Morven North Offshore Wind Array Project

Environmental Impact Assessment Report

Volume 3, Annex 18.1: Shared Climate Change Risk Assessment

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1 Introduction

1.1.1.1 The Morven North Offshore Wind Array Project (hereafter, 'Morven North') and the Morven South Offshore Wind Array Project (hereafter, 'Morven South') are both located within the Morven Option Lease Agreement Site (hereafter, 'Morven Site') in Scottish offshore waters (Figure 1.1). Morven North is located approximately 61km from the Aberdeenshire coast (at its closest point) and Morven South is located approximately 86km from the Aberdeenshire coast (at its closest point). Each project will comprise wind turbines, Offshore Substation Platforms (OSPs), associated foundations, inter-array and interconnector cables and cable protection. Consent for the offshore export cables of Morven North and Morven South will be sought separately.

1.1.1.2 As shown in Figure 1.1, Morven North is situated northwest of Morven South. The external boundaries of the projects correspond with the boundaries of the Morven Site.

1.1.1.3 This Shared Climate Change Risk Assessment (CCRA) Technical Report presents the climate-related physical risks on both Morven North and Morven South.

1.1.1.4 Consent for Morven North and Morven South will be sought separately, aided by the development of a separate Environmental Impact Assessment (EIA) and Habitats Regulations Assessment (HRA) for each project. However, the survey campaign and/or desk-based studies that will support the impact assessments for Morven North and Morven South are based on the Morven Site, which accommodates both Morven North and Morven South. Given the comparability and consistency of information collected to inform the assessments for both projects, the CCRA for both Morven North and Morven South is reported in the present Shared CCRA Technical Report.

1.1.1.5 The information from this Shared CCRA Technical Report provides an assessment of the current and anticipated risks on Morven North and Morven South from climate change throughout their 35-year lifetimes. This report accompanies the EIA provided in Volume 2, Chapter 18: Climate Change of the respective EIA Reports for Morven North or Morven South to support the respective consent applications.

1.1.1.6 The scope of the CCRA is defined in accordance with the Climate Change Committee recommendations and the Institute of Environmental Management and Assessment's (IEMA) guidance on climate change resilience and adaptation (IEMA, 2020). The aim of this Shared CCRA Technical Report is to evaluate the processes utilised for managing the risks through four key stages:

- an assessment of the baseline climate to understand present-day vulnerability of Morven North and Morven South to climate change and assess current climate-related risks, opportunities, and levels of adaptation;
- an assessment of future climate projections to understand future vulnerability of Morven North and Morven South to climate change;
- identify climate change hazards to Morven North and Morven South and undertake an assessment of their exposure and vulnerability;
- review potential adaptation and mitigation options.

1.1.2 Study area

1.1.2.1 The Climate Change Study Area for the Shared CCRA Technical Report encompasses the Morven North Boundary and Morven South Boundary shown in Figure 1.1 (i.e. the area in which the wind turbines, OSPs, inter-array and interconnector cables will be located).

1.1.2.2 The study areas for Morven North and Morven South for the CCRA were agreed by the Marine Directorate Licencing Operations Team (MD-LOT) via a 'Targeted Consultation Exercise' undertaken in March 2025.

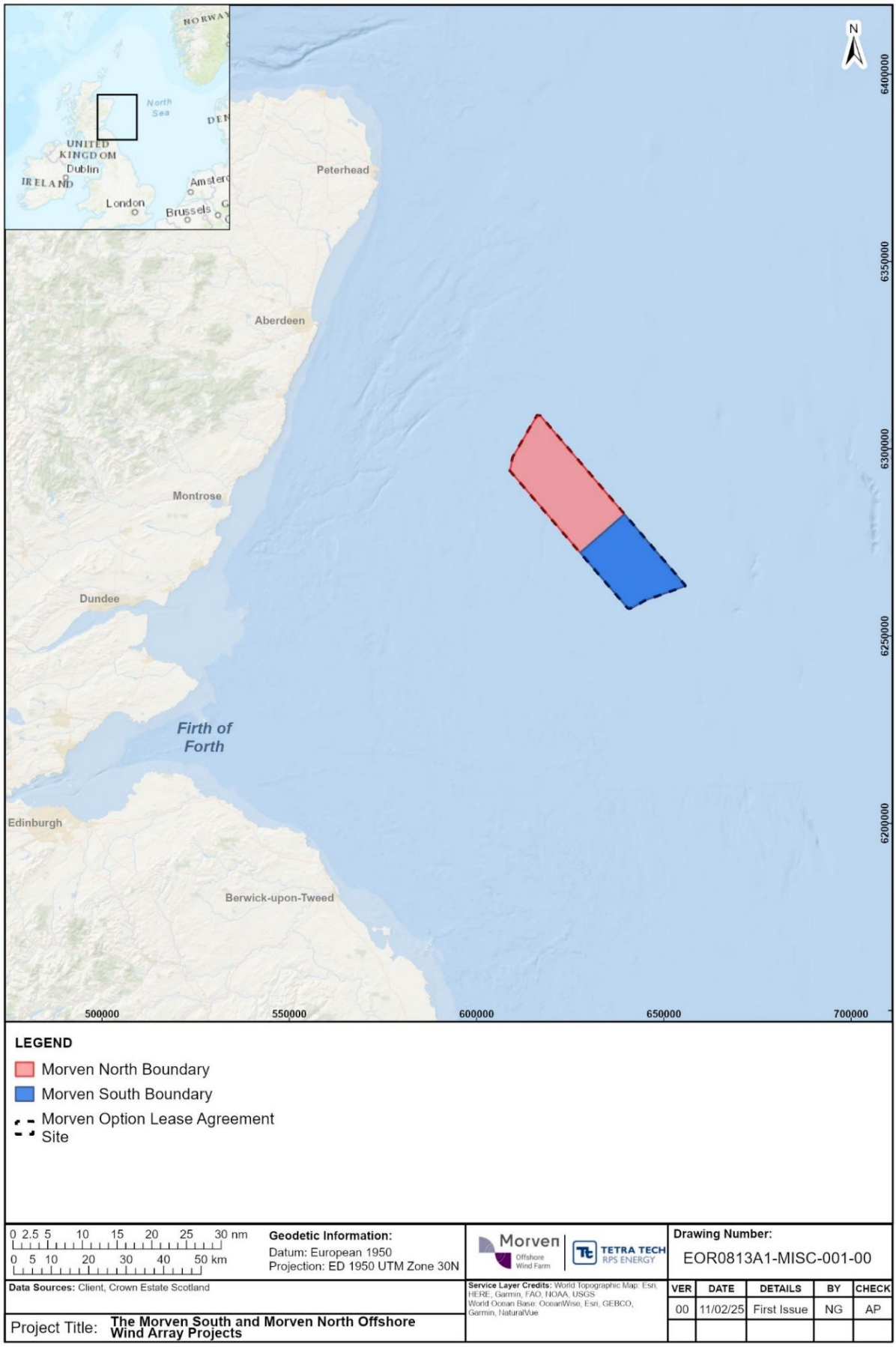

Figure 1.1: The boundaries of the Morven North and the Morven South within the Morven Option Lease Agreement Site

2 Baseline climate

2.1 Methodology

2.1.1.1 To understand the impact of climate change on Morven North and Morven South, the baseline environment must be considered. This includes both the current baseline, and the future baseline as determined by climate projections.

2.1.1.2 Baseline offshore climatic conditions have been sourced from observational data collated within the UK Offshore Energy Strategic Environmental Assessment (BEIS, 2022) and Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Reporting of the physical science (IPCC, 2021). Such data has been presented once, given it is relevant to the geographical area associated with both Morven North and Morven South.

2.1.1.3 Climate change has been identified as an event that is already taking place in the UK, in both academic research (IPCC, 2021) and in legislation and policy (HM Government, 2008; Scottish Government, 2009; HM Government, 2022; BEIS, 2022). The risks associated with rising temperatures, more frequent extreme weather patterns and rising sea levels are presented in the Climate Change (Scotland) Act 2009 and are further investigated within this section.

2.1.1.4 The results of marine climate projections, as detailed within the UK Climate Projections 2018 (UKCP18) Marine Report (Palmer *et al.,* 2018) and interrogated within the UK Climate Risk Independent Assessment (CCRA3), Chapter 4: Infrastructure (Jaroszweski *et al.,* 2021), have been used to examine future trends for wind speed, wave height and sea levels for offshore UK waters. Additional information at a regional (northern European) and global level has been taken from the IPCC Sixth Assessment Report (IPCC, 2021), where national or sub-national (i.e. central North Sea) information is not available (i.e. for sea surface temperatures). Such data has been presented once, given it is relevant to the geographical area associated with both Morven North and Morven South.

2.1.1.5 The projections are based on Representative Concentration Pathway (RCP) 8.5, which is a high-emissions scenario assuming 'business as usual' growth globally, with little additional mitigation. This is a conservative approach for this assessment. Data is largely available for the end of the 21st century. Whilst this is outside of the initial lifetime of Morven North and Morven South, these projections display climate trends that will begin to be felt throughout this century.

2.2 Regional results

2.2.1 Current baseline

2.2.1.1 Air temperatures in the central North Sea do not tend to vary beyond the range of 0°C to 19°C, with the exception of extended periods of easterly winds which can lead to extreme cold in winter and warm conditions in summer. Mean air temperatures range from lows of 1°C in January to 13°C in July (BEIS, 2022).

2.2.1.2 Annual precipitation across the North Sea averages 425mm and follows a seasonal trend with April to June tending to be the driest months, and October to January being wetter. Thunderstorms are infrequent, and snow showers vary from approximately 10 to 12 days in the central North Sea (BEIS, 2022).

2.2.1.3 As detailed within Volume 3, Annex 7.1: Physical Processes Shared Technical Report, annual mean significant wave height across the Morven North Boundary and Morven South Boundary ranges from approximately 1.75m to 1.91m, and 1.81m to 1.95m, respectively. Maximum wave heights recorded within the Morven North Boundary and Morven South Boundary were 10.09m and 9.95m, respectively. Over the duration of a site specific metocean survey (further detailed within Volume 3, Annex 7.1: Physical Processes Shared Technical Report), waves predominantly came from the north, northeast and north.

2.2.1.4 The prevailing winds in the central North Sea are from the southwest and the north northeast and tend to be stronger over the open sea than at the coast owing to the lack of shelter. Wind strengths in winter are typically in the range of Beaufort scale 4 to 6 (6 to 11m/s) with higher winds of force 8 to12 (17 to 32m/s) being much less frequent. Winds of force 5 (8m/s) and greater are recorded 60 to 65% of the time in winter and 22 to 27% of the time in summer. In April and June, winds are highly variable, with a greater incidence of north-westerly winds (BEIS, 2022).

2.2.1.5 Mean sea level (MSL) is a crucial element of climate change related risks for wind farms: global MSL rose by 0.2 m between 1901 and 2018, and continue to rise (IPCC, 2021). The average rate of sea level rise increased from 1.3mm per year between 1901 and 1971, to 1.9mm per year between 1971 and 2006, and further to 3.7mm per year between 2006 and 2018 (IPCC, 2021). Icesheet and glacier mass loss were the main contributors to such global MSL rise between 2006 and 2018 (IPCC, 2021).

2.2.2 Future baseline

2.2.2.1 It is virtually certain that sea surface temperatures will continue to increase in the 21st century, with global mean sea surface temperatures predicted to increase by approximately 2.9°C by 2100 under RCP8.5(IPCC, 2021). Sea temperatures in northern Europe (including the North Sea) are predicted to rise at a greater rate than the global average, with temperatures predicted to increase by approximately 3.4°C under RCP8.5 in the same time period. Marine heatwaves (periods of extreme high sea temperature, defined as temperatures warmer than the 99th percentile of mean sea temperatures for the region) are also expected to increase around Europe over the 21st century (IPCC, 2021).

2.2.2.2 Similarly, it is virtually certain that CO2 uptake by the ocean surface will increase (due to increased atmospheric CO2 concentrations), resulting in increased ocean acidification. CO2 uptake drives changes in seawater and calcium carbonate (CaCO3) chemistry, resulting in an overall decrease of ocean pH. Northern European sea surface pH is predicted to fall by 0.4 units by 2100 under RCP8.5 (IPCC, 2021).

2.2.2.3 The average wave height is predicted to decrease around much of the UK at a factor of about 10% to 20% over the 21st century, with average wave heights in the North Sea decreasing by approximately 0.1m. Maximum wave heights in the central North Sea are predicted to reduce by 0.5m, which could compensate for the rise in sea level, leaving the elevation of the annual maximum wave unaffected. However, owing to variation between different models, confidence in projected sea wave height changes is low (Jaroszweski *et al.,* 2021).

2.2.2.4 Given the close relationship between wave heights and wind speeds, average changes in wind speed are predicted to follow similar patterns to those predicted for average wave height, with a slight increase to the north of the British Isles. Changes in maximum wind speeds associated with storm surges vary regionally, with changes in the order of +/- 1.5m/s. However, there is little consensus between models regarding the extent and pattern of such winds in relation to climate change (Palmer *et al.,* 2018). As such, conservatively an increase in maximum wind speed should be anticipated.

2.2.2.5 The frequency and amplitude of storms is anticipated to slightly increase by the middle of the 21st century and beyond for northern Europe. Clustering of storms over time may also increase in many areas in Europe. However, projections of smaller scale hazardous weather have low confidence, due to the inability of climate models to accurately simulate these phenomena (IPCC, 2021).

2.2.2.6 Global MSL will continue to rise throughout the 21st century, a change that is projected within all future climate change scenarios. Under RCP8.5, the UK can expect to see a sea level rise of approximately 1m by 2100. This change is regionally variable, with a lesser impact anticipated in the north of the UK. The east coast of Scotland can expect to see a MSL rise of between approximately 0.5m and 0.6m by 2100 (Palmer *et al.,* 2018).

3 Climate risk and resilience scoping

3.1 Methodology

3.1.1.1 Informed by available information for Morven North and Morven South, an initial screening exercise identified the relevant climate change risks on each project based on information sourced from the UK CCRA3 (CCC, 2021) which are presented in Table 3.3.

3.1.1.2 A high-level assessment of such risks has been undertaken, considering the climate change hazards, resulting potential impact on the relevant receptors, and the exposure and vulnerability of such receptors to the potential impacts. The criteria for defining the exposure and vulnerability are presented in Table 3.1, below. The matrix for determining the significance of effect is presented in Table 3.2 and considers the exposure and vulnerability of the receptors identified.

3.1.1.3 Given the variability in the nature of the potential impacts of climate change on Morven North and Morven South, receptors have been identified on an impact-specific basis, whereby all receptors relate to the continued safe and effective operation of Morven North and Morven South. In line with IEMA (2020) guidance, the vulnerability and susceptibility have been considered in determining the severity of risk.

3.1.1.4 The assessment of effects has considered the designed-in measures adopted as part of Morven North and Morven South (primary mitigation) in determining the vulnerability of a receptor to the hazard. Should an effect be significant after primary mitigation is applied, further mitigation is presented where relevant to reduce the residual effect to negligible and not significant in EIA terms.

Table 3.1: Hazard, exposure and vulnerability definitions

Factor	Score definitions
Hazard: refers to the possible, future occurrence of natural or human physical events that may have adverse effects on vulnerable and exposed elements. The presence of a hazard is identified and weighted based on the location's exposure to that hazard. For example, a hazard may occur within a particular scenario, however the relative exposure to that hazard is how it will be measured.	
Exposure: considers the nature of the impacts and the degree of certainty based on the obtained climate projections. Exposure is necessary, but not determinant of risk. A site can be exposed but not vulnerable.	**Major**: large change to climate condition and large increase in the frequency of the event.
	Moderate: a large, measurable change in climate conditions at a regular frequency.
	Minor: change in climate conditions that may have measurable effect on a receptor, but which are low likelihood of occurring or infrequent.
	Negligible: no change in climate conditions.
Vulnerability: the degree of vulnerability of each receptor to the hazard. Vulnerability can be seen as situation specific.	**High**: short term, acute impact to functionality or a large, measurable decrease in receptor lifespan following the occurrence of a climate impact. Major increase in the need for maintenance and repairs.
	Medium: measurable decrease in receptor performance or lifespan or increase in necessary maintenance and repairs following the occurrence of a climate impact.
	Low: small measurable impact to a receptor's performance following climate impact, or deterioration of a receptors' lifespan due to a chronic effect.
	Negligible: no measurable impact to a receptor's performance following climate impact, or deterioration of a receptors' lifespan due to a chronic effect.

Table 3.2: Climate risk significance matrix

Vulnerability	Exposure			
	Major	**Moderate**	**Minor**	**Negligible**
High	Significant	Significant	Significant	Not Significant
Medium	Significant	Significant	Not Significant	Not Significant
Low	Significant	Not Significant	Not Significant	Not Significant
Negligible	Not Significant	Not Significant	Not Significant	Not Significant

3.1.1.5 Table 3.3 shows the climate change hazards and potential impacts to Morven North and Morven South that have been identified prior to any mitigation and the risk scores assigned. Appropriate design measures have been identified as necessary to accordingly reduce the risk to an acceptable level and mitigate a potential significant effect. Given the proposed infrastructure is consistent between Morven North and Morven South, the identified risks and potential consequences apply to both. As such, the information within Table 3.3 is relevant to both Morven North and Morven South.

3.1.1.6 The total construction phase for both Morven North and Morven South (expected maximum duration of 10 years, if run consecutively) will not be lengthy enough for significant climate change risks compared to the present-day baseline to occur. Any risks that would arise relate to worker health impacts due to heightened temperatures, increased frequency and intensity of extreme weather events. The Applicant will employ industry standard health and safety practices with respect to heatstroke or storm events offshore. As such, there are not considered to be any further significant climate change risks associated with the construction phase. This phase has not been considered further within this CCRA.

3.1.1.7 As with the construction phase, it is considered unlikely that the decommissioning phase for both Morven North and Morven South (expected maximum duration of 10 years, if run consecutively) would be lengthy enough for significant climate change risks beyond those considered within the operation and maintenance (O&M) phase assessment, detailed below. Any risks that would arise relate to worker health impacts due to heightened temperatures, increased frequency and intensity of extreme weather events. The Applicant will employ industry standard health and safety practices with respect to risks such as heatstroke or storm events offshore. As such, there are not considered to be any further significant climate change risks associated with the decommissioning phase. This phase has not been considered further within this CCRA.

3.2 Climate change risk assessment

3.2.1 Morven North

3.2.1.1 The climatic change hazards to Morven North have been identified and are presented in Table 3.3. These risks relate to consistently heightened air and sea surface temperatures, MSL rise, changes to rainfall patterns, increased wind speeds, increased wave heights and increased frequency and severity of extreme events such as storms. Designed-in measures are identified for each risk.

3.2.2 Morven South

3.2.2.1 The climatic change hazards to Morven South have been identified and are presented in Table 3.3. These risks relate to consistently heightened air and sea surface temperatures, MSL rise, changes to rainfall patterns, increased wind speeds, increased wave heights and increased frequency and severity of extreme events such as storms. Designed-in measures are identified for each risk.

Table 3.3: Risk scores for Morven North and Morven South

Hazard	Potential impact	Designed-in measures	Exposure	Vulnerability	Significant
Operations and maintenance					
Increases in average and extreme temperatures, both in winter and summer.	Heating/overheating of turbine mechanisms may result in failure of electrical equipment and gear boxes. Heating/overheating may inhibit power infrastructure performance and export. Expansion of wind turbine materials leading to degradation. Operating conditions could be impacted, leading to a shutdown of wind turbines resulting in decreased electricity generation. Consistently heightened temperatures could lead to efficiency losses due to overheating, or the failure of electrical equipment within the offshore substations.	Safety margin within the wind turbine design to be fitted with automatic shutdowns/lockdowns with regards to spinning too fast. The OSP electrical plant will be located within an internal structure. Appropriate cooling plant will be designed to account for a range of temperature conditions.	Moderate	Low	Not significant
Increase in sea surface temperatures and ocean acidification.	Increased temperatures and ocean acidification may lead to accelerated corrosion of submerged structures, including inter-array and interconnector cables, and wind turbine and OSP foundations.	Application of anti-corrosion protective coatings where appropriate and accounting for sea level rise.	Minor	Low	Not significant

Hazard	Potential impact	Designed-in measures	Exposure	Vulnerability	Significant
Changes to rainfall patterns, leading to increased annual precipitation.	Increased wear and tear resulting in erosion and degradation of blade surfaces, increased drag and thereby decreased energy production. Increased wear and tear resulting in erosion and degradation of the OSPs.	Inspections to be carried out to assess wind turbine and OSP condition, where conditions allow (annually for above sea level structures, and every four years for below sea level structures). Use of durable materials within the OSP structures, in line with appropriate design standards for offshore wind in the North Sea.	Moderate	Low	Not significant
Increased frequency and intensity of extreme weather i.e. storms.	Increased wear and tear of mechanical systems from high wind speeds. Damage to wind turbines from fatigue and erosion as a result of the impact force of rain and hail. Results in degradation of blade surfaces, increased drag and thereby decreasing energy production. Increased loading from ice build-up. Increased wear and tear resulting in erosion and degradation of the OSP.	Wind turbines to be fitted with automatic shutdowns/lockdowns with regards to spinning too fast. Use of durable materials within the OSP structures, in line with appropriate design standards for offshore wind in the North Sea. Application of anti-corrosion protective coatings, where appropriate and accounting for sea level rise.	Moderate	Low	Not significant
Increased wind speeds and changes to wind patterns.	Increased occurrence of wind speeds beyond the cut-off points of the wind turbines leading to a more frequent shut down of wind turbines. Increased wear and tear of mechanical systems from high wind speeds. Increased wear and tear resulting in erosion and degradation of the OSPs.	Inspections to be carried out to assess wind turbine and OSP condition, where conditions allow (annually for above sea level structures, and every four years for below sea level structures). Wind turbines to be fitted with automatic shutdowns/lockdowns with regards to spinning too fast. Use of durable materials within the OSP structures, in line with appropriate design standards for offshore wind in the North Sea.	Moderate	Low	Not significant

Hazard	Potential impact	Designed-in measures	Exposure	Vulnerability	Significant
Increase in MSL.	Additional loading on the wind turbine and OSP structures, resulting in structural stress and additional corrosion.	Application of anti-corrosion protective coatings, where appropriate and accounting for sea level rise.	Moderate	Low	Not significant
Increased wave height.	Degradation of wind turbine and OSP structures and foundations due to additional loading. Degradation to wind turbine and OSP foundations, and undersea cabling due to scour from sediment transfer. Failure at cable joints may also result.	Inspections to be carried out to assess wind turbine and OSP condition, where conditions allow (annually for above sea level structures, and every four years for below sea level structures). Design standards for structural safety in line with international requirements, with allowance for increased heights of extreme waves and sea level rise. Inclusion of scour protection on offshore equipment where necessary.	Moderate	Low	Not significant
Changes in the tidal range.	Degradation to wind turbine and OSP foundations, and undersea cabling due to scour from sediment transfer. Failure at cable joints may also result.	Inclusion of scour protection on offshore equipment where necessary.	Minor	Low	Not significant

4 Summary

4.1 Morven North

4.1.1.1 This Shared CCRA Technical Report has assessed the potential impacts of climate change on Morven North and the suitability of the proposed mitigation measures, informed by a review of baseline offshore climatic conditions sourced from observational data, and future baseline offshore climate projections which consider a conservative high-emissions scenario.

4.1.1.2 A high-level risk assessment has been undertaken, considering the hazard, resulting potential impact on the relevant receptors, and the exposure and vulnerability of such receptors to the potential impacts. A matrix for determining the significance of effect has been used, informed by the designed-in measures adopted as part of Morven North.

4.1.1.3 When considering the proposed mitigation within the above Table 3.3, the potential risk posed to Morven North would be negligible and not significant in EIA terms.

4.2 Morven South

4.2.1.1 This Shared CCRA Technical Report has assessed the potential impacts of climate change on Morven South and the suitability of the proposed mitigation measures, informed by a review of baseline offshore climatic conditions sourced from observational data, and future baseline offshore climate projections which consider a conservative high-emissions scenario.

4.2.1.2 A high-level risk assessment has been undertaken, considering the hazard, resulting potential impact on the relevant receptors, and the exposure and vulnerability of such receptors to the potential impacts. A matrix for determining the significance of effect has been used, informed by the designed-in measures adopted as part of Morven South.

4.2.1.3 When considering the proposed mitigation within the above Table 3.3, the potential risk posed to Morven South would be negligible and not significant in EIA terms.

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