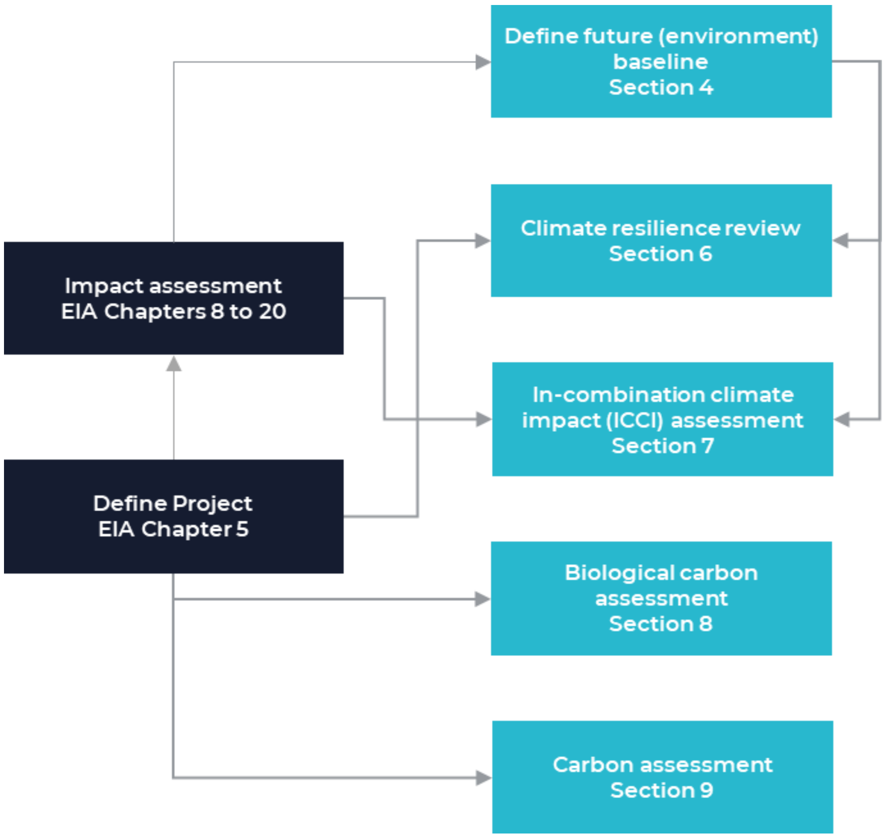


Figure 1-1 Outline process for the climate and carbon assessments

The following entities have contributed to the assessment:

- OWPL – preparation of the climate assessment; and
- Xodus Group Limited (Xodus) – approach to climate assessment and preparation of the carbon assessment.

2 LEGISLATION, POLICY, AND GUIDANCE

This section sets out the relevant legislation and guidance applicable to the climate and carbon topic that is additional to the general legislation presented in EIA report (Offshore and Onshore EIA Reports) chapter 3: Planning policy and legislative context.

2.1 Legislation

- The Climate Change (Scotland) Act 2009: Section 1 of this legislation originally set a target for an 80% reduction in emissions by the year 2050. Subsequent amendments to this legislation were made (see below) to increase the ambition of Scotland's emissions reduction targets.
- The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019: This legislation increased the ambition of Scotland's emissions reduction target within Section 1 of The Climate Change (Scotland) Act 2009 to net zero by 2045 and revised interim and annual emissions reduction targets (Table 2-1):

Table 2-1 Interim and selected annual targets set by Scotland's climate change legislation (presented as every 5 years from 2025 to 2045) (Scottish Government, 2023a)

YEAR	CARBON REDUCTION TARGET[1]
2025	61.7%
2030 (interim target)	75.0%
2035	82.5%
2040 (interim target)	90.0%
2045	100 % (net zero emissions)

- The EIA Regulations for the Project, including The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017 (as amended); The Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017 (as amended); The Marine Works (Environmental Impact Assessment) Regulations 2007 (for the offshore Project), and The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017 (for the onshore Project):
  - Schedule 3 of The Marine Works (Environmental Impact Assessment) Regulations 2007 and Schedule 4 of the other EIA Regulations requires:
    - A description of the relevant aspects of the current state of the environment (the "baseline scenario") and an outline of the likely evolution thereof without implementation of the project as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge;
    - A description of the aspects of the environment likely to be significantly affected by the development, including, in particular, population, fauna, flora, soil, water, air, climatic factors, material assets, including the architectural and archaeological heritage, and landscape; and

[1] *Expressed as percentage reductions from the 1990/1995 baseline.*

    - A description of the likely significant effects of the development on the environment resulting from the impact of the project on climate (for example the nature and magnitude of Greenhouse Gas (GHG) emissions) and the vulnerability of the project to climate change.
- International frameworks including the United Nations (UN) Framework Convention on Climate Change (UNFCCC) (1992), the Kyoto Protocol (1997) and the Paris Agreement (2015):
  - The UNFCC was adopted with the ultimate aim of preventing dangerous human interference with the Climate system. The Kyoto Protocol and the Paris agreement then built on the Convention.
  - The Kyoto Protocol committed industrialised countries and economies in transition to limit and reduced GHG emissions in accordance with agreed targets.
  - The Paris Agreement aims to hold the increase in the global temperature average to well below 2°C above pre-industrial levels and limit the temperature increase to 1.5°C above pre-industrial levels.
- Islands (Scotland) Act 2018:
  - The Islands' (Scotland) Act 2018 introduced measures to help create the right environment for sustainable growth in and around Scotland's islands now and in the future. This includes the development of a National Islands Plan, published in 2019 (Scottish Government, 2019a). Strategic Objective 9 of the plan is "to contribute to climate change mitigation and adaptation and promote clean, affordable and secure energy". The commitments under the objective relate to achieving net-zero emissions, securing renewable energy and to implement plans to improve the resilience of the Islands to climate change.

2.2 Policy

- Climate change policy:
  - Blue Economy Vision (Scottish Government, 2022): This plan sets out the long-term vision for Scotland's Blue Economy (the marine, coastal and the inter-linked freshwater environment) and identifies six outcomes up to 2045 to deliver on the aspirations for the marine environment. Of the six outcomes, those related to this report are:
    - Scotland's marine ecosystems are healthy and functioning, with nature protected and activities managed using an ecosystem-based approach to ensure negative impacts on marine ecosystems are minimised and, where possible, reversed; and
    - Scotland's blue economy is resilient to climate change, contributing to climate mitigation and adaptation, with marine sectors decarbonised, resource efficient and supporting Scotland's Net Zero and Nature Positive commitments.
  - Scottish biodiversity strategy post-2020: statement of intent (Scottish Government, 2020): Sets the direction for a new biodiversity strategy which will respond to the increased urgency for action to tackle the twin challenges of biodiversity loss and climate change.
  - Climate ready Scotland: climate change adaptation programme 2019-2024 2024 (Scottish Government, 2019b): The second report, as required under Section 53 of the Climate Change (Scotland) Act 2009 was launched in September 2019, and outlines how Scotland is preparing for the impacts of climate change over the period to.
  - British Energy Security Strategy (BEIS, 2022a): A 10-point plan, primarily focussed on investment in the North Sea to reduce dependence on imported oil and gas, and deliver an accelerated transition from fossil fuels.
- Marine planning policy:
  - Scotland's National Marine Plan (Scottish Government, 2015): This plan sets out policies and objectives requiring marine planners and decision makers to consider the potential impacts of a development on the

marine environment and is useful to identify some of the key concerns and issues that should be addressed in any impact assessment. Policies relevant to this chapter include:

    - GEN 5 – "*Marine planners and decision makers must act in the best way calculated to mitigate, and adapt to, climate change*".
    - Renewables 7 – "*Marine planners and decision makers should ensure infrastructure is fit for purpose now and in the future. Consideration should be given to the potential for climate change impacts on coasts vulnerable to erosion*".
  - The Pilot Pentland Firth and Orkney Waters Marine Spatial Plan (Scottish Government, 2016): This non-statutory plan sets out an integrated planning policy framework to guide marine development, activities and management decisions, whilst ensuring the quality of the marine environment is protected.
  - Draft Orkney Marine Spatial Plan (Orkney Island Council, 2022): General Policy 3 of this draft plan supports the implementation of carbon reduction measures, a rapid transition to zero carbon energy generation and fuels, climate change adaptation sustainable economic development, activities and use, and, alignment with public authorities climate change duties.
    - General Policy 3c: Proposals for development and/or activities are required to demonstrate that adequate climate change adaptation and resilience measures, including appropriate nature-based solutions, have been built into the project over its lifetime.
- Onshore planning policy:
  - National Planning Framework 4 (NPF4) (Scottish Government, 2023b): Policy 1 gives significant weight to the global climate emergency in order to ensure that it is recognised as a priority in all plans and decisions
  - Highland-Wide Local Development Plan (HwLDP) (The Highland Council, 2012): Policy 64 highlights if the development borders the coast and therefore may be at risk from climate change; and
  - Caithness and Sutherland Local Development Plan (CaSPlan), 2018 (The Highland Council, 2018): Describes the investment of renewable energy in the area to help adapt to the unavoidable impacts of a changing climate.

2.3 Guidance

- Institute of Environmental Management and Assessment (IEMA) Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation (IEMA, 2020): This document serves as a reference point and guidance for considering climate change resilience and adaptation in EIA; and
- IEMA Environmental Impact Assessment Guidance to Assessing Greenhouse Gas Emissions and Evaluating their Significance – 2nd Edition (IEMA, 2022): This guide provides assistance with addressing GHG emissions assessment and mitigation in EIAs and complements the climate change guidance.

3 SCOPING AND CONSULTATION

Stakeholder consultation has been ongoing throughout the EIA and has played an important part in ensuring the scope of the baseline characterisation and impact assessment are appropriate with respect to the Project and the requirements of the regulators and their advisors.

The Scoping Report was submitted to Scottish Ministers (via Marine Scotland - Licensing Operations Team (MS-LOT)[2]) and The Highland Council (THC) on 1st March 2022, who then circulated the report to relevant consultees[3]. Relevant comments from the Offshore and Onshore Scoping Opinions are detailed in Table 3-1, which provides a response on how these comments have been addressed within this climate and carbon assessment report.

[2] MS-LOT have since been renamed the Marine Directorate - Licensing Operations Team (MD-LOT).

[3] The Scoping Report was also submitted to the Orkney Islands Council (OIC), as the scoping exercise included consideration of power export to the Flotta Hydrogen Hub, however, this scope is not covered in the Onshore and Offshore EIA Report and will be subject to a separate Marine Licence application to MD-LOT and a planning application to OIC.

Table 3-1 Summary of scoping opinion responses specific to climate and carbon assessment

CONSULTEE	COMMENT	RESPONSE
Offshore Scoping Opinion and consultee responses		
Scottish Ministers (via MS-LOT)	Section 1.4.6.3 of the Scoping Report proposes that the impact of climate change effects will be considered in a standalone assessment that will be appended to the EIA Report. The Scottish Ministers agree with the approach outlined by the Developer in the Scoping Report and that the assessment will be based on a Life Cycle Assessment ("LCA") approach and note that the IEMA Environmental Impact Assessment Guide "Assessing Greenhouse Gas Emissions and Evaluating Their Significance" ("IEMA GHG Guidance") will be utilised to provide further insight on this matter. For the avoidance of doubt the Scottish Ministers advise that this standalone assessment must include the pre-construction, construction, operation and decommissioning phases of the Proposed Development, including consideration of the supply chain as well as benefits beyond the life cycle of the Proposed Development.	The carbon assessment has considered all stages of the Project, including manufacturing of materials and components through to decommissioning. This has been based on an LCA approach, as requested. The carbon payback, which represents the period of time before a product or Project has avoided more Carbon Dioxide Equivalent (CO_2e) emissions than has been produced by its construction and operation, is provided in Section 9.7.2. The Project will have a positive contribution to achieving the United Kingdom (UK) carbon budget and will avoid the use of more carbon-intensive forms of energy production, such as fossil-fuels, as outlined in Section 9.7.2. The effects of this positive contribution towards climate change reduction goals and targets extend beyond the life cycle of the Project.
NatureScot	Assessment approach: The impact of climate change effects should be considered, both in future proofing the project design and how certain climate stressors may work in combination with potential effects from the proposed wind farm. The EIA Report should also consider the carbon cost of the wind farm (including supply chain) and to what extent this is offset through the production of green energy.	This climate and carbon assessment has been prepared as a supporting document to the Offshore EIA Report and Onshore EIA Report and assesses the vulnerability of the onshore and offshore Project to climate change (see Section 6) and presents the carbon impact assessment (see Section 9). The potential in-combination impact of climate stressors on the effects of the Project have been considered (see Section 7).

CONSULTEE	COMMENT	RESPONSE
NatureScot	We are broadly content with the impacts that are scoped in. However, we recommend the following additional impact should also be scoped in for assessment: Change to coastal processes and landforms resulting from measures to address any re-exposure by coastal change of a buried cable landfall.	Offshore EIA Report, chapter 8: Marine physical and coastal processes assesses the potential re-exposure of buried cables at the landfall and changes to coastal processes and landfall morphology during the operation and maintenance stage. Furthermore, the vulnerability of the offshore Project to projected changes in sea level rise and coastal erosion is assessed in Section 6.
NatureScot	Potential impacts: Due to accelerating sea level rise, some landfall locations could experience coastal retreat over decades, manifested as periodic beach lowering and erosion of the coastal edge during clusters of storms. If this resulted in re-exposure of buried cable(s), then work to secure the cable(s) such as re-burial or installation of hard protection, could affect coastal processes and landforms. Robust planning for this eventuality would help adapt the overall project to one of the key effects of climate change.	Offshore EIA Report, chapter 8: Marine physical and coastal processes assesses the potential re-exposure of buried cables at the landfall and changes to coastal processes and landfall morphology during the operation and maintenance stage. Furthermore, the vulnerability of the offshore Project to projected changes in sea level rise and coastal erosion is assessed in Section 6.
Onshore Scoping Opinion and consultee responses		
THC	A statement is required which outlines the main development alternatives studied by the applicant and an indication of the main reasons for the final project choice. This is expected to highlight the following: • The range of routes that may have been considered; • Locational criteria and economic parameters used in the location selection; • Design and locational options for all elements of the proposed development; and • The environmental effects of the different options examined. Such assessment should also highlight sustainable development attributes including for example assessment of carbon emissions / carbon savings and biodiversity net gain.	A description of the site selection process and assessment of alternatives is included within the EIA Reports (chapter 4 of the Offshore and Onshore EIA Report). This report provides an assessment of the climate resilience as well as an assessment of carbon emissions and carbon savings. The incorporation of carbon emissions / carbon savings in the Project design has been considered and will continue to be so through to detailed design.

CONSULTEE	COMMENT	RESPONSE
		A separate Outline Biodiversity Enhancement Plan has been produced which details the various proposals for biodiversity enhancement being considered by the Project (OWPL, 2023).
THC	Carbon balance calculations should be undertaken and included within the EIAR with a summary of the results provided focussing on the carbon payback period for the wind farm.	A carbon assessment is provided in Section 9. The carbon payback period is discussed in Section 9.7.2.
THC	The EIAR needs to address all relevant climatic factors which can greatly influence the impact range of many of the preceding factors on account of seasonal changes affecting, rainfall, sunlight, prevailing wind direction etc. From this base data information on the expected impacts of any development can then be founded recognising likely impacts for each phase of development including construction, operation and decommissioning. Issues such as dust, air borne pollution and / or vapours, noise, light, can then be highlighted. Consideration must also be given to the potential health and safety risks associated with lightning strikes given the proximity of recreational routes through the site.	This report assesses and addresses all relevant climatic factors which may influence the impact range of many prevailing factors and subsequently the impacts upon each stage of the project (construction, operation and maintenance, and decommissioning). See Section 6.3.
THC	There may be impacts on woodland. Any felling required will be taken into account in calculating the carbon balance of the Proposed Development, and consideration will be given to any required replanting under the Scottish Government's Policy on Control of Woodland Removal.'	The potential for carbon loss or disturbance from tree felling is assessed in Section 8.2. Further details on the potential tree felling requirements for the onshore Project are also included in Onshore EIA Report, chapter 12: Land use and other users and Onshore EIA Report, Supporting Study (SS) 10: Forestry and woodland survey report.
Scottish Environment Protection Agency (SEPA)	Scottish Planning Policy states (Paragraph 205) that "Where peat and other carbon rich soils are present, applicants must assess the likely effects of development on carbon dioxide (CO_2) emissions. Where peatland is drained or otherwise disturbed, there is	The potential for carbon loss from disturbance or loss of peat is assessed in Section 8.2. Further details on the potential disturbance to peat are also included in Onshore EIA Report,

CONSULTEE	COMMENT	RESPONSE
	liable to be a release of CO_2 to the atmosphere. Developments must aim to minimise this release.	chapter 8: Geology and hydrology and Onshore EIA Report, Outline Plan (OP) 4: Outline peat management plan.
SEPA	The planning submission must a) demonstrate how the layout has been designed to minimise disturbance of peat and consequential release of CO2 and b) outline the preventative/mitigation measures to avoid significant drying or oxidation of peat through, for example, the construction of access tracks, drainage channels, cable trenches, or the storage and re-use of excavated peat. There is often less environmental impact from localised temporary storage and reuse rather than movement to large central peat storage areas.	The potential for carbon loss from disturbance or loss of peat is assessed in Section 8.2. Further details on the potential disturbance to peat, and mitigation measures to reduce this disturbance, are also included in Onshore EIA Report, chapter 8: Geology and hydrology and Onshore EIA Report, OP 4: Outline peat management plan.

4 FUTURE BASELINE CHARACTERISATION

This section is informed by the Offshore and Onshore EIA Report chapters and summarises the current evidence and future predictions for:

- Marine and coastal climate change, based on outputs from the Marine Climate Change Impacts Partnership (MCCIP), UKCP18 and other publicly available data sources. This section focusses on changes over the 30-year operational period of the offshore Project; and
- Terrestrial climate change based on outputs from UK Climate Projections 2018 (UKCP18) and other publicly available data sources. This section focusses on changes over the 30-year operational period of the onshore Project.

The future environmental baseline is used to inform the climate change resilience review in Section 6 and the ICCI assessment in Section 6.3.3.

4.1 Study areas

The following study areas are referred to across the assessment, as displayed in Figure 4-1.

- Offshore Project area: The entire offshore Project, including all offshore components seaward of Mean High Water Springs (MHWS) (Wind Turbine Generators (WTGs), cables, foundations, Offshore Substation Platforms (OSPs) and all other associated infrastructure) required during operation of the Project, for which OWPL are seeking consent; and
- Onshore Project area: defines the Red Line Boundary for the Planning Permission in Principle (PPP) application, including all onshore components landward of Mean Low Water Springs (MLWS) (underground cables, substation, access, and all other associated infrastructure).

The study area varies across the different assessments provided within this report, as set out below. Figure 4-1 presents the study areas identified for the climate change and carbon assessment:

- Climate resilience review - both the offshore and onshore Project areas;
- ICCI assessment - the study areas for each EIA topic are defined as per chapters 8 to 20 of the Offshore EIA Report and chapters 8 – 17 of the Onshore EIA Report (currently in preparation);
- Blue carbon assessment (offshore) - the offshore Project area;
- Biological carbon store assessment (onshore) - the onshore Project area; and
- Carbon assessment - both the offshore and onshore Project areas.

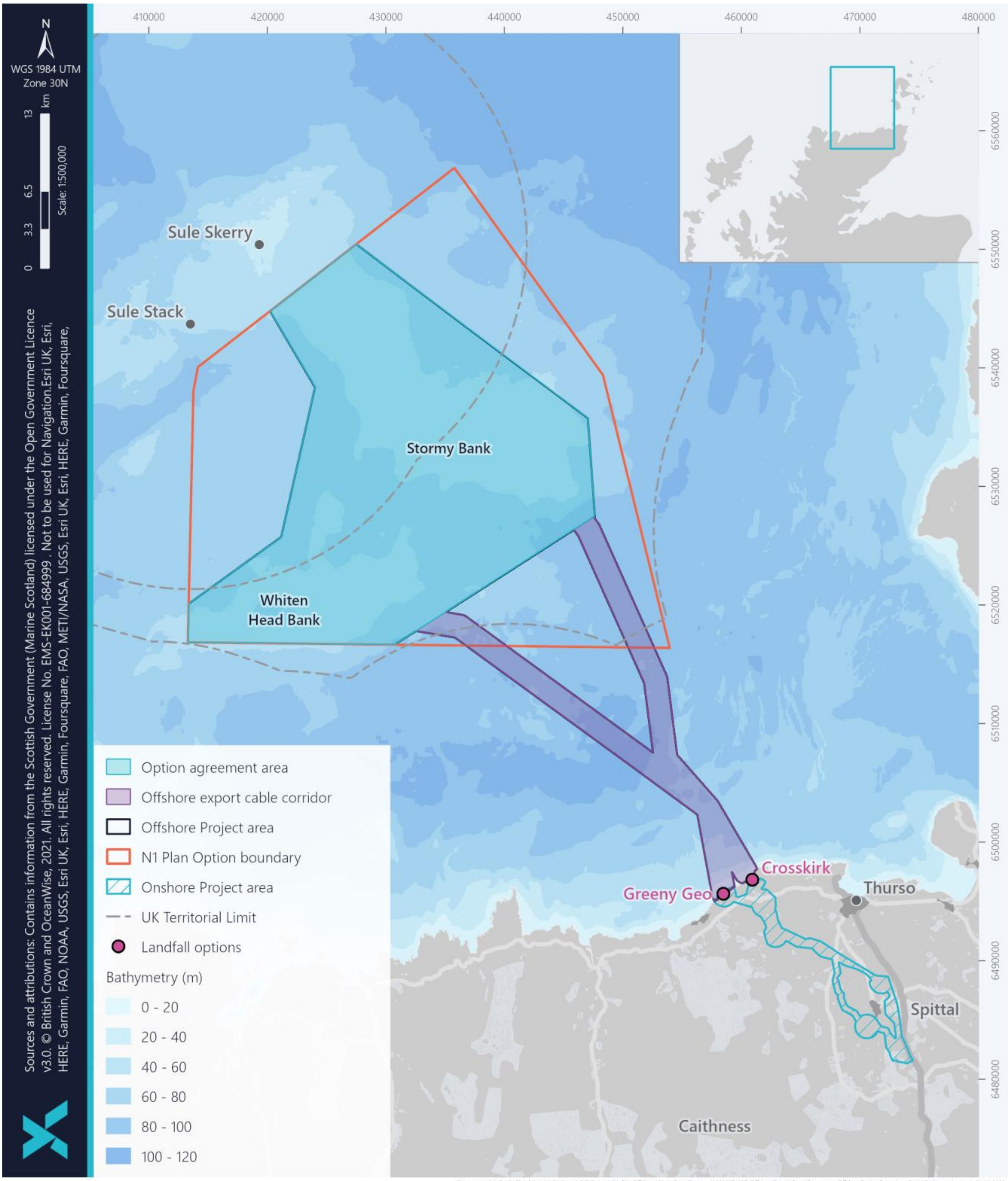


Figure 4-1 Project overview

4.2 Data sources

A review was undertaken of the literature and data relevant to this assessment, relating to climate change and carbon and this was used to provide an overview of the future baseline environment. The two key sources on climate projections include the MCCIP and the UKCP18. The UKCP18 is a climate analysis tool that forms part of the Met Office Hadley Centre Climate Programme and is recommended for use in the IEMA Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation (IEMA, 2020). The MCCIP publishes evidence reviews and summaries on marine climate change, focused on the UK, including regions such as the North Sea, the Celtic Sea, the Irish Sea, the English Channel and the North Atlantic (MCCIP, 2022). A summary of these two data sources is provided below:

- The UKCP18 projections are available to download from the Met Office website. The projections have been based on the latest findings in climate science and, as per IEMA guidance, predictions associated with the highest emissions scenario (Representative Concentration Pathway (RCP 8.5)) are utilised in this assessment. RCP 8.5 assumes a change in global surface temperature of 4.3°C from 2081 to 2100 when compared to the pre-industrial period (1850 to 1900) (Met Office, 2018). RCP 8.5 represents a scenario of high energy demand where there is slow income growth, some technological change, and increased energy intensity where GHG emissions remain unmitigated (Riahi *et al.*, 2011). The UKCP18 projections are most applicable to onshore and coastal areas (mean sea level and storm surge trends) (Met Office, 2021); and
- The MCCIP reports summarise the current evidence for climate change, based on observed and modelled trends in climate data and the physical, biological, and socio-economic environment. In addition, they also provide predictions for the physical, biological, and socio-economic environment, based on modelled climate projections. The emissions scenarios used for climate projections differ between the different modelling studies reviewed within the MCCIP report. The climate projections for the offshore Project are based on different emissions scenarios or modelled predictions for the physical environment as applicable. Details are provided within each topic section in the future baseline description, in Section 4.3. Generally, the MCCIP predictions are provided for 2100.

4.3 Future baseline description

This section describes historic climate trends, future climate projections, and the potential indirect impact of climate change on biological and socio-economic receptors. Where appropriate, the information presented here is consistent with the topic-specific chapters of the Offshore and Onshore EIA Report.

The future climate projections described are based on modelled data and the timescales considered for the different receptors are dependent on the availability of the modelled data. Where available, changes over the 30 year operation and maintenance stage of both the offshore and onshore Project, are described. However, predictions to 2100 are considered for some climate variables, where the data is only available over this timeline.

4.3.1 Physical environment

4.3.1.1 Air temperature

Projections for the 21st century (Met Office, 2019a), indicate temperatures for all months will continue to increase. As the air temperature increases, winters are expected to become warmer and wetter, while summers become cooler and drier. However, there will be cooler seasonal periods due to natural variation that will still occur.

The most recent decade (2012-2021) has been 0.2°C warmer than the 1991-2020 average, and 1°C warmer than the period 1961-1990, with the 21st century being the warmest of any period of equal length for the last three centuries (Kendon *et al.*, 2022). In particular, since 1997, Scotland has had increasingly warmer years than was recorded in 1961-1990 particularly from 2010 – 2019 where the average temperature has been 0.69°C warmer (Adaptation Scotland, 2021). All areas of the UK are projected to be warmer (more in summer than in winter), by the end of the 21st century (Met Office, 2021).

Under the high emission scenario (RCP 8.5), the 10% and 90% probability levels for warmer temperatures are estimated to be between 0.7°C – 4.2°C warmer in winter, and 0.9°C to 5.4°C in summer, by 2070 compared to 1981 to 2000 mean. Hotter summers are also expected to become a more common occurrence. For the period 1981- 2000, there was a 10% probability of seeing a summer as hot as the summer of 2018 (UK-wide average of 15.8°C). At the time of UKCP18 publication (in 2018), the probability of a hotter summer had already increased to between 10 – 25%, and with future warming, dependant on the emission scenario, by mid-century the probability of hot summers could be as high as 50% (Lowe *et al.*, 2019). Temperatures in Scotland, particularly in the Project region, are expected to be comparatively lower than other areas of the UK (e.g. south of England) (Met Office, 2019a).

According to Met Office Hadley Centre (2018), at present, the UK is experiencing higher maximum temperatures and longer warm spells in recent years. The average length of warms spells has doubled, increasing from 5.3 days in 1961-1990 to over 13 days in the decade 2008-2017. A further study in 2020 suggests that the current chance of experiencing days where temperatures increase above 40°C is extremely low, however by the year 2100, under a high emissions scenario the UK could see 40°C days every 3-4 years (Christidis *et al.*, 2020).

Similarly, the UKCP18 projections also indicate that summers with warmer temperatures will become more common, with the frequency of daytime temperature exceeding 30°C for two or more consecutive days increasing (mainly confined to the southeast of the UK) (Met Office, 2021a). Although, winter temperatures are also expected to increase this does not rule out the possibility for cold periods or severe snow storms (Adaptation Scotland, 2021).

4.3.1.2 Precipitation and flood risk

There has been an increase in annual average rainfall over the UK. The largest changes have been observed in Scotland, where the last decade (2008-2017), has been 11% wetter than 1961-1990, and 4% wetter than 1981-2010. Overall, the quantity of rain from extremely wet days has increased by 17% when comparing 2008-2017 with the 1961-1990 period (Lowe *et al.*, 2019).

Under the high emission scenario (RCP 8.5), by 2070, on average, precipitation levels are expected to continue to increase in winter but decrease in summer. Changes in levels of winter precipitation levels will vary between a 1% decrease to a 35% increase, while precipitation in summer periods are expected to vary between a 47% decrease to a 2% increase, in comparison to the 1981 to 2000 mean (Lowe *et al.*, 2019). It is therefore expected that winters will become wetter, not only in increased total precipitation levels, but also an increase in number of 'wet' days. Summer is expected to become drier with a decrease in rainfall, however, extreme downfalls during the summer are expected to be heavier (Adaptation Scotland, 2021).

The overall trend of reduced precipitation levels in summer is expected to be lower in the north of Scotland compared with the south of the UK (Met Office, 2019a). The UKCP18 projections also indicate that the intensity and frequency of heavy rainfall events in summer and autumn are likely to increase, but while the intensity of hourly rainfall is expected to increase, overall summers are projected to be drier (Met Office, 2021a).

Significant changes in the various forms of precipitation (such as rain and snow) are likely to result in related impacts including flooding and drought, which in turn is likely to result in consequences to human health, infrastructure and the natural capital of the UK. According to the Met Office (2021b), the threshold used by both the Met Office and the Environment Agency Flood Forecasting Centre to issues flash flood alerts, is hourly rainfall exceeding 30 millimetre (mm) per hour. Presently, it is projected that by the year 2070, the UK will meet this threshold twice as often as 1990 (Met Office, 2021b).

Figure 4-2 and Figure 4-3 display the SEPA river and surface water flood risk maps, representing the likelihood of flooding on a range from high (10% probability in a given year), medium (0.5% probability in a given year) and low (0.1% probability in a given year). River flooding has a high likelihood along the channels of the Forss Water, River Thurso, Burn of Achanarras, Halkirk Burn and Calder Burn and associated minor tributaries. The onshore substation search area is adjacent to the Burn of Achanarras, and the western edge of the area has a high likelihood of river flooding (Figure 4-2). The indicative substation location has been placed entirely outwith the high flood risk area; however, parts of the cable route and / or construction activities will be required in areas of high flood risk in both corridors of the onshore Project area. There is also a high risk of river flooding in a small area north of Loch Lieurary.

An area with high likelihood of surface water flooding is present in the main channel of the Forss Water between Forss and Crosskirk Bay (Figure 4-3). Small, isolated areas of high surface water flood risk are present around the Moss of Halkirk, south of Houstry Mains, and in the Thurso River valley near Hoy and Braal Holdings. These areas are mainly associated with minor watercourses or ditches.

The conservative UK Climate Projections 2009 (UKCP09) high emissions scenario was considered by SEPA to predict the future river flood risk for the 2080s, shown as the medium likelihood (i.e. 0.5% probability in a given year) flood risk on Figure 4-2. This figure shows that the area of medium likelihood flood risk in the 2080s (represented in yellow on Figure 4-2) is likely to increase, expanding out to areas that are currently of a low likelihood flood risk. Scotland has begun to see an increase in significant flooding events widespread across the country, particularly, over the last four decades where there has been an increase of over 20% high river flow runoff and 45% winter river flow run off (Adaptation Scotland, 2021). It is expected that some Scottish river catchments peak river flows may increase >50% by 2080, under the high emissions scenario (Adaptation Scotland, 2021) as demonstrated in Figure 4-2.

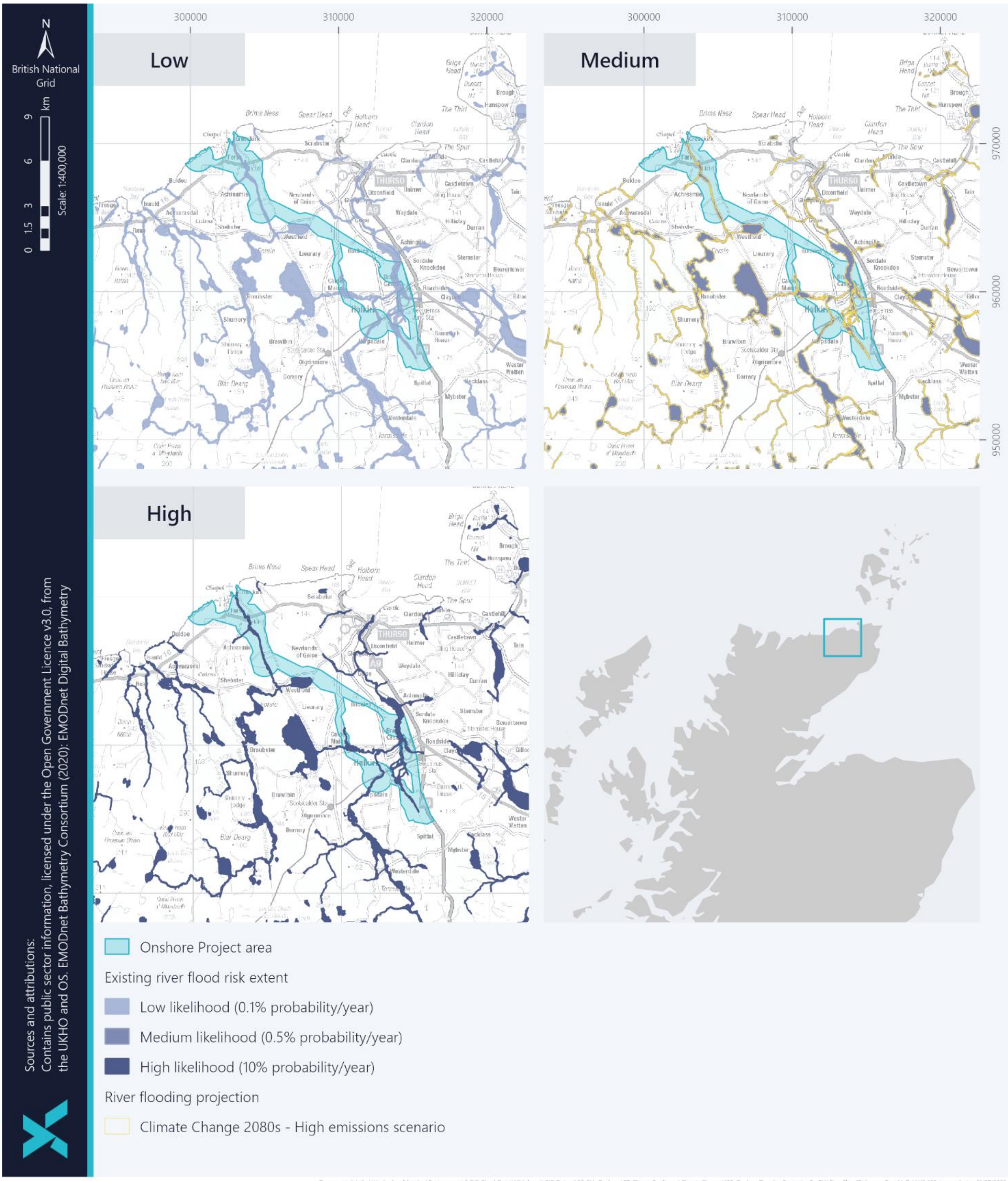


Figure 4-2 River flood risk potential across the onshore Project area (SEPA, 2023a)

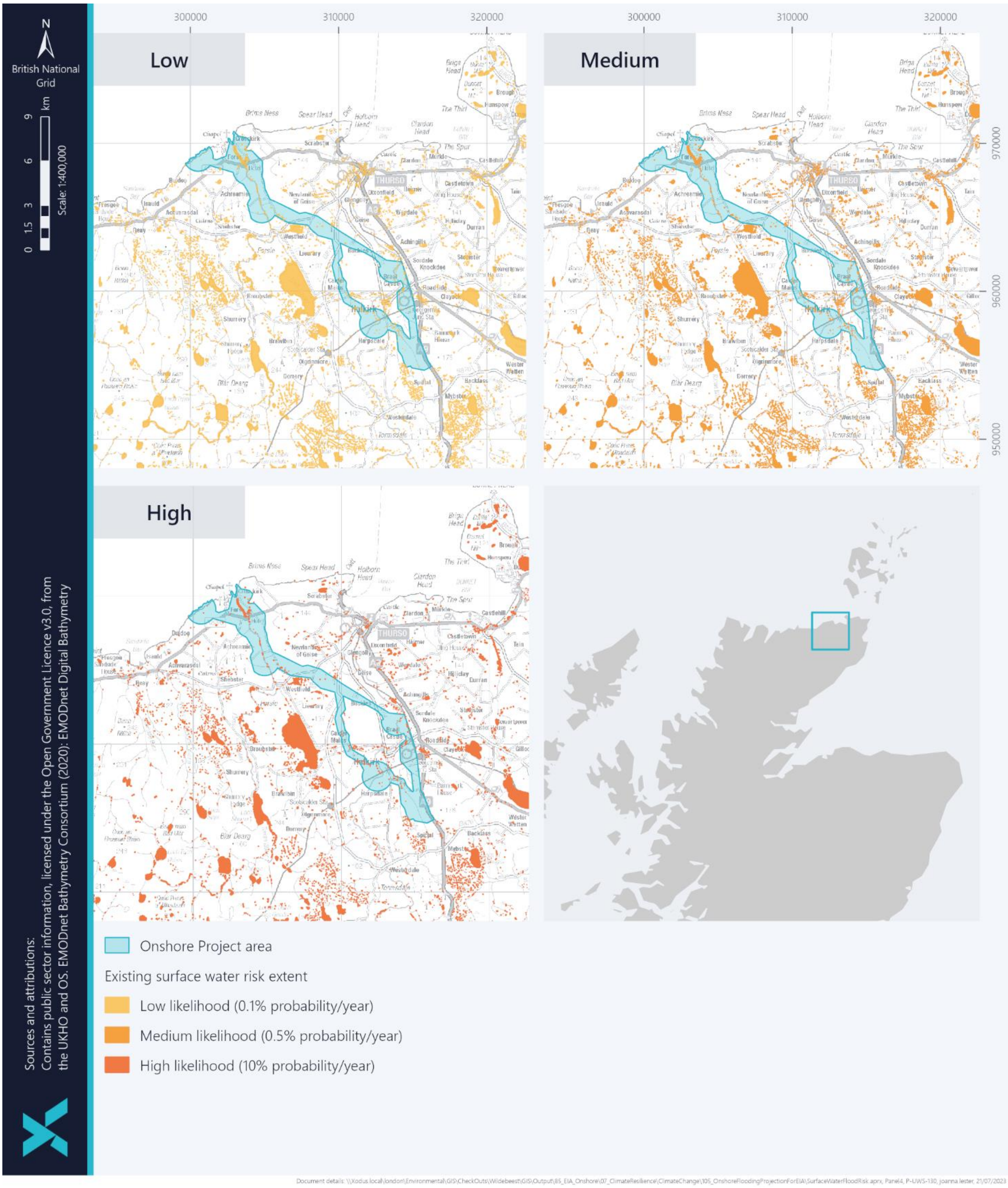


Figure 4-3 Surface water flood risk potential across the onshore Project area (SEPA, 2023a)

4.3.1.3 Wind, storms, and waves

Analysis of observed and modelled wind and wave data can be used to identify long-term trends in weather patterns. The frequency and intensity of storms within the north of the Atlantic Ocean is increasing, with a much weaker trend observed in the United Kingdom Continental Shelf (UKCS). However, there is a low confidence in attributing these historical changes in weather patterns to climate change and the high degree of variability in the data also creates difficulties in identifying historic trends over time. Time-series data on mean significant wave height generally also shows an increase in wave heights in the northeast of the Atlantic Ocean, mainly attributed to Atlantic swell rather than increased wind speeds (Wolf *et al.*, 2020).

There is uncertainty with regard to future predictions for storms and waves, and it is expected that the trends observed in the frequency and intensity of waves and storms will continue to be influenced by natural variability. Additionally, future trends are difficult to predict due to a low confidence in attributing historic trends in storms and waves to climate change. However, ongoing changes in the climate may potentially affect storms with cumulative effects on wind and wave heights.

To date, no convincing trends have been observed in storms, as determined by maximum gust speeds. For the second half of the winter season (2050 – 2100), under a high emission scenario (RCP 8.5), global projections for the UK indicate that near surface wind speeds will increase, especially during the winter season and this will accompany an increase in winter storm frequency (Met Office, 2019c).

The most recent MCCIP report card indicates that the mean significant wave height in the north of the UK has reduced over the last 30 years compared with an increase in the south. Bircheno *et al.*, (2023) suggest that the trend of an overall reduction in mean significant wave height in the north of the UK will continue through to 2100 but that the height of the most severe waves could increase by 2100.

Wave height projections are further supported by Palmer *et al.* (2018) where simulations undertaken for UKCP18 RCP 8.5 suggest projections of average wave heights changing by 10-20%, with a tendency toward lower wave heights for the 21st century. Changes in extreme / severe wave heights is also predicted under the UKCP18 climate projections to the order of 10-20%, but there was no conclusion between models on whether there would be an increase or decrease in wave height (Palmer *et al.*, 2018).

Overall, there is considered to be a low confidence in the future predictions for wind, storms and waves (Palmer *et al.*, 2018; Wolf *et al.*, 2020).

4.3.1.4 Sea surface and near bottom temperatures

Sea Surface Temperature (SST) around the UK has generally shown a significant warming trend of around 0.3°C per decade over the last 30 years. The strongest warming trend across this domain occurred in the southern North Sea, where values of greater than 0.4°C were experienced (Cornes *et al.*, 2023). The trend is shown in Figure 4-4.

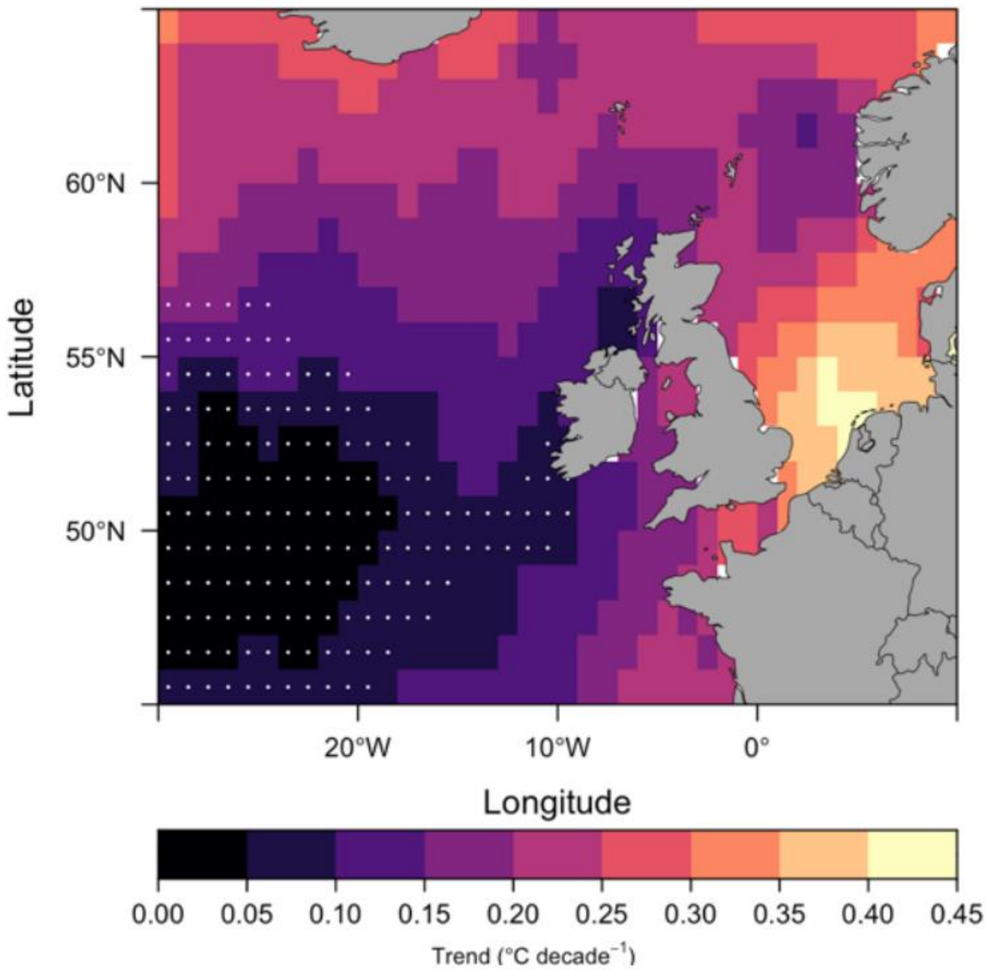
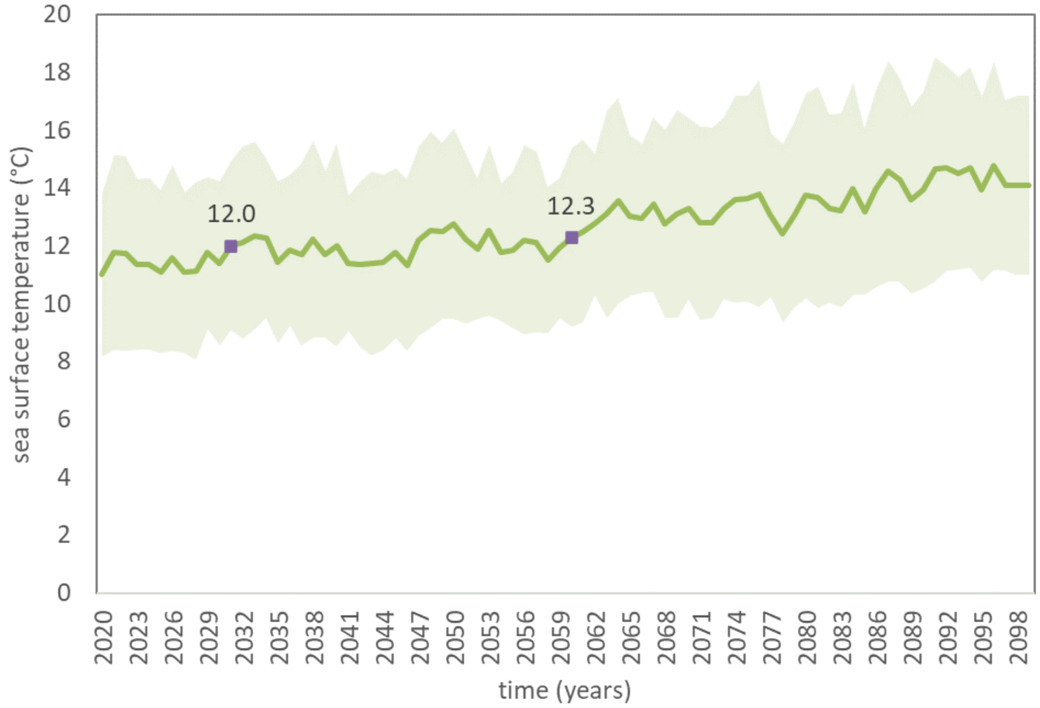


Figure 4-4 Trends in annual average SST for 1981-2021[4] (as presented in Cornes et al., 2023)

Figure 4-5 shows the sea temperature projections during the operation and maintenance stage of the offshore Project. A mean sea surface temperature of 12.0 °C is projected at the start of the operation and maintenance stage in 2031 and of 12.3 °C by cessation of operations in 2060. A mean seabed temperature of 11.4 °C is projected at the start of the operation and maintenance stage in 2031. The same projected mean seabed temperature of 11.4 °C is expected at cessation of operations in 2060. However, the mean seabed temperature is projected to peak at 11.9 °C in 2050. An indication of the variability in the projection is shown in light green[5]. The sea temperature projection is obtained from the NEMO-ESREM ocean model (Wakelin *et al.*, 2020), one of the key models used to inform Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report. The projections are output at 7 km resolution round the UK coast and the data shown in Figure 4-5 corresponds to the 7 km grid cell in which the offshore Project is located.

[4] *White dots presented on the map indicate grid cells, where trends are not significant at the 95% confidence level.*

[5] *Note, per UKCP18, there may be a greater than 10% chance that the real-world response lies outside these ranges and this likelihood cannot be accurately quantified.*



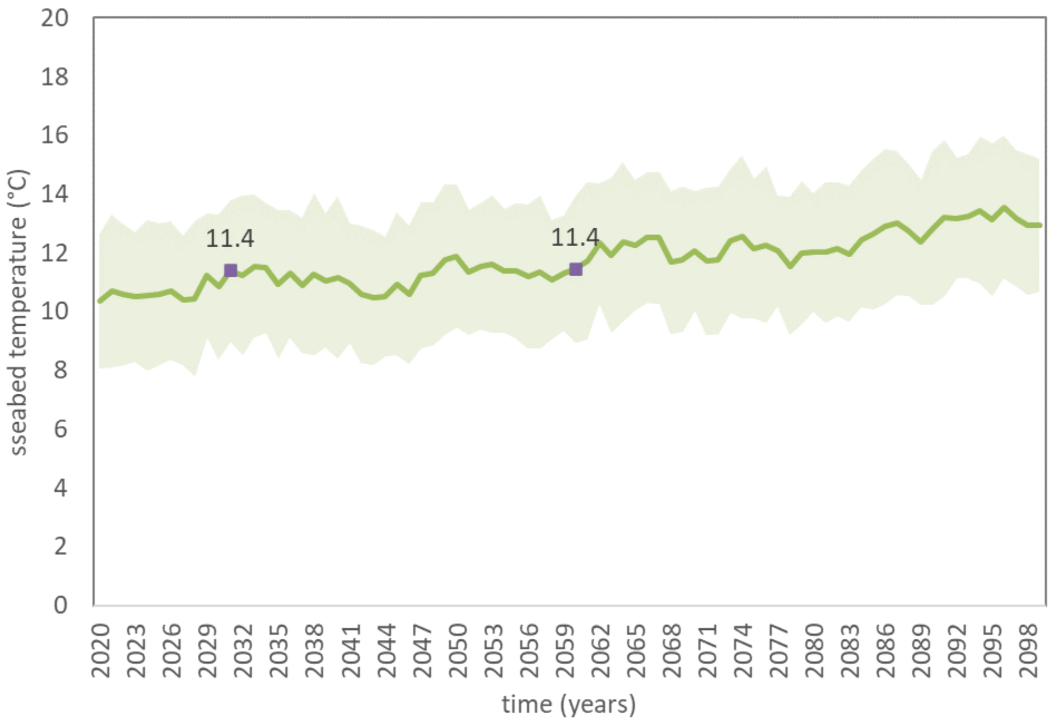


Figure 4-5 Mean sea surface temperature (top) and seabed temperature projections (bottom) for the offshore Project area (RCP8.5). The shaded region represents the standard deviation for each year calculated from monthly data (Wakelin et al., 2020)

Under the RCP 8.5 scenario, model simulations predict a continued warming trend around the UK for the end of the century (2079 – 2098). The warming is expected to be greatest across the North Sea in both SST and near-bottom temperatures, which is a continuation of the spatial pattern of trend observed in recent decades (Cornes *et al.*, 2023).

4.3.1.5 Dissolved oxygen, salinity and stratification

Dissolved oxygen is essential for all marine life with oxygen being more soluble in colder water and less soluble in warmer water. Since the 1960s, the global oceanic oxygen content has declined by more than 2%. Sustained observations in the North Sea reveal the recent onset of oxygen deficiency in late summer, partly due to ocean warming. The intensity and extent of oxygen deficiency has also increased over time based on re-analysis of dissolved oxygen data over the past 100 years (Queste *et al.*, 2013; Mahaffey *et al.*, 2023).

Under the high emissions scenario (RCP 8.5), for UK shelf waters, models project that annual mean oxygen concentration will decline most in North Sea regions and the Celtic Sea (decreases of 5.6 to 5.9% by 2100). Deeper regions exposed to exchange with the open ocean (the Irish shelf and Shetland shelf) are expected to be less affected, decreasing by 2.9 to 3.1% (Mahaffey *et al.*, 2023).

Salinity has also shown a general decrease in the west of the UKCS in the last five years, although this trend is weaker in other regions of the UKCS, such as the North Sea, where there is no clear long-term trend (Dye *et al.*, 2020). By 2100, it is predicted that waters will be less saline in the North Sea, due to ocean circulation changes driven by climate change (Dye *et al.*, 2020). This trend is weaker in waters to the southwest of the UKCS in the Celtic Sea, Irish Sea and English Channel. The predicted change in sea surface and near-bottom salinity is provided in Table 4-1 below.

Table 4-1 Predicted changes in sea surface and near bottom salinity (comparing 1960 to 1989 with 2069 to 2098 (Tinker et al., 2016)

REGION	SURFACE SALINITY (CHANGE IN PSU*)	NEAR BOTTOM SALINITY (CHANGE IN PSU)
Northern North Sea	-0.62(±0.65)	-0.52 (±0.52)
Shelf Regions	-0.41 (±0.47)	-0.33 (±0.38)
***PSU = Practical Salinity Unit**		

Stratification is the process by which less dense water sits above a layer of more dense water. Stratification restricts exchange between layers, limits the exchange of water masses, nutrients, phytoplankton and dissolved gases. Stratification also limits the ventilation of waters beneath the surface mixed layer, with a gradual decrease of oxygen in bottom waters throughout summer months until winter remixing of the entire water column allows replenishment of the oxygen deficit from the atmosphere (Sharples *et al.*, 2022). There is a suggestion of earlier onset of seasonal stratification in UK shelf seas and tentative evidence of long-term trends in the strengthening of stratification. Projections suggest that by 2100, thermal stratification in UK shelf seas will extend in duration by around 2 weeks (with both earlier onset and later breakdown), and increase in strength, due to changes in air temperature (Sharples *et al.*, 2022).

4.3.1.6 Ocean acidification

Ocean acidification is a consequence of climate change, in which the physical properties of the ocean are altered, with resulting impacts on marine biota. Ocean acidification occurs as increases in anthropogenic CO_2 absorbed by the ocean causes a decline in pH.

The global ocean absorbs approximately a quarter of anthropogenic CO_2 emissions annually. The north Atlantic Ocean contains more anthropogenic CO_2 than any other ocean basin, and surface waters are experiencing an ongoing decline in pH (increasing acidity). Rates of acidification in bottom waters are occurring faster at some locations than in surface waters (Findlay *et al.*, 2022).

The bottom waters around the UK are projected to experience faster rates of decline in pH, due to seasonal processes that influence the carbonate chemistry at depth that can exacerbate the global ocean acidification signal. Trends of pH in bottom waters of the greater North Sea are 0.0040/yr under a high emission scenario (Findlay *et al.*, 2022).

Under the high emission scenarios (RCP 8.5), it is projected that bottom waters on the North-West European Shelf seas will become corrosive to more soluble forms of calcium carbonate (aragonite). Episodic undersaturation events are projected to begin by 2030. By 2100, up to 90% of the north-west European shelf seas may experience undersaturation for at least one month of each year. This increase in acidification will result in the bottom waters becoming uninhabitable by benthic organisms that are currently operating at tolerance thresholds (Findlay *et al.*, 2022).

4.3.1.7 Sea level rise and coastal erosion

Sea level rise and coastal erosion are also potential impacts of climate change. Sea level rise occurs as sea ice continues to decline and as seawater expands as it warms. A long-term increase in the rate of sea level rise in the 20th century is well-documented and the average rate of global sea level rise was recorded as 3.2 mm per year between 1993 and 2010 (Horsburgh *et al*., 2020).

Rates of sea level rise vary by location, in accordance with regional and local conditions. Climate change is expected to contribute to 1 – 2 mm increase in the sea level rise per year in the UK, and when vertical land movement is considered, this rate increases for the south of England by an additional 1 mm per year and decreases in some parts of Scotland. Sea level rise is expected to continue through to and beyond 2100. Overall, the rise in sea level in the UK is expected to be slightly lower than the global average (Horsburgh *et al*., 2020).

Figure 4-6 shows the sea level projections over the operation and maintenance stage of the offshore Project, relative to a baseline period of 1981-2000. A mean sea level rise of 0.13 metres (m) is projected by start of operations in 2031 and of 0.31 m by cessation of operations in 2060. The range associated with the projection is shown in light blue, i.e. models project that there is 95% likelihood that a mean sea level rise of more than 0.08 m will occur by 2031 and 5% likelihood that a sea level rise of more than 0.18 m will occur by 2031, similarly models project that there is 95% likelihood that a sea level rise of more than 0.20 m will occur by 2060 and 5% likelihood that a sea level rise of more than 0.45 m will occur by 2060[6]. The projection for the average height of the sea over a year is obtained from multiple models that were used to inform the IPCC Fifth Assessment Report. The projections are output at 12 km resolution

[6] *Note, per UKCP18, there may be a greater than 10% chance that the real-world response lies outside these ranges and this likelihood cannot be accurately quantified.*

round the UK coast and the data shown in Figure 4-6 corresponds to the 12 km grid in which the offshore Project lies.

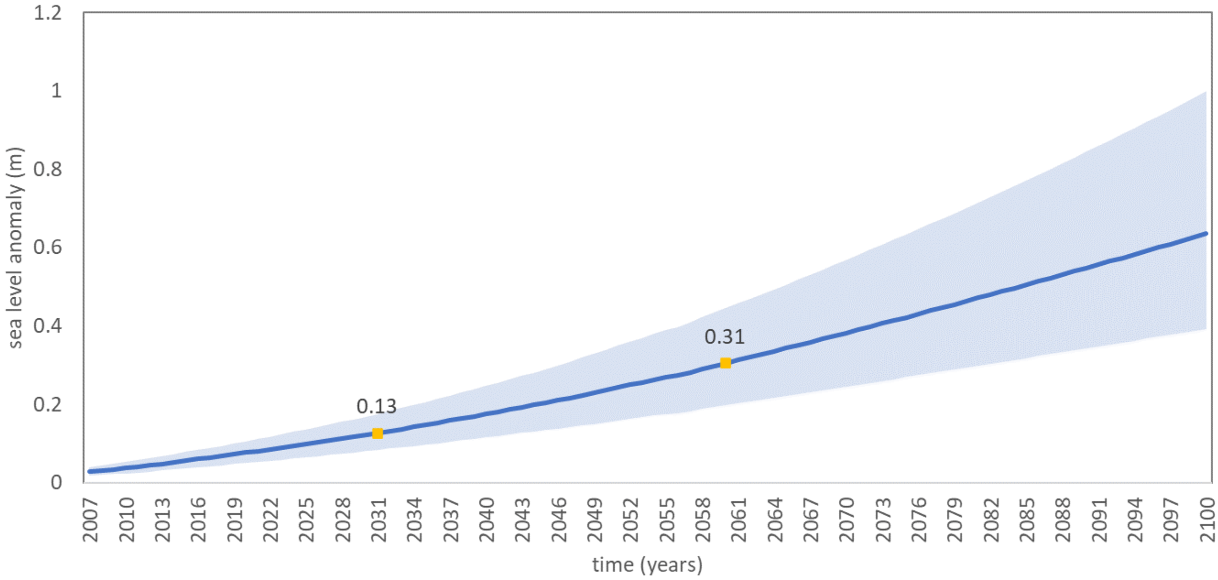


Figure 4-6 Mean sea level projections for the Project for 2007 – 2100. The shaded period represented the projected range (Source: multiple models used to inform the IPCC Fifth Assessment Report)

Sea level rise is expected to contribute to coastal erosion, and it is assessed that 17% of the UK coastline is currently experiencing erosion. In Scotland, the coastlines are generally less susceptible to erosion, as a greater proportion of the coastline is considered 'hard or mixed', and only 12% of the soft / erodible coastline has eroded landwards since the 1970's. In addition to sea level rise, coastal erosion results from many factors, including reduced sediment supply, storms and anthropogenic disturbance (Masselink *et al.*, 2020; Adaptation Scotland, 2021).

As described in the Offshore EIA Report, chapter 8: Marine physical and coastal processes, the coastline where the offshore Export Cable Corridor (ECC) achieves landfall is characterised by hard and mixed substrate, with cliffs along much of the coast (Hurst *et al.*, 2021) and is considered non-erodible based on the updated Dynamic Coast project (Dynamic Coast, 2021). Analysis of the coastline according to Google Earth imagery between 2004 and 2021 indicates there has been no change to the coastline since the early 2000s. However, with the predictions of relative sea level rise and the landward movement of high water associated with relative sea level rise, there is the potential that this would result in coastal erosion. This erosion would likely be constrained to locations which have a softer and more erodible frontage (Horsburgh *et al.*, 2020). Consequently, this is less likely to apply to the landfall location given the nature of the geology there. Furthermore, the timescale of this change would be beyond the operational life of the Project.

Coastal erosion across the UK is predicted to continue to increase due to the projected increases in sea level rise (1-2 mm per year) (Horsburgh *et al.*, 2020). The confidence in the predictions is medium – high for sea level rise and medium for coastal erosion (Horsburgh *et al.*, 2020; Masselink *et al.*, 2020).

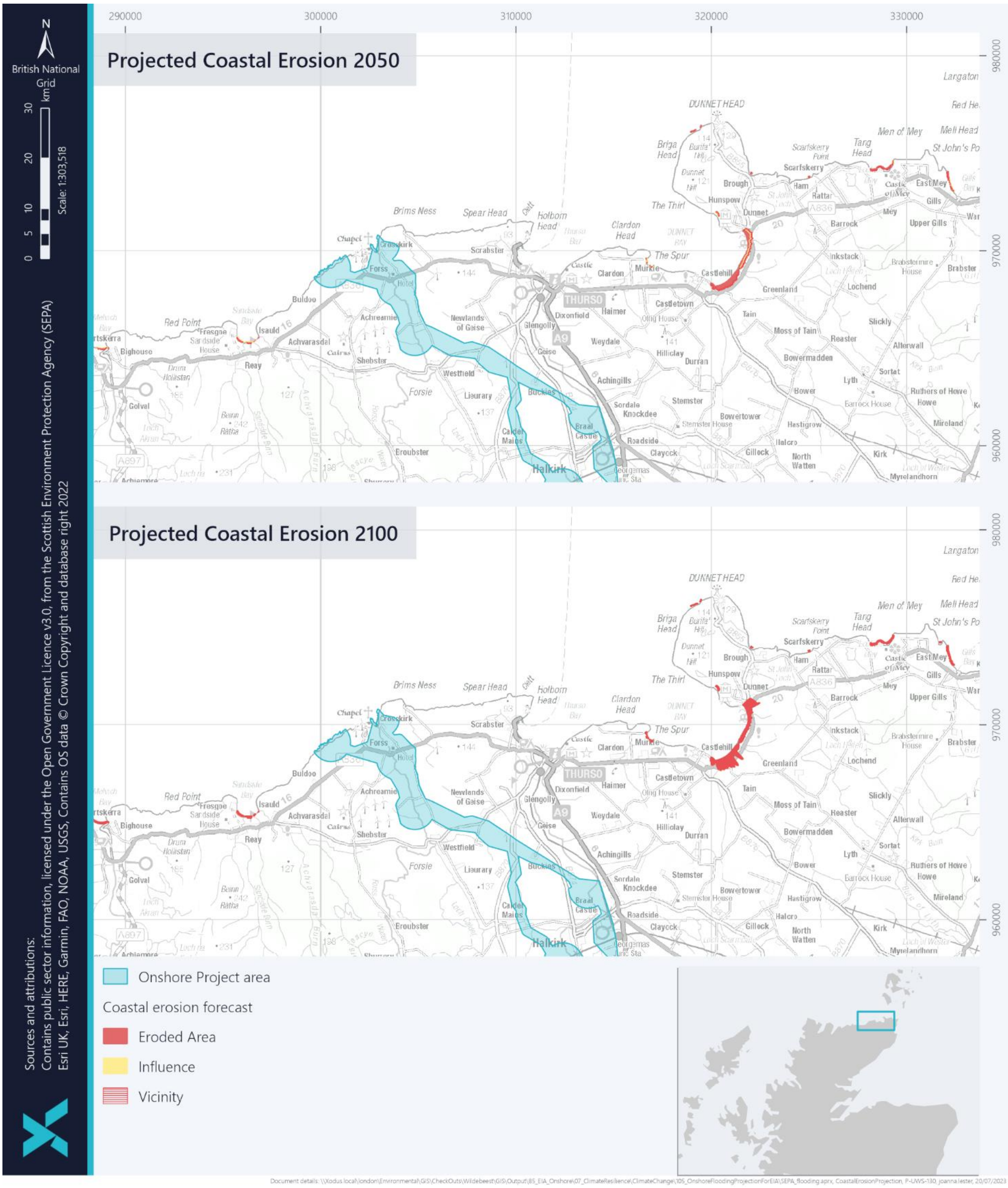


Figure 4-7 Coastal erosion projections from 2050 - 2100 for the onshore Project, relative to a baseline period of 1981 to 2000 (RCP 8.5)[7] (Dynamic Coast, 2021)

[7] *Influence refers to a 10 m buffer around the eroded areas polygon which may be damaged by storms. Vicinity is a further 50 m buffer surrounding the influence polygon to understand the assets present.*

4.3.2 Biological environment

The biological environment may be affected by changes in the physical environment. Indirect impacts of climate change may also arise through changes in habitats and predator-prey relationships. The following section summarises the information provided within each chapter of the Offshore EIA Report and the Onshore EIA Report relating to these potential impacts of climate change on the biological environment. It has not been possible to undertake a further evaluation of potential climate-related biological effects, due to uncertainty in how the physical environment will respond to climate change and the associated complexity of identifying the impacts of climate change amongst other factors that can influence the physical environment and related biological receptors (Küpper and Kamenos, 2017).

4.3.2.1 Offshore

4.3.2.1.1 Benthic subtidal and intertidal ecology

Coastal, intertidal, and subtidal habitats (see Offshore EIA Report, chapter 10: Benthic subtidal and intertidal ecology) may be directly affected by changes in the physical environment. For instance, changes have been observed in dune slacks in England, with 30% of this habitat being lost between 1990 and 2012 (Burden *et al.*, 2020). Changes in species composition may also arise as a result of climate change, linked to the thermal affinities of species (e.g. cold or warm-water species), such as the increased abundance of warm-water kelp species (*Laminaria ochroleuca*) (Mieskowsa *et al.*, 2020; Moore *et al.*, 2020).

4.3.2.1.2 Fish and shellfish ecology

Evidence of changes in the fish and shellfish distribution as a result of increased warming has already been observed, including northward shifts of population boundaries for a number of species by a number of studies. Increasing sea surface temperatures may result in a regional shift of fish species into deeper and colder waters. Declines in recruitment may occur if these environments do not contain the specific habitat requirements of some species (e.g. sandeel spawning grounds). Shifts in migratory timings, or other life history stages, that are influenced by environmental cues such as temperature, may also occur. As a result of natural variation, there is limited confidence in attributing climate change to observed changes in fish and shellfish communities. It is also extremely difficult to predict climate change impacts on fish and shellfish populations (see Offshore EIA Report, chapter 11: Fish and shellfish ecology).

4.3.2.1.3 Marine mammals

For marine mammals, changes in distribution and abundance are often correlated with influences on prey and prey availability. For example, the regional shift in fish and shellfish species, as described above, from deeper and colder waters as a result of increasing SSTs may result in change prey availability for marine mammal and megafauna species (BEIS, 2022a). Albouy *et al.* (2020) assessed that white beaked dolphin, grey seal, harbour porpoise and harbour seal were ranked within the top twenty most vulnerable species of marine mammals to climate change extinction risk, assessed in relation to changes in sea temperatures associated with a high and low emissions scenario by comparing present day to 2030 – 2059 and 2070 - 2099. However, due to the complexity of both anthropogenic and environmental pressures, it is not possible to predict accurately how the distribution and abundance of these species will change over the lifecycle of the Project (see Offshore EIA Report, chapter 12: Marine mammals and megafauna,).

4.3.2.1.4 Offshore and intertidal ornithology

Key drivers of seabird populations are climate change and fisheries, along with pollutants, invasive alien species and by-catch in fisheries. Trends in seabird numbers in breeding populations are better known than numbers at sea and breeding numbers for many species have declined since the 1980s. In 2022, Highly Pathogenic Avian Influenza (HPAI) adversely affected survival and productivity within seabird colonies across the UK, and investigations are underway to determine the long-term effects on species' populations, combined with the other aforementioned pressures. It is therefore highly likely that breeding numbers of most of our seabird species will continue to decline under a scenario with continuing climate change, should all other drivers of seabird population change remain the same. Climate change has been identified as the strongest influence on future seabird population trends (see Offshore EIA Report, chapter 13: Ornithology,).

4.3.2.2 Onshore

4.3.2.2.1 Terrestrial non-avian ecology

A significant portion of the onshore Project area consists of man-made or improved grasslands and arable fields and the greatest impact to these are likely to be from changes to farming practices. The plant species found in unimproved or semi-improved grassland areas are likely to be affected adversely by the wetter winters (and increased flooding events) and drier summers. Similarly, the habitats most likely to be influenced by climate change are wetlands and wet woodlands whereby increasing rainfall in winter may benefit these areas unlike the predicted drier summers where adverse effects would be expected (see Onshore EIA Report, chapter 10: Terrestrial non-avian ecology). Not only is it anticipated that plant species will have a direct impact from wet and dry extremes the predicted increasing temperatures are likely to influence changes in flowering periods that would be earlier than present. This will subsequently mismatch pollinating times between plant species and associated pollinator species (Robbirt *et al*., 2014).

Populations of terrestrial and freshwater animals may also be affected by climate change, particularly in relation to increased air temperature and storms affecting breeding seabirds and also in relation to reduced food abundance resulting from increased air temperature and decreased summer rainfall. Similarly, changes in freshwater habitats may affect the species that depend on these environments.

4.3.2.2.2 Freshwater ecology

Climate change impacts, particularly mediated through temperature and flow regimes, have the potential to change the River Thurso and may already be changing the Forss Water. According to Jackson *et al.* (2018) both the River Thurso and Forss Water (found within the onshore Project area) may be subject to the highest maximum temperatures, which are very likely to impact all native fish species. It is possible that a widespread reduction in abundance in Atlantic salmon and European eel will occur within the onshore Project area (see Onshore EIA Report, chapter 9: Freshwater ecology).

Pearce-Higgin (2021) highlighted the disruption of marine food webs (indirect impact), increased temperatures and increased storms (both direct) will affect breeding seabird populations and drier summers are anticipated to impact upland breeding waders through reduced prey availability. There is strong evidence that species are shifting their ranges further north, including some which have colonised large parts of the UK from continental Europe. New migratory insects are arriving in the UK from continental Europe and some existing summer migrants are becoming permanent residents; for example, the red admiral butterfly is increasingly overwintering in the UK (Morecroft & Speakman, 2015) (see Onshore EIA Report, chapter 10: Terrestrial non-avian ecology).

4.3.2.2.3 Terrestrial ornithology

Bird ranges in the UK have shifted northwards (by an average of 37 km from 1990-2008) but have lagged behind corresponding changes in temperature (Morecroft & Speakman, 2015). There is a possibility that climate change may affect bird populations – notably breeding seabirds and upland waders. For example, climate change is disrupting marine food webs while higher temperatures and storms directly affect breeding seabirds, while drier summers affect upland breeding waders through reduced prey availability (Pearce-Higgins, 2021). However, the onshore Project area is not situated in the uplands, and no breeding seabird colonies were found (see Onshore EIA Report, chapter 11: Terrestrial ornithology). As there are no proposed land use changes, and climate change is unlikely to have a measurable effect on much ornithology in this area within the Project lifetime, in most cases the future baseline will be the same as the current baseline.

4.3.3 Socio-economic environment

Impacts on the physical and biological environment may also affect human activities in marine and terrestrial environments. Summary information from relevant chapters in the Offshore and Onshore EIA Reports has been provided in relation to potential impacts of climate change on the socio-economic environment. It has not been possible to undertake a further evaluation of potential climate-related socio-economic effects, due to uncertainty in how the physical / biological environment will respond to climate change and the associated complexity of identifying the impacts of climate change amongst other factors that influence the physical / biological environment and related socio-economic receptors (Küpper and Kamenos, 2017).

4.3.3.1 Offshore

Stock abundance, such as the result of range shifts of commercial fish and shellfish species driven by climate change will likely gradually affect the commercial fisheries sector (Offshore EIA Report, chapter 14: Commercial fisheries). However, attributing these changes solely to climate change is difficult due to the multitude of factors that also influence fish stocks (Pinnegar *et al.*, 2020).

With regards to shipping and navigation (Offshore EIA Report, chapter 15: Shipping and navigation), it is possible that climate change and measures taken to slow the effects of climate change could have an effect on shipping and navigation receptors. However, given the temporal nature of climate change, any effects are expected to develop in the long-term (post operational life of the Project) rather than the short- or medium-term.

For marine archaeological receptors, climate change is not anticipated to affect buried marine archaeology sites. However, sea level rise and increased extreme weather events associated with climate change may result in the erosion and gradual destruction of coastal archaeological sites that are located close to sea level (Offshore EIA Report, chapter 16: Marine archaeology and cultural heritage).

Recreation and tourism activities are highly seasonal, driven by periods of optimal weather and tidal conditions. As climate change may result in unfavourable or more favourable weather and tidal conditions, the future baseline condition for these activities has the potential to change. Climate change may also impact wildlife resulting in declines in abundance of species and/or spatial and temporal changes in their distribution which has the potential to change the future baseline condition for wildlife tourism activity.

There remains a need to increase the understanding of the potential effects of climate change on the characteristic landscapes in the vicinity of the offshore Project and to develop longer term strategies that will mitigate any adverse effects of climate change (Offshore EIA Report, chapter 18: Seascape, landscape and visual assessment).

4.3.3.2 Onshore

Multiple climate hazards pose risks to crops, livestock (i.e. agricultural capacity) and commercial trees (as discussed in Onshore EIA Report, chapter 12: Land use and other users). The UK's agricultural and forestry productivity are essential for both future domestic food security and achieving net zero emissions by 2050. The productivity in these sectors is dependent on the health and diversity of terrestrial ecosystems (HM Government, 2022).

In addition, it is recognised that as the UK becomes more dependent on electricity as our dominant energy source, people and the economy will be increasingly exposed and vulnerable to electricity system failures. Risks of electricity system failures resulting from climate-related hazards may also become more common as the variability of weather increases.

4.4 Summary of future baseline environment

A summary of the physical climate projections anticipated for the offshore and onshore Project is provided in Table 4-2 below.

Table 4-2 Summary of climate projections

CLIMATE VARIABLE	RELEVANT TO	PREDICTED CHANGE
Extreme weather events	The offshore and onshore Project	• Increase in the occurrence of heavy rainfall events.
		• Increased occurrence in winter high wind events (i.e. winter storms).
		• Increased occurrence of heat waves.
	The offshore Project	• Reduced mean significant wave height.
	The offshore Project	• Increased severe mean annual maximum wave height.

CLIMATE VARIABLE	RELEVANT TO	PREDICTED CHANGE
Changing weather patterns (i.e. long-term shift in average climate conditions)	The offshore and onshore Project	• Increased air temperature.
		• Decreased summer rainfall (i.e. drier summers).
		• Increased winter rainfall.
Changing sea conditions (i.e. long-term shift in average climate conditions)	The offshore Project	• Increased sea surface and near-bottom temperature.
		• Decreased dissolved oxygen.
		• Decreased salinity.
		• Earlier onset of stratification and delayed breakdown of seasonal stratification.
		• Predicted decrease in pH.
Sea level rise and coastal erosion	The offshore and onshore Project	• Increased sea level.
		• Increased erosion of sedimentary shores along the north coast of Scotland.

4.5 Data gaps and uncertainties

The key uncertainties associated with assessing the impact of climate change on the physical, biological and socio-economic environment include:

- Uncertainty in the modelled predictions: Based on the uncertainty around the assumptions for the future emissions scenario, uncertainty in other model inputs (e.g. current conditions etc.) and uncertainty in political and societal responses to climate change;
- Uncertainty around the response of the physical, biological and socio-economic environment to changes in climate variables;
- A paucity of high-resolution predictions for the future marine environment along timelines that are directly relevant to the offshore Project; and
- Difficulties in attributing changes in the physical, biological and socio-economic environment to climate change.

5 IMPACTS REQUIRING ASSESSMENT

The various impacts that are assessed in each of the related climate assessments for the offshore and onshore Project presented in this report are presented in Table 5-1 below.

Table 5-1 Impacts assessed for the climate assessments

ASSESSMENT	IMPACT ASSESSED	IMPACT ASSESSMENT SECTION ID
Climate resilience review	Direct impacts of climate change during the operation and maintenance stage on the offshore and onshore Project.	6.3
ICCI assessment	The inter-related effects of climate change and the impacts of offshore and onshore Project on relevant receptors identified in the Offshore EIA Report and Onshore EIA Report during the operation and maintenance stage.	7.2
Biological carbon sequestration	• Direct biological carbon habitat store loss / disturbance from the onshore Project (e.g. peat loss and disturbance and tree felling) and offshore Project (e.g. loss of blue carbon habitats); and • Cumulative effects from the onshore Project and offshore Project and other projects resulting in biological carbon habitat store loss / disturbance.	8.1 and 8.2
Carbon assessment	The impact of the Project on the global climate receptor, utilising: • Calculated carbon life cycle emissions resulting from the Project; and • The UK Carbon Budgets as a proxy for the global climate.	9

6 CLIMATE RESILIENCE REVIEW

6.1 Introduction

This section reviews the ability of the Project to withstand, respond to and recover from the projected changes in climate, as they are described in Section 4.

A climate change impact refers to the effect (i.e. damage or interference) of a projected change in a climate variable (e.g. temperature, precipitation) on the Project infrastructure, facilities or activities. This is illustrated in Figure 6-1.

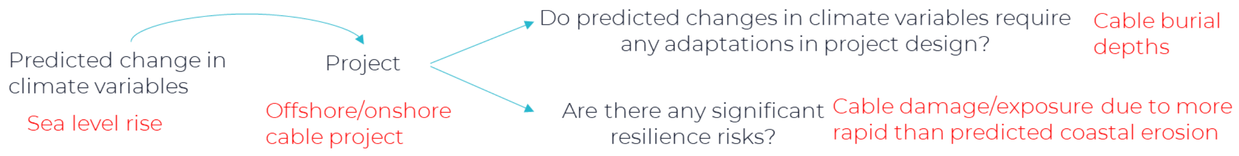


Figure 6-1 Illustration of climate resilience considerations, red text provides example

Project construction is expected to commence in 2027 (onshore) and 2028 (offshore, with the potential for pre-construction activities in 2027) therefore, the climate variables during construction are expected to be consistent with current conditions. The starting position for decommissioning is complete removal for re-use, recycling, and disposal unless there is compelling evidence to leave buried/underground sections *in situ*. As more detailed information on the decommissioning of the Project infrastructure is limited at this time, a meaningful assessment of Project resilience to climate change during the decommissioning stage is not possible. For these reasons, this review focuses on potential impacts posed by climate change on the Project during the operation and maintenance stage, including both the Project infrastructure and on operation and maintenance activities. A Decommissioning Programme (for the offshore Project) and a Decommissioning, Restoration and Aftercare Plan (for the onshore Project) will be developed and approved pre-construction to address the principal decommissioning measures for the Project, this will be written in accordance with applicable guidance and will detail the management, environmental management and schedule for decommissioning. It is therefore anticipated that decommissioning activities will be planned with the climate conditions at the time of decommissioning in mind. Therefore, it would be expected that the Project would be resilient to any changes in climate at the time of decommissioning.

6.2 Assessment methodology

This review has been conducted in accordance with the IEMA (2020) Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation, specifically Step 0: "Building Climate Resilience into the Project" and Appendix 1: "Climate Change Risk Assessment".

6.2.1 Climate change impact identification

The climate variables, as described in Section 4.3, with the potential to affect the offshore and onshore Project include:

- Extreme weather events (e.g. storm surges and waves);

- Changes in weather patterns or sea conditions; and
- Sea level rise; and
- Coastal erosion.

The Project design basis has considered elements of climate change within the components of the Project design.

The potential impacts on the offshore and onshore Project during the operation and maintenance stage associated with the projected changes in the climate variables listed above are assessed in Section 6.3. Table 6-1 outlines the projected changes in climate variables that have been scoped out of the assessment of climate resilience.

Table 6-1 Potential impacts of changing climate variables on the Project that are not further assessed

CLIMATE VARIABLE		POTENTIAL IMPACT ON THE DEVELOPMENT DESIGN OR INFRASTRUCTURE
Offshore		
Extreme weather events	Increased occurrence of heavy rainfall events.	There is only a limited potential for increased occurrence of heavy rainfall events (less extreme in the north coast of Scotland when compared with the rest of the UK, see section 4.3.1.2) and increased occurrence of heatwaves to result in disruption or increased safety risk (e.g. staff experiencing heat stress) to operation and maintenance procedures or equipment. Contractors will monitor weather patterns ahead of maintenance works and adequate health and safety measures will be in place. The WTGs and OSPs will be designed to have sufficient safety factors to account for the most extreme weather events using site data extrapolated over the expected lifetime of the Project. Therefore, this projected climate variable has been scoped out of the assessment of climate resilience.
	Increased occurrence of heatwaves.	
Changing weather patterns / sea conditions	Decreased summer rainfall.	No potential impacts on the offshore Project are expected from decreased summer rainfall, increased winter rainfall and increased ocean acidity. Therefore, this projected climate variable has been scoped out of the assessment of climate resilience.
	Increased winter rainfall.	
	Increased ocean acidity.	
	Reduced mean wave height.	No potential adverse impacts are expected from reduced mean wave height as this variable is within current conditions. Reduced wave height can positively affect accessibility to the offshore Project and reduce weather downtime throughout the year. Therefore, this projected climate variable has been scoped out of the assessment of climate resilience.

CLIMATE VARIABLE		POTENTIAL IMPACT ON THE DEVELOPMENT DESIGN OR INFRASTRUCTURE
Onshore		
Extreme weather events	Increased occurrence of heatwaves.	There is only a limited potential for increased heatwaves and increased air temperature to result in disruption or increased safety risk (e.g. staff experiencing heat stress) to operation and maintenance procedures or equipment. Contractors will monitor weather patterns ahead of maintenance works and adequate health and safety measures will be in place. The onshore export cables will be buried and are unlikely to be affected by changes in air temperature and the onshore substation will be designed to withstand heat stress. The onshore cables and onshore substation will be designed to have sufficient safety factors to account for the most extreme weather events using site data extrapolated over the expected lifetime of the onshore Project. Therefore, this projected climate variable has been scoped out of the assessment of climate resilience.
Changing weather patterns	Increased air temperature.	
	Decreased summer rainfall.	No potential impacts on the onshore Project are expected from decreased summer rainfall. Risks in relation to reduced soil moisture will be avoided by best practice design, and hence, impacts from this climate variable are considered unrealistic. Therefore, this projected climate variable has been scoped out of the assessment of climate resilience.

6.2.2 Embedded mitigation and management plans

As part of the Project design process, a number of designed-in measures and management plans have been proposed. The embedded mitigation measures that increase the resilience of the offshore and onshore Project to climate change, are described in the sections below. As there is a commitment to implementing these measures which will likely be secured through the offshore and onshore Project consent conditions, they are considered inherently part of the design of the Project and have therefore been considered in the assessment presented below (i.e. the determination of the magnitude of impact and therefore the significance of effects assumes implementation of these measures). These measures are considered standard industry practise for this type of development.

The embedded mitigation and management plans relevant to the offshore and onshore Project are described in Table 6-2.

Table 6-2 Embedded mitigation measures specific to climate resilience

EMBEDDED MITIGATION MEASURES	JUSTIFICATION
Offshore embedded mitigation	
Emergency Response Co-operation Plan (ERCoP)	An Emergency Response Co-operation Plan (ERCoP) will be in place for the offshore Project. The ERCoP will refer to the marking and lighting of the WTGs and will consider helicopters undertaking Search and Rescue (SAR operations when rendering assistance to vessels and persons in the vicinity of the OAA. The ERCoP will provide sufficient information about the Project, actions and details required in the event of an emergency situation. This will ensure that Maritime and Coastguard Agency (MCA) recommended standards and procedures are followed as well as ensuring appropriate lighting and marking is in place to facilitate aeronautical safety during) SAR helicopter operations.
Use of scour protection	The use of scour protection around the foundations of WTGs and OSPs will minimise scour effects around infrastructure. However, scour protection will only be implemented where required and will be minimised as far as is practicable. This will be informed by a scour assessment, undertaken post-consent.
Cable protection	Suitable implementation and monitoring of cable protection (via burial or external protection). Cables will be buried as the first choice of protection. External cable protection will be used where adequate burial cannot be achieved and this will be minimised as far as is practicable. This will be informed by a Cable Burial Risk Assessment (CBRA) undertaken post consent following results of the geotechnical survey.
Design standards	The WTG and structural support design shall be based on the Det Norske Veritas (DNV) and International Electrotechnical Commission (IEC) suite of standards. Versions of the standards in effect at the effective start date of the foundation detailed design shall be applicable. Design load cases and definition shall be in accordance with IEC 61400 suit of standards. All civil engineering infrastructure is designed using the return period method whereby structures are built to withstand a specific size of extreme event that has a set probability of occurring. Therefore, there is always a chance that structures encounter conditions beyond what they are designed for. This is managed through use of redundancy and fail-safe approaches to mitigate impacts of failure, as well as choosing a suitable return period. For example, infrastructure with serious consequence associated with failure, such as hospitals, nuclear power plants etc. will be designed to a significantly higher return period event than a WTG which is sited in a remote location and unmanned.
Onshore embedded mitigation	
Avoidance of sensitive areas (peatland, woodland)	Routing underground cables to avoid sensitive areas is the primary means by which impacts are minimised upon these habitats. However, where this is not possible other mitigation measures will be implemented and outlined within the Construction Environmental Management Plan (CEMP).
Compensatory planting	All felled woodland will be compensated for by an appropriately designed new compensatory forestry planting scheme.

EMBEDDED MITIGATION MEASURES	JUSTIFICATION
Peat management plan	An outline Peat Management Plan (PMP) will be provided alongside the onshore application. The final PMP will be developed in detail prior to construction to ensure that peat resources are managed in accordance with best practice. The PMP will form part of the wider mitigation measures within the CEMP.
Flood Risk Design (Sustainable Drainage Systems (SuDS))	Once the onshore cable circuits have been installed, they are deemed flood resilient. However, the indicative location for the substation infrastructure is next to a flood risk area and will require design mitigation, including SuDS. A detailed flood risk assessment will be undertaken and consider all onshore infrastructure, and flood risk mitigation measures will be embedded into the design.

6.2.3 Defining the climate change risk

The risk posed by climate change on the Project is determined by defining the likelihood and magnitude of the potential climate change impact. Existing or embedded mitigations identified within the EIA are accounted for when determining impact likelihood and magnitude.

The definitions for likelihood and magnitude are provided in Table 6-3 and Table 6-4, respectively. It should be noted that likelihood refers to the impact occurring under the worst-case assumption that the projected change does occur (i.e. that the confidence level for the projected change is high).

Table 6-3 Definitions for the likelihood

LIKELIHOOD	DEFINITION
Certain (>95%)	The event / impact will occur during the life-cycle of the Project (i.e. it is inevitable), potentially many times during the operation and maintenance stage.
Likely (66-95%)	The event / impact is likely to occur at some point during the life-cycle of the Project.
Possible (33-65%)	The event / impact is possible during the life-cycle of the Project.
Unlikely (10-32%)	The event / impact is unlikely to occur during the life-cycle of the Project.
Extremely Unlikely (0-9%)	The event / impact is extremely improbable during the life-cycle of the Project.

Table 6-4 Definitions for magnitude

MAGNITUDE	DEFINITION
High	• Permanent damage, loss or reduction in the structural integrity of the Project infrastructure and facilities; • Serious health and safety risk; and • Irreversible and irrecoverable financial or environmental impact.
Moderate	• Major damage, loss or reduction in the structural integrity of the Project infrastructure and facilities; • Major health and safety risk; and • Major financial or environmental impact.
Low	• Moderate damage, loss or reduction in the structural integrity of the Project infrastructure and facilities; • Moderate health and safety risk; and • Moderate financial or environmental impact.
Negligible	• Minimal damage, loss or reduction in the structural integrity of the Project infrastructure; • Low health and safety risk; and • Minimal financial or environmental impact.
No Change	• No damage or loss of the Project infrastructure; • No health and safety risks; and • No financial or environmental impact.

Having determined the likelihood and magnitude of the climate change impact, the risk level is determined, as either negligible, minor, moderate, or major, as shown in Table 6-5.

The risk level categories in Table 6-5 provide a threshold to determine whether or not the risk is assessed as being 'significant' in terms of the Project's resilience to climate change. Moderate and major risks are defined as 'significant' in terms of the Project's resilience to climate change.

Where the assessment identifies a significant risk from the changing climate on the Project design, mitigation measures, or adaptations to design have been proposed to avoid or reduce impacts to an acceptable risk level.

Table 6-5 Significance matrix

		LIKELIHOOD				
		EXTREMELY UNLIKELY	UNLIKELY	POSSIBLE	LIKELY	CERTAIN
MAGNITUDE	NO CHANGE	Negligible	Negligible	Negligible	Negligible	Negligible
	NEGLIGIBLE	Negligible	Negligible	Minor	Minor	Minor
	LOW	Negligible	Minor	Minor	Moderate	Major
	MODERATE	Negligible	Minor	Moderate	Major	Major
	HIGH	Minor	Moderate	Major	Major	Major

6.2.4 Data gaps and uncertainties

The evidence base for climate change assessments and the confidence in future climate projections is increasing. However, there are still data gaps present as this is a growing area of research (Küpper and Kamenos, 2017). Data sources, such as the MCCIP, aim to continue to review and publish evidence on climate change risks and impacts as and when they occur, and therefore, it is expected that the understanding of the climate change projections and impacts presented within this assessment will continue to evolve in the coming years. The assessment has been carried out using the most comprehensive and up-to-date data sources, as described in Section 4. It is acknowledged that this climate change resilience review is limited by the data available at the time of the assessment.

6.3 Assessment of climate resilience

6.3.1 Offshore

Table 6-6 Assessment of the offshore Project resilience to climate change

CLIMATE VARIABLE	IMPACT ON THE PROJECT	LIKELIHOOD	MAGNITUDE	RISK LEVEL	SIGNIFICANCE	MITIGATION / ADAPTATION REQUIRED	RESIDUAL SIGNIFICANCE
Extreme weather event: Increased occurrence of high wind events and lightning strikes during storms.	High wind events and lightning strikes have the potential to cause damage, loss or reduced structural integrity of the offshore Project infrastructure / facilities.	Possible – The WTGs and fixed foundations substructures of the offshore Project will be designed using the return period method to withstand a specific size of extreme event that has a set probability of occurring. The WTGs will also consider the relevant design codes which have sufficient safety factors to account for extreme weather events. At high wind speeds that exceed the cut-out speed, the WTGs will shut down to avoid structural damage. Identification and remediation of any damage, will take place during routine inspection and maintenance.	Low – High wind events can cause potential damage to site infrastructure as well as significant cost and health and safety risks. However, there will be no personnel present on structures during storm events resulting in a low health and safety risk and any damage is considered to be minor to moderate in the context of the Project expenditure.	Minor	Not significant	None required above embedded mitigation	Not significant
	High wind events, such that frequent cut-out speed exceedance will result in increased downtime.	Possible – Increased occurrence of high wind events may result in exceedance of the cut-out speed	Negligible – At high wind speeds that exceed the cut-out speed, the WTGs will shut down to avoid structural damage. Identification and remediation of any damage, will take place during routine inspection and maintenance.	Minor	Not significant	None required above embedded mitigation	Not significant
Extreme weather event: Increased extreme / severe wave heights.	High wave events have the potential to cause damage, loss or reduced structural integrity of the offshore Project infrastructure / facilities.	Extremely unlikely – The WTGs and fixed foundations of the offshore Project will be designed in accordance with site specific data extrapolated over the expected lifetime of the Offshore Project. The WTGs will also consider the relevant design codes using the return period method to withstand a specific size of extreme event that has a set probability of occurring. Due to foundation and WTG height, wave damage is unlikely to result in structural damage. Identification and remediation of any damage, will take place during routine inspection and maintenance. All equipment includes tolerance levels to deal with changes to parameters e.g. a small change in temperature would be well within the design limits for cables which are in any case designed to operate across a wide range of	Low – Even though the likelihood is extremely low, high wave events can cause potential damage to site infrastructure as well as significant damage, cost and health and safety risks. However, there will be no personnel present on structures during storm events resulting in a low health and safety risk and any damage, in the context of offshore Project infrastructure being designed using the return period method, is considered to be minor to moderate in the context of the Project expenditure.	Minor	Not significant	None required above embedded mitigation	Not significant

CLIMATE VARIABLE	IMPACT ON THE PROJECT	LIKELIHOOD	MAGNITUDE	RISK LEVEL	SIGNIFICANCE	MITIGATION / ADAPTATION REQUIRED	RESIDUAL SIGNIFICANCE
		climatic conditions to be suitable across the global market.					
	High wave events can cause disruption (e.g. reduced accessibility) or increased safety risk to operation and maintenance procedures or equipment / vessels.	Extremely unlikely – Disruption is only likely to occur in extreme circumstances. The likelihood of extreme waves during operation and maintenance activities is low as ahead of maintenance works, Contractors will monitor weather patterns to identify suitable weather windows (by identifying suitable weather periods and undertaking weather modelling using site specific data) to undertake operation and maintenance tasks, and will ensure health and safety protocols will be adhered to. All equipment includes tolerance levels to deal with changes to parameters e.g. a small change in temperature would be well within the design limits for cables which are in any case designed to operate across a wide range of climatic conditions to be suitable across the global market.	Low – Potential health and safety risks for if personnel required to work in sub-optimal or sudden change of weather conditions. However, there will be no personnel present on structures during storm events resulting in a low health and safety risk and any damage, in the context of the offshore Project infrastructure being designed to withstand extreme weather, is considered to be minor to moderate in the context of the Project expenditure.	Negligible	Not significant	None required above embedded mitigation	Not significant
Changing weather patterns / sea conditions: Increased air and sea temperature.	Increased temperatures (e.g. thermal expansion) has the potential to cause damage, loss or reduced structural integrity of the offshore Project infrastructure	Extremely unlikely – As part of the Project design, cables will be buried or protected to reduce potential for overheating. The infrastructure is designed to withstand heat stress. The north coast of Scotland is also predicted to have less extreme increases than elsewhere in the UK. Therefore, this impact to the offshore Project infrastructure is extremely unlikely. All equipment includes tolerance levels to deal with changes to parameters e.g. a small change in temperature would be well within the design limits for cables which are in any case designed to operate across a wide range of climatic conditions to be suitable across the global market.	Low – The functioning of the offshore export cables may be affected by overheating however, this is not expected to result in significant cost or damage.	Negligible	Not significant	None required above embedded mitigation	Not significant
	Increased temperatures may result in increased potential for biofouling of foundations due to creation of a favourable environment for microorganisms.	Extremely unlikely – Substructures will be designed to accommodate some marine growth and marine growth will be removed on a regular basis, as required.	Low – Significant marine growth has the potential to add weight. However, this is unlikely to be of any significant magnitude considering the embedded mitigations in place.	Negligible	Not significant	None required above embedded mitigation	Not significant
	Increased air temperatures can result in disruption or increased safety risk (e.g. staff experiencing heat stress) to operation and	Extremely unlikely – Predicted air temperature increases are not expected to be significant enough (the north coast of Scotland is also predicted to have less extreme increases than elsewhere in the UK) to induce heat	Low – Potential health and safety risks will be lowered by adherence to health and safety protocols	Negligible	Not significant	None required above embedded mitigation	Not significant

CLIMATE VARIABLE	IMPACT ON THE PROJECT	LIKELIHOOD	MAGNITUDE	RISK LEVEL	SIGNIFICANCE	MITIGATION / ADAPTATION REQUIRED	RESIDUAL SIGNIFICANCE
	maintenance procedures or equipment.	stress, except in extreme cases. Ahead of maintenance works, Contractors will monitor weather patterns and health and safety protocols will be adhered to.					
Sea level rise	Changing sea conditions can result in potential damage, loss or reduced structural integrity of the offshore Project components particularly WTG foundations.	Extremely unlikely – The WTG foundations will be situated at a height that will prevent any impacts from sea level rise upon the structural integrity of the foundations.	Low – Installation design will take into consideration the likely effects of sea level rise.	Negligible	Not significant	None required above embedded mitigation	Not significant
Coastal erosion	Changing sea conditions and coastal erosion can result in potential damage. Loss or reduced structural integrity of offshore export cables.	Extremely unlikely – The export cables will be installed through an HDD and ducted conduit, surfacing in-land and thus reducing potential for vulnerabilities. The offshore export cables will be buried or protected. Regular surveys will be undertaken to monitor the condition of the cables.	Moderate – Exposure of cables could increase the risk of cable to external threats, increasing risk of damage or faults.	Negligible	Not significant	None required above embedded mitigation	Not significant

6.3.2 Onshore

Table 6-7 Assessment of the Project resilience to climate change

CLIMATE VARIABLE	IMPACT ON THE PROJECT	LIKELIHOOD	MAGNITUDE	RISK LEVEL	SIGNIFICANCE	MITIGATION / ADAPTATION REQUIRED	RESIDUAL SIGNIFICANCE
Extreme weather event: such as high wind events lightning strikes during storms.	Potential damage, loss or reduced structural integrity of the onshore Project infrastructure / facilities as a result of high wind events and lightning strikes.	Possible – The onshore substation will be designed in accordance with the relevant design codes using the return period method to withstand a specific size of extreme event that has a set probability of occurring. Regular maintenance of assets will also be carried out to identify and remediate any damage.	Low – The potential damage to site infrastructure as a result of high wind events could result in significant cost and health and safety risks. However, there will be no personnel present at structures during storm events resulting in a low health and safety risk and any damage is considered to be minor to moderate in the context of the Project expenditure.	Minor	Not significant	None required above embedded mitigation	Not significant
	Disruption (e.g. reduced accessibility) or increased safety risk to operation and maintenance procedures or equipment / vehicles as a result of high wind events and lightning strikes.	Possible – Event is only likely to occur in extreme circumstances. The likelihood of extreme winds during operation and maintenance activities is low as contractors will monitor weather patterns ahead of maintenance works to identify suitable weather windows to undertake operation and maintenance tasks, and health and safety protocols will be adhered to.	Low – Potential health and safety risks for personnel with working in poor weather conditions. However, there will be no personnel present at structures during storm events resulting in a low health and safety risk and any damage is considered to be minor to moderate in the context of the Project expenditure.	Minor	Not significant	None required above embedded mitigation	Not significant
Extreme weather event: heavy rainfall events.	Potential damage, loss or reduced structural integrity of the onshore Project infrastructure / facilities (onshore substation infrastructure) as a result of high rainfall events.	Possible – The underground onshore cable circuits and substation have been designed in accordance with the relevant design codes using the return period method to withstand a specific size of extreme event that has a set probability of occurring. The onshore cable circuits are also considered flood resilient once installed and the substation will be designed to include flood protection measures such as SuDS. Regular maintenance of assets will also be carried out to identify and remediate any damage.	Low – An Air Insulated Substation (AIS) Substation is designed to withstand external environmental conditions, and Gas Insulated Substation (GIS) is housed within a building therefore reducing impact from external conditions. Therefore the potential damage to site infrastructure as a result of high wind events / rainfall is not likely to result in significant cost and health and safety risks.	Minor	Not significant	None required above embedded mitigation	Not significant
Changing weather patterns: increased winter rainfall	Potential damage, loss or reduced structural integrity of the onshore Project infrastructure / facilities (onshore substation infrastructure) as	Possible – The underground onshore cable circuits and substation have been designed in accordance with the relevant design codes using the return period method to withstand a specific size of extreme event that has a set probability of occurring. The onshore cable circuits are also considered flood	Low - An AIS Substation is designed to withstand external environmental conditions, and GIS is housed within a building therefore reducing impact from external conditions. Therefore the potential damage to site infrastructure as a result of rainfall is	Minor	Not significant	None required above embedded mitigation	Not significant

CLIMATE VARIABLE	IMPACT ON THE PROJECT	LIKELIHOOD	MAGNITUDE	RISK LEVEL	SIGNIFICANCE	MITIGATION / ADAPTATION REQUIRED	RESIDUAL SIGNIFICANCE
	a result of high rainfall events (such as soil instability e.g. landslides).	resilient once installed and the substation will be designed to include flood protection measures such as SuDS. Regular maintenance of assets will also be carried out to identify and remediate any damage.	not likely to result in significant cost and health and safety risks.				
Sea level rise	Potential damage, loss or reduced structural integrity of the onshore Project infrastructure / facilities from coastal erosion and increased flooding (e.g. exposure of cables).	Extremely unlikely – Regular surveys will be undertaken to monitor the condition of the cables. The cables will also be installed through a Horizontal Directional Drilling (HDD) and ducted, surfacing in-land and thus reducing potential for damage from any increase flooding. The onshore substation infrastructure will be located in-land and therefore no impacts are likely to occur.	Negligible – The method of cable installation at the landfalls is via HDD at depths greater than the impact of coastal erosion will reach. The onshore substation is also situated a significant distance from the coast therefore away from any coastal flood risk areas. .	Negligible	Not significant	None required above embedded mitigation	Not significant
Coastal erosion	Changing sea conditions and coastal erosion can result in potential damage. Loss or reduced structural integrity of onshore export cables.	Extremely unlikely – The export cables will be installed through an HDD and ducted conduit, surfacing in-land and thus reducing potential for vulnerabilities. The onshore export cables will be buried or protected. Regular surveys will be undertaken to monitor the condition of the cables	Medium – Exposure of cables could increase the risk of cable to external threats, increasing risk of damage or faults.	Negligible	Not significant	None required above embedded mitigation	Not significant

6.3.3 Summary

Overall, for both the offshore and onshore Project, there is the potential for climate change impacts to pose a risk to the Project infrastructure, facilities or activities. The comprehensive assessment, based on the best-available data and a prediction of the likelihood of these future occurrences has resulted in the overall risk of climate change to the Project being assessed as minor/negligible and not significant in EIA terms.

7 IN-COMBINATION CLIMATE IMPACT (ICCI) ASSESSMENT

The ICCI assessment considers how any of the predicted impacts from the Project alone could be exacerbated or reduced by any predicted future changes in the physical environment due to climate induced changes, as discussed in Section 7.2. The ICCI assessment has been conducted in accordance with IEMA (2020) Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation, specifically Step 2 to Step 7. This is illustrated in Figure 7-1.

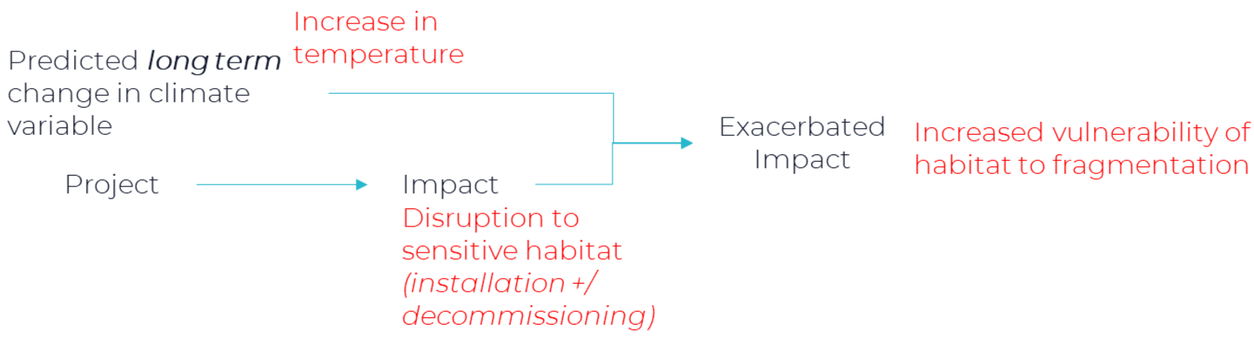


Figure 7-1 Illustration of ICCI assessment, red text provides examples

7.1 Assessment methodology

The ICCI assessment considers all potential receptors which could be impacted by the Project, as outlined within the Offshore and Onshore EIA reports. It places the impact of the Project on relevant EIA receptors in the context of future climate conditions, as outlined in Section 4.3. The approach and methodology are outlined in Sections 7.1.1 to 7.1.4 below.

7.1.1 Receptor and impact identification

Only impacts associated with operation and maintenance are considered within the ICCI assessment, as the current climate conditions are considered to be applicable for the construction stage. Furthermore, as detailed information on the decommissioning of the Project infrastructure is limited at this time, a meaningful assessment of the in-combination impact of climate change and the Project at the time of decommissioning is not possible. An onshore Decommissioning, Restoration and Aftercare Plan and an offshore Decommissioning Programme will be developed prior to decommissioning to address the principal decommissioning measures for the Project, these will be written in accordance with applicable guidance and will detail the management, environmental management, and schedule for decommissioning of the Project. Any environmental management measures would reflect the environmental baseline at the time of decommissioning.

The future climate projections are summarised in Section 4 and this information has been reviewed to identify the potential impacts of climate change on the EIA topics assessed within the Offshore and Onshore EIA Reports. The impacts of the Project are then considered alongside any impacts associated with future climate projections, to understand whether the Project impact is exacerbated or reduced.

7.1.1.1 Offshore

All EIA topics assessed in chapters 8 to 20 of the Offshore EIA report are considered within the ICCI assessment. The impacts of the offshore Project on the receiving environment are identified and assessed through the EIA process and reported in chapters 8 to 20.

The following receptors have not been considered within the ICCI assessment for the following reasons:

- Military and aviation – considered to have a negligible sensitivity to changes in climate, and therefore the likelihood of an ICCI is extremely unlikely;
- Shipping and navigation - considered to have a negligible sensitivity to changes in climate, and therefore the likelihood of an ICCI is extremely unlikely;
- Water and sediment quality - considered to have a negligible sensitivity to changes in climate, and therefore the likelihood of an ICCI is extremely unlikely;
- Marine archaeology and cultural heritage- considered to have a negligible sensitivity to changes in climate, and therefore the likelihood of an ICCI is extremely unlikely;
- Other sea users - considered to have a negligible sensitivity to changes in climate, and therefore the likelihood of an ICCI is extremely unlikely;
- Seascape, landscape and visual – the key impact to seascape, landscape and visual from climate change is considered to be in relation to effects on coastal morphology. For this reason, the marine physical and coastal processes ICCI assessment should be referred to in order to understand the likelihood of an ICCI;
- Socio-economics – climate change may have a positive or negative effect on tourism and recreation. Positive effects may arise from increased temperature, whereas negative effects may arise from sea level rise and coastal erosion. For this reason, the marine physical and coastal processes ICCI assessment should be referred to in order to understand the likelihood of an ICCI;
- Commercial fisheries - the key impact to commercial fisheries from climate change is considered to be in relation to effects on fish and shellfish (e.g. range shifts in commercially important species). For this reason, the fish and shellfish ICCI assessment should be referred to in order to understand the likelihood of an ICCI; and
- Major accidents and disasters (included in Offshore EIA Report, chapter 5: Project description, and SS2: Major accidents and disasters) – the vulnerability of the offshore Project to climate change is discussed in Section 6.3, and this considers any climate hazards which could result in major accidents and disasters

7.1.1.2 Onshore

All EIA topics assessed in chapters 8 to 17 of the Onshore EIA Report are considered within the ICCI assessment. The impacts of the onshore Project on the receiving environment are identified and assessed through the EIA process and reported in chapters 8 to 17.

The following receptors have not been considered within the ICCI assessment for the following reasons:

- Archaeology and cultural heritage - considered to have a negligible sensitivity to changes in climate, and therefore the likelihood of an ICCI is extremely unlikely. It is not anticipated that climate change will cause any changes to the baseline of buried archaeology assets within the terrestrial archaeology and cultural heritage onshore study area. The key potential climate change impact on the setting of cultural heritage assets would be in relation to habitat/vegetation loss or change that could alter the visual environment. For this reason, the terrestrial non-avian ecology ICCI assessment should be referred to in order to understand the likelihood of an ICCI;

- Air quality – the key potential climate change impact for air quality will be increases in dust and air pollutants. However, it is considered that air quality is likely to improve in the future due to uptake of lower emission vehicles, and the likelihood of an ICCI is extremely unlikely;
- Noise and vibration - considered to have a negligible sensitivity to changes in climate. The only feasible pathway of effect would be increased air temperature increasing exposure to noise as occupants of houses opened their windows. This will be adequately mitigated against through embedded mitigation measures for the substation design. Therefore the likelihood of an ICCI is extremely unlikely;
- Access, traffic and transport – considered that the traffic flow future baselines will be similar to that of the 2022 baseline. Access, traffic and transport receptors are considered to have a negligible sensitivity to changes in climate. The only feasible pathway of effect would be changes in weather patterns causing a change in the use of transport and time spent outdoors. However, the likelihood of an ICCI is extremely unlikely due to the limited impact of the onshore Project on traffic associated with adhoc maintenance trips to the onshore substation and onshore ECC; and
- Landscape and visual - considered to have a negligible sensitivity to changes in climate, and therefore the likelihood of an ICCI is extremely unlikely. The key potential climate change impact would be in relation to changes in the visual environment from habitat/vegetation loss or change. For this reason, the terrestrial non-avian ecology ICCI assessment should be referred to in order to understand the likelihood of an ICCI.

7.1.2 Embedded mitigation and management plans

As noted in Section 6.2.2, embedded mitigation and management plans are proposed to form part of the design of the Project to reduce the potential impact of the Project on the receptors outlined in Section 7.1.1. The relevant embedded mitigation measures and management plans for each EIA topic are provided in the corresponding chapters of the Offshore and Onshore EIA Reports.

7.1.3 Defining likelihood and magnitude

The consequence of the ICCI is determined by defining the likelihood and magnitude of the impact. Existing or embedded mitigations and management plans identified within the Onshore and Offshore EIA Reports are accounted for when determining impact likelihood and magnitude.

The definitions for likelihood and magnitude are provided in Table 7-1 and Table 7-2, respectively. The likelihood of the ICCI occurring considers the potential for the climate projection to occur alongside the sensitivity of the receptor and is based on expert judgement. The magnitude considers the change in the significance of the effect from the Project when the in-combination effects of climate change are considered.

Table 7-1 Definitions for likelihood

LIKELIHOOD	DEFINITION
Certain (>95%)	The event / impact will occur during the life-cycle of the Project (i.e. it is inevitable), potentially many times during the operation and maintenance stage.
Likely (66-95%)	The event / impact is likely to occur at some point during the life-cycle of the Project.
Possible (33-65%)	The event / impact is possible during the life-cycle of the Project.
Unlikely (10-32%)	The event / impact is unlikely to occur during the life-cycle of the Project.
Extremely Unlikely (0-9%)	The event / impact is extremely improbable during the life-cycle of the Project.

Table 7-2 Definitions for magnitude

MAGNITUDE	DEFINITION
High	The consequence of the effect increases to major when the in-combination effects from climate change are considered.
Moderate	The consequence of the effect increases to moderate when the in-combination effects from climate change are considered.
Low	The consequence of the effect increases to minor when the in-combination effects from climate change are considered.
Negligible / no change	There is no change in the effect in-combination with the project change in the climate variable.

Having determined the likelihood and magnitude of the ICCI, the consequence is determined, as either negligible, minor, moderate, or major, as shown in Table 7-3.

The consequence categories in Table 7-3 provide a threshold to determine whether or not the ICCI is deemed ‘significant’ in EIA terms. Moderate and major consequences are defined as a ‘significant’ impact in EIA terms.

Where the assessment identifies a significant impact climate on the Project design, mitigation measures or design changes have been proposed to avoid or reduce impacts to an acceptable level.

Table 7-3 Significance matrix

		LIKELIHOOD				
		EXTREMELY UNLIKELY	UNLIKELY	POSSIBLE	LIKELY	CERTAIN
MAGNITUDE	NO CHANGE	Negligible	Negligible	Negligible	Negligible	Negligible
	NEGLIGIBLE	Negligible	Negligible	Minor	Minor	Minor
	LOW	Negligible	Minor	Minor	Moderate	Major
	MODERATE	Negligible	Minor	Moderate	Major	Major
	HIGH	Minor	Moderate	Major	Major	Major

7.1.4 Data gaps and uncertainties

The evidence base for climate change and the confidence in future climate projections is increasing. However, there are still data gaps present and this is a growing area of research. The assessment has been carried out using the most comprehensive and up-to-date data sources, as described in Section 4. It is acknowledged that this ICCI assessment is limited by the data available at the time of the assessment.

7.2 ICCI assessment

7.2.1 Offshore

Table 7-4 summarises the ICCI assessment, which has been undertaken using the methodology described in Section 7.1.

Table 7-4 Offshore summary of ICCI assessment

EIA TOPIC	PROJECT IMPACT (OPERATION AND MAINTENANCE)	RELEVANT EMBEDDED MITIGATION MEASURES	POTENTIAL CLIMATE CHANGE PROJECTION AND IMPACT	LIKELIHOOD OF ICCI	MAGNITUDE OF ICCI	CONSEQUENCE OF ICCI	SIGNIFICANCE	ADDITIONAL MITIGATION REQUIRED?	SIGNIFICANCE OF RESIDUAL CONSEQUENCE
Marine physical and coastal processes	1. Change to the tidal, wave and sediment transport regimes resulting in impacts on morphology and coast receptors; 2. Introduction of scour; 3. Re-exposure of buried cables at landfall and changes to coastal processes and landfall morphology from remedial protection measures; and 4. Changes to water column structure with impact on stratification.	• Site selection; • Scour protection; • Implementation of suitable cable protection; • Landfall methodology to minimise the direct impact on the coastline; and • Pre-construction cable route survey.	Predicted increase in sea temperatures (e.g. influencing stratification), sea level rise, reduction in mean significant wave height, increase in mean annual maximum wave height could alter the physical environment at the offshore Project and alter the predicted effects of the offshore Project for impacts 1, 2, 3 and 4.	Extremely unlikely – The offshore Project is predicted to have minimal extent of change in metocean conditions that will be imperceptible outwith the spectrum of natural variation. Additionally, there is no change predicted in the sediment transport regime. Therefore, no ICCI is expected.	Negligible – The predicted effect of climate change is not expected to exacerbate the impact of the offshore Project.	Negligible	Not significant	No	Not significant
			Earlier onset of stratification and delayed breakdown of seasonal stratification could alter the predicted effects of the offshore Project for impact 4.	Extremely unlikely – Stratification already occurs within the wider Project area and the extent of stratification is relatively limited (based on Project specific survey data). Changes to the occurrence or properties of fronts and stratification will be dictated by mesoscale processes and regional changes to the water column, therefore, the influence of structures in the marine environment is unlikely to affect stratification in any significant manner. Therefore, no ICCI is expected.	Negligible – The predicted effect of climate change is not expected to exacerbate the impact of the offshore Project.	Negligible	Not significant	No	Not significant
Benthic and intertidal ecology	1. Temporary habitat loss/ disturbance; 2. Long-term habitat loss / disturbance; 3. Increased suspended sediment concentration and associated deposition; 4. Colonisation of hard structures; 5. Change in physical processes; 6. Impacts from the release of sediment bound contaminants; 7. Impact to benthic communities from any thermal load or Electromagnetic Fields (EMF) arising from the cable during operation; and 8. Introduction and spread of Invasive Non-native Species (INNS).	• Site selection; • The development of, and adherence to, an Environmental Management Plan (EMP); and • Landfall methodology to minimise the direct impact on the intertidal environment; • Implementation of suitable cable protection; and • Consideration benthic ecology features for final layout.	Predicted change in sea conditions (e.g. increased sea temperatures) at the limits of tolerance for benthic subtidal and intertidal ecology receptors may enhance other external effects, including those of the offshore Project, such as impacts 1, 2, 3, 4, 5, 6, 7 and 8 (Wright *et al.*, 2020).	Unlikely – Impacts of habitat loss will occur during the construction stage and will be realised during operation and maintenance. The benthic subtidal and intertidal receptors within the offshore Project area are expected to be relatively tolerant to the projected changes in sea conditions (see section 4.3.1.4) within the lifetime of the offshore Project.	Negligible – The predicted effect of climate change is not expected to exacerbate the effect of the offshore Project on benthic subtidal and intertidal ecology receptors.	Negligible	Not significant	No	Not significant
			Predicted effects of climate change on physical and coastal processes (described above) could exacerbate the predicted effects of the offshore Project impacts 3, 5 and 6.	Extremely unlikely – The offshore Project is predicted to have minimal extent of change in metocean conditions that will be imperceptible outwith the spectrum of natural variation. Additionally, there is no change predicted in the sediment transport regime. Therefore, no ICCI is expected.	Negligible – The predicted effect of climate change is not expected to exacerbate the impact of the offshore Project.	Negligible	Not significant	No	Not significant
			Predicted change in sea conditions (e.g. increased sea temperatures) could increase the spread of INNS, exacerbating the predicted effects of offshore Project impact 8.	Unlikely – While benthic subtidal and intertidal ecology receptors are expected to be relatively tolerant to the projected changes in sea conditions within the lifetime of the offshore Project, and it is possible that some species may be impacted by the spread of INNS, this is not anticipated to have a widespread effect on the benthic community over the lifetime of the Project.	Negligible – The risks from the offshore Project will be localised and reduced through the implementation of embedded mitigation measures to prevent the spread of INNS. Therefore, the effect of climate change is not expected to exacerbate the effects of the offshore Project	Negligible	Not significant	No	Not significant

EIA TOPIC	PROJECT IMPACT (OPERATION AND MAINTENANCE)	RELEVANT EMBEDDED MITIGATION MEASURES	POTENTIAL CLIMATE CHANGE PROJECTION AND IMPACT	LIKELIHOOD OF ICCI	MAGNITUDE OF ICCI	CONSEQUENCE OF ICCI	SIGNIFICANCE	ADDITIONAL MITIGATION REQUIRED?	SIGNIFICANCE OF RESIDUAL CONSEQUENCE
Fish and shellfish	1. Habitat loss and disturbance; 2. Effects of EMFs; 3. Introduction of new structures and potential fish or predator aggregation; 4. Barrier effects to diadromous fish; and 5. Indirect effects related to changes in availability or distribution of prey species	• Implementation of suitable cable protection; • Landfall methodology to minimise the direct impact on the intertidal environment (including at Forss Water); and • The development of, and adherence to, an EMP.	Predicted change in sea conditions (e.g. increased sea temperatures) at the limits of tolerance for fish and shellfish ecology receptors may enhance other external impacts, including those of the offshore Project, such as impact 1, 2, 3, 4 and 5.	Unlikely – Although uncertain, fish and shellfish are expected to be relatively tolerant to the projected changes in sea conditions within the lifetime of the offshore Project (see section 4.3.1.4), given the wide distribution of the species present.	Negligible – The risks from the offshore Project will be localised and reduced through the implementation of embedded mitigation measures. Although the climate change impact is uncertain and potentially long-lasting, the effect of climate change is not expected to exacerbate the effects of the offshore Project.	Negligible	Not significant	No	Not significant
			Indirect effects in relation to impacts on prey species (e.g. reduced availability and distribution) could enhance the predicted effects of offshore Project impacts 3 and 5.	Unlikely – Although there may be a potential reduction in prey species, this is highly uncertain.	Negligible – The risks from the offshore Project will be localised and reduced through the implementation of embedded mitigation measures. Although the climate change impact is uncertain and potentially long-lasting, the effect of climate change is not expected to exacerbate the effects of the offshore Project.	Negligible	Not significant	No	Not significant
			Predicted increase in sea temperatures could result in change of spawning and/or migratory periods, altering the predicted effects of offshore Project impacts 1, 2, 3 and 4 (Wright *et al.*, 2020).	Possible – Spawning and recruitment success may be hindered by rising sea temperatures, as the synchrony between hatching fish larvae and plankton prey is changing (Wright *et al.*, 2020).	Negligible– The impact will be long-lasting but is uncertain. The area of spawning habitat lost from the offshore Project is low and minimised through the implementation of embedded mitigation measures. Therefore, the effect of climate change is not expected to exacerbate the effects of the offshore Project	Minor	Not significant	No	Not significant
Marine mammals and megafauna	1. Noise-related impacts during operation; 2. Disturbance due to physical presence and underwater noise from vessels; 3. Vessel collision; 4. Displacement or barrier effects associated with physical presence of devices and infrastructure; and 5. Indirect effects related to changes in availability or distribution of prey species.	• Implementation of suitable cable protection; • The development of, and adherence to, an EMP; and • Development and adherence to a Marine Mammal Mitigation Protocol (MMMP).	Predicted change in sea conditions (e.g. increased sea temperatures) at the limits of tolerance for marine mammal and megafauna receptors may enhance other external effects, including those of the offshore Project, such as impacts 1, 2, 3, 4, and 5.	Low – Changes in sea conditions and additional stresses may increase the vulnerability of marine mammals with regards to range and habitat and diet specialisation.	Negligible – The climate change impact is uncertain but would be long-lasting. The risks from the offshore Project will be localised and reduced through the implementation of embedded mitigation measures. Therefore, the effect of climate change is not expected to exacerbate the effects of the offshore Project	Minor	Not significant	No	Not significant
			Indirect effects in relation to impacts on prey species (e.g. reduced availability and distribution) and marine mammal migratory patterns could enhance the predicted effects of offshore Project impacts 4 and 6.	Unlikely – The availability of prey may be impacted by range shifts of marine mammal prey species, potentially exacerbating any impact of displacement or barrier effects and long-term habitat change. However, this impact on marine mammals is highly uncertain and poorly understood.	Negligible – Climate change could result in a reduction in some prey species. However, the offshore Project structures have the potential to act as a fish aggregation area, potentially increasing prey abundance. Overall, the effect of climate change is not expected to exacerbate the effects of the offshore Project.	Minor	Not significant	No	Not significant
Offshore and intertidal ornithology	1. Direct disturbance and displacement (including barrier effects, from offshore infrastructure and due to increased vessel and helicopter activity within the OAA); 2. Indirect effects on habitats and prey species; 3. Collision risk; and 4. Combined operational collision risk and displacement.	• Site selection; • Minimum WTG blade clearance; and • Avoidance of excessive lighting wherever possible.	Increased occurrence of extreme weather events (e.g. heavy rainfall events) and sea level rise and erosion may impact breeding bird success or impact foraging success at-sea and enhance any other survival impairment (Mitchell *et al.*, 2020). This could alter offshore Projects impacts 1, 2 ,3 and 4.	Possible – Extreme weather events are expected to increase in occurrence as well as sea level rise and coastal erosion could put additional pressure on birds and result in reduced foraging success and overall tolerance of the offshore Project.	Negligible – The projected increase in frequencies of extreme weather are effects are uncertain but expected to be small. Therefore, the effect of climate change is not expected to exacerbate the effects of the offshore Project.	Minor	Not significant	No	Not significant
			Indirect effects in relation to impacts on prey species (e.g. reduced availability and distribution) and offshore ornithology migratory patterns could enhance the predicted effects of offshore Project impact 1, 2, 3, and 4.	Possible – The potential effect on prey species is uncertain. The potential exacerbating of displacement or barrier effects and long-term habitat change could put additional pressure on birds and result in indirect effects.	Negligible – Climate change effects could result in a reduction in prey species. As described above for benthic subtidal and intertidal ecology and fish and shellfish ecology, impacts on these receptors (which may act as prey for birds are anticipated to be highly localised and minimised through the use of embedded mitigation measures. Therefore, the effect of climate change is not expected to exacerbate the effects of the offshore Project.	Minor	Not significant	No	Not significant

7.2.2 Onshore

Table 7-5 summarises the ICCI assessment, which has been undertaken using the methodology described in Section 7.1.

Table 7-5 Onshore summary of ICCI assessment

EIA TOPIC	PROJECT IMPACT (OPERATION AND MAINTENANCE)	RELEVANT EMBEDDED MITIGATION MEASURES	POTENTIAL CLIMATE CHANGE PROJECTION AND IMPACT	LIKELIHOOD OF ICCI	MAGNITUDE OF ICCI	CONSEQUENCE OF ICCI	SIGNIFICANCE	ADDITIONAL MITIGATION REQUIRED?	SIGNIFICANCE OF RESIDUAL CONSEQUENCE
Land use and other users	1. Long term loss of agricultural land and soils (including peatland); and 2. Long term loss of forestry.	• Avoidance of sensitive areas; • Habitat reinstatement; and • Compensatory planting.	Predicted higher temperatures and changing rainfall patterns may affect soil chemistry (e.g. moisture, stability), peatland and forestry (with associated changes in agricultural yield and/or forestry). This may alter the predicted effect of the onshore Project on impacts 1 and 2.	Extremely unlikely - The onshore Project is predicted to have a low magnitude of impact on soils and agriculture. There is also minimal peat and forestry within the vicinity of the onshore Project area. Therefore, no ICCI is expected.	Negligible - The predicted effect of climate change is not expected to exacerbate the impact of the onshore Project.	Negligible	Not significant	No	Not significant
Geology and Hydrology	1. Groundwater flows and levels; 2. Soil compaction and erosion; 3. Changes to soil and groundwater quality; 4. Changes in flow and / or contamination of vulnerable receptors; 5. Contamination of surface watercourse or waterbodies; 6. Changes to surface water runoff; 7. Risk of flooding to the development and increased risk of flooding in areas downstream; and 8. Interactions with contaminated land.	• Avoidance of sensitive areas; • Minimising watercourse crossings and cable routes adjacent to watercourses; • Appointed Environmental Clerk of Works (ECoW); • Soil and sediment management to ensure proper soil and sediment handling; • Pollution prevention plan; • Peat management plan; • Species and habitat protection plan; • Drainage strategy; • Measures to reduce impacts on GWDTE; • Avoidance of suspected areas of contaminated land and contaminated material; and • Maintenance of a geotechnical risk register.	• Increased heavy rainfall events may lead to increased erosion of soils and rock leading to landslides, altering the predicted effect of the onshore Project on impact 2; • Sea level rise and increased occurrence of winter storms may increase the severity of coastal flooding, affecting the predicted effects on the onshore Project impacts 4, 5, 6, and 7; • Increased air temperature may lead to changes in the rate of weathering of rocks and soils, altering erosion and sedimentation patterns, altering the predicted effect of the onshore Project impact 2; • Increased winter rainfall and decreased summer rainfall may alter water resources, surface water flow and groundwater recharge, as well as change the predicted flood risk. Therefore. The predicted effects of the onshore Project impact 1, 2, 4, 5, 6, and 7; • Increased winter rainfall, and any associate flood risk, may result in changes in surface water runoff which could alter the interactions of the onshore Project with contaminated land (onshore Project impact 8); • Changes in vegetation as a result of climate change effects may impact soil erosion and sedimentation, affecting the predicted effect of the onshore Project impact 2; and • Increase in carbon emissions and increase air temperatures drying out peat, altering the predicted effect of onshore Project on peat.	Extremely unlikely - The onshore Project is predicted to have a low magnitude of impact on soils. There is also minimal peat within the vicinity of the onshore Project area. Additionally, the predicted flood risk is considered to be less extreme in Scotland in comparison to the rest of the UK and the landfalls are both situated at cliff elevations of 10 -15 m and therefore unlikely to be impacted by flooding. Therefore, no ICCI is expected.	Negligible - The predicted effect of climate change is not expected to exacerbate the impact of the onshore Project.	Negligible	Not significant	No	Not significant
Freshwater ecology	1. Mortality of important freshwater ecology receptors; 2. Damage to key freshwater habitats; and 3. Interruptions to fish passage.	• Avoidance of sensitive areas; • Avoidance of works during sensitive periods; • Sustain passage of fish at watercourse crossing locations; • No post-construction channel barriers; • Use of temporary bridges or n-shaped culverts at haul roads to reduce impacts to migrating fish;	Predicted changes in weather patterns (including increases in freshwater temperature) at the limit of tolerance for freshwater ecology receptors and may enhance external effects, such as onshore Project impacts 1, 2 and 3.	Extremely unlikely - The onshore Project is predicted to have a low magnitude of impact on terrestrial ecology. Therefore, no ICCI is expected.	Negligible - The predicted effect of climate change is not expected to exacerbate the impact of the onshore Project.	Negligible	Not significant	No	Not significant

EIA TOPIC	PROJECT IMPACT (OPERATION AND MAINTENANCE)	RELEVANT EMBEDDED MITIGATION MEASURES	POTENTIAL CLIMATE CHANGE PROJECTION AND IMPACT	LIKELIHOOD OF ICCI	MAGNITUDE OF ICCI	CONSEQUENCE OF ICCI	SIGNIFICANCE	ADDITIONAL MITIGATION REQUIRED?	SIGNIFICANCE OF RESIDUAL CONSEQUENCE
		• Fish rescues at all working areas; • Implementation of suitable cable protection; • Habitat reinstatement; • Appointed ECoW; • Pollution prevention plan; and • Species and habitat protection plan.							
Terrestrial non- avian ecology	1. Habitat loss due to land take; 2. Disturbance and damage/injury to habitats or protected species; 3. Indirect effects on habitats or protected species e.g. due to pollution or sedimentation; and 4. Reduction in deer welfare.	• Avoidance of sensitive areas; • Separating distances between excavations and GWDTE; • Use of HDD at landfalls (minimising impact on cliff coastal habitats); • Habitat reinstatement; • Appointed ECoW; • Pollution prevention plan; • Species and habitat protection plan; and • Minimising watercourse crossings.	• Predicted changes in weather patterns (and associated effects on soil chemistry) at the limit of tolerance for terrestrial non-avian ecology receptors and may enhance external effects, such as onshore Project impacts 1, 2, 3 and 4. • Predicted increases in temperature may increase the spread of pathogens or invasive species may alter the susceptibility of terrestrial non-avian ecology receptors to onshore Projects impacts 1, 2, 3 and 4; • Indirect effects in relation to changes to habitat / food resource availability (e.g. as a result of changes in temperature, soil moisture or rainfall patterns) may alter the effects of onshore Project 1, 2, 3 and 4.	Extremely unlikely - The onshore Project is predicted to have a low magnitude of impact on terrestrial ecology. Therefore, no ICCI is expected.	Negligible - The predicted effect of climate change is not expected to exacerbate the impact of the onshore Project.	Negligible	Not significant	No	Not significant
Terrestrial ornithology	1. Disturbance and damage/injury to habitats used by these animals or to individual birds; and 2. Indirect effects on habitats or terrestrial ornithology, e.g. due to pollution or sedimentation.	• Avoidance of sensitive areas; • Use of HDD at landfalls (minimising impact on cliff coastal habitats); • Habitat reinstatement; • Appointed ECoW; • Minimising watercourse crossings; • Pollution prevention plan; and • Species and habitat protection plan.	• Predicted increase in winter temperatures may result in a northward shift in bird ranges and may increase the overwinter survival rate for some species and their abundance in the UK, altering the effects of onshore Project 1 and 2. • Increased winter rainfall, however, could result in reduced overwinter survival for some small birds as a result of greater energy expenditure, increasing the susceptibility to impacts and altering the effects of onshore Project impacts 1 and 2; and • Indirect effects from changes in soil moisture and structure as a result of changes to rainfall patterns (particularly drier summers) may result in changes to the abundance and availability of food / prey, altering the onshore Project impact 1.	Extremely unlikely - The onshore Project is predicted to have a low magnitude of impact on terrestrial ornithology. Therefore, no ICCI is expected.	Negligible - The predicted effect of climate change is not expected to exacerbate the impact of the onshore Project.	Negligible	Not significant	No	Not significant

7.2.3 Summary

Overall, for both the offshore and onshore Project, there is low potential for in-combination Project and future climate impacts to adversely impact offshore or onshore receptors. The comprehensive assessment, based on the best-available data and the likelihood of these future occurrences has resulted in the overall risk of impacts on climate change from the Project being assessed as minor/negligible and not significant in EIA terms.

8 BIOLOGICAL CARBON ASSESSMENT

The biological carbon sequestration assessment considers how the Project could affect carbon stored in the marine environment, (i.e. a blue carbon assessment (Section 8.1)) and in the terrestrial environment, (i.e. onshore biological carbon store assessment (Section 8.2)).

8.1 Blue carbon assessment (offshore)

8.1.1 Introduction

Blue carbon refers to carbon captured by biological metabolic processes, i.e. in the soft tissues, shells, and skeletons of plants and animals, and buried in the marine environment in marine sediment (Porter *et al.*, 2020). Marine sediments, and particularly deep-sea sediments, are the primary store of biologically derived carbon (mostly as inorganic carbon). Scotland's biogenic marine habitats are highly productive places, with a very high rate of assimilation of carbon into plant material (662 grams of carbon per metre squared per year ($gC/m^2/yr$)), mostly in coastal areas. Yet their overall contribution to the carbon budget is relatively small compared to sediments (Burrows *et al.*, 2014; 2017).

Scotland's Exclusive Economic Zone (EEZ) covers an area of 554,755 km^2 (an area six times larger than Scotland's land area). According to Smeaton *et al.* (2020), the surficial sediment of Scotland's EEZ is thought to hold 1,515 ± 252 metric tonnes of carbon. The majority of this carbon is in the form of calcium carbonate, with a significantly lower proportion being held in the organic form.

The process in which carbon is removed from the atmosphere and stored in specific habitats, is known as carbon sequestration. The quantity of carbon held in a habitat at any specified time is the carbon stock or store, and the rate at which the carbon is stored is referred to as the carbon sequestration rate (EEA, 2022).

The assessment provided in this section expands on the information and assessment conducted in Offshore EIA Report, chapter 10: Benthic subtidal and intertidal ecology to focus on the potential effect of the offshore Project on blue carbon.

According to Porter *et al.* (2020), there are multiple pressures on carbon in stored sediment that arises from the current practices of the marine environment, the main one of which is physical disturbance to the seabed. Additionally, blue carbon habitats are subject to ongoing climate change impacts, such as acidification, deoxygenation and temperature changes of seawater (Porter *et al.*, 2020).

8.1.2 Impacts assessed

The principal threat to long-term carbon storage is any process or work that disturbs the top layers of sediment (including construction activities relating to the placement of infrastructure, such as the inter-array, interconnector and offshore export cables, and foundation installation). Resuspension of sediment allows rapid consumption of buried carbon by organisms and its subsequent release as CO_2. This effectively reduces the carbon burial rate significantly and reduces the blue carbon inventory.

The following impacts are assessed for effects on blue carbon habitats within the offshore Project area:

- Direct blue carbon habitat loss / disturbance from the placement of the offshore Project subsea infrastructure during the lifecycle of the offshore Project; and
- Cumulative effects from the offshore Project and other developments resulting in blue carbon habitat loss / disturbance from the placement of subsea infrastructure.

8.1.3 Assessment methodology

The existing data sets and literature with relevant coverage to the offshore Project, which have been used to inform the blue carbon assessment are outlined in Table 8-1.

Table 8-1 Summary of key datasets and reports

TITLE	SOURCE	YEAR	AUTHOR
Assessment of carbon budgets and potential blue carbon stores in Scotland's coastal and marine environment	https://www.nature.scot/doc/naturescot-commissioned-report-761-assessment-carbon-budgets-and-potential-blue-carbon-stores	2014	Burrow *et al.*
Assessment of Blue Carbon Resources in Scotland's Inshore Marine Protected Area Network	https://www.nature.scot/doc/naturescot-commissioned-report-957-assessment-blue-carbon-resources-scotlands-inshore-marine#:~:text=Blue%20carbon%20habitats%20in%20the,of%20inorganic%20carbon%20per%20year.	2017	Burrow *et al.*
Blue Carbon Audit of Orkney Waters	https://data.marine.gov.scot/dataset/blue-carbon-audit-orkney-waters	2020	Porter *et al.*
Re-Evaluating Scotland's Sedimentary Carbon Stocks	https://data.marine.gov.scot/dataset/re-evaluating-scotland%E2%80%99s-sedimentary-carbon-stocks	2020	Smeaton *et al.*
Marine Sedimentary Carbon Stocks of the United Kingdom's Exclusive Economic Zone	https://research-repository.st-andrews.ac.uk/bitstream/handle/10023/21555/Smeaton_2021_FES_Marine_CC.pdf?sequence=1&isAllowed=y	2021	Smeaton *et al.*

The assessment for blue carbon is undertaken following the principles set out in the Offshore EIA Report, including chapter 7: EIA methodology and chapter 10: Benthic subtidal and intertidal ecology. The sensitivity of the receptor is combined with the magnitude to determine the impact significance. Topic-specific sensitivity and magnitude criteria are assigned based on professional judgement, as described in Table 8-2 and Table 8-3.

Table 8-2 Sensitivity criteria

SENSITIVITY OF RECEPTOR	DEFINITION
High	The receptor has a very low capacity to accommodate a particular effect with a low ability to recover or adapt. The receptor is of very high carbon stock or sequestration rates.
Medium	The receptor has a low capacity to accommodate a particular effect with a low ability to recover or adapt. The receptor is of moderate carbon stock or sequestration rates.
Low	The receptor has some tolerance to accommodate a particular effect or will be able to recover or adapt. The receptor is of low carbon stock or sequestration rates.
Negligible	The receptor is generally tolerant and can accommodate a particular effect without the need to recover or adapt. The receptor is of negligible carbon stock or sequestration rates.

Table 8-3 Magnitude criteria

MAGNITUDE CRITERIA	DEFINITION
High	The impact occurs over a large spatial extent resulting in widespread, long-term, or permanent changes in baseline conditions. The impact is very likely to occur and/or will occur at a high frequency or intensity.
Medium	The impact occurs over a local to medium extent with a short- to medium-term change to baseline conditions. The impact is likely to occur and/or will occur at a moderate frequency or intensity.
Low	The impact is localised and temporary or short-term, leading to a detectable change in baseline conditions or a noticeable effect on a small proportion of a receptor population. The impact is unlikely to occur or may occur but at low frequency or intensity.
Negligible	The impact is highly localised and short-term, with full rapid recovery expected to result in very slight or imperceptible changes to baseline conditions or a receptor population. The impact is very unlikely to occur; if it does, it will occur at a very low frequency or intensity.

8.1.4 Baseline

The total standing stock of organic carbon in Scotland's marine sediments was estimated as 18.1 megatonnes of carbon, and the total sequestration capacity of Scottish seas as 7.2 megatonnes of carbon per year. Patterns of standing stocks and sequestration capacity of organic carbon follow the distribution of mud and mud-sand-gravel combinations. Most organic carbon, and the largest capacity for sequestration of organic carbon, appears to be in deep mud off the continental shelf (Burrows *et al*., 2014).

According to Porter *et al*. (2020), the carbon resource in Orkney waters (out to the 12 nautical mile limit) including surface sediments, in Orkney waters is estimated to be 67 million tonnes. This equates to a density of 9,190 tonnes of carbon/ km in Orkney waters, given the sea area of 7,290 km^2. Orkney waters are known to host up to eight blue carbon habitats: Kelp forest, maerl beds, zostera beds, saltmarsh, horse mussel, flame shell, brittlestar beds and bryzoan thicket (Porter *et al*., 2020). However, Porter *et al*., (2020) highlights that the thickness of the sediment underlying these habitats is unknown and therefore the above data may underestimate stocks. In addition, the extent of the blue carbon habitats are based on predicted habitat models.

A review of sediment accumulation rates showed that the burial rates for organic carbon are strongly dependent on sediment type (Burrows *et al*., 2014). As described in Offshore EIA Report, chapter 10: Benthic subtidal and intertidal ecology, the predicted European Nature Information System (EUNIS) habitat classification, the OAA was found to contain a variety of subtypes of Atlantic circalittoral sand (MC52), Atlantic circalittoral coarse sediment (MC32) and Atlantic circalittoral mixed sediment (MC42) as well as Atlantic circalittoral rock (MC53). The offshore ECC is characterised as circalittoral sands (MC52) and coarse sediments (MC32) with areas of mixed sediments (MC42) with patches of circalittoral rock (MC12), while the nearshore area is comprised of two large areas of Atlantic circalittoral rock (MC12) and Atlantic infralittoral rock (MB12) (occurring across the width of both the offshore ECC west and offshore ECC east). The bedrock comprises exposed bedrock with kelp as well as patches comprising sand and gravel. Burial rates for organic carbon into sand and sand/mud sediments are moderate compared to other sediment types (sand: average 0.2 gC/m^2/yr and gravel/sand - average 0.4 gC/m^2/yr) (Burrows *et al*., 2014).

According to a re-evaluation of Scotland's carbon stocks undertaken by Smeaton *et al.* (2020), organic and inorganic density within the top 10 centimetres (cm) of sediment in the offshore Project area is predicted to be relatively low. Approximately 656.4 km^2 of the OAA contains 0-2 kg/m^2 of organic carbon. Inorganic carbon ranges from 0-4 kg/m^2 over 504 km^2 and 4-8 kgs/m^2 over 152.4 km^2 as shown in Figure 8-1.

Offshore EIA Report, chapter 10: Benthic subtidal and intertidal ecology summarises the blue carbon habitats likely to be present in the offshore Project area and identifies kelp beds, intertidal macroalgae, subcanopy algae and blue mussel as most likely to be present within the study area for this receptor (OAA (+ 10 km buffer) and the offshore ECC (+15 km buffer)). Of these habitats, blue mussel was identified in the OAA, while kelp beds, intertidal macroalgae, subcanopy algae were identified in the intertidal area (Ocean Infinity, 2023).

As presented in Burrows *et al.* (2014), detailed *in-situ* surveys of the coastline using aerial photography and quadrat sampling between 1946-1955 (Walker and Richardson, 1955, 1956) estimated the total biomass of subtidal kelp around Scotland (mostly *Laminaria hyperborea*) was 10 million tonnes over about 2,900 km^2 of kelp habitat spread across a total sublittoral (<19 m depth) area of 8,000 km^2 (Walker, 1954; as presented in Burrows *et al.*, 2014).

The sequestration of carbon by macroalgae is thought to be dependent on the transport and incorporation into sediment in depositional environments and the contribution from macroalgae is smaller than that of kelp beds, typically 10-20% of macroalgal primary production (Burrows *et al*., 2014).

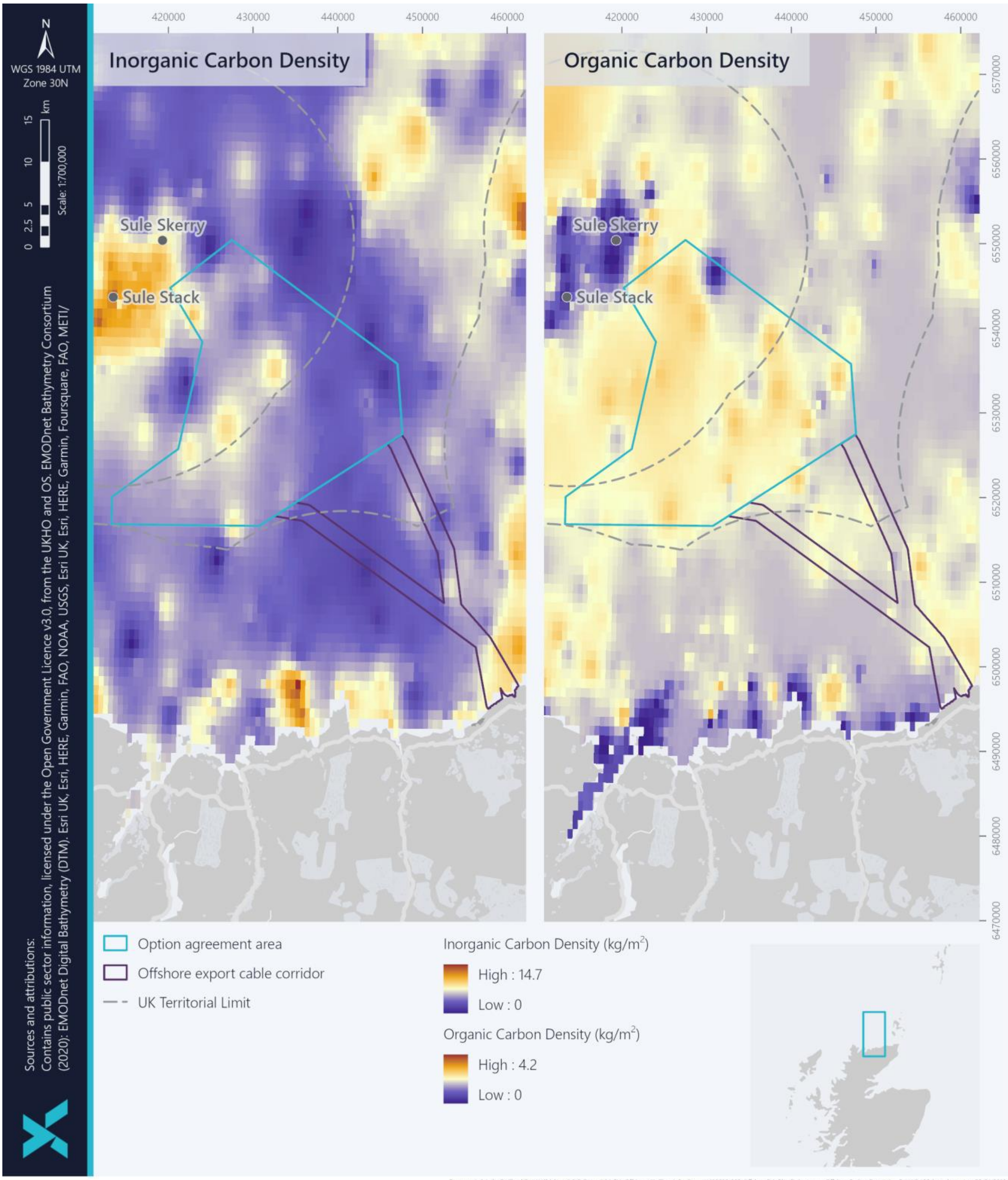


Figure 8-1 Carbon density (kg/m^2) in the top 10 cm sediment layer of the OAA and offshore ECC (Smeaton et al., 2020)

8.1.5 Impact assessment

Kelp beds are a key blue carbon habitat and are present within the intertidal area of the offshore ECC. Kelp beds are a high-value receptor and are assessed as being highly sensitive to changes in habitat (as detailed in Offshore EIA Report, chapter 10: Benthic subtidal and intertidal ecology).

According to the 'Assessment of Blue Carbon Resources in Scotland's Inshore MPAs' (Burrows *et al*., 2014), no carbon was found to be sequestered in kelp beds. However, the standing stock densities of kelp were estimated as 187.7 g organic carbon per m^2 with no inorganic carbon stores. The average rate of fixation of carbon (through production of plant material) is estimated at 685 g of organic carbon per m^2 per year, based on available literature (Burrows *et al*., 2014).

As discussed in Section 8.1.4, according to a re-evaluation of Scotland's carbon stores undertaken by Smeaton *et al.* (2020), in 2020, approximately 99.9% of the offshore Project area sediments is estimated to contain 0-2 kg of organic carbon per m^2; while 76.7% of the offshore Project area is estimated to contain 0–4 kg/m^2 of inorganic carbon and the remaining 23.3% of the offshore Project area contains 4–8 kg/m^2 of inorganic carbon. As presented in Offshore EIA Report, chapter 9: Water and sediment quality, a total of 59 samples were analysed for Total Organic Carbon (TOC) during Project-specific surveys in 2022. Sample analysis found TOC ranging from 0.06% to 0.56%. The minimum value observed across the samples was 0.06% (observed in the OAA) while the maximum value for TOC was 0.56%. Overall, organic material is considered to be low across the offshore Project.

All infrastructure related to the offshore Project will be located within a maximum area of 782 km^2 (i.e. the area of the OAA and offshore ECC combined). The offshore Project area occupies 0.14% of the Scottish EEZ. Of this, up to 8.8% will be temporarily disturbed during the construction stage and long-term habitat loss will affect up to 0.9% of the offshore Project area. This area of disturbance is approximately 0.01% of the Scottish EEZ. According to Smeaton *et al.* (2021), the UK EEZ surficial sediments are estimated to store 524 ± 68 metric tonnes (Mt) of organic carbon and 2,582 ± 168 Mt of inorganic carbon. Given the small proportion of the Scottish EEZ disturbed by the offshore Project, there is limited potential for measurable release of carbon from sediment into the marine environment as a result of the offshore Project.

As assessed in the Offshore EIA Report, chapter 10: Benthic, subtidal and intertidal ecology, kelp beds were associated with open exposed areas of bedrock close to landfall and are therefore not expected to be directly affected by trenching operations or sandwave clearance due to the fact the landfall installation activities will be undertaken using HDD and therefore direct disturbance to nearshore reef that may support kelp beds will be avoided.

Any habitat loss or disturbance from the placement of offshore export cables and HDD landfall operations will be minimal, based on the localised spatial change and low frequency of disturbance / loss expected to occur through the life-cycle of the offshore Project. Additionally, with the implementation of embedded mitigation measures such as micro-siting to avoid sensitive habitats and reducing localised habitat loss, disturbance or loss to sensitive habitats will be minimised where possible.

Consequently, the activities associated with the offshore Project are unlikely to result in significant loss or disturbance or carbon or affect the carbon sequestration potential of the immediate seabed and associated habitats, and as such, in line with the impacts assessed on kelp beds in Offshore EIA Report, chapter 10: Benthic subtidal and intertidal ecology, the magnitude of impact on blue carbon is assessed as negligible during construction, operation and maintenance, and decommissioning of the offshore Project.

It is noteworthy that the introduction of artificial structures has the potential to result in a source of carbon input, where organic material collects on structures, then dies and is assimilated into seabed sediments as carbon matter.

The presence of structures in the marine environment may result in modified sediment dynamics and can increase carbon sequestration into sediments at a small scale. However, as presented in Offshore EIA Report, chapter 8: Marine physical and coastal processes, there is no predicted change to the tidal, wave or sediment transport regime as a result of the Project presence and the magnitude of this impact is **negligible.**

Therefore, the overall effect on blue carbon from the offshore Project is assessed as **minor** and **not significant.**

8.1.6 Assessment of cumulative effects

As detailed in Offshore EIA Report, chapter 10: Benthic subtidal and intertidal ecology, four developments are considered to potentially result in cumulative effects with the offshore Project on benthic ecology receptors. These are detailed below in Table 8-4.

Table 8-4 List of developments considered for the blue carbon cumulative impact assessment

DEVELOPMENT TYPE	DEVELOPMENT NAME	STATUS	LOCATION	DATA CONFIDENCE
OWF	Pentland Floating Offshore Windfarm (PFOWF)[8]	Consented	Pentland Firth	Medium
Cable	Scottish Hydro Electric Transmission Limited (SHET-L) Orkney to Mainland High Voltage Alternating Current (HVAC) Link	Consented	Pentland Firth (Caithness to Hoy)	Medium
OWF	West of Orkney Windfarm – transmission connection to the Flotta Hydrogen Hub	Pre-consent	West of Orkney	Low
Power distribution cable	Pentland Firth East (3) Cable Replacement	Under construction	Muckle Bay, Caithness to Rackwick Bay, Orkney	High

The developments considered within the assessment of cumulative effects are those within 20 km of the offshore Project and include: the PFOWF; the SHET-L Caithness to Orkney HVAC Link, West of Orkney Windfarm transmission connection to the Flotta Hydrogen Hub, and the Pentland Firth East (3) Cable Replacement.

[8] *Pentland Floating Offshore Wind Farm (PFOWF) will incorporate the currently consented Pentland Floating Offshore Wind Demonstrator turbine, and hence PFOWF only has been considered. The PFOWF Section 36 Consent and Marine Licence was granted for 10 years. However, the cumulative effects assessment has been based on the Project Design Envelope, as specified within the EIA, and therefore, an operational life of up to 30 years for the PFOWF has been considered. Since consent was granted in June 2023, PFOWF have submitted a Screening Report to MD-LOT with the intention to request a variation to the Section 36 Consent. This variation will incorporate refinements to the Project Design Envelope and to extend the operational life to 25 years.*

The replacement works for the Pentland Firth East (3) Cable replacement are anticipated to occur by the end of August 2023, and therefore, these will not overlap with the offshore Project construction stage. The construction timelines for the West of Orkney Windfarm transmission connection to the Flotta Hydrogen Hub are unknown, however, an overlap with the construction of the offshore Project cannot be ruled out. It is also possible that the SHET-L Caithness to Orkney HVAC Link may be constructed at the same time as the offshore Project. Therefore, there is potential for cumulative temporary seabed disturbance during the construction of these three developments.

There is limited information available for the West of Orkney Windfarm transmission connection to the Flotta Hydrogen Hub. However, it is anticipated that up to five offshore export cables may be installed, with a total combined length of up to 340 km to Hoy (for all 5 cables). For the SHET-L Caithness to Orkney HVAC Link, it is anticipated that up to 1 km^2 of temporary habitat loss and disturbance may result from the seabed preparation and cable installation activities (SSE, 2019). It is expected that for both of these cable installation developments, any temporary disturbance will be highly localised with some recovery of the seabed once the installation activities are completed. Furthermore, it is likely that the temporal overlap in the construction activities of these developments and the offshore Project will be limited.

The PFOWF will be in its operation and maintenance stage during the offshore Project construction stage. Therefore, any temporary habitat loss during the operation and maintenance stage including lateral movement of the catenary mooring systems is expected to be highly localised.

Overall, the seabed disturbance, habitat loss and resulting blue carbon disturbance/loss from the cumulative developments will not substantially increase that which is associated with the offshore Project. Therefore, the impact remains as being at a low magnitude for blue carbon. Therefore, the overall effect is assessed to be minor for all receptors. The cumulative effects are not significant in EIA terms.

8.2 Biological carbon store assessment (onshore)

8.2.1 Introduction

The north of Scotland hosts a large area of carbon-rich peatland habitats. In Scotland, the wet environment prevents the decay of plant matter and peatlands act as carbon sinks, absorbing CO_2 and storing it as carbon. Land use changes can lead to release of this stored carbon as CO_2. Changes to the peatland habitat as a result of onshore Project construction and decommissioning could affect peatland carbon stores.

Woodlands are also a key carbon store in the UK and Scotland. The CO_2 stored in woodlands can be released as a consequence of natural and man-made disturbance including tree felling and disturbance to the vegetation and soils. Changes to the woodland habitat as a result of the onshore Project construction and decommissioning could affect woodland carbon stores.

8.2.2 Impacts assessed

The following impacts are assessed for effects on biological stores of carbon (peat and woodlands) within the onshore Project area:

- Direct carbon store habitat loss / disturbance from the placement of the onshore Project infrastructure during construction and decommissioning; and
- Cumulative effects from the Project and other projects resulting in carbon store habitat loss / disturbance from the placement of onshore Project infrastructure.

8.2.3 Assessment methodology

The assessment methodology for the onshore carbon store habitat / loss disturbance impact assessment is consistent with the EIA methodology presented in Onshore EIA Report, chapter 8: Geology and hydrology and Onshore EIA Report, chapter 12: Land use and other users.

8.2.4 Baseline

Peat covers more than 20% of Scotland's habitats and subsequently is Scotland's largest carbon store, estimated to hold 140 years' worth of Scotland's annual GHG. The benefits of peatlands are substantial as long as they are healthy and unfortunately it is estimated that 80% are damaged (SNH 2015). Globally, peatlands are estimated to hold 350 – 550 Gt of carbon and cover approximately 3% of the planets terrestrial area. With the increase of drought expected with climate change, globally, it is anticipated that peatlands will become a significant source for CO_2 emission (IPCC, 2014).

Forestry covers approximately 19% of Scotland's land area. There are two distinct forestry types found in Scotland, broadleaved (accounting for 27%) and coniferous (accounting for 73%) (Forest Research, 2022). Broadleaved woodland is slow growing and stores carbon over longer time periods (0.9 – 1.6 tCO_2/ha/yr) whereas coniferous woodlands have much faster growth rates and CO_2 storage rates (1.8 – 12.0 tCO_2/ha/yr), however, generally have shorter life cycle (Matthews *et al*, 2022).

During the summer of 2022, a reconnaissance walkover survey, followed by a peat depth survey was conducted for the onshore Project. These surveys identified minimal areas of peat / peatlands, with a small pocket located primarily to the southwest of the onshore Project area. Approximately 87.2% of the onshore Project area was categorised as Class 0 peatland habitat (mineral soil), with only 2% of the area categorised as Class 1 peatland habitat (nationally important carbon-rich soils). The largest area of peat was recorded to have a maximum depth of 4 m (located to the east of Harpsdale and south of Halkirk). This is reflective of the current land use within the onshore Project area, with agricultural works being the predominant use. Overall, there are no areas of extensive peat within the onshore Project area.

A forestry walkover survey was completed in February 2023 which included a more detailed assessment on areas that may be unavoidable during construction activities. Two key areas of woodland / forestry were identified: Hill of Howe Plantation and Sibster Forest.

8.2.5 Impact assessment

Peatlands and woodlands / forests are key carbon store habitats, particularly in Scotland, and are present within the onshore Project area.

Peatlands are assessed as being highly sensitive. However, in the onshore Project area, there are no areas of extensive peat, and the majority of peat areas which exist are shallow. Although areas of peat are present in the onshore Project area, any habitat loss or disturbance from the placement of onshore Project infrastructure will be minimal, based on the localised spatial change and low frequency of disturbance / loss expected to occur through the lifetime of the onshore Project. Furthermore, the Project will endeavour to microsite around sensitive habitats, such as peat / peatlands, wherever possible, to minimise any disturbance or loss. A Peat Management Plan will be implemented for the onshore Project which will provide options for reuse of any excavated material and guidance on management and handling of excavated peat and soils. An Outline Peat Management Plan will be provided alongside the Onshore EIA Report.

It is not possible to calculate the specific volumes of peat requiring excavation at this stage of the onshore Project until the onshore Project design is further refined. However, indicative calculations of carbon loss from loss or disturbance of peat have been carried out using the SEPA carbon calculator tool methodology (v1.7.0)[9]. The following assumptions were made:

- Only onshore peat considered;
- The temporary access tracks do not cross any peatland;
- Peat type is assumed to be acid bog; and
- All road type is assumed to be excavated (rather than floating or rock-filled).

Table 8-5 summarises the calculations carried out and provides the total CO_2e loss attributed to peat removal for the onshore Project.

Table 8-5 CO_2e loss attributed to peat removal

PARAMETER	VALUE
Total volume of peat removed (m^3)	810
CO_2e loss attributed to removed peat (tCO_2e)	50
Total volume affected by drainage due to the onshore Project	122
CO_2e loss attributed to drained peat (tCO_2e)	45
Total CO_2e Loss (tCO_2e)	*95*

Woodlands and forestry, are assessed as having a medium sensitivity and the key areas of forestry within the onshore Project area are considered to be of low value. Although areas of woodlands and forestry are present in the onshore Project area, any habitat loss or disturbance from the placement of onshore Project works will be minimal, based on the localised spatial change and low frequency of disturbance / loss expected to occur through the lifetime of the onshore Project. Furthermore, the Project will, wherever possible, endeavour to microsite around sensitive habitats, such as woodlands / forestry, to minimise any disturbance or loss and a planting regime used to account for any lost woodland. However, there are a couple of areas of woodland that it might not be possible to avoid depending on the final cable route

The SEPA carbon calculator (SEPA, 2023b) incorporates CO_2 loss from forest felling, stating that *Simple data should only be used where the amount of forestry to be felled is minimal*. The onshore Project is associated with up to 9.58 (0.28 ha at Hill of Howe and 9.3 ha at Sibster Forest) hectares of forestry felling which is considered minimal in the context of the total area of forestry in the wider area. The area of felled forestry will be replanted within a year of

[9] https://informatics.sepa.org.uk/CarbonCalculator/assets/Carbon_calculator_User_Guidance.pdf.

felling and therefore, per SEPA guidance, there is no net loss of forestry as a result of the onshore Project and no net loss of CO_2.

Consequently, the activities associated with the onshore Project are unlikely to affect the carbon sequestration potential of the immediate area and associated habitats, and as such the magnitude of impact on onshore carbon store habitats is assessed as negligible or low during construction, operation and maintenance and decommissioning of the onshore Project.

Therefore, in line with the effects assessed on peatlands, the overall effect on carbon store habitats from the placement of the onshore Project is assessed as minor and not significant.

8.2.6 Assessment of cumulative effects

Two developments are considered to potentially result in cumulative effects with the onshore Project on onshore biological store habitat receptors. These are detailed below in Table 8-6.

Table 8-6 List of developments considered for the onshore carbon biological store / loss disturbance cumulative impact assessment

DEVELOPMENT TYPE	DEVELOPMENT NAME	STATUS	PHASE	LOCATION	DATA CONFIDENCE
Substation	ESB Assest Development Synchronous Compensator	Open	Pre-consent application stage	Current Spittal Substation area	Medium
Cables	Spittal Synchronous Compensator Grid Connection	Consented	Approved	Current Spittal Substation area	Medium

As detailed above, peatlands and woodland / forestry are the key onshore carbon store habitats identified within the onshore Project area and are assessed as being a high value and highly sensitive receptor for peatlands and medium value and sensitivity for woodland and forestry.

Considering the overlap of the onshore Project with the ESB Assest Development Synchronous Compensator and Spittal Synchronous Compensator Grid Connection there is the potential for cumulative impacts to occur on onshore biological carbon store habitats, such as the peatlands and woodlands / forestry, from direct habitat loss or disturbance from the placement of onshore infrastructure. The construction periods of these projects are unknown. It is therefore not known whether the construction timeline of the onshore Project will overlap with the three projects identified. However, this cannot be ruled out.

As described in Section 8.2.5, there are no extensive areas of peat within the onshore Project area and any loss of forestry is also anticipated to be minimal. It is possible that cumulatively with other developments, the potential disturbance or loss of onshore carbon stores (in the form of peat and woodland) could increase slightly, although none of the two developments identified as relevant for the cumulative assessment have large footprint areas. Considering the small spatial extent of any loss associated with the onshore Project, it is anticipated that there will be no change to the magnitude of impact and as such the magnitude of impact is still considered to be negligible or low, making the overall effect minor and not significant.

9 CARBON ASSESSMENT

All industries, including the renewable energy industry, emit GHGs[10]. Renewable energy projects also avoid the emission of GHGs by replacing other, more carbon-intensive forms of electricity generation.

The Project was assessed to calculate:

- The carbon lifecycle emissions which will result from the construction (including pre-construction activities), operation and maintenance and decommissioning stages of the Project in terms of CO_2e emissions (Section 9.2). These emissions result from:
  - Embodied carbon, i.e. emissions of CO_2e incurred from the production of materials (mining raw materials, refining and forming); and
  - Direct emissions due to the combustion of fuel (e.g. material transportation; vessels, vehicles and equipment);
- The CO_2e emissions which will be avoided as a result of the Project (Section 9.4);
- The carbon intensity of electricity generated by the Project (Section 9.7.2);
- The length of time the Project will require to be operational to 'pay back' the emissions resulting from construction, operation and maintenance, and decommissioning (the 'payback period') (Section 9.7.2); and
- The impact of the Project on the global climate, using the UK Carbon Budget as a proxy (Section 9.7.1).

This carbon assessment is fit for purpose given the Project stage and level of information available at this point of the Project, however this carbon assessment is not a detailed Life Cycle Analysis per ISO 14040:2006 Environmental management — Life cycle assessment — Principles and framework.

The potential impact of the Project on biologically sequestered carbon e.g. disturbance to peat and forestry (onshore) and disturbance to carbon stores in marine habitats and seabed sediments (offshore) is assessed separately via a combination of qualitative and quantitative approaches, informed by available guidance (Section 8).

9.1 Assessment methodology

Flexibility in the final design is required for the Project as some elements cannot be finalised due to procurement and supply chain considerations, the timing of investment decisions and until further site investigations are undertaken. This carbon assessment has been carried out by assessing a variety of possible design scenarios and the output of the assessment represents an indicative value, rather than a definitive total, for the total CO_2e emissions inventory and carbon payback period. The assessment was undertaken using the Xodus-developed carbon assessment tool.

Due to the stage of development of the Project, conservative assumptions have been applied for the materials constituting the components which form the Project, the source location of these components and activity durations required to construct the Project. The assessment boundaries define the scope of the inventory and comprise the boundary of the Project (Figure 9-1), and all components contained therein, including both offshore and onshore activities.

[10] *"GHGs are the gases in the atmosphere which trap heat. In this carbon assessment a focus is on anthropogenic GHG emissions, such as CO_2, N_2O and CH_4 (summed as CO_2e) which increase the natural greenhouse effect".*

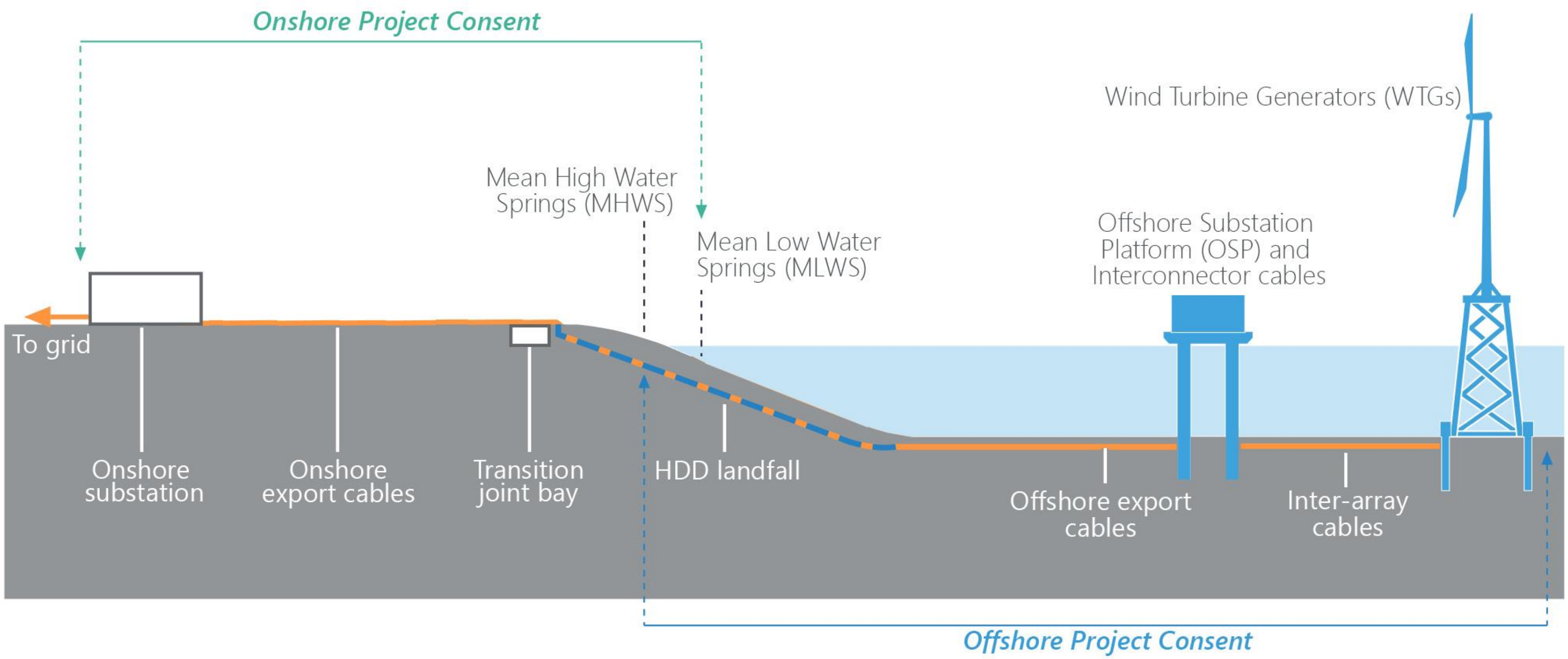
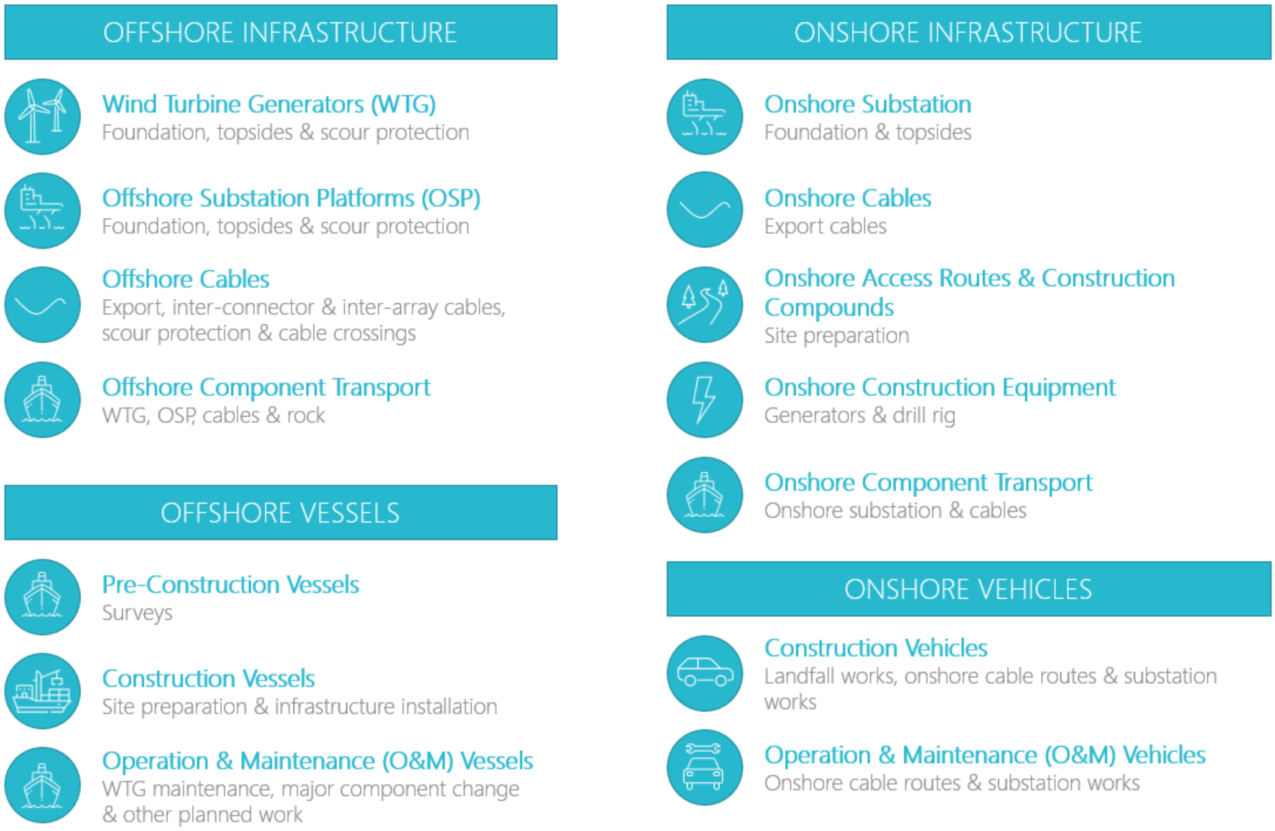


Figure 9-1 Schematic of assessment boundaries for the Project

Emissions associated with activity beyond the return of components to shore for decommissioning at the end of the lifecycle of the offshore Project are outwith the assessment boundary, however, it is considered that up to 90% of the material may be recycled (Spyroudi, 2021).



An assessment of the level of impact (beneficial or adverse) from the results of the carbon assessment has been undertaken (Section 9.7), per the methodology outlined in Section 9.1.1.

9.1.1 Defining magnitude and sensitivity

IEMA (2022) guidance states that:

> *"The crux of significance is not whether a project emits GHG emissions, nor even the magnitude of GHG emissions alone, but whether it contributes to reducing GHG emissions relative to a comparable baseline consistent with a trajectory towards net zero by 2050."*

In the absence of sector-based, or local emissions budgets, the UK Carbon Budgets can be used to contextualise the level of significance. As per IEMA (2022) guidance, all GHG emissions are classed as having the potential to be significant as all emissions contribute to climate change. In establishing the scope and boundary of emission assessment, it is standard accounting practice to exclude minor sources as these are not material. Inventories that exclude these minor sources are still considered complete. This exclusion of emission sources that are less than 1% of a given emissions inventory is based on a 'de minimis' (relatively minimal) contribution (BSI, 2019).

On this basis, where emissions from the Project are greater than 1% of the relevant annual UK Carbon Budgets the impact of the Project on the climate is considered to be major. This is summarised in Table 9-1, Table 9-2 and Table 9-3.

There is currently no published standard definition for receptor sensitivity of GHG emissions. The global climate has been identified as the receptor for the assessment. The sensitivity of the climate to GHG emissions is considered to be 'high' (IEMA, 2022). The rationale supporting this includes:

- Any additional GHG impacts could compromise the UK's ability to reduce its GHG emissions and therefore the ability to meet its future carbon budgets; and
- The importance of meeting the Paris Agreement goal of limiting global average temperature increase to well below 2°C above pre-industrial levels. Additionally, a recent report by the IPCC highlighted the importance of limiting global warming below 1.5°C (IPCC, 2021).

Table 9-1 Magnitude criteria for impact assessment

MAGNITUDE	MAGNITUDE CRITERIA DESCRIPTION
Beneficial reduction	Estimated emissions equate to a reduction of >0.1% of total emissions across the relevant five-year UK Carbon Budget period in which they arise.
Negligible change	Estimated emissions equate to ± 0.1% of total emissions across the relevant five-year UK Carbon Budget period in which they arise.
Small increase	Estimated emissions equate to between 0.1 and 1% of total emissions across the relevant five-year UK Carbon Budget period in which they arise.
Large increase	Estimated emissions equate to >1% of total emissions across the relevant five-year UK Carbon Budget period in which they arise.

Table 9-2 Consequence matrix for impact assessment

MAGNITUDE OF EMISSIONS	SENSITIVITY OF RECEPTOR: HIGH
Beneficial reduction	Beneficial
Negligible change	Minor beneficial / adverse
Small increase	Moderate adverse
Large increase	Major adverse

Table 9-3 UK carbon budget

BUDGET	ANNUAL CARBON BUDGET (MILLION TONNES CO_2e)	% REDUCTION BELOW BASE YEAR (1990)
4th carbon budget (2023 to 2027)	1,950	50% by 2025
5th carbon budget (2028 to 2032)	1,765	57% by 2030
6th carbon budget (2033 to 2037)	965	78% by 2035

9.1.2 Project Design Envelope parameters

Within the Project Design Envelope, a range of options exist for each component of the Project (Offshore EIA Report and Onshore EIA Report, chapter 5: Project description). To help refine the potential scenario, emissions from each component were assessed through each stage (i.e. construction (including pre-construction), operation and maintenance and decommissioning) and the potential combinations collated to identify a representative scenario for assessment.

A summary of the scenario used to calculate the CO_2e intensity and payback periods is presented in Table 9-4.

Table 9-4 Summary of the scenario used in the embodied carbon assessment

PARAMETER	REPRESENTATIVE SCENARIO
Offshore	
WTG rotor diameter	250 m
WTG foundation	Pin pile
Offshore export cables (total length for multiple cables)	352 km
Inter-array and inter-connector cable (total length)	650 km
OSPs	Five (no SF_6 inventory)
OSP foundation	Piles
Scour and cable protection	20,581,000 m^3
Onshore	
Onshore export cable (total length for multiple cables)	165 km

PARAMETER	REPRESENTATIVE SCENARIO
Joint Bays and ducting - Cable joint bay - Transition joint bay - Cable duct	 240 5 5
Onshore substation	One
Access routes	9,385 m^2 permanent road

9.2 Emissions inventory

The emissions inventory for the Project is divided into three stages: construction (including pre-construction activities), operation and maintenance, and decommissioning. Each of these stages is then divided three further times into a category, a component, and finally an activity or material. For example, CO_2e emissions associated with the steel used in the manufacture of the WTG would be captured as shown in Figure 5.1.

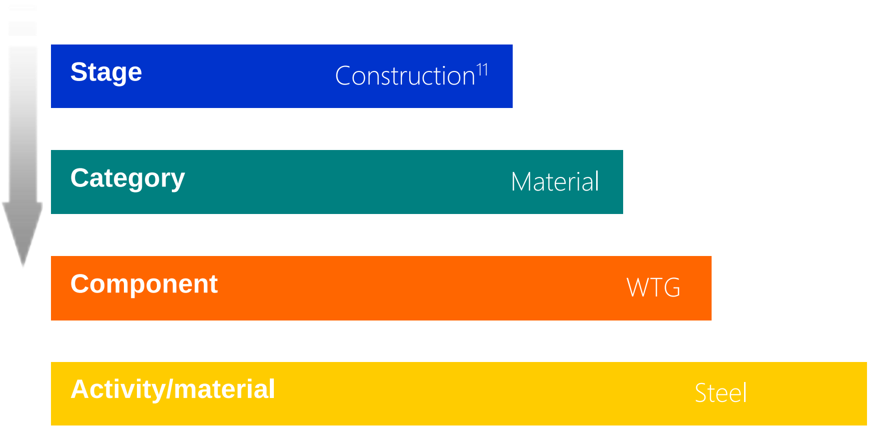


Figure 5.1 Process for identifying component materials

Each activity or material has an assigned unit of measurement and an associated emission factor. The primary data sources used to inform the assessment, in addition to Offshore EIA Report and Onshore EIA Report, chapter 5: Project description, include:

- Bath Inventory of Carbon and Energy (ICE) [Embodied carbon for standard materials and processes];
- IP 2000 [Standardised vessel fuel use];
- Digest of UK Energy Statistics (DUKES) [Emission factors for generation sources; most recent version e.g. 2021]; and
- Defra GHG reporting: conversion factors 2022.

[11] *Including pre-construction*

The details provided below set out the activities and materials accounted for in each component, within each Project stage.

Due to design confidentiality, the detailed information on which assumptions were based cannot be presented within this report, rather a summary of the assumptions, calculations and results are presented.

9.2.1 Embodied carbon: Offshore

Materials and masses were provided by OWPL based on preliminary design information. Embodied carbon in the context of the offshore Project relates to the emission of CO_2e associated with the production of new infrastructure. This has been included according to the boundaries shown in Figure 9-1 and consists of:

- WTG, including nacelle, tower, and blades:
  - The total mass of the major materials which make up the WTG (steel, iron, copper, aluminium, and fibreglass) has been estimated based on OWPL WTG provided masses and NREL material breakdown (Mone *et al.*, 2015);
- Foundation:
  - Assume pin-pile utilised with masses based on estimations provided by OWPL;
- OSPs:
  - The mass of steel in the OSP topsides has been estimated based on conventional topside fabrication approach;
  - Pin-piles were assumed to be utilised for OSP foundations; and
  - No use of SF_6 was assumed as the sector is taking action to phase out this gas which has a very high Global Warming Potential (GWP).
- Cables are assumed to be three core Cross-Linked Polyethylene (XPLE) submarine cables, with their major materials being copper, steel and polyethylene (plastic). This material composition is assumed for:
  - Inter-array cables to transfer electricity generated from each WTG to the OSPs;
  - Interconnector cables to transfer electricity between OSPs; and
  - Offshore export cables to transfer electricity from OSP to shore.
- Scour and cable protection (including rock used for cable crossings):
  - Assumed to be gravel/rock with a density of 2,700 kg/m^3.

9.2.2 Embodied carbon: Onshore

Embodied carbon in the context of the onshore Project relates to the emission of CO_2e associated with the production of new infrastructure. This has been included according to the boundaries shown in Figure 9-1 and consists of:

- Onshore export cables; which are assumed to be three core, XPLE cables, with their major materials being copper, steel and polyethylene (plastic);
- Onshore substation, transition and jointing pits and ducts assumed to primarily consist of concrete containing steel re-bar; and
- Access tracks which are assumed to consist of aggregate and/or asphalt.

9.2.3 Construction CO_2e: Offshore

Construction encompasses:

- The embodied carbon of the components (Section 9.2.1);
- The vessels used in offshore transport from the fabrication site to the offshore Project which were assumed to be by sea from Europe and the UK;
- Pre-construction vessel activity:
  - Site preparation activity including surveys and seabed preparation;
- All offshore vessel construction activity:
  - Vessel fuel consumption assumed present day values, without decarbonisation as construction activities will occur in the relative near term; and
  - Vessel activity aligns with that presented in Offshore EIA Report, chapter 5: Project description.

9.2.4 Construction CO_2e: Onshore

Construction encompasses:

- The embodied carbon of the components (Section 9.2.2):
- Transportation of the components from the fabrication site to the Project:
  - Assumed to be by sea from the UK; and
  - The number of trips and the distances to be travelled were assumed.
- Emissions from vehicles and equipment required for onshore site preparation and construction were calculated using diesel emission factors from Business, Energy and Industrial Strategy (BEIS) (2022), assuming no electrification of vehicles occurs:
  - Vehicle requirements per Onshore EIA Report, chapter 16: Access, traffic and transport for works associated with landfall, onshore cable routes and substation:
  - Vehicle assumed to be Heavy Goods Vehicle (HGV) unless for construction worker travel when use of a petrol car is assumed;
  - Construction workers not assumed to travel more than 20 km per trip;
  - Distance travelled for HGV trips assumed to be:
    - On average half the cable length for works associated with cables; and
    - Maximum distance which can be travelled in one hour (64 km) for works associated with landfall and substation;
- Equipment requirements:
  - Two generators (500 and 150 kVA) assumed to run for the times Mon-Fri 8:00 – 19:00 and Sat 8:00 – 13:00 for the entire period of construction; and
  - One drilling rig power pack assumed to run for six months for the times Mon-Fri 8:00 – 19:00 and Sat 8:00 – 13:00.

9.2.5 Operational CO_2e: Offshore

OWPL provided assumed failure rate assumptions which were used to estimate the embodied carbon required for maintenance during the operation and maintenance stage of the offshore Project. In addition, emissions from vessels required for maintenance of the offshore components are included. It has been assumed that any operation and maintenance activity does not begin until after the Project is fully operational.

The vessel requirements for operation and maintenance activities were influenced by the number of WTGs and foundations and the type of activity (e.g. component maintenance, component replacement or cable repairs).

A linear vessel decarbonisation rate has been applied for vessels during operation and maintenance given the sector is targeting net zero by 2050. This assumes current marine gas oil fuel consumption emissions in 2030, and 0 emissions by 2050, decreasing linearly over the 20-year period.

Table 9-5 compares total emissions with and without the decarbonisation vessel assumptions. This is solely for illustration and all calculations use the vessel decarbonisation emission values.

Table 9-5 Impact of vessel decarbonisation assumptions during operation and maintenance

DECARBONISATION SCENARIO	TOTAL VESSEL CO_2e
Vessel decarbonisation (tCO_2e)	225,623
No vessel decarbonisation (tCO_2e)	705,341

9.2.6 Operational CO_2e: Onshore

It is assumed that the operation and maintenance stage of the onshore Project will not produce any emissions beyond the emissions from vehicles required in the maintenance of the various onshore components. It is assumed that any operation and maintenance activity does not begin until after the Project is fully operational.

It was assumed that for each year of the operations and maintenance stage of the onshore Project, there would be:

- One return trip per month along the onshore cable route (33 km) in a petrol-fuelled 4 x 4; and
- One return trip per week to the substation in a petrol-fuelled 4 x 4, a distance of up to 25 km.

9.2.7 Decommissioning CO_2e

Decommissioning considers the decommissioning and removal of infrastructure at the end of the Project's lifetime. The details of the approach to decommissioning for the offshore Project are provided in Offshore EIA Report, chapter

5: Project description and the approach to decommissioning of the onshore Project is described in Onshore EIA Report, chapter 5: Project description.

The starting presumption is that at the end of the operational lifetime of the offshore Project, there will be a requirement for all offshore components (above and below seabed) to be completely removed to shore for re-use, recycling, incineration with energy recovery, or disposal at a licensed site. Some materials may be left *in situ*, however it is understood that this would require a robust and compelling justification to be presented to the Marine Directorate in order to be granted approval for partial removal of the offshore Project. A Decommissioning Programme will be developed and approved pre-construction to address the principal decommissioning measures for the offshore Project, this will be written in accordance with applicable guidance and will detail the management, environmental management and schedule for decommissioning.

Onshore, the preferred decommissioning option is for as close to full removal as possible, whilst recognising that this is subject to assessments and consultation closer to the time of decommissioning. A Decommissioning, Restoration and Aftercare Plan is required as a planning condition to be approved by the regulator, prior to the onshore decommissioning works. Decommissioning best practice and legislation will be applied at that time. It is expected that decommissioning follows a reverse order of the installation activities with some infrastructure potentially left *in situ*.

Due to the uncertainty associated with decommissioning requirements associated with activity which will occur in 40 years time, a nominal value of 1.2% of the total emissions for the Project was used to estimate the emissions associated with decommissioning (Thomson and Harrison, 2015)

9.3 Other GHG potentially associated with the Project

Sulphur hexafluoride (SF_6) is a GHG which has been used for insulation in WTG switchgears and in substations. SF_6, is an extremely potent fluorinated GHG with a GWP[12] of 22,800 (DEFRA, 2023).

It is estimated that around 80% of the SF_6 used globally is used in electricity transmission (National Grid, 2022). In line with UK Government targets to reach net zero, alternatives to SF_6 are being sought.

The renewables and transmission industries are beginning to substitute SF_6 for Green Gas for Grid (G^3), an insulating gas that offers 99% reduction in GWP. It is envisaged that by the time the Project is in the procurement phase, the insultation offerings that are commercially available will be enhanced significantly (as described above in Section 9.2.1).

9.4 Avoided emissions

To establish the reduction in CO_2e attributable to the Project, the potential CO_2e savings of the Project were estimated. This has been ascertained by comparing the equivalent CO_2e emissions that would be generated from

[12] *GWP is a comparison of the ability of each greenhouse gas to trap heat in the atmosphere. The chosen reference gas is carbon dioxide for consistency with the IPCC guidelines. 1 kg of SF6 has the GWP of 22,800 kg of CO_2.*

other forms of electricity generation, under the assumption that electricity generated by the Project will displace the requirement for generation from these other sources from the national grid.

To calculate electricity generation by the Project:

- A capacity factor (incorporating maintenance and repair time) of 55% was assumed, as advised by OWPL; and
- It is assumed that the Project can start producing electricity before construction is complete; and full operation is forecast to occur in 2031.

As construction will take place over a number of construction seasons / years, electricity production will increase as more WTGs are installed. Therefore, the following assumption has been made for the carbon calculations. A summary of the years of operation, the annual generation and the total generation over the Project lifetime is shown in Table 9-6.

Table 9-6 Electricity production for the representative scenario

YEARS OF OPERATION	# YEARS	ELECTRICITY PRODUCTION (MWH)
2029 – 2030	2	3,642,408 (annual)
2031 – 2060	30	10,840,500 (annual)
Total generation over operation and maintenance stage		*332,499,816*

To calculate the emissions which do not occur as a result of the electricity generated by the Project, assumptions are required around the future carbon intensity of the national grid in the absence of the Project. Such assumptions depend on how the UK energy and emissions system will evolve. This assessment has used the reference scenario projections from BEIS (2023a) which exist up to 2040, with extrapolation of the projections for the remainder of the operation and maintenance stage of the Project. Based on total generation in Table 9-6, total emissions which would have resulted, had the generation occurred via the national grid are shown in Table 9-7.

Table 9-7 National grid emissions associated with the Project electricity production

SCENARIO	TOTAL ASSOCIATED GRID EMISSIONS (tCO_2e)
Representative scenario	16,489,285

9.5 Embedded mitigation and management plans

Embedded mitigation and management plans will form part of the design of the Project to further reduce the potential impact of the Project on the global climate. The embedded mitigations and relevant management plans are described in Table 9-8.

Table 9-8 Embedded mitigation specific to the carbon assessment

EMBEDDED MITIGATION MEASURES AND MANAGEMENT PLANS	JUSTIFICATION
Offshore	
Environmental Management Plan (EMP) covering pollution prevention, biosecurity assessment and waste management	The EMP will provide the overall framework for environmental management during the construction and operation and maintenance stages. The document will provide practical guidance to ensure that all activities are carried out in a manner that minimises their impact on the environment, and that mitigation measures contained in the Application, or as otherwise agreed are fully implemented. An outline EMP is provided in Offshore EIA Report, OP1: Outline Environmental Management Plan.
Onshore	
Construction Environmental Management Plan (CEMP)	The CEMP will provide the overall framework for environmental management during the construction stage. The document will provide practical guidance to ensure that all construction activities are carried out in a manner that minimises their impact on the environment, and that mitigation measures contained in the Onshore EIA Report, or as otherwise agreed are fully implemented. The CEMP will include management measures in relation to peat management, drainage, pollution prevention, noise and vibration management, dust and air quality management, soil resource management, construction traffic management and archaeological management.

9.6 Data gaps and uncertainties

To conduct the assessment, the information contained within the Project Design Envelope has been supplemented with conservative assumptions and industry standard references. Beyond the vessel decarbonisation assumed for the operation and maintenance stage of the Project (Section 9.2.5), the assessment makes no further assumptions around future decarbonisation although it is envisaged that decarbonisation may occur in e.g. steel production (Somers, 2022), a major source of embodied CO_2e for the Project.

The categories of emissions bulleted below were excluded from the emissions inventory due to the complexity of estimation and the availability of data. Further, information about the manufacturing supply chains and processes is unknown, as suppliers have not yet been selected.

- Delivery of materials to the manufacturing plants;
- Assembly of materials at the manufacturing plants; and
- Office activity and worker travel.

These emissions are likely to represent a very small part of the total emissions for this assessment, and therefore are likely to have a low potential to alter the outcome or value of the assessment.

The assumptions about future carbon intensity of the national grid have a significant influence on the predicted payback period of the Project. While standard data for a reference scenario has been used to calculate the avoided emissions, choosing an alternative scenario could increase or decrease the calculated payback period for the Project.

9.7 Impact assessment

9.7.1 Total CO_2e emissions

The final calculated total life cycle CO_2e emissions from the Project are presented in Table 9-9 and graphically in Figure 9-2. The majority of CO2e emissions are associated with the offshore construction stage (97.8%) with embodied carbon and construction vessel activity accounting for most of these emissions. Emissions during the operation and maintenance stage of the Project are limited in comparison.

Table 9-9 CO_2e emissions from the Project

STAGE		TOTAL CO_2e (t)
		REPRESENTATIVE SCENARIO
Offshore construction	Embodied carbon	2,975,978
	Component transport from fabrication sites	182,074
	Pre-construction vessel emissions	17,109
	Construction vessel emissions	1,320,679
	TOTAL	*3,158,052*
Offshore operation	Vessel emissions	225,623
	Maintenance – embodied carbon in replaced equipment	81,242
	TOTAL	*306,865*
Offshore decommissioning	Estimated emissions	57,632
	TOTAL	57,632
Offshore total		*4,802,706*
	Embodied carbon	133,371

STAGE		TOTAL CO_2e (t)
		REPRESENTATIVE SCENARIO
Onshore construction	Component transport from fabrication sites	570
	Access route emissions	250
	Construction vehicle emissions	6,030
	Construction machinery emissions	4,583
	TOTAL	*144,805*
Onshore operation	Vehicle emissions	21
	TOTAL	*21*
Onshore decommissioning	Estimated emissions	1,738
	TOTAL	*1,738*
Onshore total		*146,564*
TOTAL PROJECT EMISSIONS		*5,006,902*

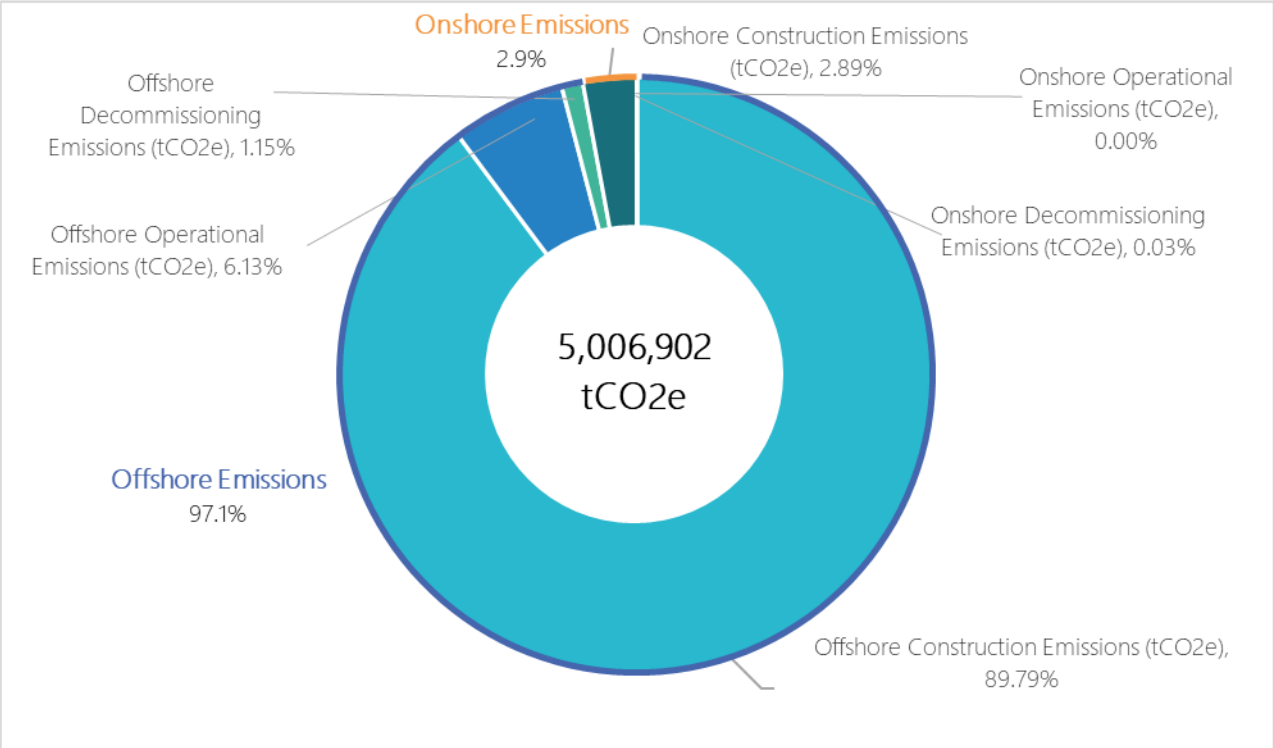


Figure 9-2: Breakdown of total CO_2e emissions by Project stage

9.7.2 Carbon intensity and payback

The carbon intensity of the Project is a measure of the emissions generated per unit of electricity produced. This figure is influenced by the Project stages considered and scope of the assessment. For clarity, both the "operation and maintenance" and "total Project" intensity figures have been presented below, using the total generation provided in Section 9.4.

Table 9-10 Calculated carbon intensity

	REPRESENTATIVE SCENARIO CARBON INTENSITY
Operation and maintenance only (gCO_2e/kWh)	0.92
Total Project (gCO_2e/kWh)	14.88

For comparison with normal operations, the projected net marginal carbon intensity of the national grid is forecast to be 2.28 gCO_2e/kWh from 2050 onwards (BEIS, 2023b). Renewable energies typically show lifecycle emissions that are an order of magnitude lower than fossil-fuel technologies (UNECE, 2021). Estimates of lifecycle offshore wind carbon intensities have produced interquartile ranges of 8 to 35 gCO_2e/kWh with a median of 12 (Schlomer *et al,* 2014). The calculated carbon intensity for the Project is conservatively estimated, resulting in a carbon intensity greater than the median.

The payback period for the Project, the period of time before the Project has avoided more carbon dioxide equivalent emissions than has been produced by its construction and operation, is estimated to be 8 years. The payback period calculation utilised the total generation provided in Section 9.4 and grid carbon intensity forecasts contained within UK Energy and Emissions Projections (BEIS, 2022b). This assessment is highly sensitive to the assumptions made about the carbon intensity of the grid electricity displaced by the Project and it is suggested that the carbon intensity of the Project is a more meaningful comparator.

Table 9-11 presents net Project emissions per 5-year carbon budget. Onshore construction is assumed to start in 2027 and offshore construction is assumed to start in 2028. Full operations commence in 2031 and continue beyond the 2050 net zero target date. As per the methodology outlined in Section 9.1.1, the magnitude of Project impact on the UK carbon budget will be negligible in the 2023-2027 period. In the 2028 to 2032 period, a small increase will occur, attributable to the main period of Project construction activity. From 2033 to 2037, the impact magnitude will be beneficial. As carbon budgets are not yet determined past 2037, it is not possible to quantify the percentage of the Project's CO_2e emissions between 2038 and 2061 (the estimated end date for the operational stage of the Project). Overall, the Project will not affect the UK Government's ability to meet any individual carbon budget and will make a positive contribution to achieving the carbon budget.

Table 9-11 Project net CO_2e emissions against the UK carbon budget

	CARBON ACCOUNTING PERIOD		
UK carbon budget (tCO_2e)	**2023 to 2027**	**2028 to 2032**	**2033 to 2037**
	1,950,000,000	1,765,000,000	965,000,000
Project emissions for period (net tCO_2e)	51,959	3,151,496	-2,655,930[13]
Project emissions as a % of UK budget	0.003%	0.18%	-0.28%

[13] *Negative net CO_2e emissions represents the displaced equivalent emissions, i.e. the "avoided" emissions.*

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11 ABBREVIATIONS

ACRONYM	DEFINITION
°C	Degrees Celsius
AIS	Air Insulated Substation
BEIS	Business, Energy and Industrial Strategy
CaSPlan	Caithness and Sutherland Local Development Plan
CBRA	Cable Burial Risk Assessment
CEMP	Construction Environmental Management Plan
CES	Crown Estate Scotland
cm	Centimetres
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
DNV	Det Norske Veritas
DUKES	Digest of UK Energy Statistics
ECC	Export Cable Corridor
ECoW	Ecological Clerk of Works
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EMF	Electromagnetic Field
EMP	Environmental Management Plan
ERCoP	Emergency Response Co-operation Plan
EUNIS	European Information Nature System
$gC/m^2/yr$	Grams of Carbon per Metre Squared per Year
gCO_2e/kWh	Grams of Carbon Dioxide Equivalent per Kilowatt-Hour
G^3	Green Gas for Grid
GIS	Gas Insulated Substation
GHG	Greenhouse Gases
GWP	Global Warming Potential
HDD	Horizontal Directional Drilling
HGV	Heavy Goods Vehicle
HPAI	Highly Pathogenic Avian Influenza
HVAC	High Voltage Alternating Current

ACRONYM	DEFINITION
HwLDP	Highland-Wide Local Development Plan
ICCI	In-combination Climate Impact Assessment
IEC	International Electrotechnical Commission
IEMA	Institute of Environmental Management and Assessment
INNS	Invasive Non-Native Species
IPCC	Intergovernmental Panel on Climate Change
JUV	Jack Up Vessel
kg/m^2	Kilogram per Squared Meter
km	Kilometres
km^2	Square kilometres
LCA	Life Cycle Assessment
m	Metres
MCA	Maritime and Coastguard Agency
MCCIP	Marine Climate Change Impacts Partnership
MD-LOT	Marine Directorate – Licensing Operations Team
MHWS	Mean High Water Springs
MLWS	Mean Low Water Spring
mm	Millimetres
MMMP	Marine Mammal Mitigation Protocol
MS-LOT	Marine Scotland-Licensing Operations Team
Mt	Metric tonnes
NPF4	National Planning Framework 4
OAA	Option Agreement Area
OIC	Orkney Islands Council
OSP	Offshore Substation Platform
OWPL	Offshore Wind Power Limited
PMP	Peat Management Plan
PO	Plan Option
PPP	Planning Permission in Principle
PSU	Practical Salinity Unit
RCP	Representative Concentration Pathway
SAR	Search and Rescue

ACRONYM	DEFINITION
SEPA	Scottish Environment Protection Agency
SF_6	Sulphur hexafluoride
SHET-L	Scottish Hydro Electric Transmission Limited
SST	Sea Surface Temperature
SuDS	Sustainable Drainage Systems
tCO_2/ha/yr	Tonnes of Carbon Dioxide per Hectare per Year
tCO_{2e}	Tonnes of Carbon Dioxide Equivalent
THC	The Highland Council
TJB	Transition Joint Bay
TOC	Total Organic Carbon
UK	United Kingdom
UKCP09	UK Climate Projections 2009
UKCP18	UK Climate Projections 2018
UKCS	United Kingdom Continental Shelf
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VMP	Vessel Management Plan
WTG	Wind Turbine Generator
XPLE	Cross-Linked Polyethylene
Yr	Year