Bellrock
OFFSHORE WIND

Bellrock Offshore Wind Farm

Wind Farm Development Area

Environmental Impact Assessment Report - Volume II

Chapter 18: Climate Change Risk

Date: April 2026

Document Number: RHDV_BEL_CST_REP_0002_002

Revision Number: 1

Classification: Public

nadara

Revision History

Rev.	Prepared By	Checked By	Approved By	Date
1	Haskoning	ES/SA	BMcG	01/04/2026

This page is intentionally blank

Contents

List of Tables

List of Plates

List of Figures (Volume III)

List of Appendices (Volume IV)

Glossary of Terminology

Term	Definition
Adaptive Capacity	The ability of a system to adjust to climate change (including climate variability and extremes), to moderate the potential damage from it, to take advantage of its opportunities, or to cope with its consequences.
Applicant	Bellrock Offshore Wind Farm Limited, the legal entity submitting Section 36 Consent and Marine Licence applications for Bellrock Wind Farm Development Area.
Bellrock Offshore Wind Farm (or the Bellrock Project)	An offshore wind farm capable of exporting up to 1.8 GW of renewable energy to the National Electricity Transmission System. The Wind Farm Development Area is located 120 km east of Stonehaven, and will connect to the National Electricity Transmission System at the proposed SSEN Transmission Hurlie substation, west of Stonehaven in Aberdeenshire. The Bellrock Offshore Wind Farm comprises of the following Development Areas: ▪ Wind Farm Development Area; ▪ Offshore Transmission Development Area; and ▪ Onshore Transmission Development Area.
Cable protection	Protective measure to minimise the effects of scour and hazards along the inter-array cables, and protecting these cables at infrastructure crossing points.
Climate	The general weather conditions prevailing over a long period of time at a location. Climate change will result in long-term change in global climate patterns such as seasonal averages and extremes.
Climate change impact	The resulting impact from a climate hazard which affects the ability of the receptor to achieve or maintain its functions or purpose.
Climate hazard	A weather or climate-related event or trend in climate conditions, which has potential to do harm to receptors.
Climate resilience	Climate resilience refers to the ability of a system, community, or asset to anticipate, prepare for, respond to, and recover from significant climate-related threats with minimal damage to social well-being, the economy, and the environment.
Climate variable	A measurable, monitorable aspect of the weather or climate conditions.
Commencement of construction	Commencement of construction to install the Wind Farm Infrastructure as authorised by the Wind Farm Development Area Section 36 Consent and Marine Licence (excluding site preparation works), being the earlier of: ▪ Intrusive pre-installation surveys; ▪ Placement on or installation in the seabed of anchors and associated scour protection, and mooring lines; ▪ Trench excavation for inter-array cables; or ▪ Trenching for, or laying of inter-array cables on or in the seabed.
Commercial Operation Date	The date that the site is fully transferred to the operations team which is likely to be the date of the taking over certificate of the last wind turbine generator to be installed.

Term	Definition
Design life	The period during which a component is expected by its designers to operate within its specified parameters.
Development Area	For consenting purposes, the area for which separate consents and/or Marine Licences will be sought by the Applicant, comprising: ▪ Wind Farm Development Area; ▪ Offshore Transmission Development Area; and ▪ Onshore Transmission Development Area.
Exposure	The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected by climate hazards.
Floating substructure	A floating structure which provides buoyancy and, in conjunction with the station keeping system, supports a superstructure (e.g. wind turbine generator or offshore substation), and maintaining its position within the structure's excursion limit.
Inter-array cables	Armoured cable containing electrical and fibre optic cores, which link the wind turbine generators to each other and to the subsea cable hubs and/or the offshore substations and include dynamic inter-array cable and static inter-array cable sections.
Mean Sea Level	The average level of the sea taking account of all tidal effects but excluding surge events.
Operational life	The expected operational life of the Wind Farm Infrastructure from the Commercial Operation Date to the first floating offshore unit being decommissioned.
Project design envelope	Includes all relevant technical, spatial and temporal elements of the Wind Farm Infrastructure, and the proposed methodology to be employed for construction, operations and maintenance, and decommissioning.
Receptor	An entity or system with potential to be affected by climate hazards and therefore vulnerable to experiencing climate change impacts such as infrastructure (WTGs affected by extreme weather conditions like high winds and storms; operational disruptions) and site personnel (personnel working on the Bellrock Wind Farm Development Area face risks such as increased frequency and intensity of storms and heatwaves).
Representative concentration pathway	Different possible trajectories of atmospheric concentrations based on socioeconomic and policy assumptions used in climate change projection modelling. The RCP scenarios are related to the concentrations of GHG that would result in target amounts of radiative forcing (measured in watts per square metre (W/m^2)) at the top of the atmosphere by 2100, relative to pre-industrial levels. Radiative forcing is a measure of the influence of factors (like GHG) on the energy balance of the Earth's atmosphere. The RCP scenarios are: ▪ RCP2.6: Pathway where radiative forcing peaks at approximately 3 W/m^2 mid-century and then declines to 2.6 W/m^2 by 2100. This would require significant reductions in greenhouse gas emissions and aims to limit global warming to below 2°C.

Term	Definition
	▪ RCP4.5: Represents a stabilization of radiative forcing at 4.5 W/m² by 2100 without overshooting. It assumes that emissions will peak around 2040 and then decline. ▪ RCP6.0: Pathway stabilises radiative forcing at 6 W/m² by 2100. Emissions peak around 2080 and then decline. ▪ RCP8.5: Radiative forcing reaches 8.5 W/m² by 2100. It assumes continued increases in greenhouse gas emissions throughout the 21st century. More details provided in **Appendix 18.1: Climate Projection Data (Volume IV), Section 1.1.**
Scour protection	Protective material positioned around anchors and substructures to avoid sediment being eroded as a result of the flow of water.
Sensitivity	Sensitivity is the degree to which a receptor is affected, either adversely or beneficially, by climate variability or change.
Shared socioeconomic pathways	Climate change scenarios that project socioeconomic global changes up to 2100. They are used to derive greenhouse gas emissions scenarios based on different climate policies and socioeconomic developments. SSPs provide narratives describing alternative pathways for human society, particularly in relation to fossil fuel use and the social and economic factors driving it.
Site preparation works	Preparatory activities undertaken within the Wind Farm Development Area/Offshore Transmission Development Area prior to the commencement of construction of the Wind Farm Infrastructure/Offshore Transmission Infrastructure, which may comprise (and which may require separate consents): ▪ Geophysical surveys, geotechnical surveys, and non-archaeological/archaeological diver/ remotely operated vehicle surveys; ▪ Seabed preparation including sand wave levelling, slope levelling for gravity based anchors (if selected), boulder clearance, and pre-lay grapnel runs; ▪ Unexploded ordnance survey and/or clearance; ▪ Debris clearance; and ▪ Out of service cable/pipeline removal.
SSEN Transmission Hurlie substation	The onshore substation to be developed by SSEN Transmission, which will receive renewable electricity from the Bellrock Project onshore substation and allow supply of renewable electricity from the wind farm to the National Electricity Transmission System.
Station keeping system	The system (including mooring lines and anchors) used to hold a floating offshore unit within its excursion limit and maintain the intended orientation of the floating offshore unit.
Subsea cable hub	A subsea device, with a gravel pad foundation, which allows the connection of multiple inter-array cables.
Vulnerability	Vulnerability is the degree to which a receptor (e.g. people, infrastructure, ecosystems) is susceptible to, or unable to cope with, adverse effects of climate change. It is typically a function of: ▪ Exposure (presence in areas affected by climate hazards); ▪ Sensitivity (degree to which it is affected); and ▪ Adaptive capacity (ability to adjust, cope, or recover).

Term	Definition
Wind Farm Development Area	The boundary within which the Wind Farm Infrastructure will be constructed, operated and maintained, and decommissioned.
Wind Farm Infrastructure	Infrastructure located within the Wind Farm Development Area including wind turbine generators; floating substructures, station keeping systems and associated scour protection; inter-array cables and associated cable protection; and subsea cable hubs; and ancillary infrastructure including buoys (including activities associated with the Wind Farm Infrastructure construction, operation and maintenance, and decommissioning).
Wind turbine generator	A wind turbine generator converts wind energy into electrical energy. The main components include rotor assembly (composed of three blades and a hub); nacelle (containing the generator, shaft and gearbox, power electronic converter and transformer); and a tower (containing lifting equipment and switchgear).

Glossary of Abbreviations

Term	Definition
CCR	Climate Change Risk
CCRA	Climate Change Risk Assessment
CMS	Construction Method Statement
DP	Decommissioning Programme
DSLP	Development Specification and Layout Plan
EIA	Environmental impact assessment
EMP	Environmental Management Plan
ERCoP	Emergency Response Cooperation Plan
FSS	Floating substructures
GHG	Greenhouse gas
H&S	Health and safety
IEMA	Institute of Environmental Management and Assessment
IPCC	Intergovernmental Panel on Climate Change
ISEP	Institute of Sustainability and Environmental Professionals
MARPOL	International Convention for the Prevention of Pollution from Ships
MCA	Maritime and Coastguard Agency
MD-LOT	Marine Directorate - Licensing Operations Team
NPF4	National Planning Framework 4
OMP	Operation and Maintenance Plan
OREI	Offshore Renewable Energy Installations
RCP	Representative concentration pathway
SSP	Shared socioeconomic pathway
UNCP	UK Climate Projection
VMNSP	Vessel Management and Navigational Safety Plan
W/m^2	Watts per square metre
WFDA	Wind Farm Development Area
WTGs	Wind turbine generators

This page is intentionally blank

18 Climate Change Risk

18.1 Introduction

1. This Chapter of the Bellrock Wind Farm Development Area (WFDA) Environmental Impact Assessment (EIA) Report evaluates the resilience and vulnerability of the Bellrock Wind Farm Infrastructure to the projected effects of climate change over the construction, operation and maintenance (O&M), and decommissioning phases.

2. The Bellrock Wind Farm Infrastructure comprises wind turbine generators (WTGs), floating substructures (FSSs), station keeping systems (SKSs) and associated scour protection, inter-array cables (IACs) and associated cable protection, subsea cable hubs, and ancillary infrastructure including buoys. Further detail on the Bellrock Wind Farm Infrastructure is provided in **Chapter 4: Project Description (Volume II)**. The following key terms adopted in the Climate Change Risk (CCR) assessment are[1]:

- **Climate resilience**: the ability of a system, community, or asset to anticipate, prepare for, respond to, and recover from significant climate-related threats with minimal damage to social well-being, the economy, and the environment;
- **Receptor**: an entity or system with potential to be affected by climate hazards and therefore vulnerable to experiencing climate change impacts such as infrastructure (e.g. WTGs affected by extreme weather conditions like high winds and storms causing operational disruptions) and site personnel (e.g. personnel working on the Wind Farm Infrastructure face risks such as increased frequency and intensity of storms and heatwaves);
- **Climate variable**: a measurable, monitorable aspect of the weather or climate conditions such as temperature and wind speed;
- **Climate hazard**: a weather or climate-related event or trend in climate conditions, which has potential to do harm to receptors such as increased precipitation or storms;
- **Climate change impact**: the resulting impact from a climate hazard which affects the ability of the receptor to achieve or maintain its functions or purpose; and
- **Vulnerability**: the degree to which a receptor (e.g. people, infrastructure, ecosystems) is susceptible to, or unable to cope with, adverse effects of climate change. It is typically a function of:
  - **Exposure** (presence in areas affected by climate hazards);
  - **Sensitivity** (degree to which it is affected); and
  - **Adaptive capacity** (ability to adjust, cope, or recover).

[1] The key terms adopted in this Chapter are based on terms applied/definitions given in the following reports: *Environmental Impact Assessment Guide to: Climate Change Resilience & Adaptation (2020)*, published by the Institute of Sustainability and Environmental Professionals, formerly known as Institute of Environmental Management and Assessment and *Annexe 1- Glossary of the report Global warming of 1.5°C (2018),* published by the Intergovernmental Panel on Climate Change.

3. The Wind Farm Infrastructure may be exposed to a range of climate hazards, defined as extreme weather events and chronic climatic changes which have the potential to harm human, environmental or infrastructure receptors (IEMA, 2020). The nature of the climate change impact will depend on the type of climate hazard and receptor, but may include impacts such as physical damage, loss or deterioration of the Wind Farm Infrastructure, disruptions to activities resulting in delays, decline in performance of the Wind Farm Infrastructure, adverse working conditions posing health and safety risks and cost implications.

4. This Chapter of the Bellrock WFDA EIA Report has been prepared to provide Marine Directorate - Licensing and Operations Team (MD-LOT) (on behalf of the Scottish Ministers) and stakeholders with sufficient information to determine the potential effect(s) of climate change on the Wind Farm Infrastructure as a receptor.

5. This Chapter should be read in conjunction with the following chapters of the Bellrock WFDA EIA Report:

- **Chapter 6: Marine Geology, Oceanography and Physical Processes (Volume II)**;
- **Chapter 17: Greenhouse Gas Assessment (Volume II)**; and
- **Chapter 20: Major Accidents and Disasters (Volume II)**.

6. The CCR assessment is likely to have key inter-relationships with the above chapters, which will be considered appropriately throughout this Bellrock WFDA EIA Report.

7. Additional information to support the climate change assessment includes:

- **Appendix 18.1: Climate Projection Data (Volume IV);** and
- **Appendix 18.2: Climate Vulnerability Assessment (Volume IV)**.

8. This Chapter was prepared by Haskoning.

18.2 Legislation, Policy and Guidance

9. **Table 18.1** describes the legislation, policy and guidance which have been considered in the preparation of this Chapter. The overarching policy and legislation relevant to the Wind Farm Infrastructure is described in **Chapter 2: Policy and Legislative Context (Volume II)**.

10. Any Legislation referred to in this EIA Report is as subsequently amended and as currently in force as at the date of this EIA Report.

Table 18.1: Summary of Relevant Legislation, Policy and Guidance for Climate Change Risk

Relevant Legislation, Policy or Guidance	Relevance to the Assessment
Legislation	
The Climate Change Act 2008 and Climate Change Act 2008 (2050 Target Amendment) Order 2019 Climate Change (Scotland) Act 2009	The Climate Change Act 2008 sets legally binding targets for the UK to reduce CO_2 emissions by at least 80% by 2050, from 1990 levels. This was amended by the Climate Change Act 2008 (2050 Target Amendment) Order 2019 which introduced a target for at least 100% reduction in greenhouse gas emissions (compared to 1990 levels) in the UK by 2050. The Climate Change Act 2008 requires the United Kingdom (UK) Government to undertake a Climate Change Risk Assessment (CCRA) every five years and identify key climate risks and opportunities to national communities and economic sectors. The Climate Change (Scotland) Act 2009 poses a similar requirement for the preparation of strategic programmes for climate change adaptation following the publication of each UK CCRA. The third UK CCRA was published in 2022, followed by the third National Adaptation Programme, which outlines priority adaptation actions to be taken. The Scottish Climate Change Adaptation Programme 2019-2024 identifies specific actions for Scotland, including a need for resilient infrastructure systems.
Policy	
National Planning Framework 4 (NPF4), Policy 2 - Climate Mitigation and Adaptation	As a long-term vision for spatial development, NPF4 supports the enhancement of the climate resilience of existing and future developments. NPF4 requires developments to be sited and designed to adapt to current and future risks from climate change (Policy 2).
Guidance	
C40 Cities: Climate Change Risk Assessment Guidance (2018)	The guidance document includes a Climate Hazard Taxonomy based on the United Nations Disaster Risk Reduction classification, which provides the basis for identifying and screening climate hazards. Although geared towards cities, the approach is largely applicable to all built environment projects.

Relevant Legislation, Policy or Guidance	Relevance to the Assessment
IEMA: Environment Impact Assessment Guide to Climate Change Resilience and Adaptation (2020)	The guidance document provides a methodology for characterising the climate baseline and assessing a development's vulnerability and resilience to climate change in the EIA process.
European Commission: Technical Guidance on the Climate Proofing of Infrastructure in the Period 2021 – 2027 (2021)	The guidance document outlines climate adaptation considerations for infrastructure projects and a risk assessment methodology for integration into impact assessments.

18.3 Consultation

11. Consultation undertaken to date for the Bellrock WFDA relevant to CCR has been in line with the general process described in **Chapter 5: EIA Methodology (Volume II)**. Key consultation pertinent to this Chapter is provided **in Table 18.2** below.

12. Chapter 17 of the Bellrock WFDA Scoping Report (**Appendix 1.1: Bellrock WFDA Scoping Report (Volume IV)**) considered the scope of Wind Farm Infrastructure's vulnerability and resilience to climate change impacts. The chapter laid out an overview the existing environment for the Bellrock WFDA and also described the broad methodology for evaluating future trends in climate change impacts and the vulnerability and resilience of the Bellrock Wind Farm Infrastructure and its associated receptors (as detailed in **Table 18.15**) to such changes.

Table 18.2: Consultation Relevant to Climate Change Risk

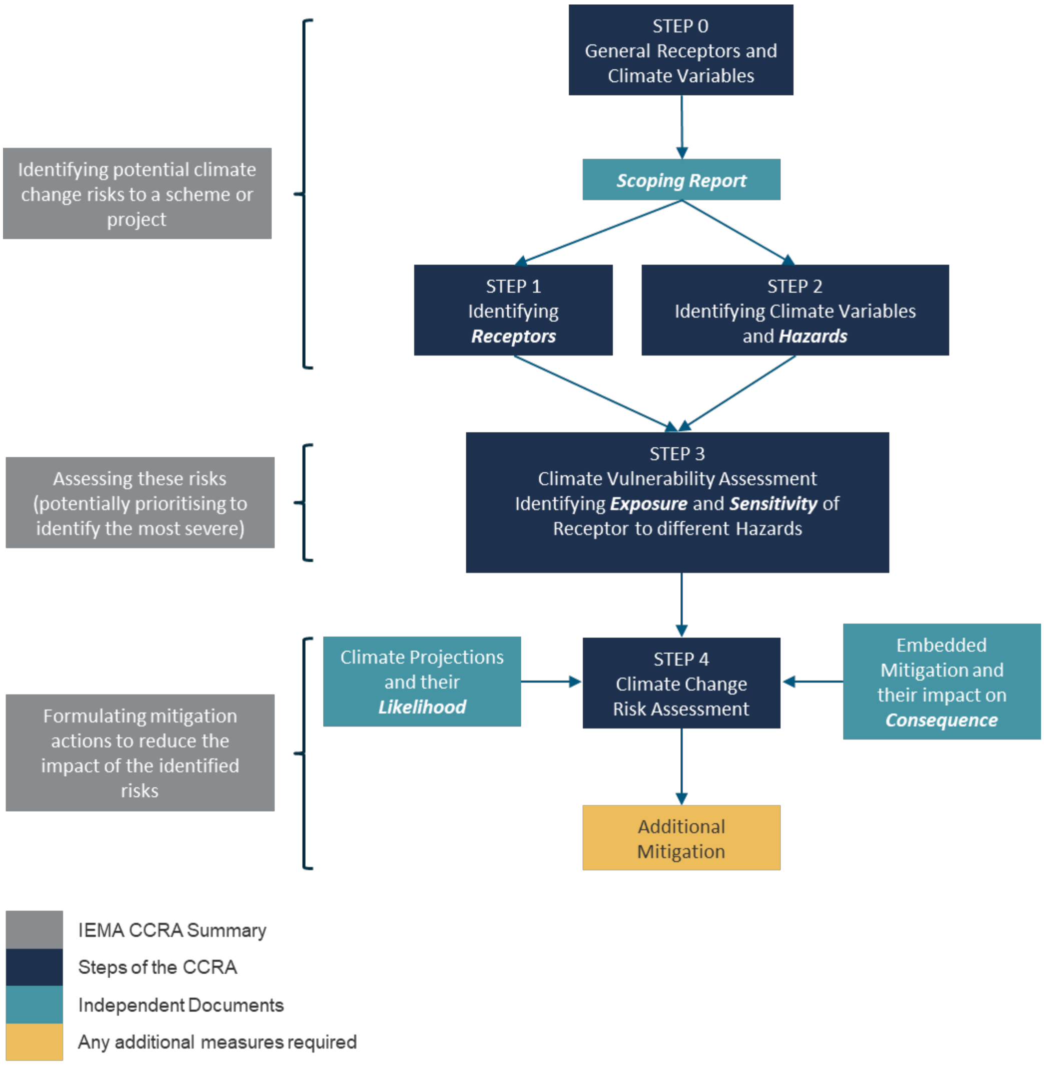
Consultee	Date/Document	Comment	How/Where Comment is Addressed
NatureScot	Representation on the Bellrock WFDA Scoping Report (2024)	The impact of climate change effects should be considered, both in futureproofing the project design and how certain climate stressors may work in combination with potential effects from the proposed wind farm.	The CCR assessment covers all phases of the Bellrock WFDA: construction, O&M and decommissioning. This has been further elaborated in **Section 18.5.1**, **Section 18.6.3**, **Section 18.8.2** and **Section 18.8.3**. **Appendix 18.1: Climate Projection Data (Volume IV)** captures climate trends up to 2099, which has been used to consider futureproofing of the project design against the relevant climate stressors.

18.4 Assessment Methodology

18.4.1 Impact Assessment Methodology

13. The methodology adopted for the CCR assessment is informed by IEMA's "Environmental Impact Assessment Guide to: Climate Change Resilience and Adaptation" (2020). As the CCR assessment considers climate change impacts on the Bellrock Wind Farm Infrastructure and its associated receptors, as opposed to the impacts of the Bellrock Wind Farm Infrastructure on other receptors, the assessment methodology differs from the general EIA approach presented in **Chapter 5: EIA Methodology (Volume II)**.

Plate 18.1: Climate Change Risk Assessment (CCRA) Methodology



18.4.1.1 Step 0 – General Receptors and Climate Variables

14. Section 17.6.1.2 of the Bellrock WFDA Scoping Report (**Appendix 1.1: Bellrock WFDA Scoping Report** (**Volume IV**)) identified climate hazards, selected from the C40 Taxonomy, and potential climate change impacts which may result in likely significant effects to the Wind Farm Infrastructure. A combination of extreme weather events and chronic climatic changes including those from temperature, precipitation, sea level rise and storms were scoped into the Bellrock WFDA EIA Report and are further described in **Table 18.12** and **Section 18.7**.

15. Section 17.6.2.2 of the Bellrock WFDA Scoping Report (**Appendix 1.1: Bellrock WFDA Scoping Report (Volume IV)**) outlines the climate hazards scoped out of the Bellrock WFDA EIA report which included wildfires, flooding, mass movements and other hazards which do not impact offshore areas.

18.4.1.2 Step 1 - Identifying Receptors

16. The first step of the CCR assessment is to identify receptors which may potentially be affected by climate change. The identified receptors include those identified during the scoping phase which are known to have already experienced a climate-related event (e.g. WTGs during storms and heavy winds) and other receptors identified during the EIA process which are likely but are yet to be impacted according to available data and literature. Receptor types considered in the CCR assessment include infrastructure (temporary and permanent) and human receptors based on the IEMA's guidance (2020).

18.4.1.3 Step 2 - Identifying Climate Variables and Hazards

17. For the second step, key climate hazards relevant to the Bellrock WFDA are identified from desk-based sources, along with climate variables which could be used to quantify or contextualise the climate hazard under current and future climate conditions, and the Bellrock Wind Farm Infrastructure and its associated receptors which they affect.

18.4.1.4 Step 3 - Climate Vulnerability Assessment

18. The third step is a climate vulnerability assessment, which identifies and assesses the potential for exposure and the sensitivities of the identified receptors to different climatic hazards. The exposure of identified receptors is defined as the receptor's spatial and temporal endurance to the climate hazard. The assessment of exposure depends on the specific hazards and risks and considers the location of the receptor and its inherent resilience to the hazard. The exposure of each receptor to relevant climate hazard and potential impacts have been categorised as High, Moderate or Low. The criteria for these are described as:

- **High exposure –** receptor has no ability to withstand, or would be substantially altered by, the projected changes to the existing/prevailing climatic factors (e.g. will lose much of its original function and form);
- **Moderate exposure –** receptor has some limited ability to withstand, or would be altered by, the projected changes to the existing/prevailing climatic conditions (e.g. will retain elements of its original function and form); and
- **Low exposure –** receptor has the ability to withstand/not be altered much by the projected changes to the existing/prevailing climatic factors (e.g. will retain much of its original function and form).

19. The sensitivity of receptors is defined by the potential of the receptor to be affected by the climate hazard. The assessment of sensitivity depends on the specific hazards and risks and considers the amount of change in the climate hazard that the receptor is able to tolerate. The sensitivity of each receptor to relevant climate hazard and impacts have been categorised as High, Moderate or Low. The criterion for these categorisations is as follows:

- **High sensitivity** – receptor has no ability to withstand/not be substantially altered by the projected changes to the existing/prevailing climatic factors or receptor is directly dependent on existing/prevailing climatic factors and reliant on these specific existing climate conditions continuing in future or only able to tolerate a very limited variation in climate conditions;
- **Moderate sensitivity** – receptor is dependent on some climatic factors but able to tolerate a range of conditions; and
- **Low sensitivity** – climatic factors have little influence on the receptors.

20. A vulnerability rating of High, Moderate or Low is then attributed to each receptor (**Table 18.3**), based on the sensitivity and exposure of the receptor to the climate hazard. Alongside the vulnerability rating, the nature of the climate change impact is also described using professional judgement to specify how the Bellrock Wind Farm Infrastructure and its associated receptors are likely to experience the climate hazard and the outcomes.

Table 18.3: Sensitivity-exposure Matrix for Determining Climate Vulnerability

Sensitivity	Exposure		
	Low	Moderate	High
Low	Low	Low	Low
Moderate	Low	Moderate	Moderate
High	Low	Moderate	High

21. Exposure is related to the location of the receptor, for example, personnel working outdoors within the Bellrock WFDA may have medium exposure to heavy rainfall (working can be paused during rainfall) but their Sensitivity will be high (because personnel could get injured).

22. Climate change impacts on Bellrock Wind Farm Infrastructure and its associated receptors are only considered to have a potential for likely significant effect where the climate vulnerability assessment identifies a moderate or high vulnerability, and therefore, only these impacts are taken forward through to Step 4 of the CCR assessment.

23. Where low vulnerability has been identified, these climate change impacts have been scoped out from further assessment, and a non-significant effect is concluded in the CCR assessment. This is in line with risk assessment approach proposed by the European Commission in its guidance note whereby only potentially significant risks from climate change are taken forward for detailed analysis (EC, 2021).

24. The assessment carried out at Step 3 is detailed in **Appendix 18.2: Climate Vulnerability Assessment (Volume IV)**.

18.4.1.5 Step 4 - Climate Risk Assessment

25. Step 4 is the climate risk assessment. For climate change impacts determined to have a moderate or high vulnerability rating during Step 3, the risk from climate change on the Bellrock Wind Farm Infrastructure and its associated receptors are qualitatively assessed based on the likelihood and consequence of the climate change impact, accounting for the climate projections and embedded mitigation measures. The degree of climate risk is then used to determine the effect significance.

26. *Likelihood* values were categorised into Almost Certain, Likely, Moderate, Unlikely or Very Unlikely. The definitions of likelihood are provided in **Table 18.4** (Adapted from IEMA, 2020)**.**

Table 18.4: Definitions of Likelihood of a Climate Change Impact

Likelihood	Description
Almost Certain	The climate change impact on the receptor is almost certain to occur numerous times during the construction, O&M or decommissioning phase.
Likely	The climate change impact on the receptor is likely to occur on several occasions during the construction, O&M or decommissioning phase.
Moderate	The climate change impact on the receptor will occur on limited occasions during the construction, O&M or decommissioning phase.
Unlikely	The climate change impact on the receptor will occur infrequently during the construction, O&M or decommissioning phase.
Very Unlikely	The climate change impact on the receptor is unlikely to occur during the construction, O&M or decommissioning phase.

27. Project-specific embedded mitigations and industry standards were qualitatively assessed to categorise any remaining *Consequences* of impacts. Consequences were categorised to Catastrophic, Major, Moderate, Minor, or Negligible. The definitions of consequence are provided in **Table 18.5.**

Table 18.5: Definitions of Consequences of a Climate Change Impact

Consequence	Description
Catastrophic	The climate change impact will result in: ▪ Permanent damage/deterioration/loss of Wind Farm Infrastructure; ▪ Severe and prolonged disruptions to critical activities or decline in performance of Wind Farm Infrastructure integral to their function; ▪ Severe cost implications; and/or ▪ Severe and irreversible health and safety implications.

Consequence	Description
Major	The climate change impact will result in: ▪ Major and extensive damage/deterioration of Wind Farm Infrastructure; ▪ Major and extensive disruptions to activities or decline in performance of Wind Farm Infrastructure; ▪ Major cost implications; and/or ▪ Major and long-term health and safety implications.
Moderate	The climate change impact will result in: ▪ Moderate but recoverable damage/deterioration of Wind Farm Infrastructure; ▪ Moderate but recoverable disruptions to activities or decline in performance of Wind Farm Infrastructure; ▪ Moderate cost implications; and/or ▪ Moderate health and safety implications.
Minor	The climate change impact will result in: ▪ Minor and localised damage/deterioration of Wind Farm Infrastructure; ▪ Minor and localised disruptions to activities or decline in performance of Wind Farm Infrastructure; ▪ Minor cost implications; and/or ▪ Minor health and safety implications.
Negligible	The climate change impact will result in: ▪ No or negligible damage/deterioration of Wind Farm Infrastructure; ▪ No or negligible disruptions to activities or decline in performance of Wind Farm Infrastructure or; ▪ No or negligible cost implications; and/or ▪ No or negligible health and safety implications.

28. The matrix used to determine the climate risk is provided in **Table 18.6**. Definitions of the climate risk ratings are provided in **Table 18.7**.

29. For the purpose of the CCR assessment, climate change impacts which are determined through professional judgement to have a High or Extreme risk rating are considered to be significant in EIA terms. Where there are significant effects, additional mitigation measures may be identified, and a residual risk rating is then determined. Climate change impacts with a moderate risk rating are considered non-significant in EIA terms as no regulatory thresholds are exceeded and is unlikely to cause irreversible harm, so the embedded mitigation measures are sufficient, however additional mitigation measures may be recommended for these potential impacts as best practice based on professional judgment.

Table 18.6: Likelihood-consequence Matrix for Determining Climate Risk and Effect Significance

Likelihood	Consequence				
	Negligible	Minor	Moderate	Major	Catastrophic
Almost Certain	Low	Moderate	High	Extreme	Extreme
Likely	Low	Moderate	Moderate	High	Extreme
Moderate	Low	Low	Moderate	High	Extreme
Unlikely	Low	Low	Moderate	Moderate	High
Very Unlikely	Low	Low	Low	Moderate	Moderate

Table 18.7: Definitions of Climate Risk Ratings

Level of Risk	Description
Extreme	The climate risk is not mitigated accounting for embedded mitigation measures. Significant impacts on the Bellrock Wind Farm Infrastructure and its associated receptors could occur without additional mitigation. Risks in this category are considered Significant.
High	The climate risk is not fully mitigated accounting for embedded mitigation measures. Impacts on the Bellrock Wind Farm Infrastructure and its associated receptors could occur without additional mitigation. Risks in this category are considered Significant.
Moderate	The embedded mitigation measures are sufficient to address this climate risk. The risk is not significant in EIA terms. Risks in this category are considered non-significant.
Low	The embedded mitigation measures greatly reduce this climate risk. The risk is not significant in EIA terms. Risks in this category are considered non-significant.

18.4.2 Cumulative Effects Assessment Methodology

30. It is highly unlikely that the CCR of the Wind Farm Infrastructure will be significantly affected by neighbouring developments as the Wind Farm Infrastructure is considered isolated from other infrastructure. The Wind Farm Infrastructure is specifically designed to withstand marine conditions and climate hazards. The operational systems and maintenance protocols of the Wind Farm Infrastructure will be designed to function independently of external influences. This autonomy further reduces the likelihood of significant impacts from neighbouring developments. Therefore, cumulative effects are scoped out of the Bellrock WFDA CCR assessment.

18.4.3 Transboundary Effects Assessment Methodology

31. It is not relevant to assess transboundary effects relating to CCR, as the assessment focusses on the effects of climate change on the Wind Farm Infrastructure receptors only. Therefore, transboundary effects are scoped out of the Bellrock WFDA CCR assessment.

18.5 Scope of the Assessment

18.5.1 Study Area

32. The scope of the CCR assessment has been limited to evaluating the vulnerability and resilience of the Bellrock Wind Farm Infrastructure and its associated receptors to the effects of climate change. Therefore, the CCR assessment study area is geographically bounded and defined by the boundary of the Bellrock WFDA.

33. UKCP18 grid cells in the vicinity of the Bellrock WFDA were used to obtain climate change projection data to represent the spatial scope of predicted future climate conditions within the Bellrock WFDA. The grid cell used for the UKCP18 land-based projections was selected as it covered mostly land within the vicinity of the Bellrock WFDA and is shown in **Figure 18.1 (Volume III)**. The grid cell used for the UKCP18 marine projections is shown in **Figure 18.2 (Volume III)** and was selected for its spatial consistency with the land-based grid cell. Both cells are located close to the Inverbervie No. 2 weather station, which increases the accuracy of the cell data.

34. The CCR assessment has been informed by historical observations and future projections of climate variables. The spatial resolution of the baseline data collected for the CCR assessment has provided representative coverage of the Bellrock WFDA and the wider region of eastern Scotland (Met Office, 2016). This supporting data can be found in **Appendix 18.1: Climate Projection Data (Volume IV)**.

35. The temporal boundary of the CCR assessment will be defined by the phases of the Bellrock Wind Farm Infrastructure: construction, O&M and decommissioning:

- The Bellrock WFDA is anticipated to have site preparation works commence in 2030 (yr 0) with construction between 2031 to 2037 (yr 1-7) and therefore, eight years of activities.
- The operational lifetime is assumed to be up to 35 years for the Bellrock Wind Farm Infrastructure, but the seabed lease will be for up to 60 years. The design life will be dictated by the major equipment suppliers, such as the WTG suppliers, and will reflect market maturity and operational experience globally at the time of construction and during operations. At the end of the design life, any repowering will be subject to separate consents.
- The duration of the decommissioning period will depend on the Bellrock WFDA end-of-life strategy but, for EIA purposes, is assumed to be similar in timescales as the construction period.

18.5.2 Data and Information Sources

36. The primary guidance document that has been used to inform the baseline characterisation, assessment methodology and mitigation design for the CCR assessment is IEMA's "Environmental Impact Assessment Guide to: Climate Change Resilience and Adaptation" (IEMA, 2020). This guidance document provides a framework for the consideration of CCR and adaptation in the EIA process and advises that future climate conditions within a development's study area should be identified and assessed with consideration of how adaptation and resilience measures have been built into the design of a development.

37. **Table 18.8** sets out the key desk-based information and data sources that have been used to inform the CCR baseline.

Table 18.8: Key Data and Information Sources for Climate Change Risk

Dataset	Year(s)	Description
CCR Assessment		
Met Office UK Climate Projection (UKCP18) Database and supporting reports.	Various	Climate change projection data and summaries for the UK for various climate variables such as air temperature and precipitation. Note: UKCP data is most applicable to onshore and coastal areas. '18' refers to the year that the data was first approved and published, although enhancements to the data have been published since and are considered as applicable.
Met Office's UK Climate Averages and Regional Climate Summaries.	Various	Historical climate observations and current climate conditions for the UK.
Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report.	Various	Current state of knowledge on climate science and possible climate futures.
Marine Climate Change Impacts Partnership (MCCIP) Reports.	Various	A collection of evidence reviews and summary reports on climate change effects in the marine environment.
Offshore Wind Climate Adaptation and Resiliency Study (New York State Energy Research and Development authority (NYSERDA), 2021).	2021	Review of key climate factors to the offshore wind sector and opportunities for climate resilience.
Department for Business, Energy and Industrial Strategy's (BEIS) Offshore Energy Strategic Environment Assessment 4 (SEA4).	2022	Observed meteorological conditions at seas around the UK.

Dataset	Year(s)	Description
IPCC Fifth Assessment Report.	2014	This report defines a range of Representative Concentration Pathways (RCP)[2], which are different possible trajectories of atmospheric concentrations of greenhouse gases (GHG), based on socioeconomic and policy assumptions used in climate change projection modelling. These are used to predict future climate conditions.
Scotland's Marine Assessment (Moffat et al. 2020).	2020	Reports on the vision for the (Scottish) seas '*clean, healthy, safe, productive, biologically diverse marine and coastal environments, managed to meet the long-term needs of nature and people*'. The assessment presents, where possible, trends for the period 2014 to 2018 with longer term data presented where this sets the 2014 to 2018 period in a longer-term context.

18.5.2.1 Assumptions and Limitations

38. The assumptions made in the CCR assessment are set out in **Table 18.9**.

Table 18.9: Assumptions and Limitations of the Climate Change Risk Assessment

Assumption/Limitation	Further Detail/Discussion
Climate change projections	A key assumption of the climate change projection data from UKCP18 is that the model is strongly dependent on the future global GHG atmospheric concentrations and emission trajectories. The RCP scenarios considered by UKCP18 (refer to **Table 18.8** and **Appendix 18.1: Climate Projection Data (Volume IV)**) cover a recent set of assumptions based upon future population dynamics, economic development, and account for international targets on reducing GHG emissions. Each RCP scenario has a different climate outcome, given that they are based upon a different set of assumptions. Noting that the UKCP18 guidance cautions against reliably placing probabilities on which scenario of GHG emissions is most likely, two RCP scenarios (RCP4.5 and RCP8.5) have been selected due to their relevance in presenting a range of possible outcomes over the operation and decommissioning phases of the Bellrock Wind Farm Infrastructure. Due to the intrinsic uncertainty within climate change projection data, the UKCP data is based upon probabilistic projections, generating a normally distributed model per output. The model outputs values for the 10th, 50th and 90th percentiles, which represents the range of uncertainty, and is therefore presented in CCR assessment. In addition, UKCP data do not cover all climate variables which may be relevant to the Bellrock WFDA. Where information gaps exist, these are supplemented with other available literature sources and it is considered that

[2] The RCP scenarios are related to the concentrations of GHG that would result in target amounts of radiative forcing (measured in watts per square metre (W/m²)) at the top of the atmosphere by 2100, relative to pre-industrial levels. Radiative forcing is a measure of the influence of factors (like GHG) on the energy balance of the Earth's atmosphere. The RCP scenarios are detailed in **Appendix 18.1: Climate Projection Data (Volume IV)**, **Section 1.1**.

Assumption/Limitation	Further Detail/Discussion
	sufficient information is available upon which to base the assessment of the vulnerability of the Bellrock Wind Farm Infrastructure to climate change.
Spatial resolution of the climate baseline	Climate change projection data are provided for defined grid cells in the UKCP18 database. The size of the grid cell determines the spatial resolution of the projection data and how it corresponds to the Bellrock WFDA. It is considered that the climate baseline across the Bellrock WFDA is adequately described by the selected grid cell. It should be noted that limited quantitative climate data is available for offshore locations and therefore the most appropriate onshore data has been used. The grid cell used for the UKCP18 land-based projections was selected as it covered mostly land within the vicinity of the Bellrock WFDA. The grid cell used for the UKCP18 marine projections was selected for its spatial consistency with the land-based grid cell. Both cells are located close to the Inverbervie No. 2 weather station, which increases the accuracy of the cell data. The grid cells used for the UKCP18 land-based projections are shown in **Figure 18.1** in **Volume III**. The grid cell used for the UKCP18 marine projections is shown in **Figure 18.2** in **Volume III**.
Temporal resolution of the climate baseline	Climate change projection data are provided as a time series. For the purpose of the CCR assessment, the data is summarised, and average values are presented by time slices, which are selected based on the development phase, as set out in **Table 18.13** It is considered that these time slices are representative of current and future conditions within the Bellrock WFDA and provide sufficient temporal coverage.

18.6 Existing Environment

39. The existing baseline for the CCR assessment is the representative present-day climate conditions within the Bellrock WFDA and the wider region of eastern Scotland.

40. Although the construction period is expected to end in the mid to late-2030s, the most recent Met Office long-term climate averages available extend only to 1991–2020. The current baseline is therefore used to characterise present-day climate conditions, while climate projection data are required to understand how those climate conditions are likely to change in the future and any adverse impacts they may cause during construction and, more notably, during the O&M and decommissioning phases. This approach enables future climate risks to be assessed relative to a well-defined current baseline.

41. The Bellrock WFDA is located 120 km east of Stonehaven, Aberdeenshire (116 km southeast of Peterhead) and covers an area of 280 km^2. The current climate for the wider region of the Bellrock WFDA is described in the report 'Met Office Eastern Scotland: Climate' (Met Office, 2016). This report provides a regional climate summary with a focus on the 30-year averaging period of 1981-2010. Scotland's Marine Assessment 2020 (Moffat et al. 2020) also provides information about Scotland's marine climate. Relevant information from these reports is summarised below, to provide the national and regional context for the climate change baseline for the Bellrock WFDA.

18.6.1 Eastern Scotland

42. January and February are the coldest months in eastern Scotland[3], with mean daily minimum temperatures of about 2°C on the northeast coast of the Grampian region. Extreme minimum temperatures usually occur in January or February, with temperatures of below -20°C regularly recorded in the region. Conversely, temperatures can occasionally reach 15°C in winter due to a southerly airstream that warms after crossing upland. Maximum temperatures occur in July and August, with mean daily maximum temperatures of less than 17°C along the Grampian coast. Extreme maximum temperatures, associated with heatwaves, can exceed 30°C in eastern Scotland.

43. Eastern Scotland experiences air frost for between 40 and 90 days per year, and ground frost for less than 90 to over 150 days per year. Frost days occur more frequently on higher ground and in deep valleys within the Grampian mountains. The frost-free season in eastern Scotland can be as little as three months.

44. Average total annual rainfall across Scotland varies from 700 mm to 1500 mm, which is high compared to the UK as a whole. Rainfall is typically well distributed throughout the year, although the wettest months tend to be in autumn and early winter, with late winter and spring usually the driest part of the year. In winter (December to February), there are around 30 wet days on average along the East Lothian and Fife coasts[4]. In summer (June to August), the East Lothian and Fife coasts have about 27 wet days. Periods of prolonged rainfall can lead to widespread flooding, especially in winter and early spring when soils are usually near saturation and snowmelt can be a contributing factor.

45. Snowfall is closely linked to with temperature. Snowfall normally occurs between November and April, with upland areas often having brief falls in October and May. Snow rarely lies at lower levels between May and October. On average, snow falls on about 20 days per winter along the northeastern coast, compared to more than 80 days over the Grampian mountains, which extend into Aberdeenshire. The number of days with snow lying has a similar distribution.

46. The prevailing wind direction in the northeast of Scotland is generally from the southwest, similar to the rest of Scotland and the UK. However, there are seasonal variations, with northeasterly winds more common in spring. The wind direction is influenced by the topography, with the Grampian mountains providing shelter to the northeast coast, which experiences fewer southwesterly winds.

47. Extreme gales occur in eastern Scotland, with the potential to cause property damage and disruption to travel and power supplies.

48. The northeast coast of Scotland experiences sea-fog (haar) in late spring and summer. There is no clear evidence of an increase in sea-fog over the past decade. Sea fog can affect transportation, shipping and oil platforms, with reduced visibility disrupting flights, grounding helicopters, and causing delays in maritime operations.

[3] Refer to **Table 18.9** for assumptions and limitations regarding spatial resolution of the climate baseline.

[4] Data for Aberdeenshire is not available, therefore the Lothian and Fife data is used as representative.

49. Average sea temperatures around Scotland reflect the influence of heat transported from oceanic waters. Sea temperatures off the coast of northeast Scotland vary from 5-7°C in winter (December to February) to 12-14°C in summer (June to August). Peak sea temperatures lag behind peak air temperatures by about a month, with the highest sea temperatures occurring in late August. The average winter sea surface temperature in the northeast of Scotland is almost 1.5°C lower than the average winter temperature for the west of Scotland.

50. Met Office UK Climate Averages (Met Office, 2022b) are only available for onshore meteorological sites because the weather stations used for data are land-based and therefore do not provide direct coverage of the Bellrock WFDA area. Existing historic climate data for the period 1991 to 2020 has been obtained from the Inverbervie No 2 (Aberdeenshire) meteorological recording station, which is the closest recording station (120 km) to the Bellrock WFDA and is considered to provide an appropriate representation of the temperature anomaly, precipitation anomaly and wind speed anomaly for the Bellrock WFDA. Climate data for station Inverbervie No 2, East Scotland, Scotland and the UK are provided in **Table 18.10** (Met Office, 2022b).

Table 18.10: Existing Local, Regional and National Climate for the 1991 to 2020 Period

Climate Variable	Units	Annual Average			
		Inverbervie No 2	East Scotland	Scotland	UK
Maximum temperature	°C	11.14	11.13	11.07	12.79
Minimum temperature	°C	5.52	4.02	4.4	5.53
Days of air frost	days	35.2	81.85	71.68	53.36
Rainfall	mm	703.44	1,187.77	1,572.72	1,162.7
Days of rainfall ≥1 mm	days	131.82	164.18	191.28	159.08
Monthly mean wind speed at 10 m	knots	12.73	10.19	10.74	9.27

18.6.2 Bellrock WFDA

51. The climate data presented above can be interpreted as follows for the specific location of the Bellrock WFDA:

- Annual average maximum and minimum temperatures are comparable with the East of Scotland and Scotland averages;
- Coastal and offshore regions can be affected by sea breezes which result in lower maximum temperatures from late spring through the summer and milder temperatures in winter when compared to inland locations;

- The Meteorological station closest to the Bellrock WFDA experiences less rainfall on average than the East of Scotland, Scotland and the UK. This is due to the predominant weather patterns for the UK whereby wetter conditions are typically experienced in the west due to the influence of southwest prevailing winds from the Atlantic Ocean. Inverbervie No 2 is sheltered from the southwest winds; and
- The monthly mean wind speed at 10 m elevation at Inverbervie No 2 is more than 18% higher than the regional, Scotland, and UK averages.

18.6.3 Predicted Future Baseline

52. Representative concentration pathways (RCP) and shared socioeconomic pathways (SSP) are defined by the Intergovernmental Panel on Climate Change (IPCC, 2014) and represent the different possible trajectories of GHG atmospheric concentrations for the next 100 years, with each pathway involving assumptions about future human behaviour and policy decisions (van Vuuren et al. 2011). **Appendix 18.1: Climate Projection Data (Volume IV)** includes further explanation of the RCP and SSP scenarios relevant to the CCR assessment and data for multiple RCP scenarios, showcasing the differences in these trajectories and their impact on the climate variables.

53. The potential effects of climate change are projected to increase over time, for the UK as a whole and for the Bellrock WFDA. Warming seas, reduced oxygen levels, ocean acidification and sea-level rise are described as key risks for the future baseline conditions in UK seas (MCCIP, 2020).

54. Climate change projection data from the Met Office's UKCP18 database is used to characterise the predicted future baseline within the Bellrock WFDA for the CCR assessment. Where information gaps exist in the UKCP18 data, these are supplemented with other available literature sources. This data is presented in **Appendix 18.1: Climate Projection Data (Volume IV)**.

55. The Met Office's UKCP18 database provides probabilistic climate change projections for the UK at a spatial resolution of 25 km grid squares from the time period of 1961 to 2100. Probabilistic projections are based on possible changes in future climate based on an assessment of climate model uncertainties and are most suitable for characterising future extremes in risk assessments, as they provide the broadest range of climate outcomes.

56. UKCP18 grid cells in the vicinity of the Bellrock WFDA were used to obtain climate change projection data to represent the spatial scope of predicted future climate conditions within the Bellrock WFDA. The grid cell used for the UKCP18 land-based projections was selected as it covered mostly land within the vicinity of the Bellrock WFDA and is shown in **Figure 18.1 (Volume III)**. The grid cell used for the UKCP18 marine projections is shown in **Figure 18.2 (Volume III)** and was selected for its spatial consistency with the land-based grid cell. Both cells are located close to the Inverbervie No. 2 weather station, which increases the accuracy of the cell data.

57. The majority of the UKCP18 probabilistic projections are land-based and therefore do not provide direct coverage of the Bellrock WFDA. The land-based projection data shows limited spatial variation, so is considered to provide an appropriate representation of the temperature anomaly and precipitation anomaly for the Bellrock WFDA.

58. Future climate projections are modelled projections and are strongly dependent on future global GHG emissions. Uncertainties associated with these projections are detailed in **Table 18.9.** In some cases, projections to the year 2100 (or later) are presented, as this is the only data available for some climate variables.

18.6.3.1 Land-Based Climate Projections – Temperature, Precipitation and Wind

59. In the UK, winters are projected to become warmer and wetter, with summers becoming hotter and drier over the 21st century, although some dry winters and wet summers will still occur.

60. By 2070 under RCP8.5 (see **Table 18.8** and **Appendix 18.1: Climate Projection Data (Volume IV)**, the probabilistic projections show that UK average changes in rainfall range from a decrease of -1% to an increase of +35% in winter and from a decrease of -47% to an increase of +2% in summer when compared against the 1981-2000 baseline average. Overall, precipitation levels are likely to continue to increase in the winter but decrease during the summer (Lowe et al. 2018). Future climate change is expected to bring about a change in the seasonality of extremes, such as increases in heavy hourly rainfall intensity in the autumn, and significant increases in hourly precipitation extremes (Met Office, 2022b).

61. Global projections over the UK indicate that the second half of the 21st century will experience an increase in near surface wind speed during the winter season. This is accompanied by an increase in the frequency of winter storms. The most recent climate projections for the UK suggest there is still uncertainty regarding the relationship between storminess and future climate change (Met Office, 2021).

62. Research indicates that climate change is expected to alter lightning patterns across Europe during the 21st century, with more frequent lightning strikes predicted for northern Europe (Kahraman et al. 2022).

63. Projected changes in temperature and rainfall are modelled with a high confidence by the global climate change models that are the basis for the UKCP18 data. Other climate parameters considered in the CCR assessment such as wind speed have more uncertainty.

64. Changes in the annual average temperature and precipitation rate anomalies compared to the 1981 - 2000 baseline are presented for the Bellrock WFDA in **Appendix 18.1: Climate Projection Data (Volume IV)** for the following scenarios (**Table 18.8**): RCP4.5 (intermediate emission) scenario and the RCP8.5 (very high emission) scenarios (Met Office, 2022). These scenarios are considered the most likely to occur during the construction, O&M, and decommissioning phases of the Bellrock Wind Farm Infrastructure and present a range of outcomes in terms of climate change projection data.

65. **Appendix 18.1: Climate Projection Data (Volume IV)** shows that under both RCP4.5 and RCP8.5 scenarios, annual, summer and winter temperatures in the Bellrock WFDA are likely to increase during the operation (2030s to 2070s) and decommissioning (2070s) phases of the Bellrock Wind Farm Infrastructure. For the operational phase of the Bellrock Wind Farm Infrastructure, under RCP8.5, the annual mean temperature is predicted to increase by between 0.5°C and 4.5°C (10th and 90th percentile respectively) by the 2070s compared to the 1981 - 2000 baseline. The mean annual maximum temperature is projected to increase by 5.3°C for the

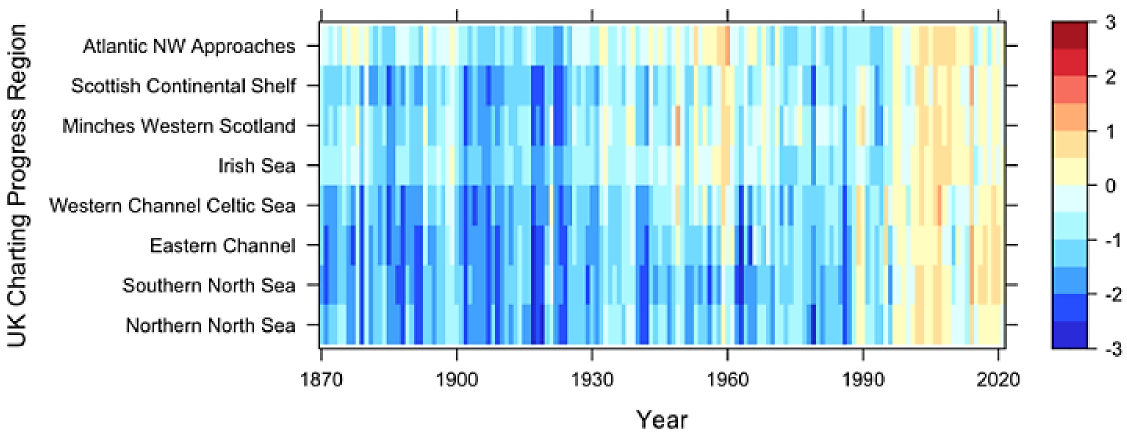
decommissioning phase of the Bellrock Wind Farm Infrastructure (2070s) under the RCP8.5 scenario (90th percentile).

66. Under the RCP8.5 scenario set out in **Appendix 18.1: Climate Projection Data (Volume IV)**, the annual precipitation anomaly projection is more variable than the air temperature anomaly projection. For the operation phase (2030s to 2070s), the annual mean precipitation is projected to change by between -1.3% and 17.0% (10th and 90th percentile). For the decommissioning phase (2070s), the annual mean precipitation is projected to change by between -5.5% and 18.2% (10th and 90th percentile).

18.6.3.2 Marine Climate Projections – Temperature, Sea Level Rise, Storm Surge and Coastal Erosion for Eastern Scotland

67. Climate change is expected to affect sea surface and near-bottom temperatures, which in addition to a decline in sea ice formation, melting ice sheets and glaciers, contribute to global sea level rise due to thermal expansion of seawater (Fox-Kemper et al. 2021). Over the last 40 years, average sea surface temperature around the UK has shown a significant warming trend of around 0.3°C per decade, with marked local and regional variations, as shown by **Plate 18.2** (sourced from E et al. 2023).

Plate 18.2: Observed Changes in UK Sea Temperatures



68. Marine heat waves are periods of localised abnormally high sea temperatures above the long-term warming trend of the upper ocean. They last for several days or weeks, and potentially for several months, and can have significant adverse effects on the marine ecosystem. Marine cold waves represent the other end of the extreme of sea temperature conditions. A comparison of observations, recorded between 1982 to 1998 and 2000 to 2016 indicate the marine heat waves have increased in frequency by an average of 3.8 events per year around the British Isles. Larger increases occurred to the north of the British Isles, where an increase of up to six additional events are experienced on average in the 2000 to 2016 period compared to 1982 to 1998 (Cornes et al. 2023).

69. The UKCP18 database does not provide information on changes to sea water properties such as sea surface temperature and acidification which may be affected by climate change. Any climate change risks to the project relating to these hazards will be assessed qualitatively.

70. Global sea levels have risen over the 20th century and are projected to continue rising over the coming centuries. Under all emission pathway scenarios, sea levels around the UK will continue to rise to 2100 (Met Office, 2022), and sea levels are projected to continue rising beyond 2100 even with large reductions in GHG emissions over the 21st century (Met Office, 2019).

71. It is predicted that future extreme sea levels will be driven by changes in mean sea level and not by the storm surge component or changes to tides. Models and observations suggest that there has been an increase in the frequency of severe storms and in significant wave heights in UK waters since the 1950s (MCCIP, 2020). In the near future, natural variability dominates any climate-related trends in storms and waves. Towards the end of the 21st century, there is some consensus that mean significant wave height is decreasing while the most extreme wave heights are increasing (Wolf et al. 2020).

72. Ocean pH is decreasing due to climate change, through a process known as ocean acidification, which means that seas globally are becoming more acidic. The oceans absorb atmospheric CO_2, which dissolves and reacts with seawater to form carbonic acid. It is projected that ocean acidification will continue to occur during the 21st century (IPCC, 2019).

18.7 Potential Impacts

18.7.1 Scope

73. As detailed in the Bellrock WFDA Scoping Report (**Appendix 1.1: Bellrock WFDA Scoping Report (Volume IV)**) and **Step 0 (Section 18.4.1.1)**) the CCR assessment considers the effects of climate change on the Bellrock Wind Farm Infrastructure and its associated receptors. The scope of the assessment therefore differs from other EIA topics, which consider the effects of the Wind Farm Infrastructure on the receiving environment. Therefore, **Table 18.11** presents the identified receptors which have the potential to be affected by climate change during the construction, O&M and decommissioning phases (**Step 1 (Section 18.8.1)**).

Table 18.11: Climate Change Risk Assessment – Impacts Scoped into the Assessment Resulting from Two Types of Climate Hazards – Extreme Weather Events and Chronic Climatic Change

Impact and Activity	Receptors	Rationale
Climate change impacts from marine climate hazards during construction.	Offshore human and Wind Farm Infrastructure receptors. Vessel movements to and from the Bellrock WFDA. Transport of plant and equipment to and from the Bellrock WFDA.	The construction activities for the Wind Farm Infrastructure have the potential to be vulnerable to marine climate hazards such as storms, sea-level rise, and extreme weather events. Assessing resilience ensures that the construction of the Wind Farm Infrastructure can withstand these conditions, minimising delays, costs, and safety risks.

Impact and Activity	Receptors	Rationale
Climate change impacts from marine climate hazards during operation.	Offshore human and Wind Farm Infrastructure receptors. Vessel movements to and from the Bellrock WFDA.	During operation, the O&M activities for the Wind Farm Infrastructure have the potential for continuous exposure to marine climate hazards. Evaluating resilience informs the development of robust maintenance plans and emergency response plans and ensures the longevity and reliability of Wind Farm Infrastructure and the safety of O&M personnel.
Climate change impacts from marine climate hazards during decommissioning.	Offshore human and Wind Farm Infrastructure receptors. Vessel movements to and from the Bellrock WFDA. Transport of plant and equipment to and from the Bellrock WFDA.	The decommissioning activities for the Wind Farm Infrastructure have the potential to be vulnerable to marine climate hazards. Assessing resilience ensures that offshore decommissioning plans are adaptable to changing conditions, reducing risks and ensuring safe conditions.

74. **Table 18.12** sets out the impacts (**Step 2, Section 18.8.2**) that have been scoped in and scoped out of the Bellrock WFDA EIA Report, in line with the Scoping Opinion (**Appendix 1.2: Bellrock WFDA Scoping Opinion (Volume IV)**).

75. The impacts presented in the CCR assessment have been summarised for each phase of the Bellrock Wind Farm Infrastructure, and the location of the identified receptors. They are further divided into specific climate change impacts in the assessment, based on the type of climate hazard and the nature of the resulting impact on the identified receptors, as outlined in **Appendix 18.2: Climate Vulnerability Assessment (Volume IV)**.

This page is intentionally blank

Table 18.12: Potential Impacts Scoped In and Out of the EIA for Climate Change Risk as Agreed in the Bellrock Wind Farm Development Area Scoping Opinion

Potential Impact	Construction	Operation and Maintenance	Decommissioning
	Advised within the Bellrock WFDA Scoping Opinion		
Impacts from extreme precipitation (e.g. rain, snow, hail, fog)	✓	✓	✓
Impacts from storm and wind (e.g. gales, storm surge, thunderstorms)	✓	✓	✓
Impacts from extreme temperatures (e.g. cold and heat waves)	✓	✓	✓
Impacts from changes in marine climate and extreme weather events	✓	✓	✓
Impacts from sea level rise	✓	✓	✓
Impacts from changes in sea conditions (e.g. wave and currents, salinity)	✓	✓	✓
Impacts from flooding, wildfires, mass movements, land changes or water stress	x	x	x
Ocean acidification	x	x	x
Transboundary impacts	x	x	x

This page is intentionally blank

18.7.2 Realistic Worst-case Scenario

76. The final design of the Wind Farm Infrastructure will be confirmed during detailed design, which takes place post-consent. To undertake a robust and precautionary impact assessment, the realistic worst-case design scenario has been defined. Realistic worst-case scenario (i.e. those that have potential to cause the greatest impact) are derived from the project design statement to ensure that all other design scenarios would have equal or less impact. Please see **Chapter 5: EIA Methodology (Volume II)** for further details on the design envelope approach.

77. There is uncertainty surrounding the scale and rate of climate change due to the complex interactions between the various natural and human factors that influence the Earth's climate system. Predicting "worst-case" scenarios with respect to climate change impacts is challenging because of the variability in future GHG emissions, socioeconomic developments and technological advancements. It is therefore difficult to pinpoint a single "worst-case" scenario, as the outcomes depend on a wide range of unpredictable variables.

78. To provide a precautionary, but robust, assessment to inform this CCR assessment, realistic worst-case scenarios have been defined in **Table 18.13** below. These are based on the project design envelope as described in **Chapter 4: Project Description (Volume II)**.

79. These have been incorporated in **Step 3, Section 18.8.3** and **Step 4, Section 18.8.4** via the climate projection data. Further details are in **Appendix 18.1: Climate Projection Data (Volume IV)**.

80. The timeframes for the construction, O&M, and decommissioning phases of the Bellrock Wind Farm Infrastructure align with different climate periods. Therefore, for the CCR assessment, realistic worst-case scenarios have been defined for each phase and the likely relevant RCP scenario. More details about the various RCP scenarios and the reasons for their selection are provided in **Appendix 18.1: Climate Projection Data (Volume IV)**.

This page is intentionally blank

Table 18.13: Realistic Worst-case Scenario for Impacts on Climate Change

Impact	Realistic Worst-case Scenario	Rationale
Construction		
Climate change impacts from marine climate hazards during construction – offshore human, Wind Farm Infrastructure and environmental receptors.	Construction phase: 2031 to 2037 (total construction duration of up to seven years), with site preparation works[1] happening in 2030 (yr 0), one year prior to the commencement of construction, which aligns with the climate period[2] of 2030s (2020 to 2039). The RCP4.5 is considered to provide a suitable representation of the expected climate conditions during the construction phase of the Bellrock Wind Farm Infrastructure.	The degree of climatic change up to and during the construction period, as distinct from standard weather fluctuations, is not likely to result in significant changes from present-day conditions, particularly when compared to the operational timeframe where change in climate hazards is more likely.
Operation and Maintenance		
Climate change impacts from marine climate hazards during operation – offshore human, Wind Farm Infrastructure and environmental receptors.	Commercial Operation Date start date: 2037 Operational life: 35 years Operation phase: 2037 to 2072, which aligns with the climate periods of 2040s (2030 to 2049), 2060s (2050 to 2069) and 2070s (2070 to 2089). RCP scenario: RCP8.5 (very high emission scenario)	For the operational phase, RCP8.5 scenario has been selected as the realistic worst-case scenario to provide a conservative assessment.
Decommissioning		
Climate change impacts from marine climate hazards during decommissioning – offshore human, Wind Farm Infrastructure and environmental receptors.	Details of the decommissioning of the Wind Farm Infrastructure will be included in the Decommissioning Programme for the Bellrock WFDA. It is recognised that legislation and industry best practices change over time, and the Decommissioning Programme will consider good industry practice, guidance and legislation for decommissioning works which includes anticipated costs and financial securities. It is also likely that the Wind Farm Infrastructure would be removed and reused or recycled, where practicable. The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning. Further details on decommissioning are provided in **Chapter 4: Project Description (Volume II)**. For the purpose of the CCR assessment, the decommissioning phase is assumed to start at the end of the operational lifetime of the Bellrock Wind Farm Infrastructure and last for a similar duration as the construction phase (seven years). This aligns with the climate period of 2070s (2070 to 2089). The RCP8.5 scenario has been selected as the realistic worst-case scenario to provide a conservative assessment.	

Impact	Realistic Worst-case Scenario	Rationale
Notes: [1] Site preparation works will commence up to one year before commencement of construction (year 0), at which point they may continue albeit as construction works (rather than site preparation works) these activities have been considered in the assessments of this Chapter, for completeness. [2] Climate change projection data are provided as a predefined time series, see **Table 18.9** for details on the temporal resolution of climate data.		

18.7.3 Embedded Mitigation Measures

81. This section outlines the embedded mitigation relevant to the CCR assessment (as shown in **Table 18.14** below). Where additional mitigation measures are proposed, these are detailed in the impact assessment (**Section 18.7**).

82. These embedded mitigation measures have been used in **Step 4, Section 18.8.4** of this assessment.

This page is intentionally blank

Table 18.14: Embedded Mitigation Measures Relevant to Climate Change Risk

Measure ID	Embedded Mitigation Measure(s)	Mitigation Type	Means of Implementation
WFDA-21	An Environmental Management Plan (EMP) will be prepared and implemented to set out the procedures to avoid, reduce, and manage potential environmental effects arising across the construction and O&M of the Bellrock Wind Farm Infrastructure, in accordance with relevant international and national legislation and guidance	Tertiary	Secured in the s.36 Consent and Marine Licence via a condition requiring an EMP to be developed and submitted to the Scottish Ministers for approval before commencement of construction. An **Outline EMP (Volume V)** is submitted alongside the s.36 consent application and Marine Licence application for the Bellrock Wind Farm Infrastructure.
WFDA-34	Adherence to the following international and national regulations and guidance, namely: ▪ International Convention for the Prevention of Pollution from Ships (MARPOL), which sets out requirements, including appropriate vessel maintenance; ▪ The International Convention for the Control and Management of Ships' Ballast Water and Sediments, which provides an international framework for the control of transfer of potentially invasive species from ballast water; and ▪ Consideration of guidance from the International Maritime Organisation (IMO, 2023) on the control and management of ships' biofouling to minimise the transfer of invasive aquatic species.	Tertiary	Secured in the s.36 Consent and Marine Licence via a condition requiring a Vessel Management and Navigational Safety Plan (VMNSP) to be developed and submitted to the Scottish Ministers for approval before commencement of construction. An **Outline VMNSP (Volume V)** is submitted alongside the s.36 consent application and Marine Licence application for the Bellrock Wind Farm Infrastructure.
WFDA-38	Development of and adherence to a Development Specification and Layout Plan (DSLP). A DSLP will be developed post-consent to finalise the Bellrock WFDA layout in consultation with the Maritime and Coastguard Agency (MCA) and Northern Lighthouse Board (NLB) in accordance with s.36 and Marine Licence requirements. Specifically in relation to climate change risk, the assessment accounts for the technical requirements of the Wind Farm Infrastructure, design specifications and operational strategy which are built upon best practice engineering codes and standards in the offshore wind sector, and standard health and safety (H&S) procedures outlined in relevant management plans. Where likely significant effects are predicted, additional mitigation will be identified from available literature sources and in collaboration with the engineering team to ensure the Wind Farm Infrastructure is resilient to impacts arising from current extreme weather events and climatic	Tertiary	Secured in the s.36 Consent and Marine Licence, via a condition requiring a DSLP to be developed and submitted to the Scottish Ministers for approval before commencement of construction.

Measure ID	Embedded Mitigation Measure(s)	Mitigation Type	Means of Implementation
	conditions. Accounting for uncertainties in longer-term climate change projections and their implications for the Bellrock Wind Farm Infrastructure, adaptive management measures will also be reviewed in line with Institute of Sustainability and Environmental Professionals (ISEP) guidance (2020) to ensure mitigation is implemented where and when appropriate. The DSLP will ensure that climate change resilience is built into the design from the outset to mitigate the risk of climate change impacts on the conditions and performance of the Wind Farm Infrastructure during the operational lifetime.		
WFDA-42	Development of, and adherence to, an Emergency Response Cooperation plan (ERCoP). The ERCoP will detail protocols that will be undertaken in the event of an emergency, including occupational H&S, and set out clear roles and responsibilities, emergency contacts and reporting and escalation pathways. Protocols for extreme weather events will also be included. The ERCoP will mitigate the risk of climate change impacts on construction site personnel, plant and equipment and other assets and the risk of delays to the construction programme due to extreme weather events, which are becoming more frequent and intense due to climate change. The ERCoP will ensures the implementation of response protocols in the event of emergencies for offshore activities.	Tertiary	Submitted to the Scottish Ministers for approval via the VMNSP, which will address all the recommendations of the Maritime and Coastguard Agency (MCA) in Marine Guidance Note 654 (MCA, 2021). An **Outline VMNSP (Volume V**) is submitted alongside the s.36 Consent application and Marine Licence application for the Bellrock Wind Farm Infrastructure.
WFDA-46	The Applicant will ensure compliance with Marine Guidance Note 654 and its annexes, where applicable, including the completion post-consent of an ERCoP and a search and rescue checklist in consultation with the MCA. The ERCoP will ensure the implementation of response protocols in the event of emergencies for offshore activities.	Tertiary	Submitted to the Scottish Ministers for approval via the VMNSP, which will address all the recommendations of the Maritime and Coastguard Agency (MCA) in Marine Guidance Note 654 (MCA, 2021). An **Outline VMNSP (Volume V**) is submitted alongside the s.36 Consent application and Marine Licence application for the Bellrock Wind Farm Infrastructure.

Measure ID	Embedded Mitigation Measure(s)	Mitigation Type	Means of Implementation
WFDA-47	Development of, and adherence to, a Decommissioning Programme (DP). The DP will set out the framework for the safe, orderly, and environmentally acceptable decommissioning and removal of the Bellrock Wind Farm Infrastructure, in the interests of safety and environmental protection. Climate change risk measures will be included in the DP to be developed prior to the commencement of construction and will include a review of site-specific weather and metocean conditions, recent extreme weather events and up-to-date climate change projection data will be undertaken to ensure risk assessments, H&S protocols and guidelines on safe working practices are suitable for future climate conditions at the time of decommissioning works. The DP will be refreshed prior to decommissioning activities commencing. The DP will mitigate the risk of climate change impacts on decommissioning site personnel, plant and equipment and other assets and the risk of delays to the decommissioning programme due to extreme weather events, which are becoming more frequent and intense due to climate change.	Tertiary	Secured in the s.36 Consent and Marine Licence, via a condition requiring a DP to be developed and submitted to the Scottish Ministers for approval before commencement of construction.
WFDA-60	Development of, and adherence to, a Construction Method Statement (CMS). The CMS will describe the methods for construction for all consented Wind Farm Infrastructure and set out the measures to be implemented to avoid or reduce adverse effects on the environment and legitimate users of the sea during the construction phase. This will include a clear definition of roles and responsibilities and reference to relevant H&S protocols. In relation to climate change, the CMS will incorporate measures to ensure construction activities are resilient to current and projected extreme weather and metocean conditions. This will include, as appropriate: ▪ Monitoring of site-specific weather and metocean conditions, including use of recognised forecasting and severe weather alert services; ▪ Programming and phasing of construction activities with regard to seasonality and short- to medium-term forecasts; ▪ Definition of safe working limits for vessel, lifting, and installation operations and procedures for suspension of works where thresholds are exceeded; ▪ Measures to secure plant, equipment, and materials during adverse weather; and ▪ Risk assessments and safety procedures that account for site-specific extreme weather risks.	Tertiary	Secured in the s.36 Consent and Marine Licence via a condition requiring a CMS to be developed and submitted to the Scottish Ministers for approval before commencement of construction.

Measure ID	Embedded Mitigation Measure(s)	Mitigation Type	Means of Implementation
	Through these measures, the CMS will mitigate risks to construction personnel, plant, and equipment, and reduce the potential for programme disruptions arising from extreme weather events.		
WFDA-61	Regular and periodic inspections and maintenance of all components of the Wind Farm Infrastructure will be undertaken over their operational lifetime to identify and remediate any damage and deterioration and maintain good working conditions. These will be included in the Operation and Maintenance Plan (OMP). Monitoring of site-specific weather and metocean conditions, recent extreme weather events and up-to-date climate change projection data will be undertaken to provide a dynamic risk assessment of climate change impacts and inform operation and maintenance planning. The OMP will mitigate the risks of climate change impacts on the conditions and performance of the Wind Farm Infrastructure and ensures that it is adaptable to future climate conditions and remains resilient over its operational life. The O&M strategy will be adaptive, with the frequency of maintenance, repair and replacement activities being adjusted based on need (i.e. increasing planned O&M visits for components with higher deterioration rates than anticipated).	Tertiary	Secured in the s.36 Consent and Marine Licence via a condition requiring an OMP to be developed and submitted to the Scottish Ministers for approval prior to the commissioning of the first WTG.

18.8 Assessment of Effects

84. The likely significant effects with respect to CCR that may occur during construction, O&M, and decommissioning of the Wind Farm Infrastructure are assessed in the following sections. The CCR assessment follows the four-step methodology set out in **Section 18.4.1** and is based on the realistic worst-case scenarios defined in **Section 18.5.2**, with consideration of embedded mitigation measures identified in **Section 18.7.3**.

18.8.1 Step 1 - Identifying Receptors

85. The Wind Farm Infrastructure and associated receptors which are considered to have potential vulnerabilities to climate hazards and therefore may experience climate change impacts during the construction, operation and decommissioning phases are listed in **Table 18.15**. Movements to and from the Bellrock WFDA are also inherently included in the receptors.

Table 18.15: Bellrock Wind Farm Development Area Receptors

Receptor Type	Receptor Description	Project Phase
Human	WFDA personnel	Construction Operation Decommissioning[2]
Infrastructure (Temporary)	Temporary assets such as marine vessels and plant and equipment.	Construction Decommissioning[2]
Infrastructure (Permanent)	Condition and performance of permanent Wind Farm Infrastructure, including: ▪ WTGs; ▪ Floating substructures; ▪ Station keeping systems; ▪ Inter-array cables; ▪ Subsea cable hubs; and ▪ Cable and scour protection.	Construction O&M
Notes: [2] Full details of the decommissioning of the Bellrock Wind Farm Infrastructure will be included in the Decommissioning Programme for the Bellrock WFDA. However, decommissioning activities are considered the CCR assessment based on the assumption that the receptors would be similar to the construction phase. It is anticipated that a CCR assessment or similar will be undertaken during the preparation of the offshore Decommissioning Programme prior to decommissioning based on a review of recent extreme weather events and the latest climate change projection data. Further details on decommissioning are provided in **Chapter 4: Project Description (Volume II)**.		

18.8.2 Step 2 - Identifying Climate Variables and Hazards

86. Based on the existing baseline information presented in **Section 18.6**, the main climate variables which could be affected by climate change that are relevant to the Bellrock WFDA are extreme temperatures, extreme precipitation, extreme storms, sea level rise, and changes to average precipitation and temperatures. The key climate hazards that have the potential to adversely affect the project's receptors are shown in **Table 18.16.**

Table 18.16: Climate Variables and Hazards Relevant to the Bellrock Wind Farm Development Area

Climate Variable	Climate Hazard
Extreme high temperatures	Increased frequency and severity of heatwaves.
Extreme low temperatures	Change in frequency of ice conditions.
Extreme low temperatures	Change in frequency and quantity of snowfall.
Average temperature increase	Increase in average temperatures.
Combined environmental change	Combined change in environmental conditions, e.g. increase in average sea surface temperatures, strong waves and increasing sea salinity can increase corrosion risks.
Combined environmental change	Increased frequency and/or severity of all types of extreme weather event or climate hazard.
Extreme precipitation	Increase in frequency and intensity of extreme precipitation events.
Sea level rise	Increased tidal range.
Extreme storms	Increase in storm intensity (wind speed).
Extreme storms	Increase in extreme wave height.
Extreme storms	Change in storm patterns, e.g. wind direction.
Lightning	Change in the frequency of lightning events.

18.8.3 Step 3 - Climate Vulnerability Assessment

87. The identified climate variables, hazards and the receptors of the Bellrock WFDA identified in Step 1 **(Section 18.8.1)** have been taken forward to the climate vulnerability assessment, which is provided in **Appendix 18.2: Climate Vulnerability Assessment (Volume IV)**. The climate vulnerability assessment is undertaken to identify the how climate hazards could result in potential climate change impacts on receptors and ensure that only impacts with a potential for likely significant effect is taken forward in the CCR assessment. Vulnerability has been determined based on the sensitivity and exposure of the Bellrock Wind Farm Infrastructure and its associated receptors to the climate hazard.

88. However, it is important to note that the degree of climatic change up to and during the construction period, as distinct from standard weather fluctuations, is not likely to result in significant changes from present-day conditions. These risks are primarily extreme weather risks rather than climate change risks. Nevertheless, these have been included due to their potential to harm human or Wind Farm Infrastructure receptors. In contrast, the O&M, and decommissioning timeframe is more likely to experience changes in climate hazards due to long-term climate change.

89. Within **Appendix 18.2: Climate Vulnerability Assessment (Volume IV)** a total of 18 potential climate change impacts across the construction, O&M and decommissioning phases of the Bellrock Wind Farm Infrastructure have been identified and assessed in the climate vulnerability assessment. Given the implementation of embedded mitigation measures, 14 of these impacts have been determined to have a low vulnerability rating. Therefore, they have been scoped out from a detailed climate risk assessment, and a non-significant effect have been concluded from these impacts.

90. The exposure to impacts from increasing temperatures are low during the construction phase across both RCP scenarios as this increase is projected to be less than 1.5 °C. During the operation phase, the exposure to these impacts will become moderate (between 1.5 – 2.5 °C) in the 2060s, across both scenarios. However, the exposure is high during the decommissioning phase where this increase is projected to be higher than 2.5°C. This is more likely is the RCP8.5 scenario, which is also established worst-case scenario for the decommissioning phase.

Similarly for impacts from rainfall, the exposure is low (less than 10% variation) to moderate (between 10-20% variation) during the construction and operation phases across both RCP scenarios. However, during the decommissioning phase, there is very high variability in the projections (meaning low confidence). The median values for this phase show that the exposure is low annually, but winter months could see high exposure.

The exposure from winds and sea level rise are projected to be low across all phases and RCP scenarios, but the frequency of storms are projected to rise. The impacts from these extreme events are covered in the risk assessment despite the low average wind speeds.

91. The sensitivity of humans/personnel receptors is high across all impacts due to the risk of injury. However, their adaptive capacity is also high as they can be moved to safety. For temporary and permanent Wind Farm Infrastructure, the sensitivity has been allocated for each unique combination of *Hazard X Receptor* to incorporate their sensitivity and adaptive capacity. Any impact causing failure of asset or permanent damage has high sensitivity (example those from storms on turbines) but impacts causing slow onset deterioration (i.e. repeated exposure to water causing corrosion) have low to moderate sensitivity.

92. A total of 4 climate change impacts have been determined to have a moderate vulnerability rating and therefore have been taken forward to Step 4 **(Section 18.8.4)** of the CCR assessment outlined below.

18.8.4 Step 4 - Climate Risk Assessment

A climate risk assessment was undertaken on the climate change impacts determined to have a moderate vulnerability rating. The assessment evaluates the degree of climate risk to the Bellrock Wind Farm Infrastructure and its associated receptors based on the likelihood and consequence of climate change impact and determines the effect significance. The results of the climate risk assessment are presented for the construction (**Table 18.17**) and decommissioning (**Table 18.18**) phases.

93. The Wind Farm Infrastructure during the O&M phase were assessed in Step 3 to have low vulnerability to climate change impacts. This is because the embedded mitigation measures associated with the design of the Wind Farm Infrastructure and the typical operational processes reduces the sensitivity and/or vulnerability of the receptors to low. As such the climate change impacts for the operation phase were found to be not significant and have therefore not been included in the Step 4 assessment.

94. The Climate Risk assessment has concluded that there are no likely significant effects on the Wind Farm Infrastructure as a result of climate change impacts during the construction, O&M, and decommissioning phases, therefore, no additional mitigation measures are required.

Table 18.17: Climate Risk Assessment – Construction Phase

Climate Hazard	Receptor	Potential Climate Change Impact	Proposed Embedded Mitigation Measure	Vulnerability	Likelihood	Consequence	Climate Risk and Effect Significance	Additional Mitigation and Residual Risk
▪ Increase in storm intensity (wind speed); ▪ Increase in frequency of storm conditions; ▪ Increase in extreme wave height; and ▪ Change in storm patterns, e.g. wind direction.	Offshore construction personnel	Extreme storminess can lead to unsafe working conditions.	Measures detailed in **Table 18.14.**	Moderate	Unlikely *Construction management plans will safeguard personnel from working in unsafe working conditions (such as those during storms) and it is unlikely that personnel will be working during the storm.*	Minor *No harm to personnel as they will not be working at the time, only delays due to downtime.*	Low (not significant)	Not required.

Table 18.18: Climate Risk Assessment – Decommissioning Phase

Climate Hazard	Receptor	Potential Climate Change Impact	Proposed Embedded Mitigation Measure	Vulnerability	Likelihood	Consequence	Climate Risk and Effect Significance	Additional Mitigation and Residual Risk
▪ Increase in storm intensity (wind speed); ▪ Increase in frequency of storm conditions; ▪ Increase in extreme wave height; and ▪ Change in storm patterns, e.g. wind direction.	Marine vessels and offshore plant and equipment	High winds and waves during extreme storm events can result in physical damage to marine vessels and plant and equipment.	Measures detailed in **Table 18.14.**	Moderate	Likely *Structural integrity of plant and equipment will be lesser as they are nearer to their design life during decommissioning phase, thereby increasing the likelihood of damage.*	Moderate *ERCoP will limit the vessel movement during storm events, so any damage from wind on the plant and equipment will not cause any additional harm but may cause damage to the plant and equipment itself.*	Moderate (not significant)	Not required.
	Offshore decommissioning personnel	Extreme storminess can lead to unsafe working conditions.		Moderate	Likely *Transport to and from the Bellrock WFDA could take up to 2 days, and this may not be sufficient time between forecast and actual landfall on the storm.*	Moderate *If personnel are on a structure, there will be protocols for staying on the structure (a safe place with food)*	Moderate (not significant)	Not required.

Climate Hazard	Receptor	Potential Climate Change Impact	Proposed Embedded Mitigation Measure	Vulnerability	Likelihood	Consequence	Climate Risk and Effect Significance	Additional Mitigation and Residual Risk
▪ Increased frequency and/or severity of all types of extreme weather event, including heatwaves, storms and wave heights.	Offshore decommissioning personnel, marine vessels and plant and equipment	Increased risk of disruption to offshore decommissioning activities during extreme weather events can lead to programme delays and associated cost implications. Prolonged or successive disruptions can result in impacts on the project's overall decommissioning programme.	Measures detailed in **Table 18.14.**	Moderate	Likely *Frequency of events will be higher at the decommissioning phase compared to the baseline.*	Moderate *Management plans and ERCoP will have protocols to deal with these events.*	Moderate (not significant)	Not required.

This page is intentionally blank.

18.9 Inter-related and Interacting Impacts

18.9.1 Inter-relationships

95. As the CCR assessment considers effects of climate change on the Bellrock Wind Farm Infrastructure and its associated receptors while other topics consider the effects of the Bellrock Wind Farm Infrastructure on other receptors in the surrounding environment, there are not considered to be any inter-relationships with other environmental effects with respect to CCR.

18.9.2 Interactions

96. The CCR assessment presented in **Section 18.8.4** and **Appendix 18.2: Climate Vulnerability Assessment (Volume IV)** inherently considers the potential for different climate hazards to interact, where relevant, and result in synergistic climate change impacts on the Wind Farm Infrastructure and its associated receptors. This includes, for example, the combined impact of extreme wind events and wave action, and extreme temperatures, or storms and flooding.

97. In addition, the embedded mitigation measures identified through the CCR assessment ensure that the Wind Farm Infrastructure and its associated receptors as a whole remains resilient to both current and future climate conditions during the construction, O&M, and decommissioning phases, and these mitigation measures remain appropriate if more than one climate change impact occurs at the same time. Combined impacts due to multiple extreme weather events are not expected to change the effect significance presented in the CCR assessment. Therefore, no additional consideration of interactions is required with respect to CCR.

18.10 Summary

98. A four-step assessment process has been undertaken to evaluate future trends in climate change impacts and the effect on the vulnerability and resilience of the Bellrock Wind Farm Infrastructure and its associated receptors to such changes. The CCR assessment has been informed by considerations of the existing baseline and predicted future baseline climates based on observed meteorological and climate conditions and climate change projection data.

99. Relevant climate variables, hazards and receptors within the Bellrock WFDA have been identified in Step 1 (**Section 18.8.1**) and Step 2 (**Section 18.8.2**), which were taken forward to a climate vulnerability assessment (Step 3, **Appendix 18.2: Climate Vulnerability Assessment (Volume IV)**) (**Section 18.8.3**). The vulnerability assessment considered whether and how the Wind Farm Infrastructure and its associated receptors may be potentially vulnerable to climate hazards and therefore experience effects from climate change impacts during the construction, O&M, and decommissioning phases.

100. A total of 18 potential climate change impacts have been identified and assessed in the climate vulnerability assessment (Step 3, **Appendix 18.2: Climate Vulnerability Assessment (Volume IV)**) (**Section 18.8.3**). Of these, 14 impacts were determined to have a low vulnerability rating due to the implementation of embedded mitigation measures, and therefore they were scoped out from further assessment. A non-significant effect has been concluded for low vulnerability impacts, as shown in **Appendix 18.2: Climate Vulnerability Assessment (Volume IV)**.

101. Four climate change impacts were determined to have a moderate vulnerability rating and therefore were taken forward to a detailed climate risk assessment (Step 4). The climate risk assessment, as presented in **Section 18.8.4**, determined that these impacts range from low to moderate risk with the implementation of embedded mitigation measures. A non-significant effect has been concluded for all four impacts, and no additional mitigation measures are therefore required.

102. The CCR assessment has concluded that there are no likely significant effects on the Wind Farm Infrastructure as a result of climate change impacts during the construction, O&M and decommissioning phases.

18.11 References

Cornes, R.C. Tinker, J. Hearmanson, L. Oltmanns, M. Hunter, W.R. Lloyd-Hartley, H. Kent, E.C. Rabe, B. Renshaw, R. (2023). The Impacts of Climate Change on Sea Temperature around the UK and Ireland.

European Commission (EC). (2021). Commission Notice C/2021/5430 - Technical guidance on the climate proofing of infrastructure in the period 2021-2027. Official Journal of the European Union, C 373, 1-92. Available at: EUR-Lex - 52021XC0916(03) - EN - EUR-Lex.

Fox-Kemper, B. Hewitt, H.T. Xiao, C. Aðalgeirsdóttir, G. Drijfhout, S.S. Edwards, T.L. Golledge, N.R. Hemer, M. Kopp, R.E. Krinner, G. Mix, A. Notz, D. Nowicki, S. Nurhati, I.S. Ruiz, L. Sallée, J.-B. Slangen, A.B.A. Yu, Y. 2021. Ocean, Cryosphere and Sea Level Change. In: Masson-Delmotte, V. Zhai, P. Pirani, A. Connors, S.L. Péan, C. Berger, S. Caud, N. Chen, Y. Goldfarb, L. Gomis, M.I. Huang, M. Leitzell, K. Lonnoy, E. Matthews, J.B.R. Maycock, T.K. Waterfield, T. Yelekçi, O. Yu, R. Zhou, B. eds. Climate Change (2021). The Physical Science Basis. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1211–1362. doi: 10.1017/9781009157896.011.

Horsburgh, K. Rennie, A. Palmer, M. (2020). Impacts of Climate Change on Sea Level Rise Relevant to the Coastal and Marine Environment around the UK. MCCIP Science Review 2020, pp. 116-131.

IEMA (2020). Environmental Impact Assessment Guide to: Climate Change Resilience and Adaptation.

IPCC (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

IPCC (2018). Annex I: Glossary [Matthews, J.B.R. (ed.)]. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V. P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 541-562, doi:10.1017/9781009157940.008.

IPCC (2019). IPCC Special Report on the Ocean and Cryosphere in a Changing Climate. [Online] Available at: https://www.ipcc.ch/srocc/.

Kahraman, A. Fowler, H. Kendon, L. (2022). Climate Change Strikes: Lightning Patterns Change with Global Warming. Environmental Research Letters.

Lowe, J.A. Bernie, D. Bett, P. Bricheno, L. Brown, S. Calvert, D. Clark, R. Eagle, K. Edwards, T. Fosser, G. Fung, F. Gohar, L. Good, P. Gregory, J. Harris, G. Howard, T. Kaye, N. Kendon, E.

Krijnen, J. Maisey, P. McDonald, R. McInnes, R. McSweeney, C. Mitchell, J.F.B. Murphy, J. *Palmer*, M. Roberts, C. Rostron, J. Sexton, D. Thornton, H. Tinker, J. Tucker, S. Yamazaki, K. Belcher, S. (2018). UKCP18 Science Overview Report. [Online] Available at: https://www.metoffice.gov.uk/pub/data/weather/uk/ukcp18/science-reports/UKCP18-Overview-report.pdf.

Marine Climate Change Impacts Partnership (2020). MCCIP Science Review 2020: Effects of climate change on the Atlantic Heat Conveyor Relevant to the UK. Marine Climate Change Impacts Partnership.

Masselink, G. Russell, P. Rennie, A. Brooks, S. Spencer, T. (2020). Impacts of Climate Change on Coastal Geomorphology and Coastal Erosion Relevant to the Coastal and Marine Environment Around the UK. MCCIP Science Review 2020, pp. 158–189.

MCA (2021). MGN 654 (M+F) Offshore Renewable Energy Installations (OREI) Safety Response. [Online] Available at: https://www.gov.uk/government/publications/mgn-654-mf-offshore-renewable-energy-installations-orei-safety-response.

Met Office (2016). Eastern Scotland: Climate. [Online] Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/weather/regional-climates/eastern-scotland_-climate-met-office.pdf.

Met Office, (2019a). UKCP18 Factsheet: Temperature. [Online] Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-fact-sheet-temperature.pdf.

Met Office, (2019b). UKCP18 Factsheet: Precipitation. [Online] Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-factsheet-precipitation.pdf.

Met Office, (2019c). UKCP18 Factsheet: Sea Level Rise and Storm Surge. [Online] Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-fact-sheet-sea-level-rise-and-storm-surge.pdf.

Met Office, (2021). UKCP18 Factsheet: Wind. [Online] Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-fact-sheet-wind_march21.pdf.

Met Office, (2022a). UK Climate Projections: Headline Findings August 2022. [Online] Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18_headline_findings_v4_aug22.pdf.

Met Office, (2022b). Location-specific long-term averages: Inverbervie No 2. [Online] Available at: https://www.metoffice.gov.uk/research/climate/maps-and-data/location-specific-long-term-averages/gfn7kmx6u.

Moffat, C. et al. (2020). Scotland's Marine Assessment. Scottish Government.

New York State Energy Research and Development Authority (NYSERDA). (2021). "Offshore Wind Climate Adaptation and Resiliency Study," NYSERDA Report Number 21-04. Prepared by ICF International, Inc. Fairfax, VA. nyserda.ny.gov/publications.

Wolf, J. Woolf, D. Bricheno, L. (2020). Impacts of Climate Change on Storms and Waves Relevant to the Coastal and Marine Environment Around the UK. MCCIP Science Review 2020, pp. 132–157.

This page is intentionally blank

This page is intentionally blank

Bellrock
OFFSHORE WIND

www.bellrockwind.co.uk