Morven South Offshore Wind Array Project

Environmental Impact Assessment Report

Volume 2, Chapter 7: Physical Processes

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7.1 Introduction

7.1.1.1 This chapter of the Morven South Offshore Wind Array Project (hereafter "Morven South") Environmental Impact Assessment (EIA) Report (hereafter, the EIA Report) presents the assessment of the likely significant effects (as per the EIA Regulations as defined in Volume 1, Chapter 2: Policy and Legislation) on physical processes. Specifically, this chapter considers the potential impacts of Morven South seaward of Mean High Water Springs (MHWS) during the construction, Operations and Maintenance (O&M) and decommissioning phases. Where relevant, this chapter also assesses the likely significant effects of Morven South on receptors landward of Mean Low Water Springs (MLWS) during the construction, O&M and decommissioning phases.

7.1.1.2 The assessment presented in this chapter has relied upon, or informed the following technical chapters and reports:

- Volume 3, Annex 7.1: Physical Processes Shared Technical Report;
- Volume 2, Chapter 8: Benthic Subtidal Ecology;
- Volume 2, Chapter 9: Fish and Shellfish Ecology;
- Volume 2, Chapter 14: Marine Archaeology;
- Volume 2, Chapter 16: Other Sea Users and Communications;
- Volume 2, Chapter 18: Climate Change.

7.1.1.3 This Physical Processes Offshore EIA Report chapter:

- presents the existing environmental baseline established from desk studies, site specific surveys, numerical modelling studies, and consultation with stakeholders;
- identifies any assumptions and limitations encountered in compiling the environmental information;
- presents the likely significant environmental impacts on physical processes arising from Morven South and reaches a conclusion on the likely significant effects, based on the information gathered and the analysis and assessments undertaken;
- highlights any necessary monitoring and/or mitigation measures which are recommended to prevent, minimise, reduce or offset the likely significant effects of the Morven South on physical processes.

7.1.1.4 The physical processes modelling that has been undertaken to support this chapter is presented in Volume 3, Annex 7.1 of the Physical Processes Shared Technical Report.

7.1.1.5 Physical Processes was reported on in the Scoping Report for the Morven Option Lease Agreement Site (hereafter, the "Morven Site Scoping Report"). (Morven Offshore Wind Limited (MvOWL), 2023). As described in Volume 1, Chapter 4: Site Selection and Consideration of Alternatives, the Morven Option Lease Agreement Site (hereafter "Morven Site") has since been divided into two smaller projects, Morven South and Morven North Offshore Wind Array Project (hereafter "Morven North").

7.1.1.6 The potential impacts to physical processes are considered to generally be the same (or less) for Morven South as identified in the Morven Site Scoping Report, (apart from the addition of the impact to seasonal stratification, following post scoping stakeholder consultation). Consequently, there has been no change in the methodology or in general the impacts that were scoped in or out in the Morven Site Scoping Report for physical processes. The advice provided by the Marine Directorate Licensing Operations Team (MD-LOT) in the Morven Site Scoping Opinion (MD-LOT, 2023) relevant to Morven South, has therefore been considered for the development of this chapter.

7.1.1.7 This chapter presents and assesses up-to-date parameters for Morven South and explains if and how any assessment aspects differ from the information set out in the Morven Site Scoping Report.

7.2 Study areas

7.2.1.1 One study area has been defined for physical processes:

- The Morven South Physical Processes Study Area.

7.2.1.2 The study area defined for physical processes is shown in Figure 7.1 and defined as follows:

- The Morven South Physical Processes Study Area includes the Morven South Boundary, plus one spring tidal excursion from the Morven South Boundary. One spring tidal excursion of between circa 5km in the east west orientation and 14km in the north south orientation from the Morven South Boundary was identified through interim numerical modelling techniques and is defined as the distance that suspended sediment is transported due to tidal currents before being carried back on the returning tide. The interim model was informed from bathymetric datasets available as part of the Marine Environmental Data Information Network (MEDIN).

7.2.1.3 The Morven South Physical Processes Study Area encompasses the entire water column, including the seabed that may be influenced by changes to physical processes due to Morven South. It is however noted that although the Morven South Physical Processes Study Area forms the focus for the assessment, the numerical model domain is not limited to this region. The modelling domain includes all banks within the Firth of Forth Banks Complex Marine Protected Area (MPA), which is located to the west of the Morven South Boundary, however this is outside of the Morven South Physical Processes Study Area, as shown in Figure 7.1.

7.2.1.4 The study area for physical processes for the Morven Site was presented and agreed during the scoping process for the Morven Site. The underlying principles used to define the study area for Morven South have not changed, other than the limits have been applied relative to the Morven South Boundary, rather than the Morven Site boundary. The study area for Morven South for physical processes were presented to and confirmed by the MD-LOT via a “Targeted Consultation Exercise” undertaken in Quarter 1, 2025 and as detailed in Table 7.5.

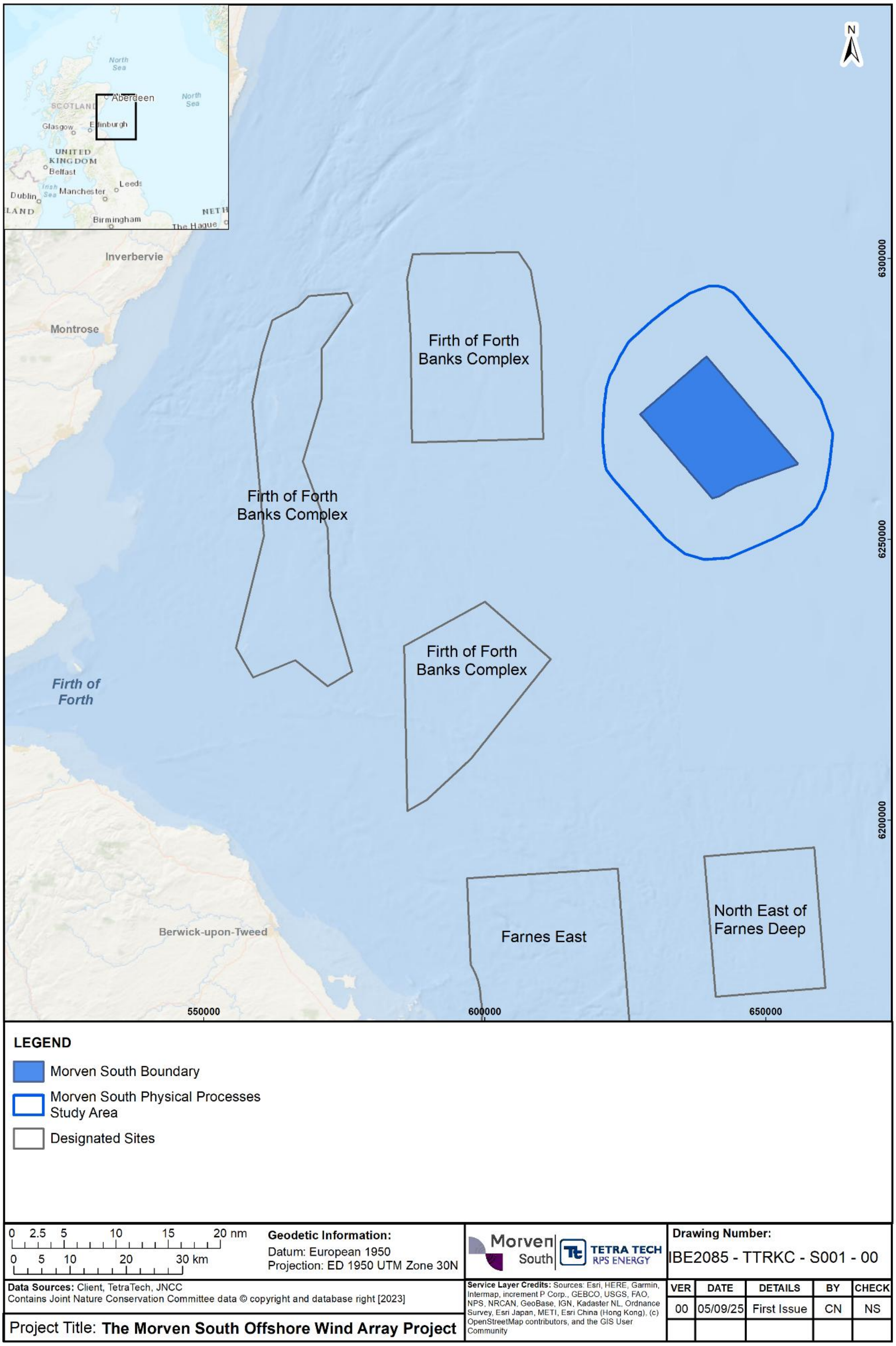

Figure 7.1: Physical Processes Study Area for Morven South

7.3 Legislative and policy context

7.3.1.1 Policy and legislation on renewable energy infrastructure is presented in Volume 1, Chapter 2: Policy and Legislation. Policy and legislation specific to physical processes is contained in the Marine and Coastal Access Act 2009 (UK Government, 2009), the Sectoral Marine Plan (SMP) for Offshore Wind Energy (Scottish Government, 2020), and the draft updated SMP for Offshore Wind Energy (Scottish Government, 2025), the Scottish National Marine Plan (NMP) (Scottish Government, 2015) and the United Kingdom (UK) Marine Policy Statement (MPS) (UK Government, 2011). The updated draft SMP for Offshore Wind Energy does not include any new specific policies for physical processes which had not been previously covered in the original 2020 publication. A summary of the policy provisions relevant to physical processes are provided in Table 7.2 to Table 7.4 below.

Table 7.1: Summary of provisions within the Marine and Coastal Access Act 2009 (Scottish Government, 2020) of relevance to physical processes

Summary of relevant policy	How and where considered in the EIA Report
General policies	
Part 5 of the Marine and Coastal Access Act 2009 enables the designation of Marine Conservation Zones (MCAs) in the Scottish offshore region, stating the protected feature or features and the conservation objectives for the MCA. Consideration of MCAs is required for any marine licence application or application for development consent which includes a deemed marine licence. To further the conservation objectives of an MCA, it must be determined whether an application may have a significant effect upon the protected features of an MCA or any ecological or geomorphological process on which the conservation of any protected feature of an MCA is (wholly or in part) dependent.	This physical processes chapter includes an assessment on the potential changes to suspended sediment concentrations (SSCs), waves, tides, sediment transport and water column processes during the relevant phases of Morven South, as discussed under Section 7.11 and supported by the modelling presented in Volume 3, Annex 7.1: Physical Processes Shared Technical Report. The best practice design and construction procedures to reduce these impacts are considered within Volume 1, Chapter 3: Project Description, with project committments provided in Volume 3, Annex 6.4: EIA Commitments Register. Designed-in measures of relevance to physical processes are presented under Section 7.10 of this chapter.

Table 7.2: Summary of provisions within the Sectoral Marine Plan for Offshore Wind Energy (Scottish Government, 2020) of relevance to physical processes

Summary of relevant policy	How and where considered in the EIA Report
General policies	
The following impacts will require consideration at a project-level: • loss of/damage to marine and coastal habitats; • effects on subsea geology, sediments and coastal processes arising from changes in hydrodynamics and existing wave regimes. (4.1)	This physical processes chapter includes an assessment on the potential changes to suspended sediment concentrations (SSCs), waves, tides, sediment transport and water column processes during the relevant phases of Morven South, as discussed under Section 7.11 and supported by the modelling presented in Volume 3, Annex 7.1: Physical Processes Shared Technical Report. The best practice design and construction procedures to reduce these impacts are

Summary of relevant policy	How and where considered in the EIA Report
	considered within Volume 1, Chapter 3: Project Description, with project commitments provided in Volume 3, Annex 6.4: EIA Commitments Register. Designed-in measures of relevance to physical processes are presented under Section 7.10 of this chapter.

Table 7.3: Summary of provisions within the Scottish National Marine Plan (Scottish Government, 2015) of relevance to physical processes

Summary of relevant policy	How and where considered in the EIA Report
General policies	
Development and use of the marine environment must: • comply with legal requirements for protected areas and protected species; • not result in significant impact on the national status of Priority Marine Features (PMFs); • protect and, where appropriate, enhance the health of the marine area. (GEN 9)	This physical processes chapter includes an assessment on the potential changes to SSCs, waves, tides, sediment transport and water column processes during the relevant phases of Morven South, as discussed under Section 7.11 and supported by the modelling presented in Volume 3, Annex 7.1: Physical Processes Shared Technical Report. The best practice design and construction procedures to reduce these impacts are considered within Volume 1, Chapter 3: Project Description, with project committments provided in Volume 3, Annex 6.4: EIA Commitments Register. Designed-in measures of relevance to physical processes are presented under Section 7.10 of this chapter.
The management requirements of protected sites must be met. These include MPAs and Special Areas of Conservation (SACs), as well as former Natura 2000 sites and the marine components of Sites of Special Scientific Interest (SSSIs) and Ramsar sites. Locally designated areas should also be considered, as appropriate. (4.41 – 50)	Identification of designated sites is discussed under Section 7.6. No designated sites are within the Morven South Physical Processes Study Area, as noted in Section 7.7.2.
Requirement for all regulators to ensure that there is no significant risk of hindering the achievement of the conservation objectives of an MPA before giving consent to an activity, plan, or project. A management intervention will be required if a significant risk of the achievement of an MPAs conservation objectives is identified. This intervention will be practical and proportionate, using the most appropriate statutory mechanism to reduce the risk. (4.47)	Identification of designated sites is discussed under Section 7.6. No designated sites are within the Morven South Physical Processes Study Area, as noted in Section 7.7.2

Summary of relevant policy	How and where considered in the EIA Report
Marine planning should consider opportunities to protect important geodiversity features and prevent deterioration or enhance where appropriate. (4.60)	Diversity of physical features has been characterised as part of the baseline scenario (Section 7.7.1). Seabed morphology has been identified as a receptor within the assessment of significance within Section 7.11 which includes seabed features (tunnel valleys, moraines and channels, although these features are undesignated). The physical processes assessment of effects followed the methodology set out in Volume 1, Chapter 6: EIA Methodology. No significant impacts are predicted.
Cumulative impacts affecting the ecosystem of the marine plan area should be addressed in decision making and plan implementation. (GEN21)	A whole project assessment and cumulative effects assessment (CEA) has been undertaken within section 7.13, following a screening assessment as presented in Volume 3, Annex 6.2: Cumulative Effects Screening. No significant cumulative effects are predicted.
Offshore Wind and Marine Renewable Energy Policy	
Marine planners and decision makers must ensure that renewable energy projects demonstrate compliance with EIA and Habitats Regulations Appraisal (HRA) legislative requirements (RENEWABLES 5)	Legislative requirements for offshore wind farms are considered within Volume 1, Chapter 2: Policy and Legislation and within Section 7.3 of this chapter.
A strategic approach to mitigating potential impacts and cumulative impacts on the marine environment forms an integral part of marine planning and decision making, while issues arising in the coastal interface should align between marine and terrestrial processes. (11.32)	A whole project assessment and CEA has been undertaken within section 7.13, following a screening assessment as presented in Volume 3, Annex 6.2: Cumulative Effects Screening. No significant cumulative effects are predicted.
Offshore and onshore infrastructure supporting renewable energy developments should account for the potential impact of climate change. Additionally, offshore renewable devices may also have the potential to change wave energy dissipation and coastal processes, and this impact should be considered by marine planners and decision makers. (11.34)	Section 7.7.3 outlines the future baseline scenario in the absence of Morven South. The potential impact of climate change is addressed within Volume 2, Chapter 18: Climate Change. Impacts to the wave climate are assessed within Section 7.11, which is supported by the modelling presented in Volume 3, Annex 7.1: Physical Processes Shared Technical Report, covering a range of storm conditions.

Table 7.4: Summary of provisions within the United Kingdom Marine Policy Statement (United Kingdom Government, 2011) of relevance to physical processes

Summary of relevant policy	How and where considered in the EIA Report
General policies	
Ensure a sustainable marine environment which promotes healthy, functioning marine ecosystems and protects marine habitats, species, and heritage assets. (Introduction)	This physical processes chapter includes an assessment on the potential changes to SSCs, waves, tides, sediment transport and water column processes during the relevant phases of Morven South, as discussed under Section 7.11

Summary of relevant policy	How and where considered in the EIA Report
	and supported by the modelling presented in Volume 3, Annex 7.1: Physical Processes Shared Technical Report.
Biodiversity is protected, conserved, and where appropriate recovered, and loss has been halted. (2.2)	This physical processes chapter includes an assessment on the potential changes to SSCs, waves, tides, sediment transport and water column processes during the relevant phases of Morven South, as discussed under Section 7.11 and supported by the modelling presented in Volume 3, Annex 7.1: Physical Processes Shared Technical Report.
Coastal change and flooding	
Account should be taken of the impacts of climate change throughout the operational life of a development including any de-commissioning period. Marine plan authorities should seek to minimise and mitigate any geomorphological changes that an activity or development will have on coastal processes, including sediment movement. (2.6.8.6)	Section 7.7.3 outlines the future baseline scenario in the absence of Morven South. The potential impact of climate change is addressed within Volume 2, Chapter 18: Climate Change. Impacts to the wave climate are assessed within Section 7.11, which is supported by the modelling presented in Volume 3, Annex 7.1: Physical Processes Shared Technical Report, covering a range of storm conditions. The physical processes assessment of effects includes the impact of Morven South on sediment transport during the O&M phase.

7.4 Consultation

7.4.1.1 The approach to consultation for Morven South is set out in Volume 1, Chapter 5: Consultation. A summary of the issues raised during consultation activities undertaken to date specific to physical processes is presented in Table 7.5, together with how these issues have been considered in the production of this physical processes EIA Report chapter. Further detail is presented within Volume 3, Annex 5.1: Consultation Annex.

Table 7.5: Summary of key consultation issues raised during consultation activities undertaken for Morven South of relevance to physical processes

Date	Consultee and type of consultation	Summary of issue(s) raised	Applicant's response to issue raised and, if applicable, where considered in this chapter
Pre-Scoping Workshop			
18 April 2023	NatureScot: Pre-Scoping Workshop	NatureScot encouraged a clear distinction between receptors/pathways, noting that receptors are the geodiversity features of MPAs and all others are the pathways. If pathways approach is included in the EIA, then the assessment should only consider magnitude of change for pathways rather than also assessing sensitivity as this is not suitable for pathways.	A consistent approach regarding physical processes pathways and receptors has been applied within the assessment. The magnitude of each impact is discussed, followed by the sensitivity of the receptors, which together allow the significance of effect to be determined for each impact. This is the approach maintained within Section 7.11. Physical processes may also be pathways to other ecological impacts, for example within Volume 2, Chapter 8: Benthic Subtidal Ecology
18 April 2023	NatureScot: Pre-Scoping Workshop	NatureScot suggested that the loss and damage of seabed may be considered as a receptor, however this depends on the receptor pathway distinction.	Designated and undesignated seabed has been identified as a receptor to changes in physical processes (due to waves, tides, sediment transport and deposition). The magnitude of change, including to the seabed has been quantified as part of Volume 3, Annex 7.1: Physical Processes Shared Technical Report and is discussed under Section 7.11, along with the ascribed sensitivity for each impact. Further ecological implications are considered under Volume 2, Chapter 8: Benthic Subtidal Ecology.
18 April 2023	NatureScot: Pre-Scoping Workshop	NatureScot encouraged further technical consultation on the modelling methodology and invited consultation on a	The Applicant responded confirming the intention to undertake the modelling in line with the Berwick Bank Offshore

Date	Consultee and type of consultation	Summary of issue(s) raised	Applicant's response to issue raised and, if applicable, where considered in this chapter
		summary of modelling methods and proposed presentation of outputs.	Wind Farm, with results presented in a similar manner. Reference was provided to the Berwick Bank Wind Farm Technical Report. This report outlines the modelling methodology using the Mike Suite of Software and includes a series of baseline plots for the various physical processes elements, with a further series of plots representing potential changes due to the project. The proposed assessment methodology was included in Section 7.1.8 of the Morven Site Scoping Report.
18 April 2023	NatureScot: Pre-Scoping Workshop	NatureScot highlighted the importance of considering whether the bathymetry data used is of sufficient resolution to distinguish the different types of bedforms.	It was confirmed that the bathymetric data is available to 1m resolution and is more than sufficient for the HD modelling. The bathymetry used in the modelling in described in Volume 3, Annex 7.1: Physical Processes Shared Technical Report under the baseline characterisation of the bathymetry.
Scoping Opinion			
30 November 2023	MD-LOT: Scoping Opinion	Scoping Opinion received on 30 November 2023. MD-LOT reiterated MD-SEDD advice that the baseline water column conditions should be described in the EIA Report. The potential changes to water column structure including timing and extent of seasonal stratification, and potential impacts on productivity and higher trophic levels, should be assessed. The impacts of infrastructure on water column mixing should be included in the assessment, and if uncertainties exist, 3D modelling may be required.	A baseline description of the mixing and stratification has been included in Section 7.7.1 and in more detail in Volume 3, Annex 7.1: Physical Processes Shared Technical Report. The impact to seasonal stratification has been scoped in and assessed under Section 7.11.6, drawing on the modelling study described in the Physical Processes Shared Technical Report. Potential impacts on productivity and higher trophic levels are discussed within Volume 2, Chapter 21: Inter-related and Ecosystem Effects.
30 November 2023	MD-LOT: Scoping Opinion	MD-LOT agreed with the NatureScot representation that impacts from scour around	Secondary scour has been scoped in and assessed within the impact to sediment

Date	Consultee and type of consultation	Summary of issue(s) raised	Applicant's response to issue raised and, if applicable, where considered in this chapter
		seabed infrastructure should be scoped into the EIA Report.	transport and sediment transport pathways due to the presence of the infrastructure (Section 7.11.4.10).
30 November 2023	MD-LOT: Scoping Opinion	In line with the representation from NatureScot, MD-LOT advised that the full range of mitigation measures, published guidance, and monitoring requirements are discussed in the EIA Report.	Designed-in measures and mitigation are discussed under Section 7.10, published guidance under Section 7.8.1 and monitoring requirements under Section 7.11.7.
30 November 2023	MD-LOT: Scoping Opinion	In line with the NatureScot representation, MD-LOT advised that potential cumulative impacts must be fully assessed for each project phase, once modelling outputs are available, in order to clarify if the impacts to physical processes will be localised.	In addition to the presence of Morven South, the physical processes modelling assessed the magnitude of the impact of the combined presence of Morven South and Morven North. This aided the whole project assessment and CEA described under Section 7.12 and undertaken under Section 7.13.
30 November 2023	MD-LOT: Scoping Opinion	MD-LOT agreed with the NatureScot representation that transboundary impacts can be scoped out of the EIA Report for physical processes.	Transboundary effects have been screened out for further assessment for physical processes, as noted under Section 7.14.
30 November 2023	MD-LOT: Scoping Opinion	MD-LOT agreed with the NatureScot representation that it is acceptable to screen out the Firth of Foth Banks Complex MPA shelf banks and mounds and moraines of the MCZ assessment.	Receptors of relevance to physical processes are discussed throughout Section 7.11.
30 November 2023	MD-SEDD: Scoping Representation	MD-SEDD advised that the potential changes to water column structure including timing and extent of seasonal stratification should be assessed within the EIA.	The impact to seasonal stratification has been scoped in and assessed under Section 7.11.6, drawing on the modelling study described in Section 5.2.4 of Volume 3, Annex 7.1: Physical Processes Shared Technical Report.
30 November 2023	MD-SEDD: Scoping Representation	MD-SEDD advised that the baseline water column conditions should be described in the EIA, including details on timing and strength of stratification. Typical frontal positions in the region should also be noted, along with the	A baseline description of the mixing and stratification has been included in Section 7.7.1 and in more detail in Volume 3, Annex 7.1: Physical Processes Shared Technical Report. The link between stratification and fronts to primary

Date	Consultee and type of consultation	Summary of issue(s) raised	Applicant's response to issue raised and, if applicable, where considered in this chapter
		link between stratification and fronts to primary productivity and higher trophic levels and ecosystem services.	productivity and higher trophic levels has been discussed within Volume 2, Chapter 21: Inter-related and Ecosystem Effects.
30 November 2023	MD-SEDD: Scoping Representation	MD-SEDD advised that an assessment of how the infrastructure could alter water column processes should be performed, in terms of the generation of turbulent wakes or by altering the near sea surface wind speeds. 3D modelling may be required to aid the assessment should uncertainties exist in the assessment of this impact. The impact on productivity and higher trophic levels should also be considered in the EIA.	A high level 3D modelling study to assess the impact on seasonal stratification has been undertaken following consultation with MD-LOT and Marine Directorate – Science Evidence Data and Digital (MD-SEDD). The modelling study is discussed within Volume 3, Annex 7.1: Physical Processes Shared Technical Report. The assessment of the impact on seasonal stratification is discussed under Section 7.11.6, including the assessment of the impact due to a reduction in wind wakes due to Morven South. The impact on primary productivity and higher trophic levels has been discussed within Volume 2, Chapter 21: Inter-related and Ecosystem Effects.
30 November 2023	NatureScot: Scoping Representation	Impacts from scour around seabed infrastructure should be scoped in.	Secondary scour has been scoped in and assessed within the impact to sediment transport and sediment transport pathways due to the presence of the infrastructure (Section 7.11.4.10).
30 November 2023	NatureScot: Scoping Representation	Potential cumulative impacts should be fully assessed for each project phase, once modelling outputs are available, in order to clarify if the impacts to physical processes will be localised.	In addition to the presence of Morven South, the physical processes modelling assessed the magnitude of the impact of the combined presence of Morven South and Morven North. This aided the whole project assessment and CEA described under Section 7.12 and undertaken under Section 7.13.
30 November 2023	NatureScot: Scoping Representation	The full range of mitigation measures, published guidance, and monitoring requirements	Designed-in measures and mitigation are discussed under Section 7.10, published

Date	Consultee and type of consultation	Summary of issue(s) raised	Applicant's response to issue raised and, if applicable, where considered in this chapter
		should be discussed in the EIA Report.	guidance under Section 7.8.1 and monitoring requirements under Section 7.11.7.
Post Scoping			
11 April 2024	MD-LOT/MD-SEDD: Further email consultation post scoping	In response to the Applicant seeking agreement on the proposed approach to the assessment of seasonal stratification, on 02 May 2024, MD-LOT requested a method statement on the approach to assessment.	Detailed physical processes stratification method statement provided on 22 May 2025.
22 May 2024	MD-LOT: Email response to Physical Processes Stratification Method Statement	MD-SEDD requested further information on methodology on assessment of the impact to stratification and advised that the fundamental mechanism for stratification to be impacted is through the addition of turbulence within the water column. MD-SEDD highlighted the limitations of two-dimensional (2D) modelling in this regard and advised the use of incorporating three-dimensional (3D) modelling within the assessment. Clarification should be provided on how the support structures are being parameterised as sub-grid scale objects within the modelling and the effect of wind wakes on stratification.	Addendum to physical processes stratification method statement shared with MD-LOT on 26 July 2024, whereby proposal to provide high level 3D modelling in the assessment of seasonal stratification was incorporated. The assessment of the impact due to the presence of the infrastructure within the water column and due to a reduction in wind wakes is presented in Section 7.11.6.
26 July 2024	MD-LOT: Email response to Addendum to Physical Processes Stratification Method Statement	On 26 August 2024, MD-LOT responded. MD-SEDD welcomed the use of the 3D model and considered the development of a smaller domain to be pragmatic. Further details on the simulation duration or time periods were requested and advised the capture of the onset and decay of stratification over a spring neap cycle. MD-SEDD recommended that the Scottish Shelf Waters -	The Applicant provided further details in response via email on 11 February 2025, including MIKE 3 documentation on the parametrisation of structures.

Date	Consultee and type of consultation	Summary of issue(s) raised	Applicant's response to issue raised and, if applicable, where considered in this chapter
		Reanalysis Service (SSW-RS) data should be examined to determine suitable time periods to model. MD-SEDD requested clarification on pier parameterisation.	
21 July 2025	MD-LOT: Quarterly meeting	MD-LOT is content with the proposed approach to mitigation and post-consent plans. Relevant to physical processes this includes the Cable Plan (CaP), the Construction Method Statement (CMS), Operation and Maintenance Plan (OMP), Development Specification and Layout Plan (DSLP) and Decommissioning Programme (DP) to be provided post-consent.	The CaP, which will be submitted post-consent, will outline the technical specifications of the cables used in Morven South and describe the installation methodology and cable protection required, which will solidify the assessment on physical processes. Similarly the other plans to be provided post-consent provide clarity to construction, O&M and decommissioning activities which may influence physical processes. Designed-in measures and mitigation relevant to physical processes for Morven South are outlined in Section 7.10
11 February 2025	MD-LOT/MD-SEDD: Further email consultation post Physical Processes Stratification Method Statement	On 27 March 2025, MD-LOT responded. MD-SEDD advised that, in general, the refinements to the computational mesh and vertical resolution are pragmatic and welcomed the sensitivity analysis undertaken. It was queried if additional turbulence generated by the structures would be adequately represented by the parameterisation method, however acknowledged that the high horizontal resolution may compensate. MD-SEDD accepted the proposal for an idealised approach with static boundary forcing for the proposed short model run and accepted the	A high level 3D modelling study to assess the impact on seasonal stratification has been undertaken following consultation with MD-LOT and MD-SEDD. The modelling study is discussed within Volume 3, Annex 7.1: Physical Processes Shared Technical Report. The assessment of the impact on seasonal stratification is discussed under Section 7.11.6.

Date	Consultee and type of consultation	Summary of issue(s) raised	Applicant's response to issue raised and, if applicable, where considered in this chapter
		absence of atmospheric forcing in the modelling. MD-SEDD advised that an analysis should be performed on the SSW-RS data to identify a typical year from which to simulate model. MD-SEDD also advised that peak summer and onset periods should be modelled over a spring neap cycle in addition to model warm up time.	
13 March 2025	MD-LOT: Targeted Consultation on Morven North and Morven South and approach to CEA	On 21 July, MD-LOT responded to the targeted consultation letter on the revised consenting strategy. This included the new Morven South Physical Processes Study Area. MD-LOT noted that there are no additional aspects requiring consideration following the revision to the proposed approach to consenting and advised discussing the CEA approach further with NatureScot.	The Morven South Physical Processes Study Area has been adopted for the assessment of physical processes and is shown in Section 7.2. The approach to CEA has been discussed and agreed with NatureScot, and is presented in Section 7.12.

7.5 Scope of the assessment

7.5.1 Impacts scoped into the assessment

7.5.1.1 The scope of this EIA Report has been developed in consultation with relevant statutory and non-statutory consultees as detailed in Table 7.5. The potential effects scoped into the physical processes assessment can largely be broken down into two main groups; those related to the installation and maintenance of the infrastructure which are associated with increased SSC and deposition, and those related to the presence of the infrastructure which are related to changes in physical processes, (e.g. tides, waves, water column processes and sediment transport). Taking into account the scoping and consultation feedback and advice, Table 7.6 summarises the potential impacts which have been scoped into this assessment. Where an impact is likely to occur within a specific development phase of the project, this is indicated within each relevant topic chapter (a '✓' is used to denote the phase the potential impact can occur, conversely a 'X' outlines there is no impact within this project phase), where relevant.

Table 7.6: Potential impacts scoped into the physical processes assessment

C= Construction, O= Operations and Maintenance, D= Decommissioning phases

"✓" is used to denote the phase the potential impact can occur, "✗" outlines there is no impact within this project phase

Potential impact	Phase			Activity
	C	O	D	
Increased SSCs and associated deposition	✓	✓	✓	Site preparation (foundations, cabling)
				Foundation installation
				Cable installation
				Cable repair and reburial
				Cable removal
Impacts to the wave regime due to the presence of infrastructure	✗	✓	✗	Presence of wind turbine and Offshore Substation Platform (OSP) foundations and associated scour protection
				Presence of cables and cable protection
Impacts to the tidal regime due to the presence of infrastructure	✗	✓	✗	Presence of wind turbine and OSP foundations and associated scour protection
				Presence of cables and cable protection
Impacts to sediment transport and sediment transport pathways due to the presence of infrastructure	✗	✓	✗	Presence of wind turbine and OSP foundations and associated scour protection
				Presence of cables and cable protection
Impacts to seasonal stratification due to the presence of infrastructure	✗	✓	✗	Presence of wind turbine and OSP foundations

7.5.2 Impacts scoped out of the assessment

7.5.2.1 There are no identified impacts which have been scoped out of the assessment. Impacts due to the presence of infrastructure were scoped in for the O&M phase only, with the magnitude of the impacts less during the construction and decommissioning phases, due to the partial presence of the infrastructure.

7.6 Approach to baseline characterisation

7.6.1.1 The physical processes baseline environment has been characterised through site specific data and a literature review of key desktop datasets and reports (see Table 7.7). This list is not exhaustive; further datasets and reports are covered in more detail within Volume 3, Annex 7.1: Physical Processes Shared Technical Report.

7.6.2 Relevant guidance

7.6.2.1 Specific to the physical processes baseline, the following guidance documents have been considered:

- Guidelines in the use of metocean data through the lifecycle of a marine renewables development, Construction Industry Research and Information Association (CIRIA) C666, ABPmer Ltd *et al*., (2008);
- Collaborative Offshore Wind Energy Research into the Environment (COWRIE) - Coastal Process Modelling for Offshore Wind Farm Environmental Impact Assessment (Lambkin *et al*.,2009);
- Guidance on Environmental Impact Statement (EIS) and Natura Impact Statement (NIS) Preparation for Offshore Renewable Energy Projects, Department of Communications, Climate Action and Environment, (Barnes, 2017);
- Advice to Inform Development of Guidance on Marine, Coastal and Estuarine Physical Processes Numerical Modelling Assessments. Natural Resources Wales (NRW) Report No 208, 139pp, Pye *et al.,* (2017);
- Guidance on Marine Baseline Ecological Assessments and Monitoring Activities for Offshore Renewable Energy Projects Parts 1 and 2 (Department of the Environment, Climate and Communications (DECC), 2018);
- Guidance on Best Practice for Marine and Coastal Physical Processes Baseline Survey and Monitoring Requirements to inform EIA of Major Development Projects (Brooks *et al*., 2018);
- Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards (Natural England, 2022);
- Nature considerations and environmental best practice for subsea cables in English inshore and UK offshore waters (Natural England and JNCC, 2022).

7.6.3 Desktop study

7.6.3.1 Information on physical processes within the Morven South Physical Processes Study Area was collected through a detailed desktop review of existing studies and datasets. These are summarised in Table 7.7 below.

Table 7.7: Summary of key desktop reports used to characterise the physical processes baseline

Title	Source	Year	Author
European Centre for Medium-range Weather Forecast (ECMWF) European Wave Model	ECMWF – Wave Data	2025	ECMWF
United Kingdom Hydrographic Office (UKHO) - Published Charts and Tide tables	Charts 1409 0:200000 and 273 0:200000 incorporating tidal diamonds with current stream data	2024	UKHO
Joint Nature Conservation Committee (JNCC) MPA Mapper	JNCC MPA	2023	JNCC
Scottish Shelf Model 3.02 – 27 Year Reanalysis. SSW-RS	Marine Scotland	2022	Barton *et al.*
European Marine Observation and Data Network (EMODnet) seafloor geomorphology	EMODnet – Seafloor geomorphology	2021	EMODnet
Atlas of UK Marine Renewable Energy Resources • Annual mean significant wave height (m) • Annual mean wave power (kW/m) • Mean spring tidal range (m)	Atlas of UK Marine Renewable Energy Resources	2017	ABP Marine Environmental Research (ABPmer),

Title	Source	Year	Author
British Geographical Survey (BGS) Seabed Geology Layers	Marine Scotland	2017	BGS
European Marine Observation and Data Network (EMODnet) seabed substrate map (250 k scale)	EMODnet – Seabed Substrate	2016	EMODnet
Monthly average non-algal Suspended Particulate Matter (SPM) concentrations on the UK shelf waters	Centre for Environment, Fisheries and Aquaculture Science (Cefas) Climatology Data	2016	Cefas
Suspended Sediment Climatologies around the UK	Cefas Climatology Report	2016	Cefas
MEDIN including Admiralty Marine Data Portal	Admiralty Marine Data Portal - bathymetry data	2003 - 2009	MEDIN

7.6.4 Identification of designated sites

7.6.4.1 All designated sites within the Morven South Physical Processes Study Area and qualifying interest features that could be affected by the construction, O&M and decommissioning phases of Morven South were identified using the three-step process described below:

- Step 1: All designated sites of international, national and local importance within the Morven South Physical Processes Study Area were identified using a number of sources. These sources included the Marine Directorate website, the Atlas of Marine Protection website and JNCC resources.
- Step 2: Information was compiled on the relevant geomorphological/physical features for each of these sites.
- Step 3: Using the above information and expert judgement, sites were included for further consideration if:
  - a designated site directly overlaps with the Morven South Boundary and therefore has the potential to be directly affected by Morven South;
  - sites and associated features were located within the Morven South Physical Processes Study Area for impacts associated with Morven South and therefore have the potential to be indirectly affected by Morven South.

7.6.5 Site specific surveys

7.6.5.1 A summary of the surveys undertaken to inform the physical processes assessment of effects is outlined in Table 7.8 and further detail of the survey methodologies and results is included within Volume 3, Annex 7.1: Physical Processes Shared Technical Report.

Table 7.8: Summary of site specific surveys

Title	Extent of survey	Overview of survey	Survey contractor	Date	Reference to further information
Geophysical survey	Morven North Boundary and Morven South Boundary	Geophysical survey to establish bathymetry, seabed geology, morphology and sediments, involving magnetometer, Side Scan Sonar (SSS), Single Beam Echosounder (SBES), Multibeam Echosounder (MBES), 2D Ultra-High Resolution Seismic (UHRS) and Sub-Bottom Profiler (SBP).	Gardline and XOcean	April – August 2022	Gardline, 2022
Metocean survey	Morven North Boundary and Morven South Boundary	Metocean survey to establish wave and current data at a location within the Morven North Boundary (Partrac North) and a location within the Morven South Boundary (Partrac South). Three metocean devices were deployed in the vicinity of each survey area, consisting of a Light Detection and Ranging (LiDAR) buoy, wavebuoy and subsea mooring.	Partrac	October 2022 – April 2024	Partrac, 2024
Benthic subtidal survey	Morven North Boundary and Morven South Boundary	Seabed imagery and grab sampling with particle size analysis	Gardline	April – August 2022	Gardline, 2023

7.7 Baseline environment

7.7.1 Overview of baseline environment

7.7.1.1 A summary of the physical processes baseline environment is provided in the following sections. Full details of the analysis undertaken to develop the physical processes baseline is provided in Volume 3, Annex 7.1: Physical Processes Shared Technical Report, which includes information on model development, resolution, calibration, and the modelling techniques implemented to develop the baseline characteristics, where relevant.

Bathymetry

7.7.1.2 The Morven South Boundary bathymetry ranges in depth from 64m to a maximum of 76m relative to Lowest Astronomical Tide (LAT), as shown by the geophysical data captured in 2022. The deepest point is located near the southeastern edge of the site, while the shallowest parts lie towards the centre. The seabed here exhibits gentle undulations with an overall gradient of less than 1°, indicating a relatively stable and low relief underwater landscape.

7.7.1.3 A notable geomorphological feature within the Morven South Boundary is a sandbank located in the southeastern area, which rises approximately 4m above the surrounding seabed and extends roughly 4km at its widest point. This sandbank is a significant sedimentary feature likely influenced by local hydrodynamic conditions.

7.7.1.4 Shoals are also present across the Morven South Boundary. One discrete seabed feature rises circa 2m above the surrounding seabed and exhibits relatively steep gradients of up to 8° on its flanks, suggesting localised seabed variability.

7.7.1.5 Megaripples are present within the Morven South Boundary, reflecting sediment transport processes, although they are not extensive or well defined.

Hydrography

7.7.1.6 The mean tidal range near the Morven South Boundary is reported between 2.4m and 2.7m, according to the Atlas of UK Marine Renewable Energy Resources (ABPmer, 2017). This is consistent with tidal ranges reported at nearby standard ports, including Montrose with a mean tidal range of 3.0m and Aberdeen with 2.75m.

7.7.1.7 Site specific metocean data collected during 2023 showed that maximum current speeds recorded within the Morven South Boundary were up to 0.88m/s with mean speeds of 0.24m/s. Near-surface currents peaked at 0.85m/s while near-bed currents reached 0.61m/s. Current directions predominantly follow a north north-east to south south-west alignment. The modelled depth-averaged peak current speeds during spring tide flood and ebb phases reached up to 0.59m/s and 0.61m/s respectively.

Wave climate

7.7.1.8 Wave propagation in the North Sea generally follows cyclonic patterns, influenced by tidal waves and residual circulation. While strong winds are common, wave heights vary considerably due to factors such as water depth and fetch limitations. Annual mean significant wave heights across the Morven South Boundary range from approximately 1.81m to 1.95m, with annual mean wave power between 14.8kW/m and 17.5kW/m.

7.7.1.9 Site specific metocean monitoring was undertaken using a Waverider buoy deployed within the Morven South Boundary between October 2022 and April 2024. The maximum spectral significant wave height recorded was 9.95m, with peak wave periods reaching up to 20s. The most significant storm event during this period was Storm Babet in October 2023, originating from the east. Dominant wave directions at the site were from the north north-east and north.

Littoral currents

7.7.1.10 Littoral currents within the Morven South Physical Processes Study Area are driven by a combination of tidal, wave, and meteorological forces. While tidal currents are the primary influence, residual currents generated by storm events also contribute to the overall current regime. Physical processes modelling of a 1 in 1 year storm from the dominant northerly wave sector, showed that the presence of the northerly waves travelling southwards increase the currents on the flood tide while reducing them on the ebb.

Water column processes

7.7.1.11 Site specific surveys conducted by Partrac between October 2022 and May 2024 identified evidence of seasonal stratification. Conductivity Temperature Depth (CTD) measurements showed consistent, well-mixed conditions from October through to February, with minimal differences between surface and seabed parameters. Springtime brought the onset of seasonal stratification, with small temperature and salinity differences developing between surface and seabed waters. In August 2023, the thermocline was observed to be between 26m and 28m depth at a location within the Morven South Boundary (Partrac South), with a warmer surface layer evident above the thermocline and cooler, denser water below, confirming seasonal stratification within the Morven South Boundary. The location of Partrac North is provided in Figure 4.7, Section 4.3 of Volume 3, Annex 7.1: Physical Processes Shared Technical Report.

7.7.1.12 To provide a longer term and broader context, the SSW-RS dataset, covering 27 years from 1993 to 2019, was utilised. This dataset offers detailed vertical profiles of temperature and salinity across the Scottish continental shelf. Spatial analysis of temperature differences between near-surface and near-bed layers at peak stratification during a typical year on 02 August 2016 showed that within the Morven South Boundary, a temperature difference was evident of between 3.73°C and 4.62°C (Barton *et al*., 2022).

7.7.1.13 Further analysis using the SSW-RS data examined monthly thermocline positions from March to October 2016 within the Morven Site. Prior to stratification onset in March, near-surface and near-bed temperatures were similar. A weak thermocline developed by April at around 6.7m depth. This deepened through May and became more pronounced during June, with the thermocline between 20.1m and 30.2m. During July and August, the thermocline moved closer to the surface layer, at depths between 10.1m and 20.1m. Stratification weakened in September and waters became fully mixed again by October.

Geology and seabed substrate

7.7.1.14 Marine bedrock data at a scale of 1:250,000, provided by the BGS, indicates that the site is predominantly underlain by chalk formations dating from the Upper Cretaceous period, specifically from the Cenomanian to Maastrichtian stages. Seafloor geomorphology data from EMODnet reveals notable features such as moraine landforms within the Morven South Boundary.

7.7.1.15 Although no sub-seabed interpretation was part of the site specific geophysical survey scope, detailed imaging of surficial Holocene sediments was obtained alongside information on Quaternary sediments approximately 50m below the seabed, and imaging of sub-cropping Palaeozoic and Mesozoic soils. The predominant seabed sediment across the Morven South Boundary is fine to coarse sand with gravel and shell content. Sediments were found to be relatively homogenous, consistent with the widespread presence of megaripples dominating much of the seabed.

7.7.1.16 Numerous areas of higher reflectivity in SSS data correspond to medium sand containing shells, shell fragments, and occasional gravels, pebbles, and cobbles. The surficial sands and gravelly sands are generally thin, with boulders and cobbles common in the troughs between megaripples. Across the Morven South Boundary, a total of 5,287 boulders were identified, with boulder density highest in the northeast and central regions of the Morven South Boundary.

7.7.1.17 Seabed substrate mapping at the 1:250,000 scale using the Folk16 classification from EMODnet shows sand as the dominant substrate within the Morven South Physical Processes Study Area, with some areas of slightly gravelly sand and gravelly sand. This generally homogenous sandy substrate is consistent with the site specific seabed survey findings.

Sediment transport

7.7.1.18 The MIKE21 Sediment Transport module was employed to assess seabed sediment transport rates, as described in Section 4.8 of Volume 3, Annex 7.1: Physical Processes Shared Technical Report.

7.7.1.19 Under tidal current only conditions, residual current speeds were low, reaching up to 0.007m/s within the Morven South Boundary. These currents generally flow in a northwesterly direction. Correspondingly, sediment transport rates were low, with a maximum potential transport of approximately 0.01m^3/d/m within the Morven South Boundary under calm conditions.

7.7.1.20 At peak flood tide, seabed level reductions reached a maximum of circa 1mm per day, with corresponding increases during ebb tides of approximately 1mm per day. With seabed level changes of below 1mm per day under peak tidal flows, this suggests that while the seabed is mobile, it remains stable overall.

7.7.1.21 During storm events originating from the north, wave action enhances flood tide currents and increases residual current speeds to approximately 0.07m/s flowing south south-west. Sediment transport capacity similarly increases on the flood tide, reaching up to 0.3m^3/d/m after the course of one day. Seabed level changes during such storm conditions continue to show opposing increases and decreases between flood and ebb tides, indicating that tidal forces remain the dominant influence even during storms. Overall, storm conditions affect seabed mobility, increasing sediment transport but maintaining the fundamental tidal-driven sediment dynamics.

Suspended sediments

7.7.1.22 The primary factors influencing SSCs in the water column are tidal currents, which fluctuate throughout the spring neap tidal cycle and at different tidal stages such as high water, peak ebb, low water, and peak flood. SSC levels can also be temporarily elevated by wave-driven currents during storm events.

7.7.1.23 Turbidity monitoring was conducted by Partrac at a location within the Morven South Boundary, during the November 2022 to November 2023 survey campaign. The data indicate generally low turbidity levels, peaking during the winter months and storm season. During storms, wave-driven currents elevate SSC temporarily, causing significant increases compared to baseline conditions, which then subside gradually post-storm. The seasonal nature of storms thus drives a seasonal pattern in SSC. Elevated SSCs during storm events are less pronounced in deeper waters due to reduced wave penetration compared to shallower areas.

7.7.1.24 For broader context, the Cefas Climatology Report 2016 provides spatial distribution data for average non-algal SPM across the UK Continental Shelf from 1998 to 2015. The highest SPM plumes are associated with large river discharges, such as those into the Thames Estuary, The Wash, and Liverpool Bay, where mean SPM values exceed 30mg/l (Cefas, 2016). Within and around the Morven South Boundary, mean SPM levels during this period were estimated to range from 0mg/l to 1mg/l, with higher values typically observed during winter months, reaching up to approximately 3mg/l. This dataset confirms the generally low baseline suspended sediment levels in the Morven South Physical Processes Study Area relative to major sediment sources elsewhere around the UK Continental Shelf.

7.7.2 Designated sites

7.7.2.1 There are no designated sites identified within or overlapping the Morven South Physical Processes Study Area. The nearest designated site is the Firth of Forth Banks Complex MPA, the closest part of which lies 17.3km to the northwest of the Morven South Boundary. This is beyond the extent of the Morven South Physical Processes Study Area by over 10km and thus has not been considered in the baseline or assessment of effects.

7.7.3 Future baseline scenario

7.7.3.1 The EIA Regulations require the following to be included within the EIA Report: “a description of the relevant aspects of the current state of the environment (baseline scenario) and an outline of the likely evolution thereof without development as far as natural changes from the baseline scenario can be assessed with reasonable effort, on the basis of the availability of environmental information and scientific knowledge.”

7.7.3.2 In the event that Morven South does not come forward, an assessment of the future baseline conditions has been carried out and is described within this section. The baseline environment for physical processes is not static and will exhibit a degree of natural change over time. Such changes will occur with or without the Morven South infrastructure in place due to natural variability.

7.7.3.3 Future baseline conditions would be altered by climate change resulting in sea level rise and increased storminess (Met Office, 2018). This is unlikely to have the effect of significantly altering tidal patterns and sediment transport regimes offshore within the Morven South Boundary. The return period of the wave climates would be altered (e.g. what is currently defined as a 1 in 50 year event may become a 1 in 20 year event) as deeper water would allow larger waves to develop. Although increased water depth would potentially increase the wave climate, sandwave migration is driven by tides and sediment source rather than waves (Kenyon *et al*, 2005). Therefore, features such as the sandwaves and megaripples found within the Morven South Boundary would continue to develop regardless of wave climate. There is, however, a notable degree of uncertainty regarding how future climate change will impact prevailing wave climates within the North Sea and beyond.

7.7.3.4 Seasonal stratification may also increase in magnitude and be prevalent through more months of the year, due to a rise in ocean temperatures. This may result in increased impacts to tidal fronts, and position of the thermocline within the water column. A 2020 study by Guancheng et. al on the increasing ocean stratification over the past half century found that stratification has increased by 5.3% globally from 1960 to 2018, at a rate of 0.90% per decade, predominantly due to temperature changes (Guancheng *et al*., 2020). Further the study states that global warming has changed oceanic temperature and salinity fields and therefore impacts to stratification are expected (Guancheng *et al*., 2020). Projected future changes in stratification will have an effect on density-driven ocean circulation and is projected to continue to increase due to ocean warming and freshwater input from ice-melt (Guancheng *et al*., 2020).

7.7.3.5 The Intergovernmental Panel on Climate Change (IPCC) Special Report on the Ocean and Cyrosphere in a Changing Climate (Bindoff *et al*., 2019), also notes that observed warming and high-latitude freshening result in a decrease in ocean density over time relative to the deeper ocean, having an effect on surface and deep water mixing. The paper also projects that by 2100, the annual mean stratification of the top 200m will be between 1% and 30% relative to the 1986 to 2005 period, depending on the emission scenario (Bindoff *et al*., 2019). This annual mean stratification was averaged from 1986 to 2005 between 60º South and 60º North (Bindoff *et al*., 2019) in relation to the percentage change in ocean density between surface waters and deeper waters.

7.7.4 Data limitations and assumptions

7.7.4.1 Following stakeholder consultation, a modelling study and a range of reports and datasets have been collated for the purpose of establishing the baseline environment within the Morven South Physical Processes Study Area. All desktop sources are listed under paragraph 7.6.2.1. Additionally, considerable data collection campaigns have been undertaken by the Applicant, including geophysical, metocean and benthic surveys.

7.7.4.2 Although some physical processes are complex and inter-related, there are a considerable amount of data available. There are limitations associated with any modelled datasets analysed in the interpretation of the baseline, for example tidal, wind, wave, salinity, temperature and suspended sediment data, however as far as practicable, the most current and reliable information has been assessed and underpinned by comparison with measured data where available. Limitations in modelled datasets may include uncertainties or inaccuracies within input data, assumptions and approximations within the modelling in representing physical reality and uncertainties within statistical methods used, for example extreme value analysis. Data limitations and tolerances for site specific survey campaigns within the Morven South Boundary are discussed within the relevant reports (Gardline, 2022; Partrac, 2024 and Gardline, 2023).

7.7.4.3 Due to the quantity, coverage and quality of available data covering the Morven South Physical Processes Study Area, it is considered that the data employed are sufficient for the purposes of the assessment of effects presented. Any limitations within the datasets and reports are not considered to have any implications for the conclusions of the assessment.

7.8 Methodology for assessment of effects

7.8.1 Overview

7.8.1.1 The physical processes assessment of effects has followed the methodology set out in Volume 1, Chapter 6: EIA Methodology and followed guidance as listed in Section 7.6.2.

7.8.1.2 In addition, the physical processes assessment of effects has considered the legislative framework as defined by:

- the SMP for Offshore Wind Energy (Scottish Government, 2020);
- the Scottish NMP (Scottish Government, 2015);
- the UK MPS (UK Government, 2011).

7.8.1.3 Numerical modelling has been undertaken to fully assess the potential impacts of all phases of development upon physical processes. This modelling was undertaken to determine the magnitude of the impact to enable the assessment of significance of impacts upon physical processes and included the assessment of tidal flow, wave climate, littoral currents, water column processes, sediment transport and SSCs. The details of the modelling are presented in Volume 3, Annex 7.1: Physical Processes Shared Technical Report.

7.8.2 Assessment criteria

7.8.2.1 The approach for determining the significance of effects is a two-stage process that involves defining the magnitude of the potential impacts and the sensitivity of the receptors. This section describes the criteria applied in this chapter to assign values to the magnitude of potential impacts and the sensitivity of the receptors. The terms used to define magnitude and sensitivity are based on those which are described in further detail in Volume 1, Chapter 6: EIA Methodology.

7.8.2.2 The criteria for defining magnitude in this chapter are outlined in Table 7.9 below.

Table 7.9: Definition of terms relating to the magnitude

Magnitude of impact	Definition
High	Change in physical processes which results in the loss of a marine feature, (e.g. blockage of sediment pathway resulting in loss of bank). Persists for a long-term duration (i.e. more than five years and is irreversible). (Adverse). Change in physical processes which results in the creation of a marine feature, (e.g. change in current regime leading to formation of sandwaves). Persists for a long-term duration (i.e. more than five years and is irreversible). (Beneficial).
Medium	Alteration of physical processes which effects the rate at which a marine feature is maintained (e.g. reduction in accretion rate). Persists for a long-term duration (i.e. more than five years). (Adverse). Alteration of physical processes which effects the rate at which a marine feature is developing (e.g. reduction in erosion rate). Persists for a long-term duration (i.e. more than five years). (Beneficial).
Low	Variation in physical processes which maintains the marine feature (e.g. localised change in sediment pathway which does not destabilise bank). Persists for a medium-term duration (i.e. one to five years).
Negligible	Imperceptible variation in physical process (e.g. in the order of natural variability) and of short-term duration (i.e. less than one year). No observable impact either adverse or beneficial.

7.8.2.3 The criteria for defining sensitivity in this chapter are outlined in Table 7.10 below.

Table 7.10: Definition of terms relating to the sensitivity of the receptor

Value (sensitivity of the receptor)	Description
Very high	Very high importance and rarity, international receptor with no potential or very limited potential for recovery
High	High importance and rarity, international and/or national receptor and limited potential for recovery
Medium	High or medium importance and rarity, regional receptor, and potential for recovery
Low	Low or medium importance and rarity, local receptor and high potential for recovery
Negligible	Very low importance and rarity, local receptor and very high potential for recovery

7.8.2.4 The significance of the effect upon physical processes is determined by correlating the magnitude of the impact and the sensitivity of the receptor. The particular method employed for this assessment is presented in Table 7.11.

7.8.2.5 In cases where a range is suggested for the significance of effect, there remains the possibility that this may span the significance threshold (i.e. the range is given as minor to moderate). In such cases the final significance is based upon the expert's professional judgement as to which outcome delineates the most likely effect, with an explanation as to why this is the case.

7.8.2.6 For the purposes of this assessment:

- a level of effect of moderate or more will be considered a “significant” effect in terms of the EIA Regulations;
- a level of effect of minor or less will be considered “not significant” in terms of the EIA Regulations.

7.8.2.7 Effects of moderate significance or above are therefore considered important in the decision making process, while effects of minor significance or less warrant little, if any, weight in the decision making process.

Table 7.11: Matrix used for the assessment of the significance of the effect

Sensitivity of receptor	Magnitude of impact: Negligible	Low	Medium	High
Negligible	Negligible	Negligible to minor	Negligible to minor	Minor
Low	Negligible to minor	Negligible to minor	Minor	Minor to moderate
Medium	Negligible to minor	Minor	Moderate	Moderate to major
High	Minor	Minor to moderate	Moderate to major	Major
Very high	Minor	Moderate to major	Major	Major

7.9 Parameters for assessment

7.9.1 Maximum Design Scenario

7.9.1.1 The Maximum Design Scenarios (MDSs) identified in Table 7.12 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. These scenarios have been selected from the details provided in Volume 1, Chapter 3: Project Description. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the Project Design Envelope (PDE) (e.g. different infrastructure layout), to that assessed here, be taken forward in the final design scheme.

7.9.1.2 The results of the physical processes study, particularly the numerical modelling output detailed in Volume 3, Annex 7.1: Physical Processes Shared Technical Report, will be used to support and inform the following chapters:

- Volume 2, Chapter 8: Benthic Subtidal Ecology;
- Volume 2, Chapter 9: Fish and Shellfish Ecology;
- Volume 2, Chapter 14: Marine Archaeology;
- Volume 2, Chapter 16: Other Sea Users and Communications;
- Volume 2, Chapter 18: Climate Change.

Table 7.12: Maximum Design Scenario considered for the assessment of potential impacts on physical processes

C= construction, O= O&M, D= decommissioning phases

"✓" is used to denote the phase the potential impact can occur, "✗" outlines there is no impact within this project phase

Potential impact	Phase			Maximum Design Scenario	Justification
	C	O	D		
Increased SSCs and associated deposition	✓	✓	✓	**Construction phase** <u>Site preparation foundations:</u> • Sandwave clearance activities undertaken over an approximate fifteen month duration within the wider five year construction programme. • Wind turbines and OSP foundations: sandwave clearance has been calculated based on the assumption of clearance at up to 80% of locations. Spoil volume per location has been calculated on the basis of 58 locations supporting the three-legged suction bucket wind turbine foundations and 5 locations supporting gravity base OSP foundations. This equates to a total sandwave clearance area for Morven South of 3,753,226m^2 or 11,259,679m^3 based on sandwaves 3m in height. The single greatest sandwave clearance area may occur due to the bridge-linked High Voltage Direct Current (HVDC) converter OSP with gravity base foundations, with a clearance area up to 597,800m^2 or volume of up to 1,793,400m^3. <u>Site preparation cabling:</u> • Inter-array cables: sandwave clearance along 63.0km of cable length, with a base width of 20m, to an average depth of 3m. Total spoil volume of 6,048,000m^3.	**Construction phase** <u>Site preparation foundations and cabling:</u> • The volume of material to be cleared from individual sandwaves will vary according to the local dimensions of the sandwave (height, length, and shape) and the level to which the sandwave must be reduced. These details are not fully known at this stage, however based on the available data from the geophysical survey (Gardline, 2022), it is anticipated that the sandwaves requiring clearance within the Morven South Boundary are likely to be circa 3m in height. • The MDS for sandwave clearance to allow the installation of wind turbines and OSPs and their associated scour protection has been selected in line with standard practice and based on the greatest potential volume of suspended sediments at an individual location, rather than over the Morven South Boundary. Maximum concentrations of suspended sediments within the water column at a particular location during a tidal cycle are considered critical with regards to the maximum potential deposition on the seabed. Note that although sediment plumes from a sandwave clearance operation at an individual foundation may extend and interact with sediment plumes resulting from similar works at an adjacent turbine location, if these operations are undertaken simultaneously, sediment plumes will align with the tidal currents,

Potential impact	Phase			Maximum Design Scenario	Justification
	C	O	D		
				• Interconnector cables: sandwave clearance along 39.6km of cable length, with a base width of 20m, to an average depth of 3m. Total spoil volume of 3,801,600m^3. • Total cabling spoil volume of 9,849,600m^3, which assumes that 15% of total length of inter-array and interconnector cables will require sandwave clearance. • Removal of up to 5km of disused cables.	with SSC rapidly diminishing with increasing distance from the works. Thus, selection of the MDS is based upon maximum concentrations and the maximum potential seabed deposition at any one location. For all scenarios considered, this would be the bridge-linked HVDC converter OSP with gravity base foundations, thus MDS selection has also focused on the maximum potential concentrations at individual wind turbine foundations. On consideration of the total area over the Morven South Boundary as a whole, the selected MDS covers in excess of 80% of the alternative option with the greatest site coverage. • Similarly, the MDS for sandwave clearance to allow for the installation of cables and associated cable protection has been selected in line with standard practice, based on the greatest potential volume of suspended sediments at an individual location. However, as many elements are the same for all scenarios considered under the PDE (sandwave clearance width, proportion of cables requiring clearance, sandwave heights and length of interconnector cables), the selected MDS is thus primarily based upon the scenario with the greatest length of inter-array cabling. Therefore, the selected MDS is also capable of producing the largest sandwave clearance areas and volumes over the Morven South Boundary as a whole. • Site clearance activities may be undertaken using a range of techniques, the suction hopper dredger will result in the greatest increase in suspended sediment and largest plume extent as material is

Potential impact	Phase			Maximum Design Scenario	Justification
	C	O	D		
					released near the water surface during the disposal of material • Boulder clearance activities will result in minimal increases in suspended sediment concentrations and have therefore not been considered in the assessment.
				Foundation installation: • Undertaken over an approximate 21 month duration. • Wind turbines: installation of up to 34 monopiles of 16m diameter, drilled to a depth of 64m at a rate of up to 1.5m/h. Three monopiles installed concurrently. Spoil volume of 14,358m^3 per pile. • OSPs: installation of four High Voltage Alternating Current (HVAC) collector OSPs with foundations consisting of 16m diameter monopiles, drilled to a depth of 64m at a rate of up to 1.5m/h. Two monopiles installed concurrently. Spoil volume of 14,357m^3 per pile. • OSPs: installation of one HVDC converter OSP with six-legged jacket foundations, each with a pile diameter of 5m, drilled to a depth of 80m at a rate of up to 1.45m/h. Three piles installed concurrently. Spoil volume of 1,888m^3 per pile.	Foundation installation: • Installation of foundations via augured (drilled) operations results in the release of the largest volume of sediment. The greatest volume of sediment disturbance by drilling at individual foundation locations and across the Morven South Boundary as a whole is associated with monopiles for wind turbines. The selected OSP scenario represents the greatest volume of sediment to be released for a drilling event. • The greatest drilling rate represents the maximum level of increase in suspended sediment concentration. Maximum drilling rates are similar for all scenarios. • Selected scenario includes allowance for just over half of the wind turbine monopiles to be installed via drilling, based on the scenario of the 67 larger wind turbines (rather than the 95 smaller turbine option in the PDE), which may yield the greatest spoil volumes per pile and thus represents the MDS for this activity.
				Cable installation: • Inter-array cables: Installation via trenching of up to 420km of cable, with a trench width of up to 3m and a depth of up to 3m. Total spoil	Cable installation: • Cable routes inevitably include a variety of seabed material and in some areas 3m depth may not be achieved or may be of a coarser nature which

Potential impact	Phase			Maximum Design Scenario	Justification
	C	O	D		
				• volume of 1,890,000m^3 assuming triangular cross section of the trench. Installed over a period of one year. • Interconnector cables: installation via trenching of up to 264km of cable, with a trench width of up to 3m and a depth of up to 3m. Total spoil volume of 1,188,000m3 assuming triangular cross section of the trench. Installed over a period of one year.	settles in the vicinity of the cable route. The assessment therefore considers the upper bound in terms of suspended sediment and dispersion potential. • Cables may be buried by ploughing, trenching or jetting with trenching or jetting mobilising the greatest volume of material to increase suspended sediment concentrations.
				Operations and maintenance phase Project lifetime of 35-years • Inter-array cables: repair of up 10km of cable in two events every five years. Reburial of up to 17km of cable in a maximum of one event every five years. • Interconnector cables: repair of up to 2km of cable in each of 10 events every 25 years. Reburial of up to 11km of cable in a maximum of one event every five years.	**Operations and maintenance phase** • The greatest foreseeable number of cable reburial and repair events is considered to the MDS for sediment dispersion.
				Decommissioning phase Inter-array and interconnector cables would be removed where it is possible and appropriate to do so. The MDS will assess the removal of all cables.	**Decommissioning phase** • The removal of cables may be undertaken using similar techniques to those employed during installation, therefore the potential increases in SSC and deposition would be in line with the construction phase. • Scour and cable protection are anticipated to remain in-situ.
Impacts to the wave regime due to the	×	✓	×	**Operations and maintenance phase**	**Operations and maintenance phase**

<table>
<tr><th rowspan="2">Potential impact</th><th colspan="3">Phase</th><th rowspan="2">Maximum Design Scenario</th><th rowspan="2">Justification</th></tr>
<tr><th>C</th><th>O</th><th>D</th></tr>
<tr><td>presence of infrastructure</td><td></td><td></td><td></td><td rowspan="3"><u>Foundations</u>
Wind turbines: 95 installations with monopile foundations, each with a 15m diameter with scour protection to a height of 2.5m. Total footprint of 3,578m^2 per wind turbine, including scour protection.
OSPs: four HVAC collector OSP installations with circular footprint gravity base foundations, each with a diameter of 17m at the surface and 67m at the seabed, with a caisson diameter of 51m and with scour protection to a height of 4.0m. Total footprint of 40,471m^2 per OSP.
OSPs: one bridge-linked HVDC converter OSP installation with two rectangular footprint gravity base foundations, each with dimensions of 180x240m at the surface and 195x255m at the seabed and with scour protection to a height of 4.0 m. Total footprint of 74,725m^2 per foundation.
<u>Cabling</u>
Inter-array cables: cable protection along 42.0km of the cable, with a height of up to 3m and up to 10m width. Up to 5 cable crossings, each crossing has a height of up to 4m, a width of up to 36m and a length of up to 80m.
Interconnector cables: cable protection along 26.4km of the cable, with a height of up to 3m and up to 10m width. Up to 5 cable crossings, each crossing has a height of up to 4m, a width of up to 36m and a length of up to 80m.</td><td rowspan="3">Physical processes are comprised of tides, waves and sediment transport and these aspects are integrated (i.e. without the influence of tides and waves there would be no sediment transport) as outlined by the following:
The tidal regime is influenced by changes in bathymetry due to the placement of scour protection and the obstruction of tidal flow due to foundation structures within the water column
The wave climate is influenced by obstruction within the water column however changes in bathymetry would only cause effects in shallow water
The sediment transport regime is affected by obstructions in the sediment transport pathways and also potential changes to the littoral currents which drive this process (i.e. those factors which also affect tide and wave climate)
A holistic approach has therefore been applied to assessing the MDS.

With regard to the wind turbines, the greatest surface blockage to influence wave climate is generally from the monopile foundations, which also provide the largest obstruction to tidal flows over the Morven South Boundary. Three-legged suction bucket foundations have the largest footprint at each wind turbine and within the Morven South Boundary as a whole in terms of scour protection and provide the greatest influence on bathymetry. Monopiles have been selected as the MDS due to the magnitude of the water column obstruction over the Morven South Boundary as a whole, compounded with the largest surface obstruction within the Morven South Boundary.

When considering the OSPs, the greatest in-water column blockage to influence tidal flow and wave climate from the</td></tr>
<tr><td>Impacts to the tidal regime due to the presence of infrastructure</td><td>×</td><td>✓</td><td>×</td></tr>
<tr><td>Impacts to sediment transport and sediment transport pathways due to the presence of infrastructure</td><td>×</td><td>✓</td><td>×</td></tr>
</table>

Potential impact	Phase			Maximum Design Scenario	Justification
	C	O	D		
				The inclusion of five cable crossings within the MDS is a conservative assumption.	HVAC and HVDC OSPs are the gravity base foundations, which also present the largest footprints to affect changes in bathymetry and sediment transport pathways. The gravity base foundations also result in the greatest surface blockage which will predominantly affect wave climate and overall have been selected as the MDS for both HVAC and HVDC OSPs.
Impacts to seasonal stratification due to the presence of infrastructure	×	✓	×	**Operations and maintenance phase** Foundations • Wind turbines: 95 installations with monopile foundations, each with a 15m diameter. • OSPs: four HVAC collector OSP installations with circular footprint gravity base foundations, each with a diameter of 17m at the surface and 67m at the seabed and with a caisson diameter of 51m. • OSPs: one bridge-linked HVDC converter OSP installation with two rectangular footprint gravity base foundations, each with dimensions of 180x240m at the surface and 195x255m at the seabed.	**Operations and maintenance phase** The presence of infrastructure above and below the water line could alter seasonal stratification (e.g. where water density varies by depth), potentially impacting physical features within the Morven South Boundary. Downstream reductions in the wind field and the knock-on effect on waves and tides may alter seasonal stratification, therefore the largest surface obstruction and water column obstruction have the potential to cause the greatest impact to stratification. As per the impacts to waves, tides, sediment transport and sediment transport pathways, the MDS for water column infrastructure has been selected based on a holistic approach, which mirrors those impacts. Cable protection and cable crossings were not included within the assessment of this impact due to their seabed position at the bottom of the water column in deep waters, which negates their potential to impact upon water column mixing and position of the thermocline.

7.10 Designed-in measures and mitigation

7.10.1.1 As part of the project design process, a number of measures (primary and tertiary) have been adopted to reduce the potential for impacts on physical processes (see Table 7.13). For the purposes of the EIA process, the term "designed-in measure" is used to include the following measures (adapted from IEMA, 2016 and IEMA, 2024):

- Measures included as part of the design of Morven South. These include modifications to the location or design of Morven South, which are integrated into the application for consent. These measures are considered standard industry practice for this type of development and are referred to as primary mitigation in IEMA, 2016 and IEMA, 2024.
- Measures required to meet legislative requirements, or actions that are generally standard practice used to manage commonly occurring environmental effects. These measures are secured through the conditions of the marine licences and referred to as tertiary mitigation in IEMA, 2016 and IEMA, 2024.

7.10.1.2 As there is a commitment to implementing these measures, they are considered inherently part of the design of Morven South and have therefore been considered in the assessment presented in Section 7.11 (i.e. the determination of magnitude and therefore significance assumes implementation of these measures).

7.10.1.3 The requirement for any additional mitigation measures is dependent on the significance of the effects on physical processes. Where significant effects have been identified, further mitigation measures (referred to as secondary mitigation in IEMA, 2016 and IEMA, 2024) have been identified to reduce the significance of effect to acceptable levels following the initial assessment. These are measures that could further prevent, reduce and, where possible, offset any adverse effects on the environment. These measures are set out, where relevant, in Section 7.11.

7.10.1.4 All designed-in measures and mitigation are detailed in Volume 3, Annex 6.4: EIA Commitments Register.

Table 7.13: Designed-in (primary and tertiary) measures adopted as part of Morven South

Reference number	Designed-in measures adopted as part of Morven South	Justification	Primary or tertiary
MM-1	Development of and adherence to a Scour Protection Management Plan (SPMP)	There is the potential for scouring of seabed sediments to occur due to interactions between the metocean regime (waves and currents) and foundations or other seabed structures. This scouring can develop into depressions around the structure. The use of scour protection around offshore structures and foundations will be employed, as described in detail in Volume 1, Chapter 3: Project Description. It is therefore likely that any secondary scour effects associated with scour protection would be confined to within a few metres of the direct footprint of that scour protection material, as design criteria for cable protection will ensure this is the case.	Primary

Reference number	Designed-in measures adopted as part of Morven South	Justification	Primary or tertiary
		The presence of scour protection has been included in the modelled scenarios used within the assessment of effects to protect foundations from the effects of scour. The SPMP will set out the approach to scour protection installation and monitoring. This will maximise protection of offshore infrastructure as far as possible during the project lifecycle.	
MM-2	Development of and adherence to a Cable Plan which will include a Cable Burial Risk Assessment (CBRA) and cable burial and protection monitoring throughout the operational phase.	Interactions between the metocean regime (waves and currents) and subsea cables have the potential to disturb seabed sediments, leading to increased SSCs and altering the sediment transport regime. To address this, minimum burial depths and cable protection measures will be implemented around inter-array and interconnector cables. These measures will ensure the cables remain adequately protected throughout the O&M phase of Morven South. A Cable Plan will set out the approach to protection of cables during the project lifecycle. The Cable plan will implement management and monitoring of cable protection (via burial or external protection where adequate burial depth, as identified via risk assessment, is not feasible) with any damage, destruction or decay of cables notified to Maritime and Coastguard Agency, Northern Lighthouse Board, Kingfisher and UK Hydrographic Office no later than 24 hours after discovered. This will reduce the probability of cables becoming unburied and impacting other sea users and marine ecology receptors Cable burial and protection monitoring will be undertaken throughout the operational phase to assess the status of cable burial and any deployed protection. It will include the requirement of minimum burial depths of 0.5m or the use of cable protection around inter-array and interconnector cables and will include a CBRA. Cable protection may be necessary in some locations where sufficient cable burial depth cannot be achieved or where cables become exposed during the lifetime of Morven South.	Primary

Reference number	Designed-in measures adopted as part of Morven South	Justification	Primary or tertiary
		The CBRA will consider relevant activities in the vicinity of inter-array and interconnector cables and confirm appropriate means of protection taking account of the final inter-array and interconnector cable. The CBRA will identify the appropriate target burial depth to ensure the cables remain buried, or appropriately protected, where target burial depths cannot be achieved, for the duration of Morven South, to reduce the risk of cable exposure.	
MM-3	Development and adherence to an Operation and Maintenance Plan (OMP) that will include the requirement for any cable rock protection re-installed during the operations phase to follow industry standard guidelines for slope angle and rock grading	The OMP will provide details of routine inspections which may be required post-construction including of inter-array and interconnector cables to ensure target burial depth is maintained. Routine inspections of cable and scour protection will be detailed, to monitor impact to physical processes and determine if remedial works are required. If secondary scour is identified, remedial works may be undertaken to both mitigate environmental impacts and to provide asset security.	Primary
MM-4	Development of and adherence to a Construction Method Statement	The CMS will ensure that all works are carried out efficiently, safely, and in compliance with environmental and regulatory requirements. The Construction Method Statement will outline the planned approach, procedures, and safety measures for the offshore construction activities.	Primary
MM-20	Installation of infrastructure over or adjacent to existing cables will be subject to crossing or proximity agreements between Morven North and other parties, prior to the start of the construction phase.	To ensure close communication and planning between both parties to ensure disruption of activities is reduced and coexistence is facilitated. This will reduce the likelihood of accumulated sediment plumes from various activities.	Tertiary
MM-23	Development of and adherence to a Decommissioning Programme	As required under Section 105 of the Energy Act 2004 (as amended by the Energy Act 2008 and the Scotland Act 2016). A decommissioning programme will consider best practice at the time of decommissioning.	Tertiary

Reference number	Designed-in measures adopted as part of Morven South	Justification	Primary or tertiary
MM-41	A minimum of 1,000m spacing between wind turbines	Sufficient spacing between wind turbines will mitigate potential wake effects between wind turbines for Morven South.	Primary

7.11 Assessment of significant effects

7.11.1.1 The potential impacts arising from the construction, O&M and decommissioning phases of Morven South are listed in Table 7.12, along with the MDS against which each impact has been assessed.

7.11.1.2 An assessment of the likely significance of the effects of Morven South on physical processes receptors caused by each identified impact is given in Sections 7.11.2 to 7.11.6.

7.11.1.3 Receptors to impacts to physical processes include the undesignated seabed morphology within the Morven South Physical Processes Study Area and the thermocline and position of the tidal front (impacts to seasonal stratification only). There are no designated sites with qualifying features of relevance to physical processes within the Morven South Physical Processes Study Area. Undesignated seabed substrate and seabed features are discussed collectively under seabed morphology, when applicable.

7.11.2 Increased Suspended Sediment Concentrations and associated deposition

7.11.2.1 Increased SSCs and associated deposition may arise due to seabed preparation involving sandwave clearance, the installation of the wind turbines and OSP foundations, the installation and/or maintenance of inter-array and interconnector cables and associated decommissioning activities. This impact is relevant to the construction, O&M, and decommissioning phases of Morven South and may cause direct and indirect impacts to receptors.

7.11.2.2 The following scenarios were assessed:

- site preparation activities – sandwave clearance and dredging to facilitate wind turbine, OSP and cable installation;
- drilled pile installation – across the range of hydrodynamic conditions;
- inter-array/interconnector cable installation (with the same characteristics) – through sandy seabed sediment;
- cable repair and reburial activities;
- decommissioning activities such as cable and foundation removal.

7.11.2.3 Modelling was undertaken related to the MDS as outlined in Table 7.12 with the detail of the assessment provided in Volume 3, Annex 7.1: Physical Processes Shared Technical Report.

Construction phase

<u>Magnitude of impact</u>

7.11.2.4 The preparation of the seabed involves sandwave clearance activities within the Morven South Boundary, which may lead to increased SSCs and associated deposition. The MDS for sandwave clearance was along 63.0km of inter-array cable and 39.6km of interconnector cable, with a base width of 20m, to an average depth of 3m. This equates to a total spoil volume of 6,048,000m^3 and 3,801,600m^3 for the inter-array and interconnector cables respectively, totalling 9,849,600m^3 for all cables across the Morven South Boundary, with 15% of cables requiring sandwave clearance. Preparation activities have also been assumed to include the removal of up to 5km of disused cables. Sandwave clearance may be required at up to 80% of the wind turbine and OSP foundation locations. Spoil volume per location has been calculated on the basis of 58 locations supporting the three-legged suction bucket wind turbine foundations and five locations supporting gravity base OSP foundations. This equates to a total sandwave clearance area of 3,753,226m^2 for Morven South or a volume of 11,259,679m^3 for wind turbine foundations based on sandwaves 3m in height. The MDS was selected based on the greatest potential volume of suspended sediments at an individual sandwave clearance location. The single greatest sandwave clearance area may occur due to the bridge-linked HVDC converter OSP with gravity base foundations, with a clearance area up to 597,800m^2 or volume up to 1,793,400m^3.

7.11.2.5 The installation of infrastructure within the Morven South Boundary may also lead to increased suspended sediment concentrations and associated deposition. The MDS is for the drilled installation of up to 34 wind turbine monopile foundations and four HVAC collector OSPs with monopile foundations, each with a diameter of 16m and drilled to a depth of 64m at a rate of up to 1.5m/h. One additional HVDC converter OSP is included in the MDS installation, with a foundation consisting of six jacket legs, with four 5m piles per leg and drilled to a depth of 80m at a rate of up to 1.45m/h. Up to three piles may be installed concurrently, with a spoil volume per pile up to 14,358m^3 for the monopiles and 1,888m^3 for the jacket leg foundation. For the installation of inter-array cables (420km) and interconnector cables (264km) a trench of up to 3m in width and typical maximum depth 3m, with a triangular cross section may be excavated. This equates to total spoil volumes of 1,890,000m^3 and 1,188,000m^3 for inter-array and interconnector cables respectively for Morven South.

7.11.2.6 Modelling was undertaken for representative areas of sandwave clearance, as detailed under Section 6.2 of Volume 3, Annex 7.1: Physical Processes Shared Technical Report. The modelling undertaken to quantify the potential increases in SSC and sedimentation simulated the use of a suction hopper dredger to remove material from the crest of sandwaves and deposit material in the adjacent area. In practice, plough dredging may be undertaken, however this type of operation would have less impact in terms of both SSC and sedimentation footprint. The bridge-linked HVDC converter OSP with gravity base foundations was selected for modelling based on the potential to release the greatest potential volume of suspended sediments at an individual sandwave clearance foundation location. The modelling assumed a clearance dredging rate of 20,000m^3/h with a spill of 3%, with an average clearance depth of 3m, with sediment being deposited at the north and south of the clearance area. Due to the spill during dredging, a small plume with concentrations less than 210mg/l was present in the foundation sandwave clearance modelling results, however disposal resulted in much higher concentrations of 17,200mg/l at the release site. When resuspension of material occurs following slack tide, concentrations in the order of 500mg/l were shown by the modelling to reach circa 5km from the activity. Average SSCs during the course of the dredge and disposal campaign were seen to be <1mg/l, with the plume envelope limited to within 13km from the source of the activity, and within the Morven South Physical Processes Study Area. SSC would be increased for a limited period in the vicinity of the sandwave clearance activity and would not become widespread throughout the Morven South Boundary. Average sedimentation is focused within circa 200m of the site of release with a maximum depth 0.5m to 2.0m, while the finer sediment fractions are distributed in the vicinity at much smaller depths, circa 5mm to 50mm. The dispersion of the released material would continue on successive tides and be incorporated into the baseline sediment transport regime.

7.11.2.7 Furthermore, two representative interconnector cable clearance operations were modelled across a 20m wide clearance corridor at a rate of 20,000m^3/h for an average clearance depth of 3m, assuming 100% spill rate. Results showed higher SSCs during the dredging operation compared to the sandwave clearance activity for the foundation, due to the assumption that all mobilised sediments may enter the water column with no separate disposal mechanism. SSCs of up to 650mg/l were found in the vicinity of the releases, with narrow plumes (with width circa 200m) of up to 50mg/l extending up to 6.5km in a north northeasterly direction within the Morven South Boundary. Plume widths increased with distance from the activity due to dispersion. The greatest area of increased SSC, extending circa 8km from the releases within the Morven South Boundary is also associated with remobilisation of the deposited material on the subsequent tide with concentrations of up to 400mg/l, but typically in the order of 20mg/l to 50mg/l over greater areas. Average SSC over the campaign were typically <100mg/l. Average sedimentation is seen to be below 20mm depth within the Morven South Boundary, reducing to less than 2mm one day following the cessation of activity and is therefore reversible. Concurrent clearance operations may result in an increased area of sedimentation but is expected to remain within the Morven South Physical Processes Study Area. Elevated SSC and increased sedimentation are expected to be local and limited to the extent of the Morven South Physical Processes Study Area for any selected sandwave clearance activity during the construction stage. Figures 6.9 to 6.11 under Section 6.23 of Volume 3, Annex 7.1: Physical Processes Shared Technical Report present the potential plume lengths and concentrations within the Morven South Boundary, whilst Figures 6.12 and 6.13 present the potential sedimentation.

7.11.2.8 Modelling was also undertaken to examine a range of locations within the Morven South Boundary, with three concurrent drilling operations at adjacent locations. The modelled scenario examined drilling of 16m diameter monopiles, as detailed under Section 6.2 of Volume 3, Annex 7.1: Physical Processes Shared Technical Report. The drilled pile installations are anticipated to generate plumes with average SSCs <0.2mg/l over the campaign at the discharge locations within the Morven South Boundary, decreasing a short distance from the discharge location, to 0.01mg/l within 400m. Instantaneous concentrations on the peak ebb and flood tides are <0.16mg/l within the plume envelope, increasing to circa 1.2mg/l around slack water when the low current speeds prevent dispersion of the sediments. These levels would be localised and only persist for a short period within a few tidal cycles. Some small areas of increased suspended sediment were observed in the modelling, where material has been deposited on slack tides and subsequently re-suspended, however SSCs remain low. Following the cessation of drilling, the turbidity levels will reduce within a few hours as tidal currents reduce. Sedimentation after the cessation of construction is considered reversible as it would not be discernible from the background sediments due to the limited magnitude of deposition and the similar nature of the material.

7.11.2.9 For the inter-array and interconnector cable installation, the SSCs reached are larger than for the pile installation, due to the larger volume of sediment mobilised, with resuspension giving rise to concentrations up to 0.7mg/l in an amalgamated plume. The average sedimentation during the modelled trenching operation is <0.004mm and is greatest at the location of the trenching, reducing rapidly, as shown by the modelling one day following cessation of the activity. Due to the low magnitude of sedimentation, the impact would not be detectible against the baseline.

7.11.2.10 Following the completion of the clearance and installation activities, the turbidity levels are expected to return to baseline within a couple of tidal cycles. It would however be anticipated that spring tides following the works may mobilise and redistribute unconsolidated seabed material deposited at the end of the construction phase; this material will therefore be incorporated into the existing transport regime. Following installation, the native seabed material settles close to where it is mobilised and remains in-situ. This would be expected as the baseline modelling indicated that sediment transport potential is limited across the Morven South Boundary. The sedimentation is concentrated at the area of disturbance, as material effectively returns to the site from where it was disturbed.

7.11.2.11 The impact is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the undesignated seabed within the Morven South Physical Processes Study Area directly. The magnitude is therefore considered to be low.

<u>Sensitivity of the receptor</u>

7.11.2.12 Undesignated, low value seabed morphology within the Morven South Physical Processes Study Area may be impacted upon by changes in SSC and associated deposition. This includes a number of seabed features (tunnel valleys, moraines and channels) which lie within the Morven South Physical Processes Study Area. As discussed within Section 7.7.1 and in more detail in Section 4.2 of Volume 3, Annex 7.1: Physical Processes Shared Technical Report, the seabed is located in deep waters with depths between 64m to 76m LAT. The dominant, sandy substrate is generally considered to be recoverable after some time due to the low sediment transport rates in the area and any sedimentation would be comprised of native material. The low sediment transport rates will ensure any disturbed material would be deposited close by, after a short period of suspension, thus not impacting significantly on seabed morphology. There are no designated sites within the Morven South Physical Processes Study Area.

7.11.2.13 Undesignated seabed morphology within the Morven South Physical Processes Study Area is deemed to be of low vulnerability, low recoverability and low value. The sensitivity of the receptor is therefore, considered to be low.

Significance of the effect

7.11.2.14 Average SSCs during the course of the dredge and disposal campaign for the foundation sandwave clearance activity were seen to be <1mg/l, with the plume envelope limited to within 13km from the source of the activity, and within the Morven South Physical Processes Study Area. Disposal operations resulted in SSCs up to 17,200mg/l at the release site. Average sedimentation is circa 0.5m to 2.0m within 200m of the activity.

7.11.2.15 During the installation of the wind turbine and OSP foundations within the Morven South Boundary, the sediment plumes are <0.2mg/l and do not persist or result in discernible sedimentation. Sediment plumes associated with the inter-array and interconnector cable installation have concentrations up to 0.7mg/l.

7.11.2.16 The structure of the offshore seabed sandy substrate within the Morven South Physical Processes Study Area would remain unchanged as the deposition is of native material and the supporting hydrodynamic processes are not altered by the minimal level of bathymetric change as a result of the construction phase sediment releases. Similarly, seabed features would remain stable and supporting hydrodynamics processes.

7.11.2.17 Overall, for undesignated seabed morphology, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the very localised and intermittent nature of the impact across the Morven South Boundary, with a very limited area of seabed potentially being impacted at any one time compared to the area of the Morven South Boundary as a whole.

Secondary mitigation and residual effect

7.11.2.18 No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13), is not significant in EIA terms.

Operations and maintenance phase

Magnitude of impact

7.11.2.19 O&M activities within the Morven South Boundary may lead to increases in SSC and associated sediment deposition.

7.11.2.20 The MDS is for up to 10km inter-array cable repair (two events every five years) and a reburial event of up to 17km (maximum once every five years). The MDS includes repair of up to 2km of interconnector cable per event (10 events every 25 years) and reburial of up to 11km of interconnector cable in a maximum of one event every five years. This will involve similar methods as those for cable installation activities (i.e. trenching/jetting, with trench width up to 3m and trench depth up to 3m).

7.11.2.21 In each case the length of the repair or reburial activity may be up to 17km; therefore, the magnitude of the impacts would be a fraction of those for the construction phase, with events being undertaken over the duration of the 35 year project lifetime. The sediment plumes and sedimentation footprints would be dependent on which section of the cables is being repaired however the entire length has been quantified under the construction phase scenario discussed under paragraphs 7.11.2.4 to 7.11.2.11.

7.11.2.22 In relation to any potential secondary scouring arising in the vicinity of scour protection or cable protection, the potential increase in SSCs would be significantly less than impacts arising during construction. As outlined in the SPMP, post-construction routine inspections will be undertaken and if secondary scour is identified, remedial works may be undertaken to mitigate environmental impacts.

7.11.2.23 The impact is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the undesignated seabed within the Morven South Physical Processes Study Area directly to a much lesser degree than the construction phase. The magnitude is therefore considered to be negligible.

<u>Sensitivity of the receptor</u>

7.11.2.24 The sensitivity of the receptor to changes in SSCs and sedimentation remains the same as for the construction phase.

7.11.2.25 Undesignated seabed morphology within the Morven South Physical Processes Study Area is deemed to be of low vulnerability, low recoverability and low value. The sensitivity of the receptor is therefore, considered to be low.

<u>Significance of the effect</u>

7.11.2.26 The significance of the effects would be reduced from the construction phase, as the works are limited to intermittent, discrete repair activities.

7.11.2.27 Overall, for undesignated seabed morphology, the magnitude of the impact is deemed to be negligible and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the very localised and intermittent nature of the impact across the Morven South Boundary, with a very limited area of seabed potentially being impacted at any one time compared to the area of the Morven South Boundary as a whole.

<u>Secondary mitigation and residual effect</u>

7.11.2.28 No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13), is not significant in EIA terms.

Decommissioning phase

7.11.2.29 The MDS for the decommissioning phase (Table 7.12) includes the removal of all inter-array and interconnector cables where practicable, with scour and cable protection remaining in-situ.

<u>Magnitude of impact</u>

7.11.2.30 During decommissioning, increases in SSCs and the potential impact on the physical features would be of lesser magnitude than the construction phase with scour and cable protection remaining in-situ. In the case of piled foundations, there is no significant disturbance of the seabed during decommissioning as piles would be cut off. SSCs would increase temporarily if suction caissons were removed using overpressure to release. Decommissioning of gravity bases would involve the removal of ballast, which may release sediment into the water column. As per the MDS table, increases in SSC due to the removal of inter-array and interconnector cables would be similar to those experienced during the construction phase, as retrieval would be undertaken using similar techniques to installation. The increase in suspended sediments and the potential impacts on physical features may persist during decommissioning, however they are temporary and localised in nature. Following decommissioning, changes in SSCs and sedimentation would return to baseline levels.

7.11.2.31 The impact is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the undesignated seabed within the Morven South Physical Processes Study Area directly to a much lesser degree than the construction phase due to some activities such as drilling and sandwave clearance not being included in the MDS. The magnitude is therefore considered to be negligible.

Sensitivity of the receptor

7.11.2.32 As with the construction phase, in response to sedimentation which has been identified as localised and composed of native material, the structure and function of the seabed substrate and features is of low vulnerability and recoverable.

7.11.2.33 Undesignated seabed morphology within the Morven South Physical Processes Study Area is deemed to be of low vulnerability, low recoverability and low value. The sensitivity of the receptor is therefore, considered to be low.

Significance of the effect

7.11.2.34 Overall, for undesignated seabed morphology, the magnitude of the impact is deemed to be negligible and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the very localised nature of the impact across the Morven South Boundary at any one time, with a very limited area of seabed potentially being impacted compared to the area of the Morven South Boundary as a whole.

Secondary mitigation and residual effect

7.11.2.35 No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13), is not significant in EIA terms.

7.11.3 Impacts to the wave regime due to the presence of infrastructure

7.11.3.1 The presence of infrastructure in the water column, such as wind turbine and OSP foundations, may lead to changes to the wave regime and could potentially impact physical features and physical processes receptors, during the O&M phase of Morven South. Modelling was undertaken using the MDS as outlined in Table 7.12, including the presence of scour protection as outlined in the Project Description (Volume 1, Chapter 3: Project Description). The detail of the numerical modelling underpinning the assessment is provided in Section 5 of Volume 3, Annex 7.1: Physical Processes Shared Technical Report. The magnitude of the impact is detailed in this section along with the assessment of the effect of changes to physical processes on relevant receptors.

Operations and maintenance phase

Magnitude of impact

7.11.3.2 Changes may occur in the wave regime due to the introduction of Morven South infrastructure during the O&M phase. The MDS in terms of hydrographic impacts is for up to 95 wind turbines with monopile foundations, each with a 15m diameter with scour protection to a height of 2.5m and a total footprint of 3,578m^2 per wind turbine. Additionally, the MDS includes four HVAC collector OSP installations with circular footprint gravity base foundations, each with a diameter of 17m at the surface and 67m at the seabed, with a caisson diameter of 51m and with scour protection to a height of 4.0m. The total footprint is 40,471m^2 per HVAC collector OSP installation. The MDS includes for a maximum of one bridge-linked HVDC converter OSP installation supported by two rectangular footprint gravity base foundations, with dimensions of 180x240m at the surface and 195x255m at the seabed and with scour protection to a height of 4.0m. The total footprint per foundation is

74,725m^2, or 149450m^2 per bridge-linked HVDC converter OSP installation. Cable protection will only be used where burial cannot be achieved, however, the MDS includes inter-array cable protection along 42.0km of the cable, and interconnector cable protection along 26.4km of the cable, with a height of up to 3m and up to 10m width. Within the MDS, the inclusion of a contingency of up to 5 cable crossings for the inter-array cables and 5 cable crossings for the interconnector cables is a conservative assumption, as it is unlikely there would be any crossings in reality. Each cable crossing is assumed to have a height of up to 4m, a width of up to 36m and a length of up to 80m. The modelled scenario presented in Volume 3, Annex 7.1: Physical Processes Shared Technical Report, used a representative wind turbine and OSP arrangement within the modelled scenario.

7.11.3.3 Examination of a 1 in 1 year storm from the southerly sector (of greatest influence of approaching storms) shows the deflection of waves by the structures result in a reduction in the lee and increases where the waves had been deflected either side of each structure. Increases in the wave height were in the order of up to 0.2m and decreases up to 0.8m in the vicinity of the bridge-linked HVDC converter OSP gravity base foundations, equating to 14% of the baseline significant wave height. Notably smaller changes to the wave climate are incurred by the HVAC collector OSP gravity base foundations and wind turbine foundations.

7.11.3.4 For a 1 in 20 year southerly storm event, the pattern is similar, with increases in significant wave height at the structures is up to circa 0.2m and decreases up to 0.9m in the lee of the bridge-linked HVDC converter OSP gravity base foundations. Due to the larger baseline associated with the return period compared to the 1 in 1 year storm, the overall impact on the wave climate is less pronounced, equating to 12% of the baseline significant wave height.

7.11.3.5 The wave regime is highly variable due to meteorological conditions, with the scale of the impact being well within the natural variation. The changes to wave climate would be reversible on decommissioning (i.e. following removal of the infrastructure).

7.11.3.6 The impact is predicted to be of local spatial extent, long-term duration, continuous and high reversibility, in the event of infrastructure being removed. It is predicted that the impact will affect the undesignated seabed within the Morven South Physical Processes Study Area directly and indirectly. The magnitude is therefore considered to be low.

Sensitivity of the receptor

7.11.3.7 Undesignated, low value seabed morphology within the Morven South Physical Processes Study Area may be impacted upon by changes in the wave regime. This includes a number of seabed features (tunnel valleys, moraines and channels) which lie within the Morven South Physical Processes Study Area. The seabed is located in deep waters and is considered to be of low vulnerability to changes in the wave regime, recoverable after some time. There are no designated sites within the Morven South Physical Processes Study Area.

7.11.3.8 Undesignated seabed morphology within the Morven South Physical Processes Study Area is deemed to be of low vulnerability, low recoverability and low value. The sensitivity of the receptor is therefore, considered to be low.

Significance of the effect

7.11.3.9 Due to the presence of the infrastructure, the wave climate reduces in the lee of the foundations by less than 10% of baseline significant wave height increasing either side of the wind turbine for a 1 in 1 year storm. Changes are concentrated on the specific locations of the foundations and are not widespread. Offshore bank morphology or sediment composition would not be influenced by changes of this magnitude.

7.11.3.10 Overall, for undesignated seabed morphology, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the limited impact to the seabed due to a change in wave climate in the deepwater location of Morven South.

Secondary mitigation and residual effect

7.11.3.11 No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13), is not significant in EIA terms.

7.11.4 Impacts to the tidal regime due to the presence of infrastructure

7.11.4.1 The presence of infrastructure in the water column may lead to changes to the tidal regime, principally during the O&M phase of Morven South. Modelling was undertaken using the MDS as outlined in Table 7.12 including the presence of scour protection as outlined in Volume 1, Chapter 3: Project Description. The detail of the numerical modelling underpinning the assessment is provided in Section 5 of Volume 3, Annex 7.1: Physical Processes Shared Technical Report. The magnitude of the impact is detailed in this section along with the assessment of the effect of changes to physical processes on relevant receptors.

Operations and maintenance phase

Magnitude of impact

7.11.4.2 The presence of infrastructure within the Morven South Boundary may lead to changes in tidal regime during the O&M phase of Morven South. The MDS in terms of hydrographic impacts is the same as outlined under wave impacts in Section 7.11.3. The modelling is presented in Volume 3, Annex 7.1: Physical Processes Shared Technical Report.

7.11.4.3 The results of the modelling indicated that peak tidal flows are redirected in the immediate proximity of the bridge-linked HVDC converter OSP gravity base foundations by a maximum variation of 0.3m/s, which constitutes circa 55% of peak baseline flow, however this reduces significantly with distance from the structures, reducing to less than 0.01m/s within 3km (less than 2% of baseline current speeds). These changes are limited to the Morven South Physical Processes Study Area which may have a direct impact on the hydrodynamic regime and persist for the entire lifecycle of Morven South. However, they would be imperceptible beyond the immediate vicinity of the Morven South Boundary and would be reversible on decommissioning. The limited nature of these changes would not influence the tidal regime which underpins offshore bank morphology. The tidal wakes produced by the four circular HVAC collector OSP gravity base foundations and 95 monopile wind turbine foundations are seen to increase and decrease the current speeds by a notably lesser amount than the bridge-linked HVDC converter OSP gravity base foundations, due to their size and obstruction within the water column.

7.11.4.4 The hydrodynamic regime is highly variable through tidal cycles and due to meteorological conditions, with the scale of the impact being well within the natural variation. The changes to tidal currents, are insignificant in terms of the hydrodynamic regime. Impacts on tidal current would be reversible on decommissioning (i.e. following removal of the infrastructure).

7.11.4.5 The impact is predicted to be of local spatial extent, long-term duration, continuous and high reversibility, in the event of infrastructure being removed. It is predicted that the impact will affect the undesignated seabed within the Morven South Physical Processes Study Area directly and indirectly. The magnitude is therefore considered to be low.

Sensitivity of the receptor

7.11.4.6 Undesignated, low value seabed morphology within the Morven South Physical Processes Study Area may be impacted upon by changes in the tidal regime. This includes a number of seabed features (tunnel valleys, moraines and channels) which lie within the Morven South Physical Processes Study Area. The seabed is considered to be of low vulnerability to changes in the tidal regime and would be recoverable after some time. There are no designated sites within the Morven South Physical Processes Study Area.

7.11.4.7 Undesignated seabed morphology within the Morven South Physical Processes Study Area is deemed to be of low vulnerability, low recoverability and low value. The sensitivity of the receptor is therefore, considered to be low.

Significance of the effect

7.11.4.8 Changes in tidal velocity due to Morven South are predominantly limited to the vicinity of the wind turbine and OSP foundations, reaching a maximum of 0.3m/s and reducing significantly with distance from the structures. Changes are limited to <0.01m/s within 3km (less than 2% of baseline current speeds). Offshore bank morphology or sediment composition would not be influenced by changes of this magnitude.

7.11.4.9 Overall, for undesignated seabed morphology, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the localised scale of the changes within the Morven South Boundary, with the majority of the area subject to changes of less than 0.001m/s.

Secondary mitigation and residual effect

7.11.4.10 No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13), is not significant in EIA terms.

7.11.5 Impacts to sediment transport and sediment transport pathways due to the presence of infrastructure

7.11.5.1 During the O&M phase the presence of infrastructure in the water column may alter the sediment transport and sediment transport pathways leading to changes within the Morven South Physical Processes Study Area. Modelling was undertaken using the MDS as outlined in Table 7.13 including the presence of scour protection as outlined in Volume 1, Chapter 3: Project Description. The detail of the numerical modelling underpinning the assessment is provided in Section 5 of Volume 3, Annex 7.1: Physical Processes Shared Technical Report. The magnitude of the impact is detailed in this section along with the assessment of the effect of changes to physical processes on relevant receptors.

Operations and maintenance phase

Magnitude of impact

7.11.5.2 Due to the presence of infrastructure during the O&M phase, changes may occur in the sediment transport and sediment transport pathways within the Morven South Boundary. The MDS in terms of impacts to sediment transport and sediment transport processes is the same as outlined under wave impacts in Section 7.11.3. The modelling is presented in Volume 3, Annex 7.1: Physical Processes Shared Technical Report.

7.11.5.3 Sediment transport is driven by a combination of tidal currents and wave conditions, the magnitude of these has been individually quantified as described in Sections 7.11.3 and 7.11.4. For a 1 in 1 year storm from 000° during the flood tide the wave climate is in concert with tidal flow reducing the tidal flow on the lee side of structures further. However, during the ebb flow, the wave climate and tidal flow are in opposition reducing the magnitude of the littoral current. With the presence of infrastructure, wave climate causes a small reduction in the magnitude of flow while there is little difference between the magnitude of littoral current flow and the tidal flows. During the 1 in 1 year storm from 000°, the bridge-linked HVDC converter OSP gravity base foundations have incurred changes of up to circa 60% (0.3m/s) of the baseline littoral currents in the vicinity of the foundations, however this is reduced to zero by circa 6km from the structures and is therefore confined to the Morven South Physical Processes Study Area. Note that changes of this magnitude occur over a very limited extent of the Morven South Boundary, with changes due to the wind turbine foundations and HVAC collector OSP generally ranging from 0.002m/s to 0.03m/s (up to circa 7% of baseline) across the Morven South Boundary.

7.11.5.4 Residual currents are effectively the driver of sediment transport and therefore any changes to residual currents would have a direct impact on sediment transport which would persist for the lifecycle of Morven South. However, if the presence of the foundation structures does not have a significant influence on either tide or wave conditions (see impact assessments presented in Sections 7.11.3 and 7.11.4 for changes in tidal and wave regime) they cannot therefore have a significant effect on the sediment transport regime. For completeness, the residual current and sediment transport was simulated with the foundations, cable protection and scour protection in place.

7.11.5.5 The maximum change in residual current and sediment transport is up to circa 0.10m/s and 0.80m^3/d/m respectively within close proximity to the bridge-linked HVDC converter OSP gravity base foundations. Changes in the residual current and sediment transport reduce with increasing distance from the wind turbine and OSP foundations towards baseline levels and are not widespread. Within circa 4km, sediment transport load has reduced to circa 0.01m^3/d/m, which is circa 5% of the 1 in 1 year storm baseline values. The remainder of the proposed infrastructure within the Morven South Boundary is observed to have a much smaller impact on residual currents and sediment transport, with the maximum change in residual current and sediment transport up to circa 0.02m/s and 0.35m^3/d/m respectively at the wind turbine foundations, with sediment load reaching baseline values within 2km. Within the Morven South Boundary, the majority of the area is limited to changes of less than 0.003m/s in residual current speed or less than 0.05m^3/d/m of sediment load.

7.11.5.6 It is also important to note, that although percentage changes observed may be large, the baseline sediment transport rates are low (up to circa 0.15m^3/d/m in the vicinity of the Morven South bridge-linked HVDC converter OSP gravity base foundations), thus even a perceived small change in magnitude may form a large percentage of baseline values. Structures located within the water column will have a direct impact on sediment transport at the location in which they are installed, by acting as a physical barrier to sediment transport in that location, where previously sediment transport was able to take place. Therefore, it is important to contextualise this impact within the wider sediment transport regime. It is noted that areas of reduced residual current and sediment transport are often accompanied by a similar increase in close proximity. This indicates that the residual current and resulting sediment transport paths are adjusted to accommodate the structures rather than transport pathways being cut off and the overall regime being affected.

7.11.5.7 The hydrodynamic regime is highly variable through tidal cycles and due to meteorological conditions, with the scale of the impact being well within the natural variation. The changes to tidal currents, wave climate, littoral currents, and sediment transport are insignificant in terms of the hydrodynamic regime and would not alter offshore bank morphological processes. Effects on tidal current and wave climate and hence the sediment transport regime, would be reversible on decommissioning.

7.11.5.8 In addition to wind turbine and OSP foundations, scour protection and cable protection, interactions between the metocean regime (waves and currents) and subsea cables have the potential to disturb seabed sediments, leading to changes in sediment transport pathways and the sediment transport regime. To address this, there is a commitment for minimum burial depths of 0.5m for inter-array and interconnector cables (or the use of cable protection where the minimum burial depths cannot be achieved). Routine inspections (as scheduled in the OMP) will be undertaken at regular intervals to ensure cables remain buried at the target burial depth and are not exposed, and hence not impacting on the sediment transport regime. Refer to Section 7.10 for designed-in measures and mitigation relevant to physical processes.

7.11.5.9 The use of scour protection around offshore foundations or cables (as represented in the modelling) will be employed to reduce the potential for scouring of seabed sediments to occur due to interactions between the metocean regime and seabed infrastructure. Scour is the result of net sediment removal over time due to the complex 3D interaction between the structure and ambient flows (currents and/or waves). Such interactions may result in locally accelerated mean flow and locally elevated turbulence levels that also locally enhance sediment transport potential. Without scour protection, scour holes would continue to deepen and widen until equilibrium scour depth is reached, which eventually accommodates and dissipates the increased flow velocities and near-bed vortices and thus becomes part of the seabed morphology.

7.11.5.10 The CaP will detail the likely extent of any potential scour around cabling and aim to mitigate this through site specific detailed design of cable protection measures. It is therefore likely that any secondary scour effects associated with cable protection would be confined to within a few metres of the direct footprint of that scour protection material, as design criteria for cable protection will ensure this is the case. It has been determined by Sinclair, *et al*., 2023 that generally these effects act on a very small scale around the cable and they are unlikely to have wider implications for the benthic environment [and ultimately the seabed substrate] around the inter-array and interconnector cables.

7.11.5.11 Similarly, the volume and extent of foundation scour protection undertaken will be based on conservative values and include contingencies, and will be dependent on the foundation type, geometry and location, so as to reduce as far as practical the occurrence of scour. Any impacts would therefore only relate to secondary scour which would be very localised and of negligible magnitude; typically confined to within a few metres of the direct footprint of that scour protection material.

7.11.5.12 Post-construction routine inspections will be undertaken and if secondary scour is identified, remedial works may be undertaken to mitigate environmental impacts, as will be outlined in the OMP which will be produced post-consent.

7.11.5.13 The impact is predicted to be of local spatial extent, long-term duration, continuous and high reversibility, in the event of infrastructure being removed. It is predicted that the impact will affect the undesignated seabed within the Morven South Physical Processes Study Area directly and indirectly. The magnitude is therefore considered to be low.

<u>Sensitivity of the receptor</u>

7.11.5.14 Undesignated, low value seabed morphology within the Morven South Physical Processes Study Area may be impacted upon by changes in the sediment transport regime. This includes a number of seabed features (tunnel valleys, moraines and channels) which lie within the Morven South Physical Processes Study Area. The seabed is considered to be of low vulnerability to changes in the sediment transport regime and would be recoverable after some time. There are no designated sites within the Morven South Physical Processes Study Area.

7.11.5.15 Undesignated seabed morphology within the Morven South Physical Processes Study Area is deemed to be of low vulnerability, low recoverability and low value. The sensitivity of the receptor is therefore, considered to be low.

<u>Significance of the effect</u>

7.11.5.16 Offshore bank morphology or sediment composition would not be influenced by changes to sediment transport of this magnitude due to the presence of the infrastructure.

7.11.5.17 Overall, for undesignated seabed morphology, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the localised scale of the changes within the Morven South Boundary, with the majority of the area subject to changes in sediment transport of less than $0.05m^3/d/m$.

Secondary mitigation and residual effect

7.11.5.18 No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13), is not significant in EIA terms.

7.11.6 Impacts to seasonal stratification due to the presence of infrastructure

7.11.6.1 The presence of infrastructure above and below the water line could alter seasonal stratification (e.g. where water density varies by depth), principally during the O&M phase of Morven South. Downstream reductions in the wind field and the knock-on effect on waves and tides may alter seasonal stratification, therefore the largest surface obstruction and water column obstruction have the potential to cause the greatest impact to stratification.

7.11.6.2 Modelling was undertaken using the MDS as outlined in Table 7.12, with the detail provided in Section 5.2.4 of Volume 3, Annex 7.1: Physical Processes Shared Technical Report. The magnitude of the impact is detailed in this section along with the assessment of the effect of changes to physical processes on relevant receptors.

Operations and maintenance phase

Magnitude of impact

7.11.6.3 The presence of infrastructure within the Morven South Boundary may lead to changes to water column structure during the O&M phase of Morven South. The MDS in terms of hydrographic impacts is for up to 95 wind turbines with monopile foundations, each with a 15m diameter. Additionally, the MDS includes four HVAC collector OSP installations with circular footprint gravity base foundations, each with a diameter of 17m at the surface and 67m at the seabed and with a caisson diameter of 51m. The MDS includes for a maximum of one bridge-linked HVDC converter OSP installation supported by two rectangular footprint gravity base foundations, with dimensions of 180x240m at the surface and 195x255m at the seabed. The modelled scenarios presented in Volume 3, Annex 7.1: Physical Processes Shared Technical Report, used a representative wind turbine and OSP arrangement within the modelled scenarios.

7.11.6.4 As per the modelling for waves, tides and sediment transport, baseline and post-construction simulations were undertaken to establish the change in salinity and temperature due to Morven North. These simulations were undertaken for a period representative of the onset of stratification in spring and peak stratification in late summer, when the thermocline differs in strength and position. Details of this modelling are provided in Section 5.2.4 of Volume 3, Annex 7.1: Physical Processes Shared Technical Report.

7.11.6.5 The results of the modelling indicated that temperature is the dominant and most critical factor for stratification within the Morven South Boundary, with the largest temperature differences attributed to the OSP structures due to the size of the obstruction within the water column. At the onset of stratification, a small increase in temperature was observed in the modelling at the surface layer, which was largely countered by a small increase in temperatures, as the warmer surface temperatures are seen to disperse through the water column. The mixing was seen to penetrate the thermocline, but did not persist through the remainder of the water column to the seabed. Although mixing was evident in the simulations, changes in temperatures due to the infrastructure were less than 0.22% of baseline values following a spring neap cycle, with a stratified water column remaining at the end of this period. Note these results relate to the one bridge-linked HVDC converter OSP, and other infrastructure would have a much lesser impact across the Morven South Boundary. Thus, the infrastructure of Morven South is not seen to delay the onset of stratification during a typical year, however, may cause minimal differences to approximately the upper half of the water column. The maximum change in salinity was circa 0.0024% of baseline values.

7.11.6.6 During peak stratification, modelling suggests a more notable change in temperature due to Morven South than during the onset of stratification. Following a spring neap cycle, temperature changes reached up to circa 2.7% of baseline values, with a reduction in surface water temperatures and increase in temperatures through the water column due to vertical mixing, penetrating deeper than during the onset of stratification. However, the extent of changes of this magnitude remain within the Morven South Physical Processes Study Area. Note that the change in temperature due to the infrastructure (a maximum of circa 0.3°C increase in the mid layers, with a decrease in the surface layers) is significantly less than the background temperature difference between the stratified layers, and thus a potential change of this magnitude would not breakdown stratification by allowing the water column to become fully mixed. The position of the thermocline is also unlikely to be significantly impacted, as evidenced by the results of the modelling. The maximum change in salinity was circa 0.0086% of baseline values.

7.11.6.7 In summary, potential changes to seasonal stratification due to Morven South are limited, with the largest percentage temperature changes from baseline occurring during the peak summer stratification period when the potential energy anomaly is at its greatest. The potential energy anomaly in the peak summer period would require more energy to fully mix the water column, in comparison to the lower energy required to potentially break up stratification at its onset. It is anticipated that there would be no notable impact on the position of the thermocline or breakdown in seasonal stratification due to the infrastructure, although there may be marginally more mixing within the water column. To provide context to these changes, it is noted that in terms of water column obstruction within the Morven South Boundary, which has an area of 347.64km^2, the infrastructure may cover 0.04% of the Morven South Boundary at a maximum. It is thus anticipated that there would be an inconsequential effect on the overall pattern of seasonal stratification within the Morven South Physical Processes Study Area. Changes to temperature are shown to be less than 0.02°C over the majority of the Morven South Boundary.

7.11.6.8 It is noted that in addition to the impact to seasonal stratification due to the physical obstruction within the water column, a further impact may arise due to downstream reductions in the wind field and the knock-on effect on waves and tides. Recent studies, as outlined in paragraphs 5.2.4.22 to 5.2.4.25 of Volume 3, Annex 7.1: Physical Processes Shared Technical Report, determined that reduction in downstream wind speeds due to offshore wind turbines may reach close to 10% at 10m above MSL, depending on the size and scale of the infrastructure. The same reduction was assumed for Morven South, although designed-in measures such as wind turbine spacing will in reality likely yield a lesser reduction at this altitude, and even less at the water surface, where it may have an impact on stratification. Furthermore, as noted in paragraph 5.2.4.23 of Volume 3, Annex 7.1: Physical Processes Shared Technical Report, when unstable meteorological conditions are present, which accounts for most weather situations, wind turbine wakes are typically localised within the offshore wind farm.

7.11.6.9 Studies in the North Sea have shown wind speed reductions at the surface due to these wakes in the order of 0.1m/s to 0.5m/s, depending on a range of factors including but not limited to the season and density of wind turbines (Akhtar *et al*., 2021; Christiansen *et al*., 2022). Christiansen *et al*. (2022) noted that "as a result of constantly changing wind directions, pronounced wake patterns disappear when averaging over time". The limited reduction in wind speed due to the presence of the infrastructure is not considered to have a marked effect on waves and currents within the Morven South Boundary, which are predominantly determined from other factors, such as swell and the large scale tidal regime.

7.11.6.10 In conclusion, when holistically assessing the potential impact on seasonal stratification, any reduction to stratification due to the presence of Morven South within the water column, may also be countered by any potential increase to stratification caused by a decrease in wind speeds, as the two impacts would likely have opposing, though not equal, effects. Furthermore, any increase in seasonal stratification due to climate change, as evident from a recent IPCC Special Report (Bindoff *et al*., 2019), may counteract the stratification reduction due to water column infrastructure, although it is recognised that there is uncertainty in how these two opposing effects may interact.

7.11.6.11 The impact is predicted to be of local spatial extent, long-term duration, intermittent and high reversibility, in the event of infrastructure being removed. It is predicted that the impact will affect the receptors within the Morven South Physical Processes Study Area indirectly. The magnitude is therefore considered to be low.

Sensitivity of the receptor

7.11.6.12 The receptors associated with changes to seasonal stratification due to the presence of infrastructure are considered to be the thermocline and the position of the tidal front in the Morven South Physical Processes Study Area. The baseline SSW-RS data presented and discussed in Section 5.2.4 of Volume 3, Annex 7.1: Physical Processes Shared Technical Report, shows the onset of stratification in spring with a weak and shallow thermocline, strengthening and changing position within the water column as it progresses to peak stratification in summer, before becoming fully mixed during the autumn period. Within the Morven South Boundary, the maximum stratification is shown to occur in the south with differences between near-surface and near-bed temperatures up to 4.62°C, with the least stratified area in the north with a temperature difference of 3.73°C.

7.11.6.13 Frontal positions are predominantly controlled by tidal mixing, however changes in mixing and the potential energy anomaly due to Morven South are limited and would not be of the scale to affect the onset, peak or decay of seasonal stratification. The position of the front between the seasonally stratified area and the fully mixed area, lies to the west of the Morven South Boundary. Any changes to seasonal stratification would be fully recoverable by the removal of the infrastructure. As a physical processes receptor, the thermocline and position of the tidal front are of medium value.

7.11.6.14 The thermocline and tidal frontal position are deemed to be of low vulnerability, high recoverability and medium value. The sensitivity of the receptor is therefore, considered to be low.

Significance of the effect

7.11.6.15 Previous studies and offshore wind developments in the North Sea (Dudgeon, 2009; Arcus, 2012; Repsol and EDP Renewables, 2013; MORL, 2014) have demonstrated no significant impacts on waves and tides, with negligible effects to stratification fronts, as a result of the presence of offshore wind infrastructure. A study by Carpenter *et al*. (2016) concluded that there is expected to be very little impact on large scale stratification at the current offshore wind farm capacity in the North Sea, however it is recognised that further research is required on the impact on large scale stratification due to the increase in leased capacity in the North Sea.

7.11.6.16 Due to the scale of Morven South and the designed-in measure of sufficient spacing between wind turbines, the effect would be insignificant in terms of the impact on waves and tides over Morven South as a whole and will not be expected to change the wave or tidal regime in the Morven South Physical Processes Study Area. Therefore, there is unlikely to be any knock-on impact to stratification from these pathways. It is likely that any disruption to the thermocline would occur towards the onset or decay of stratification, when the thermocline is at its weakest and located towards the water column surface and when the potential energy anomaly is less, however vertical mixing is likely to be confined to a short distance from the wind turbine foundations due to the low current speeds in the area. (For further detail, refer to Section 5.2.4: Volume 3, Annex 7.1: Physical Processes Shared Technical Report).

7.11.6.17 With regard to wind effects on seasonal stratification, a reduction in wind wake which occurs primarily at hub height is anticipated to have very limited effect on stratification though the water column. Any increase in stratification due to a reduction in wind speed would have an opposing effect to any potential reduction in stratification due to the presence of infrastructure within the water column. Any changes to seasonal stratification are considered to be highly localised and will not result in wide scale changes to the tidal front.

7.11.6.18 Overall, for the thermocline and tidal front, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms. Minor has been determined due to the limited evidence and understanding that still remains concerning this impact, and the use of high level modelling to support the assessment.

Secondary mitigation and residual effect

7.11.6.19 No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13), is not significant in EIA terms.

7.11.7 Proposed monitoring

7.11.7.1 Site-specific monitoring is not proposed because the assessment concluded that Morven North would not give rise to significant effects on physical processes, either alone or when considered cumulatively with other plans, projects, or activities. The Applicant will, however, continue to liaise with MD-LOT, and other key stakeholders to help identify opportunities for proportionate, evidence-led regional or strategic monitoring that can improve the understanding of the environmental implications of offshore wind, particularly where recognized evidence gaps exist. This may include contributing to, or participating in, relevant ongoing initiatives under the ScotMER programme (Scottish Government, 2026).

7.12 Whole project assessment and Cumulative Effects Assessment Methodology

7.12.1 Methodology

7.12.1.1 The Morven Programme comprises four distinct projects: Morven South, Morven North, Morven Hawthorn Pit Grid Connection Project (MHPGC Project), and Morven Branxton Area Grid Connection Project (MBAGC Project).

7.12.1.2 The following assessment scenarios have been considered to identify the Likely Significant Effects (LSE[1])of Morven South in combination with other projects on the same receptor, as follows (and summarised in Table 7.14):

- Whole project assessment: to identify the potential impacts associated with Morven South together with each grid connection option in turn, (Scenario 1: MHPGC and Scenario 2: MBAGC Project), each of which would comprise a "Whole Project";
- Morven Programme assessment: to identify potential impacts associated with all four components of the Morven Programme (Scenario 3);
- CEA: to identify the potential impacts associated with Morven North together with other relevant projects, plans and activities including other components of the Morven Programme, using a tiered approach (Scenario 4).

7.12.1.3 The whole project assessment and CEA have been undertaken in accordance with the methodology described in Volume 1, Chapter 6: EIA Methodology.

Table 7.14: Scenarios to be considered in the Morven South whole project assessment and Cumulative Effects Assessment for physical processes

Whole project assessment		Morven Programme assessment (Offshore Ornithology and Shipping and Navigation ONLY)	Cumulative effects assessment
Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
Morven South + MHPGC Project	Morven South + MBAGC Project	Morven South + Morven North + MHPGC Project + MBAGC Project	Morven South + Tier 1, Tier 2 and Tier 3 Plans/Projects screened in

7.12.1.4 For the purposes of this physical processes chapter, Scenarios 1, 2, and 4 have been taken forward for assessment; Scenario 3 has not been included as it is not applicable to this chapter. As discussed in Volume 1, Chapter 6: EIA Methodology, the Morven Programme assessment (Scenario 3) is only required for specific chapters to provide further context to, and to support, the conclusions of the CEA scenario (Scenario 4), in agreement with the relevant stakeholders for these topics. As Scenario 3 does not form the basis of the CEA conclusions, it is considered a supplementary assessment to the CEA scenario (Scenario 4) for these specific topics. The approach to cumulative effects assessment presented in this physical processes chapter complies with the requirements under the EIA Regulations to assess the LSE[1] on the environment arising from a project cumulatively with other relevant plans, projects and activities, and no supplementary assessment of the Morven Programme (Scenario 3) is required or has been requested by relevant stakeholders with regard to physical processes.

7.12.1.5 The projects and plans determined as relevant to the CEA presented within this chapter are based upon the results of a screening exercise (see Volume 3, Annex 6.2: Cumulative Effects Screening). Each project or plan has been considered on a case-by-case basis for screening in or out of this chapter's assessment based upon data confidence, effect-receptor pathways and the spatial/temporal scales involved.

7.12.1.6 In undertaking the CEA for Morven South, it should be noted that other projects and plans under consideration will have differing potential for proceeding to an operational stage and hence a differing potential to ultimately contribute to a cumulative impact alongside Morven South. Therefore, a tiered approach has been adopted, whereby all third-party projects and plans considered have been allocated into 'tiers' reflecting their current stage within the planning and development process. This provides a framework for placing relative weight upon the potential for each project/plan included in the CEA to ultimately be realised, based upon the project/plan's current stage of maturity and certainty in the project/plan's parameters. The tiered approach utilised within the Morven South CEA employs the following tiers:

- Tier 1 assessment – Existing developments either built (operational) or under construction[1]; approved developments awaiting implementation; and permitted/submitted application(s), but not yet determined, plus Morven North.

[1] Note that existing developments are included in Tier 1 CEA long list but are generally screened out of the CEA assessments, aside from the following exceptions:
1) Existing developments which were not present at the time of baseline characterisation, where a potential cumulative impact-receptor pathway has been identified.
2) Existing developments are screened into tier 1 assessments for specific topics where there is a large conceptual, temporal and spatial overlap between project impacts. In these instances, the potential for ongoing effects through cumulative impact-receptor pathways throughout project lifetime, across the development phases, means that they are considered within quantitative assessment for these topic CEAs (e.g., offshore ornithology assessments consider the cumulative effects of operational offshore wind farms).

- Tier 2 assessment – All plans/projects assessed under Tier 1, plus MHPGC Project, and plans/projects where a Scoping Report has been submitted and is in the public domain.
- Tier 3 assessment – All plans/projects assessed under Tier 1 and 2, plus MBAGC Project, and plans/projects that are reasonably foreseeable (e.g. projects identified in development plans, projects in other plans and programmes, offshore renewable energy projects that have a Crown Estate Scotland Lease Option Agreement).

7.12.1.7 The specific projects and plans screened into the CEA for physical processes are outlined in Table 7.15 and shown in Figure 7.2.

7.12.1.8 All impacts considered for the Morven South alone assessment have been taken forward to the whole project and CEA assessment. Some of the potential impacts considered within the Morven South alone assessment are specific to a particular phase of development (e.g. construction, O&M or decommissioning). Where cumulative effects with other plans or projects only have potential to occur where there is spatial or temporal overlap with Morven South during certain phases of development, impacts associated with a certain phase may be omitted from further consideration where no plans or projects have been identified that have the potential for cumulative effects during this period.

7.12.1.9 Projects which form part of the baseline assessment are not considered for further assessment within the CEA, for example existing cables which may be subject to intermittent O&M activities.

7.12.1.10 The Physical Processes Cumulative Study Area is defined as two tidal excursions from the Morven South Boundary. For the purposes of CEA screening, any plans or projects outside a Zone of Influence (ZoI) of 28km were excluded from the long list for physical processes. Numerical modelling has been undertaken to quantify the cumulative impact of Morven South and Morven North, as presented in Volume 3, Annex 7.1: Physical Processes Shared Technical Report.

Table 7.15: List of other projects and plans considered within the Cumulative Effects Assessment for physical processes

Project/plan	Status [i.e. Application, Consented, Under Construction, Operational]	Distance from Morven South (km)	Description of project/plan	Estimated dates of construction (If applicable)	Estimated dates of operation (If applicable)	Overlap with Morven South [e.g. Project construction phase overlaps with Morven South construction phase]
Tier 1						
Morven North Offshore Wind Array Project	Application submitted/Awaiting decision	0	Morven North is proposed for up to 96 turbines at a capacity of 1500MW.	2033-2042	2038-2073 or 2043-2078	Project construction phase and O&M phase overlap with Morven South construction and O&M phases. Potential for project decommissioning to overlap with Morven South decommissioning phase.
Ossian	Consenting/Pre-Construction	5	The Ossian Floating Wind project is proposed for up to 3,610MW capacity.	2029-2038	2039 - unknown	Project construction phase and O&M phase overlap with Morven South construction and O&M phases. Potential for project decommissioning to overlap with Morven South decommissioning and O&M phases.
Eastern Green Link 2	Construction / Recommission	16	Scotland to England Green Link	2025-2029	2030 - unknown	Project O&M phase overlap with Morven South construction and O&M phases. Project decommissioning phase may overlap with Morven South O&M and decommissioning phases.
Tier 2						
Morven Hawthorn Pit Grid Connection Project	Consenting/Pre-Construction	0	Potential transmission for the Morven North/ Morven South.	Unknown	Unknown	Unknown. Project construction phase, O&M and decommissioning phases may overlap with Morven South construction, O&M and decommissioning phases.
Ossian – Offshore Wind Farm Export cable	Consenting/Pre-Construction	5	Maximum six offshore export cables associated	Unknown	Unknown	Unknown. Project construction phase, O&M and decommissioning phases may overlap with Morven South construction, O&M and decommissioning phases.

Project/plan	Status [i.e. Application, Consented, Under Construction, Operational]	Distance from Morven South (km)	Description of project/plan	Estimated dates of construction (If applicable)	Estimated dates of operation (If applicable)	Overlap with Morven South [e.g. Project construction phase overlaps with Morven South construction phase]
			with the Ossian Array.			
Eastern Green Link 3	Consenting/Pre-Construction	3	Scotland to England Green Link	2028-2033	2034 - unknown	Project construction phase and O&M phase overlap with Morven South construction and O&M phases. Project decommissioning phase may overlap with Morven South O&M and decommissioning phases.
Eastern Green Link 5	Consenting/Pre-Construction	4	Scotland to England Green Link	2030-2034	2035 - unknown	Project construction phase and O&M phase overlap with Morven South construction and O&M phases. Project decommissioning phase may overlap with Morven South O&M and decommissioning phases.
Tier 3						
Morven Branxton Area Grid Connection Project	In Planning	0	Potential transmission for the Morven North/ Morven South.	Unknown	Unknown	Unknown. Project construction phase, O&M and decommissioning phases may overlap with Morven South construction, O&M and decommissioning phases.
Holistic Network Design Follow Up Exercise (HNDFUE)	In Planning	-	National Grid ESO's HNDFUE for proposed assets necessary for delivering 20.7GW of successful ScotWind offshore wind capacity post 2030.	Unknown	Unknown	Unknown. Project construction phase, O&M and decommissioning phases may overlap with Morven South construction, O&M and decommissioning phases.

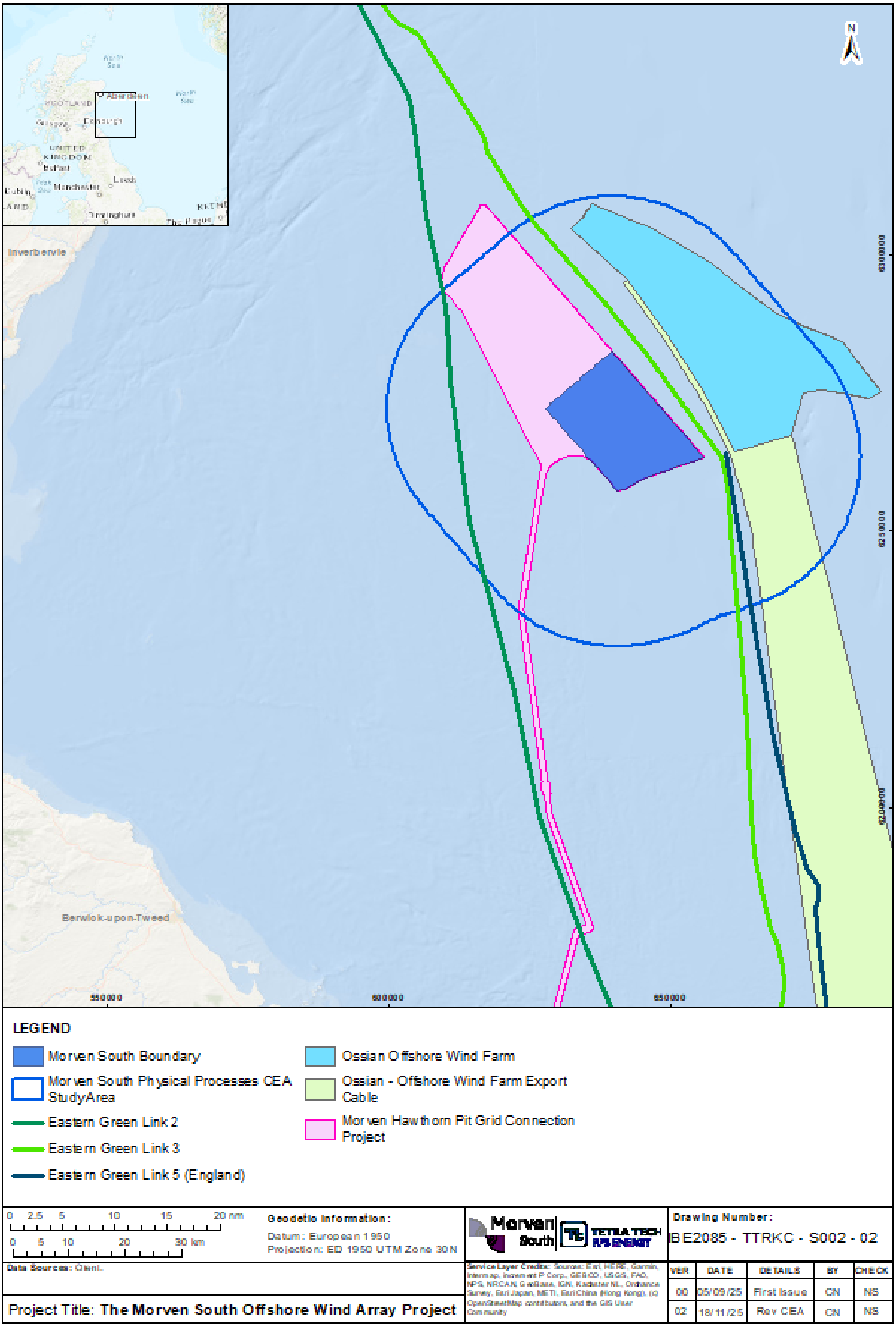

Figure 7.2: Other projects/plans screened into the Cumulative Effects Assessment for physical processes

7.12.2 Maximum Design Scenario

7.12.2.1 The cumulative MDSs identified in Table 7.16 have been selected as those having the potential to result in the greatest potential cumulative effect on an identified receptor or receptor group. The cumulative MDSs have been based on the Morven South alone assessment MDS (Table 7.12), as well as publicly available information on other third-party projects and plans that have been screened into the CEA (Table 7.15). Where applicable, the Morven North alone assessment MDS, the Project Description contained within the MHPGC Project Scoping Report and project information available for MBAGC Project have also informed the cumulative MDSs outlined in Table 1.19.

Table 7.16: Maximum Design Scenario considered for the assessment of potential whole project and cumulative effects on physical processes

C= Construction, O= Operations and maintenance, D= Decommissioning phases

"✓" is used to denote the phase the potential impact can occur, "✗" outlines there is no impact within this project phase

Potential Cumulative Effect	Phase			Maximum Design Scenario	Justification
	C	O	D		
Increased SSCs and associated deposition	✓	✓	✓	**Scenario 1** MDS as described for Morven South (Table 7.12), assessed cumulatively with MHPGC Project. **Scenario 2** MDS as described for Morven South (Table 7.12), assessed cumulatively with MBAGC Project. **Scenario 4** MDS as described for Morven South (Table 7.12), assessed cumulatively with the following other projects and plans: **Tier 1** • Morven North • Ossian • Eastern Green Link 2 **Tier 2** • MHPGC Project • Ossian Offshore Wind Farm Export Cable • Eastern Green Link 3 • Eastern Green Link 5 **Tier 3** • MBAGC Project • HNDFUE	The potential for and extent of likely significant cumulative effects will be greatest when the greatest number of other projects and plans are considered in combination. The projects and plans within the Physical Processes Cumulative Study Area are considered to capture the potential overlap of impacts during the construction, O&M and decommissioning phases. Activities from projects and plans that potentially increase SSCs during the temporal overlap with the Morven South phases have been included as these may create a cumulative impact and LSE on physical features/ receptors. Intermittent operations, such as the repair or reburial of offshore cables

Potential Cumulative Effect	Phase			Maximum Design Scenario	Justification
	C	O	D		
					from potential upcoming projects, have been included in the cumulative assessment. These activities, although potentially in their O&M phase, are not included within the background assessment as they are not continual and therefore do not contribute to background conditions in a consistent manner.
Impacts to the wave regime due to the presence of infrastructure	×	✓	×	**Scenario 1** MDS as described for Morven South (Table 7.12), assessed cumulatively with MHPGC Project. **Scenario 2** MDS as described for Morven South (Table 7.12), assessed cumulatively with MBAGC Project. **Scenario 4** MDS as described for Morven South (Table 7.12), assessed cumulatively with the following other projects and plans: **Tier 1** • Morven North • Ossian • Eastern Green Link 2 **Tier 2** • MHPGC Project • Ossian Offshore Wind Farm Export Cable	Infrastructure, such as foundations, scour protection and cable protection and crossings from other projects during the O&M phase may contribute to the magnitude of this effect when considered in combination with Morven South.

Potential Cumulative Effect	Phase			Maximum Design Scenario	Justification
	C	O	D		
				• Eastern Green Link 3 • Eastern Green Link 5 **Tier 3** • MBAGC Project • HNDFUE	
Impacts to the tidal regime due to the presence of infrastructure	×	✓	×	**Scenario 1** MDS as described for Morven South (Table 7.12), assessed cumulatively with MHPGC Project. **Scenario 2** MDS as described for Morven South (Table 7.12), assessed cumulatively with MBAGC Project. **Scenario 4** MDS as described for Morven South (Table 7.12), assessed cumulatively with the following other projects and plans: **Tier 1** • Morven North • Ossian • Eastern Green Link 2 **Tier 2** • MHPGC Project • Ossian Offshore Wind Farm Export Cable • Eastern Green Link 3 • Eastern Green Link 5 **Tier 3** • MBAGC Project • HNDFUE	Infrastructure, such as foundations, scour protection and cable protection and crossings from other projects during the O&M phase may contribute to the magnitude of this effect when considered in combination with Morven South.

Potential Cumulative Effect	Phase			Maximum Design Scenario	Justification
	C	O	D		
Impacts to sediment transport and sediment transport pathways due to the presence of infrastructure	×	✓	×	**Scenario 1** MDS as described for Morven South (Table 7.12), assessed cumulatively with MHPGC Project. **Scenario 2** MDS as described for Morven South (Table 7.12), assessed cumulatively with MBAGC Project. **Scenario 4** MDS as described for Morven South (Table 7.12), assessed cumulatively with the following other projects and plans: **Tier 1** • Morven North • Ossian • Eastern Green Link 2 **Tier 2** • MHPGC Project • Ossian Offshore Wind Farm Export Cable • Eastern Green Link 3 • Eastern Green Link 5 **Tier 3** • MBAGC Project • HNDFUE	Infrastructure, such as foundations, scour protection and cable protection and crossings from other projects during the O&M phase may contribute to the magnitude of this effect when considered in combination with Morven South.
Impacts to seasonal stratification due to the presence of infrastructure	×	✓	×	**Scenario 1** MDS as described for Morven South (Table 7.12), assessed cumulatively with MHPGC Project. **Scenario 2** MDS as described for Morven South (Table 7.12), assessed cumulatively with MBAGC Project.	Infrastructure, such as foundations from other projects during the O&M phase may contribute to the magnitude of this effect when considered in

Potential Cumulative Effect	Phase			Maximum Design Scenario	Justification
	C	O	D		
				Scenario 4 MDS as described for Morven South (Table 7.12), assessed cumulatively with the following other projects and plans: **Tier 1** • Morven North • Ossian **Tier 2** • None **Tier 3** • None	combination with Morven South. Cable protection was not included in the assessment of the impacts to seasonal stratification due to the presence of infrastructure for Morven South, as justified in Table 7.12. Therefore each of the projects relating to offshore cables are not included in the cumulative assessment for the effect.

7.13 Whole project assessment and Cumulative Effects Assessment

7.13.1 Overview

7.13.1.1 A description of the likely significance of whole project and cumulative effects upon physical processes receptors arising from each identified impact is given below. The whole project assessment and CEA for Morven South is presented in a series of tables within this section, as outlined below for the following potential impacts:

- Increased SSCs and associated deposition (Table 7.17 to Table 7.18);
- Impacts to the wave regime due to the presence of infrastructure (Table 7.19 to Table 7.20);
- Impacts to the tidal regime due to the presence of infrastructure (Table 7.21 to Table 7.22);
- Impacts to sediment transport and sediment transport pathways due to the presence of infrastructure (Table 7.23 to Table 7.24);
- Impacts to seasonal stratification due to the presence of infrastructure (Table 7.25 to Table 7.26).

7.13.1.2 The Physical Processes Cumulative Study Area is defined as two tidal excursions from the Morven South Boundary. This compares to one tidal excursion from the Morven South Boundary for the Morven South Physical Processes Study Area, as outlined in Section 7.2. One spring tidal excursion of between circa 5km and 14km from the Morven South Boundary was identified through interim numerical modelling techniques, therefore two spring tidal excursions equate to between 10km and 28km. A spring tidal excursion is defined as the distance that suspended sediment is transported due to tidal currents before being carried back on the returning tide. Two spring tidal excursions represents where study areas for adjacent projects and developments, defined in a similar way, may intersect.

Increased Suspended Sediment Concentrations and associated deposition

7.13.1.3 There is potential for increased SSCs and associated deposition as a result of the Morven South's construction, O&M and decommissioning activities alongside other offshore wind farms and cables within the Physical Processes Cumulative Study Area. The activities include seabed preparation, installation of wind turbines and OSP foundations, and the installation and/or maintenance of inter-array cables, interconnector cables and offshore export cables.

7.13.1.4 Scenarios 1 and 2 consider the potential effects of Morven South together with the MHPGC Project or MBAGC Project respectively. Scenario 4 assesses two offshore wind projects (including Morven North) and one offshore cable within Tier 1, four offshore cables within Tier 2 (including the MHPGC Project) and two Tier 3 offshore cable projects (including the MBAGC Project). Should the other projects considered within the whole project and CEA scenarios take place concurrently with the construction, O&M or decommissioning of Morven South, there is potential for cumulative increased turbidity levels.

7.13.1.5 The summary of the whole project assessment for increased SSCs and associated deposition is presented in Table 7.17, and cumulative effects assessment for increased SSCs and associated deposition is presented in Table 7.18.

Table 7.17: Morven South whole project assessment for increased Suspended Sediment Concentrations and associated deposition

	Whole project assessment	
	Scenario 1: Morven South + MHPGC Project	**Scenario 2: Morven South + MBAGC Project**
Construction phase		
Magnitude of impact	The whole project assessment for Scenario 1 considers Morven South together with the MHPGC Project. The construction phase of the MHPGC Project may occur simultaneously with the construction phase of Morven South and is likely to include activities which will give rise to increased SSC namely, site preparation/sandwave clearance and export cable trenching. It is noted that the OSP and interconnector installation for Morven South alone have been included within the assessment presented in Section 7.11.2, therefore these elements are not included as part of the MHPGC Project.. The O&M phase of the MHPGC Project may also occur simultaneously with the construction phase of Morven South and includes cable repair and reburial events. It is noted that the interconnector cable repair and reburial activities for Morven North alone have been included within the assessment presented in Section 7.11.2. The MHPGC Project site preparation and offshore export cable installation may be undertaken in close proximity to Morven South using similar parameters and techniques to those associated with the inter-array and interconnector cable installation, although there is potential for a larger magnitude of SSCs and associated deposition due to these activities compared to the activities associated with cables for Morven South. Similarly, MHPGC Project activities may be undertaken in close proximity to clearance and foundation installation activities for Morven South. Repair and reburial activities relating to the MHPGC Project during its O&M phase may yield a combined effect of lesser magnitude, compared to its construction phase.	The whole project assessment for Scenario 2 considers Morven South together with MBAGC Project. Due to the similarities between the MHPGC Project and the MBAGC Project and the potentially similar project timelines, the assessment for Scenario 2 mirrors the assessment for Scenario 1, as presented in the column to the left. However, it is noted that due to the Tier 3 status of MBAGC Project, less information for assessment is available at this time. The whole project impact is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

	Whole project assessment	
	Scenario 1: Morven South + MHPGC Project	Scenario 2: Morven South + MBAGC Project
	It is noted that given the relationship of these projects site preparation and installation of infrastructure would be phased and SSC increases would not occur concurrently from all activities. However, should multiple operations be undertaken plumes would be advected on the tide and not towards one another. In the case of export cables and inter-array or interconnector cables these plumes may interact, however these activities would be of limited spatial extent and frequency and plume interactions likely of a low magnitude and short duration. The majority of sedimentation would occur within close proximity to each installation due to the low sediment transport rates in the area. Any changes to SSC would be reversible following cessation of the activities within a few tidal cycles, with deposited material returning to equilibrium over time. The whole project impact is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.	
Sensitivity of receptor	As discussed under Section 7.11.2, undesignated seabed morphology is considered as a low value receptor to changes in SSC and associated deposition, including tunnel valleys, moraines and channels. The dominant, sandy substrate within the Physical Processes Cumulative Study Area is generally considered to be recoverable after some time due to the low sediment transport rates in the area and any sedimentation would be comprised of native material. The low sediment transport rates will ensure any disturbed material would be deposited close by, after a short period of suspension, thus not impacting significantly on seabed morphology. Undesignated seabed morphology is deemed to be of low vulnerability, low recoverability and low value. The sensitivity of the receptor is therefore, considered to be low.	
Significance of effect	Overall, the magnitude of the whole project impact is deemed to be low and the sensitivity of the receptor is considered to be low. The whole project effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the very localised and intermittent nature of the impact across the Physical Processes Cumulative Study Area, with a very limited area of seabed potentially being impacted at any	Overall, the magnitude of the whole project impact is deemed to be low and the sensitivity of the receptor is considered to be low. The whole project effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the very localised and intermittent nature of the impact across the Physical Processes Cumulative Study Area, with a very limited area of seabed potentially being impacted at any

	Whole project assessment	
	Scenario 1: Morven South + MHPGC Project	Scenario 2: Morven South + MBAGC Project
	one time compared to the area of the Physical Processes Cumulative Study Area as a whole.	one time compared to the area of the Physical Processes Cumulative Study Area as a whole.
Further mitigation and residual significance	No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13), is not significant in EIA terms.	
Operations and maintenance phase		
Magnitude of impact	The whole project assessment for Scenario 1 considers Morven South together with MHPGC Project. The O&M phase of the MHPGC Project may occur simultaneously with the O&M phase of Morven South and includes cable repair and reburial events. It is noted that the interconnector cable repair and reburial activities for Morven South have been included within the assessment presented in Section 7.11.2. There is potential for a small proportion of the MHPGC Project export cable repair and reburial activities to be undertaken in close proximity to Morven South using similar parameters and techniques to those associated with the inter-array and interconnector cable maintenance activities for Morven South. It is noted that given the relationship of these projects, it is unlikely that concurrent repair and reburial events would be scheduled and would be of lesser magnitude than the combined activities for both projects during the construction phase. Should O&M activities be undertaken concurrently, there is potential for the plumes to interact, however these activities would be of limited spatial extent and frequency and plume interactions likely of a low magnitude and short duration. The majority of sedimentation would occur within close proximity to each activity due to the low sediment transport rates in the area. Any changes to SSC would be	The whole project assessment for Scenario 2 considers Morven South together with MBAGC Project. The assessment is assumed to be the same as Scenario 1 for this impact and phase, as discussed in the column to the left, however it is noted that due to the Tier 3 status of MBAGC Project, less information for assessment is available at this time. The whole project impact is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be negligible.

	Whole project assessment	
	Scenario 1: Morven South + MHPGC Project	Scenario 2: Morven South + MBAGC Project
	reversible following cessation of the activities within a few tidal cycles, with deposited material returning to equilibrium over time. The whole project impact is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be negligible.	
Sensitivity of receptor	The sensitivity of receptors to changes in SSCs and sedimentation remains the same as for the construction phase. Undesignated seabed morphology is deemed to be of low vulnerability, low recoverability and low value. The sensitivity of the receptor is therefore, considered to be low.	
Significance of effect	Overall, the magnitude of the whole project impact is deemed to be negligible and the sensitivity of the receptor is considered to be low. The whole project effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the very localised and intermittent nature of the impact across the Physical Processes Cumulative Study Area, with a very limited area of seabed potentially being impacted at any one time compared to the area of the Physical Processes Cumulative Study Area as a whole.	Overall, the magnitude of the whole project impact is deemed to be negligible and the sensitivity of the receptor is considered to be low. The whole project effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the very localised and intermittent nature of the impact across the Physical Processes Cumulative Study Area, with a very limited area of seabed potentially being impacted at any one time compared to the area of the Physical Processes Cumulative Study Area as a whole.
Further mitigation and residual significance	No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13, is not significant in EIA terms.	
Decommissioning phase		
Magnitude of impact	The whole project assessment for Scenario 1 considers Morven South together with MHPGC Project. The decommissioning phase of the MHPGC Project may occur simultaneously with the decommissioning phase of Morven South. Due to the relationship of the projects, it is assumed the O&M phase	The whole project assessment for Scenario 2 considers Morven South together with MBAGC Project. The assessment is assumed to be the same as Scenario 1 for this impact and phase, as discussed in the column to the left, however it is noted that due to the Tier 3 status of MBAGC Project, less information for assessment is available at this time.

	Whole project assessment	
	Scenario 1: Morven South + MHPGC Project	**Scenario 2: Morven South + MBAGC Project**
	of the MHPGC Project will not occur during the decommissioning phase of Morven South. There is the potential for MHPGC Project decommissioning activities to include cable removal, although it is anticipated that offshore cables and any offshore cable protection may be left in-situ, to minimise environmental impacts associated with their removal. It is noted that the interconnector cable removal activities for Morven South have been included within the assessment presented in Section 7.11.2. The export cable removal may be undertaken in close proximity to Morven South using similar parameters and techniques to those associated with the inter-array and interconnector cable decommissioning for Morven South. Should decommissioning activities be undertaken concurrently, there is potential for the plumes to interact, however these activities would be of limited spatial extent and frequency and plume interactions likely of a low magnitude and short duration. The majority of sedimentation would occur within close proximity to each activity due to the low sediment transport rates in the area. This is not expected to be greater than any concurrent decommissioning activities for Morven South alone. Any changes to SSC would be reversible following cessation of the activities within a few tidal cycles, with deposited material returning to equilibrium over time. The whole project impact is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be negligible.	The whole project impact is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be negligible.
Sensitivity of receptor	The sensitivity of receptors to changes in SSCs and sedimentation remains the same as for the construction phase. Undesignated seabed morphology is deemed to be of low vulnerability, low recoverability and low value. The sensitivity of the receptor is therefore, considered to be low.	

	Whole project assessment	
	Scenario 1: Morven South + MHPGC Project	Scenario 2: Morven South + MBAGC Project
Significance of effect	Overall, the magnitude of the whole project impact is deemed to be negligible and the sensitivity of the receptor is considered to be low. The whole project effect will, therefore, be of negligible adverse significance, which is not significant in EIA terms. Negligible has been determined due to the very localised nature of the impact across the Physical Processes Cumulative Study Area, with a very limited area of seabed potentially being impacted compared to the area of the Physical Processes Cumulative Study Area as a whole.	Overall, the magnitude of the whole project impact is deemed to be negligible and the sensitivity of the receptor is considered to be low. The whole project effect will, therefore, be of negligible adverse significance, which is not significant in EIA terms. Negligible has been determined due to the very localised nature of the impact across the Physical Processes Cumulative Study Area, with a very limited area of seabed potentially being impacted compared to the area of the Physical Processes Cumulative Study Area as a whole.
Further mitigation and residual significance	No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13, is not significant in EIA terms.	

Table 7.18: Morven South Cumulative Effects Assessment for increased SSCs and associated deposition

Cumulative Effects Assessment	
Scenario 4: Morven South and Tier 1, Tier 2 and Tier 3 Projects	
Construction phase	
Magnitude of impact	The cumulative effects assessment for Scenario 4 considers Morven South together with the Tier 1, Tier 2 and Tier 3 projects below. **Tier 1** Tier 1 includes Morven North, Ossian Offshore Wind Project and Eastern Green Link 2 offshore cable. The O&M phase of Ossian and Eastern Green Link 2, in addition to Morven North may occur simultaneously with the construction phase of Morven South and includes cable repair and reburial events. The construction phase of Morven North and Ossian may also occur simultaneously with the construction phase of Morven South and includes activities such as site preparation/sandwave clearance, cable and foundation installation, which will give rise to increased SSCs. Morven North is located directly to the northwest of Morven South, with the Morven South Boundary and Morven North Boundary positioned adjacent to each other. Therefore, construction activities for Morven North may be undertaken in close proximity to Morven South, and should they be undertaken concurrently, there is potential for plumes to interact, however these activities would

Cumulative Effects Assessment	
	be of limited spatial extent and frequency and plume interactions likely of a low magnitude and short duration. The majority of sedimentation would occur within close proximity to each activity due to the low sediment transport rates in the area. Ossian is located 5km from the Morven South Boundary directly to the east and northeast and is proposed for up to 265 wind turbines. Given the orientation of the tides in a predominantly north northeast to south southwest direction, there would be opportunity for the amalgamation of sediment plumes from these projects. However due to the intermittent nature of the associated activities, the likelihood of increased SSCs is low and would not persist for a long duration. The potential intermittent cable repair and reburial activities for Eastern Green Link 2 have a low percentage chance of occurring simultaneously and in a similar location to the construction activities of Morven South, however if there is the potential for plume interaction, it would likely be of a low magnitude and short duration. Any changes to SSC would be reversible following cessation of the activities within a few tidal cycles, with deposited material returning to equilibrium over time. The cumulative effect is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low. **Tier 2** Tier 2 includes the MHPGC Project, Ossian Offshore Wind Farm Export Cable, Eastern Green Link 3 and Eastern Green Link 5. The O&M phase of the Ossian Offshore Wind Farm Export Cable, Ossian and Eastern Green Link 2, 3 and 5, in addition to the MHPGC Project and Morven North may occur simultaneously with the construction phase of Morven South and includes cable repair and reburial events. The construction phase of Morven North, Ossian Offshore Wind Farm Export Cable, Ossian, Eastern Green Link 3 and 5 and the MHPGC Project may also occur simultaneously with the construction phase of Morven South and includes activities such as site preparation/sandwave clearance, foundation installation, and export cable trenching, which will give rise to increased SSCs. Construction or O&M activities from Ossian Offshore Wind Farm Export Cable Or Eastern Green Link 3 and 5 may be undertaken in close proximity to Morven South and should they be undertaken concurrently, there is potential for the amalgamation of plumes and increased deposition. These activities would be of limited spatial extent and frequency and plume interactions likely of a low magnitude and short duration. The majority of sedimentation would occur within close proximity to each activity due to the low sediment transport rates in the area. Any changes to SSC would be reversible following cessation of the activities within a few tidal cycles, with deposited material returning to equilibrium over time. The cumulative effect is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low. **Tier 3** Tier 3 includes the MBAGC Project, together with the HNDFUE offshore cabling project, with numerous potential cable routes in the vicinity of Morven South, although there is uncertainty in exact location at this stage.

Cumulative Effects Assessment	
	There is potential for short-term plume interactions during the HNDFUE project's construction, O&M and decommissioning phases, coinciding with the O&M phase of Morven South. Similarly during the construction and operation of the MBAGC Project, there is potential for the interaction of plumes with Morven South. The cumulative effect is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.
Sensitivity of receptor	As discussed under Section 7.11.2, undesignated seabed morphology is considered as a low value receptor to changes in SSC and associated deposition, including tunnel valleys, moraines and channels. The dominant, sandy substrate within the Physical Processes Cumulative Study Area is generally considered to be recoverable after some time due to the low sediment transport rates in the area and any sedimentation would be comprised of native material. The low sediment transport rates will ensure any disturbed material would be deposited close by, after a short period of suspension, thus not impacting significantly on seabed morphology. Undesignated seabed morphology is deemed to be of low vulnerability, low recoverability and low value. The sensitivity of the receptor is therefore, considered to be low.
Significance of effect	**Tier 1** Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the very localised and intermittent nature of the impact across the Physical Processes Cumulative Study Area, with a very limited area of seabed potentially being impacted at any one time compared to the area of the Physical Processes Cumulative Study Area as a whole. **Tier 2** Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the very localised and intermittent nature of the impact across the Physical Processes Cumulative Study Area, with a very limited area of seabed potentially being impacted at any one time compared to the area of the Physical Processes Cumulative Study Area as a whole. **Tier 3** Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the very localised and intermittent nature of the impact across the Physical Processes Cumulative Study Area, with a very limited area of seabed potentially being impacted at any one time compared to the area of the Physical Processes Cumulative Study Area as a whole.

Cumulative Effects Assessment	
Further mitigation and residual significance	No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13, is not significant in EIA terms.
Operations and maintenance phase	
Magnitude of impact	The cumulative effects assessment for Scenario 4 considers Morven South together with the Tier 1, Tier 2 and Tier 3 projects below. **Tier 1** Tier 1 includes Morven North, Ossian Offshore Wind Project and Eastern Green Link 2 offshore cable. The O&M phase of Ossian and Eastern Green Link 2, in addition to Morven North may occur simultaneously with the O&M phase of Morven South and includes cable repair and reburial events. The construction phase of Morven North and Ossian may also occur simultaneously with the O&M phase of Morven South and includes activities such as site preparation/sandwave clearance, foundation installation and cable trenching, which will give rise to increased SSCs. The decommissioning phases of Morven North, Eastern Green Link 2 and Ossian also may overlap with the O&M phase of Morven South and may include cable removal. The construction phases of Morven North and Ossian are the most critical to the potential increase in SSCs and associated deposition. Project activities for Morven North would be undertaken in close proximity to Morven South, and should they be undertaken concurrently, there is potential for plumes to interact, however these activities would be of limited spatial extent and frequency and plume interactions likely of a low magnitude and short duration. The majority of sedimentation would occur within close proximity to each activity due to the low sediment transport rates in the area. Any changes to SSC would be reversible following cessation of the activities within a few tidal cycles, with deposited material returning to equilibrium over time. Given that the magnitude of the O&M activities will be negligible for Morven South alone, or Morven North alone, it is not anticipated that the cumulative magnitude of Morven North construction activities during the O&M phase of Morven South will be measurably higher than for Morven South or Morven North alone. Ossian is located 5km from the Morven South Boundary directly to the east and northeast. Given the orientation of the tides in a predominantly north northeast to south southwest direction, there is opportunity for the amalgamation of sediment plumes from these projects. It is noted that a limited increase in SSCs may occur due to the mooring lines interacting with the seabed as part of the Ossian Project, however any plume amalgamation is anticipated to be of low SSC, and any sedimentation consisting of native material. The potential intermittent cable repair and reburial activities for Eastern Green Link 2 have a low percentage chance of occurring simultaneously and in a similar location to the O&M activities of Morven South, however if there is the potential for plume interaction, it would likely be of a low magnitude and short duration. The cumulative effect is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low. **Tier 2**

Cumulative Effects Assessment	
	Tier 2 includes the MHPGC Project, Ossian Offshore Wind Farm Export Cable, Eastern Green Link 3 and Eastern Green Link 5. The O&M phase of Ossian Offshore Wind Farm Export Cable, Ossian and Eastern Green Link 2, in addition to the MHPGC Project and Morven North may occur simultaneously with the O&M phase of Morven South and includes cable repair and reburial events. The construction phase of Morven North, the MHPGC project, Ossian and the Ossian Offshore Wind Farm Export Cable may also occur simultaneously with the O&M phase of Morven South and includes activities such as site preparation/sandwave clearance, foundation installation, and export cable trenching, which will give rise to increased SSCs. The decommissioning phases of Ossian Offshore Wind Farm Export Cable, Morven North, Ossian and Eastern Green Link 2, 3 and 5 also may align with the O&M phase of Morven South and may include cable and foundation removal. Activities from Ossian Offshore Wind Farm Export Cable and Eastern Green Link 3 and 5 may be undertaken in close proximity to Morven South and should they be undertaken concurrently, there is potential for the amalgamation of plumes and increased deposition. These activities would be of limited spatial extent and frequency and plume interactions likely of a low magnitude and short duration. The majority of sedimentation would occur within close proximity to each activity due to the low sediment transport rates in the area. Any changes to SSC would be reversible following cessation of the activities within a few tidal cycles, with deposited material returning to equilibrium over time. The cumulative effect is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low. **Tier 3** Tier 3 includes the MBAGC Project, together with the HNDFUE offshore cabling project, with numerous potential cable routes in the vicinity of Morven South, although there is uncertainty in exact location at this stage. There is uncertainty in the exact location of the potential cable routes, however as per other offshore cables, there is potential for short-term plume interactions during the project's construction, O&M and decommissioning phases, coinciding with the O&M phase of Morven South. The cumulative effect is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.
Sensitivity of receptor	The sensitivity of receptors to changes in SSCs and sedimentation remains the same as for the construction phase. Undesignated seabed morphology is deemed to be of low vulnerability, low recoverability and low value. The sensitivity of the receptor is therefore, considered to be low.
Significance of effect	**Tier 1** Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been

Cumulative Effects Assessment	
	determined due to the very localised and intermittent nature of the impact across the Physical Processes Cumulative Study Area, with a very limited area of seabed potentially being impacted at any one time compared to the area of the Physical Processes Cumulative Study Area as a whole. **Tier 2** Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the very localised and intermittent nature of the impact across the Physical Processes Cumulative Study Area, with a very limited area of seabed potentially being impacted at any one time compared to the area of the Physical Processes Cumulative Study Area as a whole. **Tier 3** Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the very localised and intermittent nature of the impact across the Physical Processes Cumulative Study Area, with a very limited area of seabed potentially being impacted at any one time compared to the area of the Physical Processes Cumulative Study Area as a whole.
Further mitigation and residual significance	No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13), is not significant in EIA terms.
Decommissioning phase	
Magnitude of impact	The cumulative effects assessment for Scenario 4 considers Morven South together with the Tier 1, Tier 2 and Tier 3 projects below. **Tier 1** Tier 1 includes Morven North, Ossian Offshore Wind Project and Eastern Green Link 2 offshore cable. Seagreen 1 Offshore Wind Project is not included in this assessment phase, as it is anticipated to be decommissioned prior to the decommissioning of Morven South. The O&M phase of Ossian, Morven North and Eastern Green Link 2 may occur simultaneously with the decommissioning phase of Morven South and includes cable repair and reburial events. The decommissioning phase of Ossian, Eastern Green Link 2 and Morven North may also occur simultaneously with the decommissioning phase of Morven South and includes cable and foundation removal. Project activities from Morven North would be undertaken in close proximity to Morven South and should they be undertaken concurrently, there is potential for plumes to interact, however these activities would be of limited spatial extent and frequency and plume interactions likely of a low magnitude and short duration. The majority of sedimentation would occur within close proximity

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	to each activity due to the low sediment transport rates in the area. Any changes to SSC would be reversible following cessation of the activities within a few tidal cycles, with deposited material returning to equilibrium over time. Ossian is located 5km from the Morven South Boundary directly to the east and northeast. Given the orientation of the tides in a predominantly north northeast to south southwest direction, there would be opportunity for the amalgamation of sediment plumes from these projects. It is noted that a limited increases in SSCs may occur due to the mooring lines interacting with the seabed as part of the Ossian Project, however any plume amalgamation is anticipated to be of low SSC, and any sedimentation consisting of native material. The magnitude of the impact is considered less than during the standalone or cumulative Morven South construction phase, as it is unlikely concurrent activities from different projects would be undertaken in the same location and anticipated that some project infrastructure may be left in-situ. The cumulative effect is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be negligible. **Tier 2** Tier 2 includes the MHPGC Project, Ossian Offshore Wind Farm Export Cable, Eastern Green Link 3 and Eastern Green Link 5. The O&M and decommissioning phases of Ossian Offshore Wind Farm Export Cable, Ossian, the MHPGC Project, Morven North and Eastern Green Link 2, 3 and 5 may occur simultaneously with the decommissioning phase of Morven South and includes cable repair and reburial events or cable and foundation removal. Activities from the MHPGC Project, EGL 3 and 5 and Ossian Offshore Wind Farm Export Cable may be undertaken in close proximity to Morven South and should they be undertaken concurrently, there is potential for the amalgamation of plumes and increased deposition. These activities would be of limited spatial extent and frequency and plume interactions likely of a low magnitude and short duration. The majority of sedimentation would occur within close proximity to each activity due to the low sediment transport rates in the area. Any changes to SSC would be reversible following cessation of the activities within a few tidal cycles, with deposited material returning to equilibrium over time. With no construction activities to consider under this phase, the magnitude of the impact is likely to be less than during the Morven South construction or O&M phases. The cumulative effect is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be negligible. **Tier 3** Tier 3 includes the MBAGC Project, together with the HNDFUE offshore cabling project, with numerous potential cable routes in the vicinity of Morven South, although there is uncertainty in exact location at this stage.

Cumulative Effects Assessment	
	There is potential for short-term plume interactions during the MBAGC Project and HNDFUE project's O&M and decommissioning phases, coinciding with the decommissioning phase of Morven South. The cumulative effect is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be negligible.
Sensitivity of receptor	The sensitivity of receptors to changes in SSCs and sedimentation remains the same as for the construction phase. Undesignated seabed morphology is deemed to be of low vulnerability, low recoverability and low value. The sensitivity of the receptor is therefore, considered to be low.
Significance of effect	**Tier 1** Overall, the magnitude of the cumulative impact is deemed to be negligible and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of negligible adverse significance, which is not significant in EIA terms. Negligible has been determined due to the very localised nature of the impact across the Physical Processes Cumulative Study Area, with a very limited area of seabed potentially being impacted compared to the area of the Physical Processes Cumulative Study Area as a whole. **Tier 2** Overall, the magnitude of the cumulative impact is deemed to be negligible and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of negligible adverse significance, which is not significant in EIA terms. Negligible has been determined due to the very localised nature of the impact across the Physical Processes Cumulative Study Area, with a very limited area of seabed potentially being impacted compared to the area of the Physical Processes Cumulative Study Area as a whole. **Tier 3** Overall, the magnitude of the cumulative impact is deemed to be negligible and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of negligible adverse significance, which is not significant in EIA terms. Negligible has been determined due to the very localised nature of the impact across the Physical Processes Cumulative Study Area, with a very limited area of seabed potentially being impacted compared to the area of the Physical Processes Cumulative Study Area as a whole.
Further mitigation and residual significance	No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13), is not significant in EIA terms.

Impacts to the wave regime due to the presence of infrastructure

7.13.1.6 There is potential for impacts to the wave regime due to the presence of Morven South infrastructure during the O&M phase, alongside the presence of other offshore wind farms and cables within the Physical Processes Cumulative Study Area.

7.13.1.7 Scenarios 1 and 2 consider the potential effects of Morven South together with the MHPGC Project or MBAGC Project respectively. Scenario 4 assesses two offshore wind projects (including Morven North) and one offshore cable within Tier 1, four offshore cables (including the MHPGC Project) within Tier 2 and two Tier 3 offshore cable projects (including the MBAGC Project).

7.13.1.8 The summary of the whole project assessment for impacts to the wave regime due to the presence of infrastructure is presented in Table 7.19, and cumulative effects assessment for impacts to the tidal regime due to the presence of infrastructure is presented in Table 7.20.

Table 7.19: Morven South whole project assessment for impacts to the wave regime due to the presence of infrastructure

	Whole project assessment	
	Scenario 1: Morven South + MHPGC Project	**Scenario 2: Morven South + MBAGC Project**
Operations and maintenance phase		
Magnitude of impact	The whole project assessment for Scenario 1 considers Morven South together with MHPGC Project. The O&M phase of the MHPGC Project may occur simultaneously with the O&M phase of Morven South and includes the presence of cable protection and cable crossings on the seabed. Morven South and the MHPGC Project are in close proximity to each other, however due to the deepwater location of Morven South, the impact of cable protection in this area on wave climate has been shown to be negligible in the physical processes modelling (Section 5.2.2: Volume 3, Annex 7.1: Physical Processes Shared Technical Report). Due to the similarly deepwater location of the MHPGC Project, there is not anticipated to be any greater impact than the Scenario of Morven South alone, presented in Section 7.11.3. The whole project impact is predicted to be of local spatial extent, long-term duration, continuous and high reversibility on removal of the infrastructure. It is predicted that the impact will affect the receptor directly and indirectly. The magnitude is therefore, considered to be low.	The whole project assessment for Scenario 2 considers Morven South together with MBAGC Project. The assessment is assumed to be the same as Scenario 1 for this impact and phase, as discussed in the column to the left, however it is noted that due to the Tier 3 status of MBAGC Project, less information for assessment is available at this time. The whole project impact is predicted to be of local spatial extent, long-term duration, continuous and high reversibility on removal of the infrastructure. It is predicted that the impact will affect the receptor directly and indirectly. The magnitude is therefore, considered to be low.
Sensitivity of receptor	As discussed under Section 7.11.3, undesignated and low value seabed morphology, including tunnel valleys, moraines and channels may also be impacted upon by changes in the wave regime. The seabed is located in deep waters and is considered to be of low vulnerability to changes in the wave regime, recoverable after some time. Undesignated seabed morphology is deemed to be of low vulnerability, low recoverability and low value. The sensitivity of the receptor is therefore, considered to be low.	
Significance of effect	Overall, the magnitude of the whole project impact is deemed to be low and the sensitivity of the receptor is considered to be low. The whole project effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has	Overall, the magnitude of the whole project impact is deemed to be low and the sensitivity of the receptor is considered to be low. The whole project effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has

	Whole project assessment	
	Scenario 1: Morven South + MHPGC Project	Scenario 2: Morven South + MBAGC Project
	been determined due to the limited impact to the seabed due to a change in wave climate in the deepwater location of Morven South.	been determined due to the limited impact to the seabed due to a change in wave climate in the deepwater location of Morven South.
Further mitigation and residual significance	No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13), is not significant in EIA terms.	

Table 7.20: Morven South cumulative effects assessment for impacts to the wave regime due to the presence of infrastructure

Cumulative Effects Assessment	
Scenario 4: Morven South and Tier 1, Tier 2 and Tier 3 Projects	
Operations and maintenance phase	
Magnitude of impact	The cumulative effects assessment for Scenario 4 considers Morven South together with the Tier 1, Tier 2 and Tier 3 projects below. **Tier 1** Tier 1 includes Morven North, Ossian Offshore Wind Project and Eastern Green Link 2 offshore cable. The O&M phase of Ossian and Eastern Green Link 2, in addition to Morven North may occur simultaneously with the O&M phase of Morven South and includes the presence of foundations and associated scour protection, cable protection and cable crossings on the seabed. Morven South and Morven North are in close proximity to each other, however due to the deepwater location of Morven South and Morven North, the impact of cable protection in this area on wave climate has been shown to be negligible in the physical processes modelling (Section 5.2.2 of Volume 3, Annex 7.1: Physical Processes Shared Technical Report). There is not anticipated to be any greater impact due to the additional cable protection, crossings or scour protection than the Scenario of Morven South alone, presented in Section 7.11.3. The combined presence of Morven South and Morven North was included as a scenario in the physical processes modelling. Morven North is of a similar scale and capacity as Morven South, with 96 wind turbines proposed at a minimum separation distance of 1000m. Maximum changes in wave height were not seen to increase compared to the Scenario of Morven South alone, presented in Section 7.11.3. Some modelled differences were observed beyond the Morven South Boundary and Morven North Boundary, however, these are limited in magnitude, for example from the dominant storm direction from the north, up to a maximum of circa 0.1m within 20km of the Morven Site,

Cumulative Effects Assessment	
	gradually reducing to baseline beyond this. This applies to both 1 in 1 year and 1 in 20 year storms from the north, with the less severe storm producing a marginally smaller extent of change. There is not anticipated to be any change to the wave climates within the Firth of Forth Banks Complex MPA due to the Morven South and Morven North infrastructure when present simultaneously. Ossian is located 5km from the Morven South Boundary directly to the east and northeast, with a greater number of wind turbines (265 floating foundations) compared to Morven South and Morven North in combination, however will employ the same minimum wind turbine separation of 1000m. It is anticipated that waves from the northeast through to the east may induce more widespread reductions in the wave height within the Morven South Boundary and it can be inferred from the results of the physical processes modelling, that peak changes in wave height within the Morven South Boundary will not be affected. There is potential to decrease the wave height within the Firth of Forth Banks Complex MPA from this direction, although the decreases in wave height are expected to be small. As inferred from the physical processes modelling, cable protection and crossings associated with Eastern Green Link 2 will have a negligible impact on wave climate. The cumulative effect is predicted to be of local spatial extent, long-term duration, continuous and high reversibility on removal of the infrastructure. It is predicted that the impact will affect the receptor directly and indirectly. The magnitude is therefore, considered to be low. **Tier 2** Tier 2 includes the MHPGC Project, Ossian Offshore Wind Farm Export Cable, Eastern Green Link 3 and Eastern Green Link 5. The O&M phase of Ossian Offshore Wind Farm Export Cable, Ossian and Eastern Green Link 2, 3 and 5, in addition to the MHPGC Project and Morven North may occur simultaneously with the O&M phase of Morven South and includes the presence of foundations and associated scour protection, cable protection and cable crossings on the seabed. As shown or inferred from the physical processes modelling, cable protection and crossings associated with the MHPGC Project, Ossian Offshore Wind Farm Export Cable and Eastern Green Link 3 and 5 will have a negligible impact on wave climate. The cumulative effect is predicted to be of local spatial extent, long-term duration, continuous and high reversibility on removal of the infrastructure. It is predicted that the impact will affect the receptor directly and indirectly. The magnitude is therefore, considered to be low. **Tier 3** Tier 3 includes the MBAGC Project, together with the HNDFUE offshore cabling project, with numerous potential cable routes in the vicinity of Morven South, although there is uncertainty in exact location at this stage. As shown or inferred from the physical processes modelling, cable protection and crossings associated with the MBAGC Project or HNDFUE offshore cabling project will have a negligible impact on wave climate. The cumulative effect is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility on removal of the infrastructure. It is predicted that the impact will affect the receptor directly and indirectly. The magnitude is therefore, considered to be low.

Cumulative Effects Assessment	
Sensitivity of receptor	As discussed under Section 7.11.3, undesignated and low value seabed morphology, including tunnel valleys, moraines and channels may also be impacted upon by changes in the wave regime. The seabed is located in deep waters and is considered to be of low vulnerability to changes in the wave regime, recoverable after some time. Undesignated seabed morphology is deemed to be of low vulnerability, low recoverability and low value. The sensitivity of the receptor is therefore, considered to be low.
Significance of effect	**Tier 1** Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the limited impact to the seabed due to a change in wave climate in the deepwater location of Morven South. **Tier 2** Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the limited impact to the seabed due to a change in wave climate in the deepwater location of Morven South. **Tier 3** Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the limited impact to the seabed due to a change in wave climate in the deepwater location of Morven South.
Further mitigation and residual significance	No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13), is not significant in EIA terms.

Impacts to the tidal regime due to the presence of infrastructure

7.13.1.9 There is potential for impacts to the tidal regime due to the presence of Morven South infrastructure during the O&M phase, alongside the presence of other offshore wind farms and cables within the Physical Processes Cumulative Study Area.

7.13.1.10 Scenarios 1 and 2 consider the potential effects of Morven South together with the MHPGC Project or MBAGC Project respectively. Scenario 4 assesses two offshore wind projects (including Morven North) and one offshore cable within Tier 1, four offshore cables (including the MHPGC Project) within Tier 2 and two Tier 3 offshore cable projects (including the MBAGC Project).

7.13.1.11 The summary of the whole project assessment for impacts to the tidal regime due to the presence of infrastructure is presented in Table 7.21, and cumulative effects assessment for impacts to the tidal regime due to the presence of infrastructure is presented in Table 7.22.

Table 7.21: Morven South whole project assessment for impacts to the tidal regime due to the presence of infrastructure

	Whole project assessment	
	Scenario 1: Morven South + MHPGC Project	**Scenario 2: Morven South + MBAGC Project**
Operations and maintenance phase		
Magnitude of impact	The whole project assessment for Scenario 1 considers Morven South together with MHPGC Project. The O&M phase of the MHPGC Project may occur simultaneously with the O&M phase of Morven South and includes the presence of cable protection and cable crossings on the seabed. Morven South and the MHPGC Project are in close proximity to each other, however due to the deepwater location of Morven South, the impact of cable protection in this area on the tidal regime has been shown to be negligible in the physical processes modelling (Section 5.2.1: Volume 3, Annex 7.1: Physical Processes Shared Technical Report). Due to the similarly deepwater location of the MHPGC Project, there is not anticipated to be any greater impact than the Scenario of Morven South alone, presented in Section 7.11.4. The whole project impact is predicted to be of local spatial extent, long-term duration, continuous and high reversibility on removal of the infrastructure. It is predicted that the impact will affect the receptor directly and indirectly. The magnitude is therefore, considered to be low.	The whole project assessment for Scenario 2 considers Morven South together with MBAGC Project. The assessment is assumed to be the same as Scenario 1 for this impact and phase, as discussed in the column to the left, however it is noted that due to the Tier 3 status of MBAGC Project, less information for assessment is available at this time. The whole project impact is predicted to be of local spatial extent, long-term duration, continuous and high reversibility on removal of the infrastructure. It is predicted that the impact will affect the receptor directly and indirectly. The magnitude is therefore, considered to be low.
Sensitivity of receptor	As discussed under Section 7.11.4, undesignated and low value seabed morphology, including tunnel valleys, moraines and channels may also be impacted upon by changes in the tidal regime. The seabed is considered to be of low vulnerability to changes in the tidal regime and would be recoverable after some time. Undesignated seabed morphology is deemed to be of low vulnerability, low recoverability and low value. The sensitivity of the receptor is therefore, considered to be low.	
Significance of effect	Overall, the magnitude of the whole project impact is deemed to be low and the sensitivity of the receptor is considered to be low. The whole project effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has	Overall, the magnitude of the whole project impact is deemed to be low and the sensitivity of the receptor is considered to be low. The whole project effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has

	Whole project assessment	
	Scenario 1: Morven South + MHPGC Project	**Scenario 2: Morven South + MBAGC Project**
	been determined due to the localised scale of the changes within the Morven South Boundary, with the majority of the area subject to changes of less than 0.001m/s (Section 5.2.1: Volume 3, Annex 7.1: Physical Processes Shared Technical Report). Cables are not anticipated to further influence the tidal regime in this deepwater location.	been determined due to the localised scale of the changes within the Morven South Boundary, with the majority of the area subject to changes of less than 0.001m/s. Cables are not anticipated to further influence the tidal regime in this deepwater location.
Further mitigation and residual significance	No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13), is not significant in EIA terms.	

Table 7.22: Morven South Cumulative Effects Assessment for impacts to the tidal regime due to the presence of infrastructure

Cumulative Effects Assessment	
Scenario 4: Morven South and Tier 1, Tier 2 and Tier 3 Projects	
Operations and maintenance phase	
Magnitude of impact	The cumulative effects assessment for Scenario 4 considers Morven South together with the Tier 1, Tier 2 and Tier 3 projects below. **Tier 1** Tier 1 includes Morven North, Ossian Offshore Wind Project and Eastern Green Link 2 offshore cable. The O&M phase of Ossian and Eastern Green Link 2, in addition to Morven North may occur simultaneously with the O&M phase of Morven South and includes the presence of foundations and associated scour protection, cable protection and cable crossings on the seabed. Morven South and Morven North are in close proximity to each other, however due to the deepwater location of Morven South, the impact of cable protection in this area on the tidal regime has been shown to be negligible in the physical

Cumulative Effects Assessment	
	processes modelling (Section 5.2.1: Volume 3, Annex 7.1: Physical Processes Shared Technical Report). There is not anticipated to be any greater impact due to the additional cable protection, crossings or scour protection than the Scenario of Morven South alone, presented in Section 7.11.4. The combined presence of Morven South and Morven North was included as a scenario in the physical processes modelling. Morven North is of a similar scale and capacity as Morven North, with 96 wind turbines proposed at a minimum separation distance of 1000m. Lower baseline current speeds were observed in the results within the Morven South Boundary compared to the Morven North Boundary. Modelled magnitudes of change in current speeds were not seen to increase with Morven South and Morven North infrastructure in place simultaneously compared to the Scenario of Morven South alone, presented in Section 7.11.4. This is due to the designed-in measure of minimum spacing between turbines and locations of the bridge-linked HVDC converter OSP gravity base foundations, which are not adjacent. Note, there will be a maximum of one bridge-linked HVDC converter OSP within the Morven Site, however the modelling has incorporated one HVDC OSP within both the Morven South Boundary and Morven North Boundary, in order to provide a representation of a worst case scenario impact due to each separate project. Ossian is located 5km from the Morven South Boundary directly to the east and northeast. Drawing on the conclusions from the physical processes modelling of the combined presence of Morven South and Morven North, there would be no evident increase in the change in current speeds when considering Tier 1 Offshore Wind Projects, due to the changes being limited to the locality of the structures and the distance between the foundations of other projects and Morven South. It is also noted that the floating infrastructure of Ossian would have a lesser impact on the tidal regime than fixed infrastructure as the foundations will not occupy the entire water column. This impact has been scoped out in the Ossian Offshore Wind Farm EIA. As inferred from the physical processes modelling, cable protection and crossings associated with Eastern Green Link 2 will have a negligible impact on the tidal regime. The cumulative effect is predicted to be of local spatial extent, long-term duration, continuous and high reversibility on removal of the infrastructure. It is

Cumulative Effects Assessment	
	predicted that the impact will affect the receptor directly and indirectly. The magnitude is therefore, considered to be low. **Tier 2** Tier 2 includes the MHPGC Project, Ossian Offshore Wind Farm Export Cable, Eastern Green Link 3 and Eastern Green Link 5. The O&M phase of Ossian Offshore Wind Farm Export Cable, Ossian and Eastern Green Link 2, 3 and 5, in addition to the MHPGC Project and Morven North may occur simultaneously with the O&M phase of Morven South and includes the presence of foundations and associated scour protection, cable protection and cable crossings on the seabed. As shown and inferred from the physical processes modelling, cable protection and crossings associated with the MHPGC Project, Ossian Offshore Wind Farm Export Cable and Eastern Green Link 3 and 5 will have a negligible impact on the tidal regime. The cumulative effect is predicted to be of local spatial extent, long-term duration, continuous and high reversibility on removal of the infrastructure. It is predicted that the impact will affect the receptor directly and indirectly. The magnitude is therefore, considered to be low. **Tier 3** Tier 3 includes the MBAGC Project, together with the HNDFUE offshore cabling project, with numerous potential cable routes in the vicinity of Morven South, although there is uncertainty in exact location at this stage. As shown and inferred from the physical processes modelling, cable protection and crossings associated with the MBAGC Project and HNDFUE offshore cabling project will have a negligible impact on the tidal regime. The cumulative effect is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility on removal of the infrastructure. It is predicted that the impact will affect the receptor directly and indirectly. The magnitude is therefore, considered to be low.
Sensitivity of receptor	As discussed under Section 7.11.4, undesignated and low value seabed morphology, including tunnel valleys, moraines and channels may also be impacted upon by changes in the tidal regime. The seabed is considered to be

Cumulative Effects Assessment	
	of low vulnerability to changes in the tidal regime and would be recoverable after some time. Undesignated seabed morphology is deemed to be of low vulnerability, low recoverability and low value. The sensitivity of the receptor is therefore, considered to be low.
Significance of effect	**Tier 1** Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the localised scale of the changes within the Morven South Boundary, with the majority of the area subject to changes of less than 0.001m/s. Similar can be expected at other offshore wind farms and cables are not anticipated to further influence the tidal regime in this deepwater location. **Tier 2** Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the localised scale of the changes within the Morven South Boundary, with the majority of the area subject to changes of less than 0.001m/s. Similar can be expected at other offshore wind farms and cables are not anticipated to further influence the tidal regime in this deepwater location. **Tier 3** Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the localised scale of the changes within the Morven South Boundary, with the majority of the area subject to changes of less than 0.001m/s. Similar can be expected at other offshore wind farms and cables are not anticipated to further influence the tidal regime in this deepwater location.

Cumulative Effects Assessment	
Further mitigation and residual significance	No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13), is not significant in EIA terms.

Impacts to the sediment transport and sediment transport pathways due to the presence of infrastructure

7.13.1.12 There is potential for impacts to sediment transport and sediment transport pathways due to the presence of Morven South infrastructure during the O&M phase, alongside the presence of other offshore wind farms and cables within the Physical Processes Cumulative Study Area.

7.13.1.13 Scenarios 1 and 2 consider the potential effects of Morven South together with the MHPGC Project or MBAGC Project respectively. Scenario 4 assesses two offshore wind projects (including Morven North) and one offshore cable within Tier 1, four offshore cables (including the MHPGC Project) within Tier 2 and two Tier 3 offshore cable projects (including the MBAGC Project).

7.13.1.14 The impact on seabed morphology due to secondary scour has been screened out of the whole project and cumulative assessment, as any potential secondary scour will be highly localised and of no greater magnitude than the Scenario of Morven South alone.

7.13.1.15 The summary of the whole project assessment for impacts to sediment transport and sediment transport pathways due to the presence of infrastructure is presented in Table 7.23, and cumulative effects assessment for impacts to sediment transport and sediment transport pathways is presented in Table 7.24.

Table 7.23: Morven South whole project assessment for impacts to sediment transport and sediment transport pathways due to the presence of infrastructure

	Whole project assessment	
	Scenario 1: Morven South + MHPGC Project	**Scenario 2: Morven South + MBAGC Project**
Operations and maintenance phase		
Magnitude of impact	The whole project assessment for Scenario 1 considers Morven South together with MHPGC Project. The O&M phase of the MHPGC Project may occur simultaneously with the O&M phase of Morven South and includes the presence of cable protection and cable crossings on the seabed. Morven South and the MHPGC Project are in close proximity to each other, however due to the deepwater location of Morven South, and the limited effect of waves and tides on the seabed, the impact of cable protection in this area on sediment transport pathways has been shown to be negligible in the physical processes modelling (Section 5.3: Volume 3, Annex 7.1: Physical Processes Shared Technical Report). The low heights of cable protection and crossings in comparison to the water depth will result in a very limited direct impact to sediment transport, as only a small proportion of the water column would be blocked by the structures. Due to the similarly deepwater location of the MHPGC Project, there is not anticipated to be any greater impact than the Scenario of Morven South alone, presented in Section 7.11.5. The whole project impact is predicted to be of local spatial extent, long-term duration, continuous and high reversibility on removal of the infrastructure. It is predicted that the impact will affect the receptor directly and indirectly. The magnitude is therefore, considered to be low.	The whole project assessment for Scenario 2 considers Morven South together with MBAGC Project. The assessment is assumed to be the same as Scenario 1 for this impact and phase, as discussed in the column to the left, however it is noted that due to the Tier 3 status of MBAGC Project, less information for assessment is available at this time. The whole project impact is predicted to be of local spatial extent, long-term duration, continuous and high reversibility on removal of the infrastructure. It is predicted that the impact will affect the receptor directly and indirectly. The magnitude is therefore, considered to be low.
Sensitivity of receptor	As discussed under Section 7.11.5, undesignated and low value seabed morphology, including tunnel valleys, moraines and channels may also be impacted upon by changes in the sediment transport regime. The seabed is considered to be of low vulnerability to changes in the sediment transport regime which would consist of native material and would be recoverable after some time.	

	Whole project assessment	
	Scenario 1: Morven South + MHPGC Project	Scenario 2: Morven South + MBAGC Project
	Undesignated seabed morphology is deemed to be of low vulnerability, low recoverability and low value. The sensitivity of the receptor is therefore, considered to be low.	
Significance of effect	Overall, the magnitude of the whole project impact is deemed to be low and the sensitivity of the receptor is considered to be low. The whole project effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the localised scale of the changes within the Morven South Boundary, with the majority of the area subject to changes in sediment transport of less than $0.05m^3/d/m$ (Section 5.3: Volume 3, Annex 7.1: Physical Processes Shared Technical Report). Cables are not anticipated to further influence the sediment transport regime in this deepwater location.	Overall, the magnitude of the whole project impact is deemed to be low and the sensitivity of the receptor is considered to be low. The whole project effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the localised scale of the changes within the Morven South Boundary, with the majority of the area subject to changes in sediment transport of less than $0.05m^3/d/m$. Cables are not anticipated to further influence the sediment transport regime in this deepwater location.
Further mitigation and residual significance	No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13), is not significant in EIA terms.	

Table 7.24: Morven South Cumulative Effects Assessment for impacts to sediment transport and sediment transport pathways due to the presence of infrastructure

	Cumulative effects assessment
	Scenario 4: Morven South and Tier 1, Tier 2 and Tier 3 Projects
Operations and maintenance phase	
Magnitude of impact	The cumulative effects assessment for Scenario 4 considers Morven South together with the Tier 1, Tier 2 and Tier 3 projects below. **Tier 1** Tier 1 includes Morven North, Ossian Offshore Wind Project and Eastern Green Link 2 offshore cable.

	Cumulative effects assessment
	The O&M phase of Ossian and Eastern Green Link 2, in addition to Morven North may occur simultaneously with the O&M phase of Morven South and includes the presence of foundations and associated scour protection, cable protection and cable crossings on the seabed. Morven South and Morven North are in close proximity to each other, however due to the deepwater location of Morven South, the impact of cable protection in this area on sediment transport pathways has been shown to be negligible in the physical processes modelling (Section 5.3: Volume 3, Annex 7.1: Physical Processes Shared Technical Report). The low heights of cable protection, crossings and scour protection in comparison to the water depth will result in a very limited direct impact to sediment transport, as only a small proportion of the water column would be blocked by the structures. There is not anticipated to be any greater impact due to the additional cable protection, crossings or scour protection than the Scenario of Morven South alone, presented in Section 7.11.5. The combined presence of Morven South and Morven North was included as a scenario in the physical processes modelling. Morven North is of a similar scale and capacity as Morven South, with 96 wind turbines proposed at a minimum separation distance of 1km. Under both calm and storm conditions (1 in 1 year from the north), there was no discernible difference observed from the modelling results to sediment transport rates due to the combined presence of Morven South and Morven North, in comparison to the Scenario of Morven South alone, presented in Section 7.11.5. This is commensurate with the assessment from the impacts to the wave regime and tidal regime due to the presence of infrastructure. There is not anticipated to be any change to the sediment transport within the Firth of Forth Banks Complex MPA due to the Morven South and Morven North infrastructure when present simultaneously. Ossian is located 5km from the Morven South Boundary directly to the east and northeast, with a greater number of wind turbines (265 floating foundations) compared to Morven South and Morven North in combination, however it will employ the same minimum wind turbine separation of 1000m. It is anticipated that waves from the northeast through to the east may induce more widespread reductions in the wave height within the Morven South Boundary, which may have an indirect impact on sediment transport. However, it can be inferred from the results of the physical processes modelling, that peak changes in sediment transport within the Morven South Boundary will not be affected. There is potential to decrease the wave height and thus sediment transport within the Firth of Forth Banks Complex MPA from this direction, although changes are anticipated to be small due to the limited impact of waves on sediment transport in this area. As inferred from the physical processes modelling, cable protection and crossings associated with Eastern Green Link 2 will have a negligible impact on sediment transport. The cumulative effect is predicted to be of local spatial extent, long-term duration, continuous and high reversibility on removal of the infrastructure. It is predicted that the impact will affect the receptor directly and indirectly. The magnitude is therefore, considered to be low. **Tier 2** Tier 2 includes the MHPGC Project, Ossian Offshore Wind Farm Export Cable, Eastern Green Link 3 and Eastern Green Link 5.

	Cumulative effects assessment
	The O&M phase of Ossian Offshore Wind Farm Export Cable, Ossian and Eastern Green Link 2, 3 and 5, in addition to the MHPGC Project and Morven North may occur simultaneously with the O&M phase of Morven South and includes the presence of foundations and associated scour protection, cable protection and cable crossings on the seabed. As shown and inferred from the physical processes modelling, cable protection and crossings associated with the MHPGC Project, Ossian Offshore Wind Farm Export Cable and Eastern Green Link 3 and 5 will have a negligible impact on sediment transport. The cumulative effect is predicted to be of local spatial extent, long-term duration, continuous and high reversibility on removal of the infrastructure. It is predicted that the impact will affect the receptor directly and indirectly. The magnitude is therefore, considered to be low. **Tier 3** Tier 3 includes the MBAGC Project, together with the HNDFUE offshore cabling project, with numerous potential cable routes in the vicinity of Morven South, although there is uncertainty in exact location at this stage. As shown and inferred from the physical processes modelling, cable protection and crossings associated with the MBAGC Project and HNDFUE offshore cabling project will have a negligible impact on sediment transport and sediment transport pathways. The cumulative effect is predicted to be of local spatial extent, short-term duration, intermittent and high reversibility on removal of the infrastructure. It is predicted that the impact will affect the receptor directly and indirectly. The magnitude is therefore, considered to be low.
Sensitivity of receptor	As discussed under Section 7.11.5, undesignated and low value seabed morphology, including tunnel valleys, moraines and channels may also be impacted upon by changes in the sediment transport regime. The seabed is considered to be of low vulnerability to changes in the sediment transport regime which would consist of native material and would be recoverable after some time. Undesignated seabed morphology is deemed to be of low vulnerability, low recoverability and low value. The sensitivity of the receptor is therefore, considered to be low.
Significance of effect	**Tier 1** Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the localised scale of the changes within the Morven South Boundary, with the majority of the area subject to changes in sediment transport of less than 0.05m^3/d/m. Similar can be expected at other offshore wind farms and cables are not anticipated to further influence the sediment transport regime in this deepwater location. **Tier 2** Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the localised scale of the changes within the Morven South Boundary, with the majority of the area subject to

	Cumulative effects assessment
	changes in sediment transport of less than $0.05m^3/d/m$. Similar can be expected at other offshore wind farms and cables are not anticipated to further influence the sediment transport regime in this deepwater location. **Tier 3** Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible adverse** significance, which is not significant in EIA terms. Negligible has been determined due to the localised scale of the changes within the Morven South Boundary, with the majority of the area subject to changes in sediment transport of less than $0.05m^3/d/m$. Similar can be expected at other offshore wind farms and cables are not anticipated to further influence the sediment transport regime in this deepwater location.
Further mitigation and residual significance	No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13), is not significant in EIA terms.

Impacts to seasonal stratification due to the presence of infrastructure

7.13.1.16 There is potential for impacts to seasonal stratification due to the presence of Morven South infrastructure during the O&M phase, alongside the presence of other offshore wind farm infrastructure within the Physical Processes Cumulative Study Area.

7.13.1.17 Scenarios 1 and 2 consider the potential effects of Morven South together with the MHPGC Project or MBAGC Project respectively. Scenario 4 assesses two offshore wind projects (including Morven North) within Tier 1. There are no relevant projects for assessment within Tier 2 or Tier 3. Note this impact differs from the other impacts relating to the presence of infrastructure, as the impact due to cables, including offshore export cables has been screened out. This is due to the negligible impact of cables or cable protection/crossings on water column structure within the deep water location of Morven South. As such, the offshore cable projects have not been considered for this impact.

7.13.1.18 The summary of the whole project assessment for impacts to seasonal stratification due to the presence of infrastructure is presented in Table 7.25, and cumulative effects assessment for impacts to seasonal stratification is presented in Table 7.26.

Table 7.25: Morven South whole project assessment for impacts to seasonal stratification due to the presence of infrastructure

	Whole project assessment	
	Scenario 1: Morven South + MHPGC Project	**Scenario 2: Morven South + MBAGC Project**
Operations and maintenance phase		
Magnitude of impact	The whole project assessment for Scenario 1 considers Morven South together with MHPGC Project. The O&M phase of the MHPGC Project may occur simultaneously with the O&M phase of Morven South and includes the presence of cable protection and cable crossings on the seabed. The impact due to cables or cable protection/crossings has been screened out of the whole project assessment. There is not anticipated to be any greater resulting impact than the Scenario of Morven South alone presented in Section 7.11.6. The whole project impact is predicted to be of local spatial extent, long-term duration, intermittent and high reversibility on removal of the infrastructure. It is predicted that the impact will affect the receptor indirectly. The magnitude is therefore, considered to be low.	The whole project assessment for Scenario 2 considers Morven South together with MBAGC Project. The assessment is assumed to be the same as Scenario 1 for this impact and phase, as discussed in the column to the left, however it is noted that due to the Tier 3 status of MBAGC Project, less information for assessment is available at this time. The whole project impact is predicted to be of local spatial extent, long-term duration, intermittent and high reversibility on removal of the infrastructure. It is predicted that the impact will affect the receptor indirectly. The magnitude is therefore, considered to be low.
Sensitivity of receptor	The receptors to changes to seasonal stratification are considered to be the thermocline and the position of the tidal front, as discussed in Section 7.11.6. Frontal positions are predominantly controlled by tidal mixing, however changes in mixing and the potential energy anomaly due to Morven South are limited and would not be of the scale to affect the onset, peak or decay of seasonal stratification, which is not considered vulnerable to changes of this magnitude. The consideration of the MHPGC Project and MBAGC Projects with Morven South are not anticipated to have any further effect on these receptors due to their seabed location within the water column. The position of the front between the seasonally stratified area and the fully mixed area, lies to the west of the Morven South Boundary. Any changes to seasonal stratification would be fully recoverable by the removal of above seabed infrastructure. As a physical processes receptor, the thermocline and position of the tidal front are of medium value, due to undesignated status but importance for maintaining baseline water column processes. The thermocline and tidal frontal position are deemed to be of low vulnerability, high recoverability and medium value. The sensitivity of the receptor is therefore, considered to be low.	
Significance of effect	Overall, the magnitude of the whole project impact is deemed to be low and the sensitivity of the receptor is considered to be low. The whole project effect will, therefore, be of **minor adverse** significance,	Overall, the magnitude of the whole project impact is deemed to be low and the sensitivity of the receptor is considered to be low. The whole project effect will, therefore, be of **minor adverse** significance,

	Whole project assessment	
	Scenario 1: Morven South + MHPGC Project	Scenario 2: Morven South + MBAGC Project
	which is not significant in EIA terms. Minor has been determined over negligible due to the limited evidence and understanding that still remains concerning this impact, and the use of high level modelling to support the assessment.	which is not significant in EIA terms. Minor has been determined over negligible due to the limited evidence and understanding that still remains concerning this impact, and the use of high level modelling to support the assessment.
Further mitigation and residual significance	No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13), is not significant in EIA terms.	

Table 7.26: Morven South Cumulative Effects Assessment for impacts to seasonal stratification due to the presence of infrastructure

	Cumulative effects assessment
	Scenario 4: Morven South and Tier 1, Tier 2 and Tier 3 Projects
Operations and maintenance phase	
Magnitude of impact	The cumulative effects assessment for Scenario 4 considers Morven South together with the Tier 1, Tier 2 and Tier 3 projects below. As per Scenarios 1 and 2, the impact due to cables or cable protection/crossings has been screened out of the CEA. There is not anticipated to be any greater resulting impact from the MHPGC Project, MBAGC Project or other export cable projects than the scenario of Morven South alone, presented in Section 7.11.6. **Tier 1** Tier 1 includes Morven North and the Ossian Offshore Wind Project. The O&M phase of Ossian in addition to Morven North may occur simultaneously with the O&M phase of Morven South and includes the presence of foundations on the seabed and within the water column. The combined presence of Morven South and Morven North was included within the high level physical processes modelling to determine the impact on seasonal stratification.

	Cumulative effects assessment
	Morven North is of a similar scale and capacity as Morven South, with 96 wind turbines proposed at a minimum separation distance of 1000m. The modelling is discussed within Section 5.2.4 of Volume 3, Annex 7.1: Physical Processes Shared Technical Report. Potential changes to seasonal stratification due to Morven South and Morven North are limited in magnitude, with the largest percentage temperature changes from baseline occurring during the peak summer stratification period when the potential energy anomaly is at its greatest. It is anticipated that there would be no significant impact on the position of the thermocline or breakdown in seasonal stratification due to the infrastructure, although there may be marginally more mixing within the water column. Ossian is located 5km from the Morven South Boundary directly to the east and northeast. The 265 proposed floating foundations of the Ossian Project may lead to an increase in the impact on seasonal stratification. However, given the very limited and localised scale of the changes observed in the physical processes modelling discussed in Section 5.2.4 of Volume 3, Annex 7.1: Physical Processes Shared Technical Report, the cumulative effect of this project, together with Morven South and Morven North is not anticipated to be notably greater than for the Scenario of Morven South alone presented in Section 7.11.6. It is anticipated that there would be a negligible effect on the overall pattern of seasonal stratification in the North Sea, including the Firth of Forth Banks Complex MPA, due to Scenario 4. Similarly, the limited reduction in windspeed due to Morven South, Morven North and Ossian will not have a marked effect on waves and currents within the Morven South Boundary and beyond. The cumulative effect is predicted to be of local spatial extent, long-term duration, intermittent and high reversibility on removal of the infrastructure above the seabed. It is predicted that the impact will affect the receptor indirectly. The magnitude is therefore considered to be low.
Sensitivity of receptor	The receptors to changes to seasonal stratification are considered to be the thermocline and the position of the tidal front, as discussed in Section 7.11.6. Frontal positions are predominantly controlled by tidal mixing, however changes in mixing and the potential energy anomaly due to Morven South are limited and would not be of the scale to affect the onset, peak or decay of seasonal stratification which is not considered vulnerable to

	Cumulative effects assessment
	changes of this magnitude. The consideration of the CEA projects could increase the impact, however would not be of the scale to increase the vulnerability of these receptors. The position of the front between the seasonally stratified area and the fully mixed area, lies to the west of the Morven South Boundary. Any changes to seasonal stratification would be fully recoverable by the removal of the infrastructure above the seabed. As a physical processes receptor, the thermocline and position of the tidal front are of medium value, due to undesignated status but importance for maintaining baseline water column processes. The thermocline and tidal frontal position are deemed to be of low vulnerability, high recoverability and medium value. The sensitivity of the receptor is therefore, considered to be low.
Significance of effect	**Tier 1** Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms. Minor has been determined over negligible due to the limited evidence and understanding that still remains concerning this impact, and the use of high level modelling to support the assessment.
Further mitigation and residual significance	No mitigation measures for physical processes are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 7.13), is not significant in EIA terms.

7.13.2 Proposed monitoring

7.13.2.1 Site-specific monitoring is not proposed because the assessment concluded that Morven North would not give rise to significant effects on physical processes, either alone or when considered cumulatively with other plans, projects, or activities. The Applicant will, however, continue to liaise with MD-LOT, and other key stakeholders to help identify opportunities for proportionate, evidence-led regional or strategic monitoring that can improve the understanding of the environmental implications of offshore wind, particularly where recognized evidence gaps exist. This may include contributing to, or participating in, relevant ongoing initiatives under the ScotMER programme (Scottish Government, 2026).

7.14 Transboundary effects

7.14.1.1 A screening of transboundary impacts has been carried out (see Volume 3, Annex 6.3: Transboundary Effects Screening). This has identified that no likely significant transboundary effects with regard to physical processes would result from Morven South upon the interests of other European Economic Area (EEA) States.

7.15 Inter-related effects

7.15.1.1 Inter-relationships are considered to be the impacts and associated effects of different aspects of Morven South on the same receptor. Inter-related effects are considered to be either:

- Lifetime effects: Assessment of the scope for effects that occur throughout more than one phase of Morven South (construction, O&M and decommissioning), to interact to potentially create a more significant effect on a receptor than if just assessed in isolation in these three project stages (e.g. underwater sound effects from piling, wind turbines, vessels and decommissioning);
- Receptor-led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor. As an example, all effects on physical processes, such as sediment plumes, may interact to produce a different, or greater effect on this receptor than when the effects are considered in isolation. Receptor-led effects may be short-term, temporary or transient effects, or incorporate longer term effects.

7.15.1.2 A description of the likely inter-related effects arising from Morven South on physical processes is provided in Volume 2, Chapter 21: Inter-related and Ecosystem Effects.

For physical processes, the following potential impacts have been considered within the inter-related assessment:

- increased SSCs and associated deposition.
- impacts to the wave regime due to the presence of infrastructure;
- impacts to the tidal regime due to the presence of infrastructure;
- impacts to sediment transport and sediment transport pathways due to the presence of infrastructure;
- impacts to seasonal stratification due to the presence of infrastructure.

7.15.1.3 Table 7.27 lists the inter-related effects (project lifetime effects) that are predicted to arise during the construction, O&M and decommissioning of Morven South and the inter-related effects (receptor-led effects) that are predicted to arise for physical processes receptors.

7.15.1.4 As noted in paragraph 7.15.1.1, effects on physical processes also have the potential to have secondary effects on other receptors and these effects are fully considered in the topic-specific chapters. These receptors and effects are:

- Benthic subtidal ecology;

  - increased SSCs and associated deposition;
  - changes in physical processes.
- Fish and shellfish ecology;
  - increased SSCs and associated deposition.
- Marine archaeology;
  - increased SSCs and sediment deposition leading to indirect impacts on marine archaeology receptors;
  - alteration of sediment transport regime leading to indirect impacts on marine archaeology receptors.

Table 7.27: Summary of likely significant inter-related effects on the environment from individual effects occurring across the construction, operation and maintenance and decommissioning phases of Morven South (project lifetime effects) and from multiple effects interacting across all phases (receptor-led effects)

C= Construction, O= O&M, D= Decommissioning phases

"✓" is used to denote the phase the potential impact can occur, "X" outlines there is no impact within this project phase

<table>
<tr><th rowspan="2">Description of impact</th><th colspan="3">Phase</th><th rowspan="2">Likely significant inter-related effect</th><th rowspan="2">Significance</th></tr>
<tr><th>C</th><th>O</th><th>D</th></tr>
<tr><td colspan="6">Morven South lifetime effects</td></tr>
<tr><td>Increased SSCs and associated deposition</td><td>✓</td><td>✓</td><td>✓</td><td>Increases in SSC during the construction phase would not extend temporally into the O&M phase, as they are limited to a few tidal cycles and to discrete areas. Similarly, those increases which occur in the O&M phase due to maintenance activities would not extend to decommissioning. Therefore, there will be no cumulative impact on SSCs due to these activities over the lifetime of the project. Similarly any associated deposition will be localised and comprised of native material which will be anticipated to be recoverable after some time and will not span the lifetime of Morven North. The construction and decommissioning phases have the potential to contribute the most to deposition, however these phases are separated in time by limited and isolated instances of repair and reburial events during the longest phase of O&M.</td><td>Negligible adverse</td></tr>
<tr><td colspan="6">Receptor-led effects</td></tr>
<tr><td colspan="6">During principally the O&M phase, increased SSCs and associated deposition on physical features may occur due to maintenance activities; which would coincide with changes to tidal currents, wave climate, littoral currents, sediment transport and stratification due to the presence of the Morven South structures. Increased SSCs and associated deposition is the only impact considered in the assessment during the construction and decommissioning phases, and thus these phases are not relevant to receptor-led effects. Maintenance activities are sporadic, with the impacts predicted to be of local spatial extent, short-term duration and intermittent , and will not affect the overall wave, tidal, or sediment transport regime, or impact on stratification, and would therefore not be significant in EIA terms.

By definition the impacts to sediment transport are governed by the impacts to the wave and tidal regime and hence is already covered in the assessment within Section 7.11.5. Similarly, the impacts to seasonal stratification have been determined by assessing the impact on hydrodynamics, including waves and tides, and therefore have already been considered in the assessment under Section 7.11.6.</td></tr>
</table>

7.16 Summary of impacts, mitigation, Likely Significant Effects and monitoring

7.16.1.1 Information on physical processes within the Morven South Physical Processes Study Area was collected through a detailed desktop review of existing studies and datasets, site specific surveys, consultation with key stakeholders and supported by numerical modelling.

7.16.1.2 Table 7.28 presents a summary of the potential impacts, mitigation measures and the conclusion of likely significant effects on physical processes in EIA terms. The impacts assessed include:

- increased SSCs and associated deposition;
- impacts to the wave regime due to the presence of infrastructure;
- impacts to the tidal regime due to the presence of infrastructure;
- impacts to sediment transport and sediment transport pathways due to the presence of infrastructure;
- impacts to seasonal stratification due to the presence of infrastructure.

7.16.1.3 Overall, it is concluded that there will be no likely significant effects arising from Morven South during the construction, O&M or decommissioning phases.

7.16.1.4 Table 7.29 presents a summary of the potential cumulative impacts, mitigation measures and the conclusion of likely significant effects on physical processes in EIA terms. The cumulative effects assessed include:

- increased SSCs and associated deposition;
- impacts to the wave regime due to the presence of infrastructure;
- impacts to the tidal regime due to the presence of infrastructure;
- impacts to sediment transport and sediment transport pathways due to the presence of infrastructure;
- impacts to seasonal stratification due to the presence of infrastructure.

7.16.1.5 Overall, it is concluded that there will be no likely significant cumulative effects from Morven South alongside other projects/plans.

7.16.1.6 No likely significant transboundary effects have been identified in regard to effects of Morven South.

Table 7.28: Summary of Likely Significant Effects, mitigation and monitoring

C= Construction, O= Operations and Maintenance, D= Decommissioning phases

"✓" is used to denote the phase the potential impact can occur, "✗" outlines there is no impact within this project phase

Description of impact	Phase			Designed-in measures	Magnitude of impact	Sensitivity of receptor	Significance of effect	Additional mitigation measures	Significance of residual effect	Proposed monitoring
	C	O	D							
Increased SSCs and associated deposition	✓	✓	✓	MM-1, MM-2, MM-3, MM-4, MM-20, MM-23	C: Low O: Negligible D: Negligible	Undesignated seabed substrate and features: C: Low O: Low D: Low	Undesignated seabed substrate and features: C: Negligible Adverse O: Negligible Adverse D: Negligible Adverse	None	Undesignated seabed substrate and features: C: Negligible Adverse O: Negligible Adverse D: Negligible Adverse	None
Impacts to the wave regime due to the presence of infrastructure	✗	✓	✗	MM-41	O: Low	Undesignated seabed substrate and features: O: Low	Undesignated seabed substrate and features: O: Negligible Adverse	None	Undesignated seabed substrate and features: O: Negligible Adverse	None
Impacts to the tidal regime due to the presence of infrastructure	✗	✓	✗	MM-41	O: Low	Undesignated seabed substrate and features: O: Low	Undesignated seabed substrate and features: O: Negligible Adverse	None	Undesignated seabed substrate and features: O: Negligible Adverse	None
Impacts to sediment transport and sediment	✗	✓	✗	MM-1, MM-2, MM-3, MM-4, MM-20, MM-41	O: Low	Undesignated seabed substrate and features:	Undesignated seabed substrate and features:	None	Undesignated seabed substrate and features:	None

Description of impact	Phase			Designed-in measures	Magnitude of impact	Sensitivity of receptor	Significance of effect	Additional mitigation measures	Significance of residual effect	Proposed monitoring
	C	O	D							
transport pathways due to the presence of infrastructure						O: Low	O: Negligible Adverse		O: Negligible Adverse	
Impacts to seasonal stratification due to the presence of infrastructure	×	✓	×	MM-41	O: Low	Thermocline / tidal frontal position: O: Low	Thermocline / tidal frontal position: O: Minor Adverse	None	Thermocline / tidal frontal position: O: Minor Adverse	None

Table 7.29: Summary of likely significant cumulative environment effects, mitigation and monitoring

C= Construction, O= Operations and Maintenance, D= Decommissioning phases

"√" is used to denote the phase the potential impact can occur, "X" outlines there is no impact within this project phase

Description of impact	Phase			Designed-in measures	Magnitude of impact	Sensitivity of receptor	Significance of effect	Additional mitigation measures	Significance of residual effect	Proposed monitoring
	C	O	D							
Increased SSCs and associated deposition	✓	✓	✓	MM-1, MM-2, MM-3, MM-4, MM-20, MM-23	Scenarios 1&2 C: Low O: Negligible D: Negligible Scenario 4 C: Low O: Low D: Negligible	All Scenarios Undesignated seabed substrate and features: C: Low O: Low D: Low	All Scenarios C: Negligible Adverse O: Negligible Adverse D: Negligible Adverse	None	All Scenarios C: Negligible Adverse O: Negligible Adverse D: Negligible Adverse	None
Impacts to the wave regime due to the presence of infrastructure	×	✓	×	MM-41	All Scenarios O: Low	All Scenarios Undesignated seabed substrate and features: O: Low	All Scenarios O: Negligible Adverse	None	All Scenarios O: Negligible Adverse	None
Impacts to the tidal regime due to the presence of infrastructure	×	✓	×	MM-41	All Scenarios O: Low	All Scenarios Undesignated seabed substrate and features: O: Low	All Scenarios O: Negligible Adverse	None	All Scenarios O: Negligible Adverse	None

Description of impact	Phase			Designed-in measures	Magnitude of impact	Sensitivity of receptor	Significance of effect	Additional mitigation measures	Significance of residual effect	Proposed monitoring
	C	O	D							
Impacts to sediment transport and sediment transport pathways due to the presence of infrastructure	×	✓	×	MM-1, MM-2, MM-3, MM-4, MM-20, MM-41	All Scenarios O: Low	All Scenarios Undesignated seabed substrate and features: O: Low	All Scenarios O: Negligible Adverse	None	All Scenarios O: Negligible Adverse	None
Impacts to seasonal stratification due to the presence of infrastructure	×	✓	×	MM-41	All Scenarios O: Low	All Scenarios Thermocline / tidal frontal position: O: Low	All Scenarios O: Minor Adverse	None	All Scenarios O: Minor Adverse	None

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