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Volume 2 Proposed Development (Offshore)

Chapter 3 Marine Water and Sediment Quality

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Acronyms and Abbreviations

AL	Action Level
BAC	Background Assessment Concentration
BGS	British Geological Society
BW	Bathing Water
CIA	Cumulative Impact Assessment
EAC	Environmental Assessment Criteria
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EMF	Electromagnetic Field
EMODnet	European Marine Observation and Data Network
EMP	Environmental Management Plan
EQS	Environmental Quality Standard
EQSD	Environmental Quality Standards Directive
ERL	Effect Range-Low
ERM	Effect Range-Median
EU	European Union
EEZ	Exclusive Economic Zone
FEQG	Federal Environmental Quality Guidelines
GC-FID	Gas Chromatography-Flame Ionization Detector
HDD	Horizontal Directional Drilling
IC	Inorganic Carbon
LOD	Limit of Detection

MD-LOT	Marine Directorate - Licensing Operations Team
MHWS	Mean High Water Springs
MSFD	Marine Strategy Framework Directive
MW&SQ	Marine Water and Sediment Quality
NMPi	National Marine Plan Interactive Map
NVZ	Nitrate Vulnerable Zone
O&M	Operation and Maintenance
OC	Organic Carbon
OCP	Organochloropesticides
OECC	Offshore Export Cable Corridor
OSP	Offshore Substation Platform
PAH	Polycyclic Aromatic Hydrocarbon
PBDE	Polybrominated Diphenyl Ether
PCB	Polychlorinated Biphenyl
PEL	Probable Effect Levels
PSA	Particle Size Analysis
SEPA	Scottish Environment Protection Agency
SSC	Suspended Sediment Concentration
SWPA	Shellfish Water Protected Area
THC	Total Hydrocarbon Content
TEL	Threshold Effects Level
TOC	Total Organic Carbon
TSHD	Trailing Suction Hopper Dredger
UV	Ultraviolet

UVF	Ultraviolet Fluorescence
UWWTL	Urban Wastewater Treatment Legislation
WFD Legislation	Water Framework Directive Legislation
WTG	Wind Turbine Generator
ZoI	Zone of Influence

Executive Summary

This Marine Water and Sediment Quality (MW&SQ) Chapter of the Caledonia Offshore Wind Farm (OWF) Environmental Impact Assessment Report, specifically relating to the Proposed Development (Offshore), presents an overview of the existing marine environmental characteristics, up to Mean High Water Springs, for:

- Water quality (including physical parameters), Water Framework Directive Legislation Protected Areas, Bathing Waters, Shellfish Water Protected Areas, Nutrient Sensitive Areas;
- Sediment quality (including Particle Size Analysis and Total Organic Carbon); and
- Sediment contamination (including Total Hydrocarbons, Polycyclic Aromatic Hydrocarbons, Polychlorinated Biphenyls, Polybrominated Diphenyl Ethers, Organochloropesticides, organotins and metals).

The Study Area has been determined based upon the location of the Proposed Development (Offshore) and proposed infrastructure, alongside spring tidal excursions and expert judgement. In order to assess the potential changes relative to the baseline (existing) environment, a combination of complimentary approaches have been adopted for this MW&SQ assessment:

- Online database and open-source data (for example, the European Marine Observation and Data Network (EMODnet), British Geological Society, Water Classification Hub);
- Monitoring data collected during the construction of other developments in analogous environmental settings (such as the Moray West OWF); and
- Analytical assessments of site-specific survey data undertaken to provide an up-to-date representation of the physical and chemical characteristics of water and sediment occurring within the area of the Proposed Development (Offshore).

The Caledonia Site is located in water depths up to 88m below Lowest Astronomical Tide within the Moray Firth on a seabed comprised of sands with mobile bedforms present in discreet locations, indicating an active sediment transport regime. The salinity, temperature, dissolved oxygen, turbidity and pH profiles of the water column were all typical for the region. Sediment contaminants are below relevant guideline levels and toxic effects to fauna are not anticipated.

Consideration of the Design Envelope has been undertaken to identify worst case scenarios with respect to MW&SQ. Adopting a source-pathway-receptor approach, the potential impacts associated with the Proposed Development (Offshore) have been assessed, in accordance with the Scoping Opinion and subsequent stakeholder engagement, using a suite of methodologies which include numerical modelling, the evidence-base and expert judgement. Receptors identified include both non-designated sites (e.g., wider marine environment) and designated sites (e.g., coastal and transitional waterbodies). Specifically, the following impacts have been considered:

- Deterioration in water quality due to suspension of sediments;
- Release of sediment-bound contaminants from disturbed sediments; and
- Deterioration in water clarity due to the release of drilling mud.

The results of this impact assessment demonstrate that the Proposed Development (Offshore) is likely to have a negligible to minor adverse impact upon the identified receptors, which is considered not significant in Environmental Impact Assessment terms.

3 Marine Water and Sediment Quality

3.1 Introduction

3.1.1.1 This Environmental Impact Assessment Report (EIAR) chapter identifies the potential effects on Marine Water and Sediment Quality (MW&SQ) associated with the construction, operation and decommissioning of the of the Proposed Development (Offshore) seaward of Mean High Water Springs (MHWS). It is noted that MW&SQ is considered a receptor in its own right, whilst also providing an impact pathway for other receptors.

3.1.1.2 This chapter is supported by the following Technical Appendices:

- Volume 7B, Appendix 2-1: Marine and Coastal Processes Baseline Technical Report;
- Volume 7B, Appendix 3-1: Water Framework Directive (WFD) Regulatory Compliance Assessment;
- Volume 7B, Appendix 3-2: Marine Water Quality Baseline;
- Volume 7B, Appendix 3-3: Sediment Quality Baseline; and
- Volume 7B, Appendix 3-4: Sediment Contamination Baseline.

3.1.1.3 The following supporting studies relate to and should be read in conjunction with this chapter:

- Volume 2, Chapter 2: Marine and Coastal Processes;
- Volume 2, Chapter 4: Benthic Subtidal and Intertidal Ecology;
- Volume 2, Chapter 5: Fish and Shellfish Ecology; and
- Volume 2, Chapter 7: Marine Mammals.

3.2 Legislation, Policy and Guidance

3.2.1.1 Volume 1, Chapter 2: Legislation and Policy, of this EIAR sets out the policy and legislation associated with the Proposed Development (Offshore).

3.2.1.2 Legislation, Policy and Guidance that relate to the MW&SQ assessment are identified and described in Table 3-1.

Table 3-1: Legislation, Policy and Guidance.

Relevant Legislation, Policy and Guidance	Description
Scottish Legislation	
EU Exit: Marine Environmental Legislation in Scotland (Scottish Government, 2020[1])	The Marine Environment (EU Exit) (Scotland) (Amendment) Regulations 2019 (Scottish Parliament, 2019) details the amendments made to specific pieces of legislation and their practical implications, including the interpretation of existing

Relevant Legislation, Policy and Guidance	Description
	guidance. Within this document, references to EU Directives mean as applied in Scottish law by relevant Scottish legislation.
The Water Environment and Water Services (Scotland) Act 2003 (Scottish Parliament, 2003[2])	The Water Environment and Water Services (Scotland) Act 2003 make provision and enable provision to be made for or in connection with implementing the EU Water Framework Directive (WFD) 2000/60/EC. This Act establishes the legal framework for water management and environmental protection in Scotland and incorporates the key principles and requirements of the WFD. This Act, along with various other legislative instruments—such as the Water Environment (River Basin Management Planning: Further Provision) (Scotland) Regulations 2013, the Scotland River Basin District (Standards) Directions 2014, the Scotland River Basin District (Status) Directions 2014, and the Water Environment (Controlled Activities) (Scotland) Regulations 2011—collectively implement the WFD in Scotland, hereinafter referred to as the WFD Legislation.
The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) (Scottish Parliament, 2011[3]) Subsequently amended: The Water Environment (Controlled Activities) (Scotland) Amendment Regulations 2021 (Scottish Parliament, 2021[4])	The Water Environment (Controlled Activities) (Scotland) Regulations, commonly referred to as the Controlled Activity Regulations (CAR), provide a comprehensive regulatory framework for managing activities that could adversely affect Scotland's water environment. These regulations apply to rivers, lochs, transitional waters (estuaries), coastal waters, groundwater, and groundwater-dependent wetlands.
The Bathing Waters (Scotland) Regulations 2008 Subsequently amended: The Bathing Waters (Scotland) Amendment Regulations 2012 (Scottish Parliament, 2012[5])	These regulations transposed the Bathing Water Directive (76/160/EEC and revised Bathing Water Directive (rBWD) (2006/7/EC) into Scottish law. Hereinafter referred to as the 'Bathing Water Legislation'.
The Water Environment (Shellfish Water Protected Areas: Environmental Objectives etc.) (Scotland) Regulations 2013 (Scottish Parliament, 2013[6])	The Water Environment (Shellfish Water Protected Areas: Designation) (Scotland) Order 2013 identifies 84 coastal SWPAs. The Water Environment (Shellfish Water Protected Areas: Designation) (Scotland) Order 2016 designated the 85th SWPA, Loch Ryan. The regulations aim to protect and enhance the quality of these SWPAs to support shellfish life and growth, ensuring compliance with relevant EU directives.
The Action Programme for Nitrate Vulnerable Zones (Scotland) Regulations 2008 (as amended) (Scottish Parliament, 2008[7])	The Action Programme for Nitrate Vulnerable Zones (Scotland) Regulations 2008 (as amended) establish a regulatory framework to mitigate nitrate pollution in designated vulnerable zones across Scotland. These regulations were designed to comply with the requirements

Relevant Legislation, Policy and Guidance	Description
	of the EU Nitrates Directive 91/676/ECC (outlined under EU Legislation).
The Urban Waste Water Treatment (Scotland) Regulations 1994 (Scottish Parliament, 1994), and the Urban Waste Water Treatment (Scotland) Amendment Regulations 2003 (Scottish Parliament, 2003[8])	The Urban Waste Water Treatment (Scotland) Regulations 1994, as amended by the Urban Waste Water Treatment (Scotland) Amendment Regulations 2003, enacted by the Scottish Parliament, establish the regulatory framework governing the treatment of urban wastewater in Scotland. These regulations are part of Scotland's efforts to comply with the EU Urban Waste Water Treatment Directive (91/271/EEC). They set standards and requirements for the collection, treatment, and discharge of urban wastewater to protect water quality and public health. Hereinafter referred to as the Urban Waste Waster Treatment Legislation (UWWTL).
The Climate Change (Scotland) Act 2009 Subsequently amended: The Climate Change (Emission Reduction Targets) (Scotland) Act 2019 (Scottish Parliament, 2019[9])	The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 set to increase the ambition of Scotland's emission reduction target within Section 1 of the Climate Change (Scotland) Act 2009 to net zero by 2024 and revised interim and annual emission targets (Scottish Government, 2023), such as: ▪ 2025 Carbon Reduction Target: 61.7% ▪ 2035 Carbon Reduction Target: 82.5% ▪ 2045 Carbon Reduction Target: 100% (net zero emissions)
The Environmental Authorisations (Scotland) Regulations 2018 (Scottish Parliament, 2018[10])	The Environmental Authorisations (Scotland) Regulations 2018 establish a comprehensive and streamlined framework for the regulation of environmental activities in Scotland. These regulations consolidate and simplify the authorisation processes for a range of activities, including waste management, water discharge, and radioactive substances. The Scottish Environmental Protection Agency (SEPA) is the primary authority responsible for administering and enforcing these regulations, ensuring compliance and safeguarding Scotland's environment.
The Marine Strategy Regulations 2010 (Scottish Parliament, 2010[11])	The Marine Strategy Regulations 2010 implement the requirements of the EU Marine Strategy Framework Directive 2008/56/EC in Scotland. These regulations establish a framework for the sustainable management of Scotland's marine environment, aiming to achieve Good Environmental Status (GES) of marine waters by 2020 (and afterwards). The Scottish Ministers are responsible for ensuring compliance with these regulations, in coordination with other UK administrations and stakeholders, to protect and preserve the marine environment.
Marine (Scotland) Act 2010 (Scottish Parliament, 2010[12]) In addition to:	The introduction of the Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009 (collectively known as the "Marine Acts") established a new legislative and management framework for Scotland's marine environment.

Relevant Legislation, Policy and Guidance	Description
Marine and Coastal Access Act 2009 (UK Parliament, 2009[13])	This framework enables the sustainable management of competing demands on Scotland's seas. Marine planning in Scotland's inshore waters is governed by the Marine (Scotland) Act 2010, while the Marine and Coastal Access Act 2009 governs offshore waters. The Marine and Coastal Access Act 2009 is UK-wide legislation, but certain provisions apply specifically to Scotland's offshore waters (beyond 12 nautical miles).
Contextual EU and International Legislation	
EU Environmental Quality Standards Directive (2008/105/EC) Subsequently amended: Directive (2013/39/EU) (Council of the European Union, 2008[14])	The Environmental Quality Standards Directive (2008/105/EC), also known as the EQSD, sets out quality standards for waterbodies across the European Union to protect aquatic environments and human health. These standards are in line with the strategy and objectives of the European Union (EU)'s water framework directive (Directive 2000/60/EC). Within this directive, there are two key terms related to the assessment of pollutants in surface/ coastal waters: ▪ Annual Average - refers to the average concentration of a particular pollutant over the course of a year. ▪ Maximum Allowable Concentration - refers to the highest concentration of a particular pollutant that is allowed in surface water at any given time. The requirements of the Directive have been transposed to Scotland through a range of legislation, primarily the Water Environment and Water Services (Scotland) Act 2003.
EU Water Framework Directive (2000/60/EC) (Council of the European Union, 2000[15])	The WFD established a comprehensive regulatory framework for the sustainable management and protection of surface waterbodies (including rivers, lakes, coasts and estuaries) and groundwater. Waterbody classification is based on two categories: ecological and chemical status. For a waterbody to achieve an overall 'good' status, both its ecological and chemical statuses must be at least 'good'. Ecological status is determined by evaluating biological, hydromorphological, physico-chemical, and specific chemical parameters. The ecological status is classified as either high, good, moderate, poor, or bad. The requirements of the Directive have been transposed to Scotland through a range of legislation, primarily the Water Environment and Water Services (Scotland) Act 2003.
EU Bathing Waters Directive 2006/7/EC (Council of the European Union, 2006[16])	The EU's revised Bathing Water Directive (rBWD) (2006/7/EC) came into force in March 2006, replacing the previous Bathing Water Directive (76/160/EEC). The directive requires member states to identify and designate Bathing Waters (BWs), monitor them for specified microbiological parameters, and classify them based on water quality standards. The rBWD establishes more stringent standards and places an emphasis on providing information to the public. The rBWD is transposed to

Relevant Legislation, Policy and Guidance	Description
	Scotland via the Bathing Waters (Scotland) Regulations 2008.
EU Marine Strategy Framework Directive (MSFD) 2008/56/EC (Council of the European Union, 2008[17])	The objective of the MSFD, transposed in Scotland through the Marine (Scotland) Act 2010 and the Marine Strategy Regulations 2010, was to achieve Good Environmental Status (GES) of the EU's marine waters by 2020, now extended to 2024, and beyond. It establishes a framework for the protection and sustainable use of Europe's seas, ensuring they remain healthy and resilient for current and future generations. Key objectives include reducing marine pollution, protecting biodiversity, promoting sustainable fishing, and mitigating the impacts of human activities on marine ecosystems.
EU Urban Waste Water Treatment Directive (UWWTD) 91/271/EEC (Council of the European Union, 1991[18])	The Urban Waste Water Treatment Directive (UWWTD) aims to safeguard the environment from the negative impacts associated with the collection, treatment, and discharge of urban wastewater. Under the UWWTD, 'sensitive areas' refer to waterbodies affected by elevated nitrate concentrations or eutrophication, signalling the need for targeted measures to prevent further nutrient-related pollution. The UWWTD was transposed to Scotland by the Urban Waste Water Treatment (Scotland) Regulations 1994, as amended by the Urban Waste Water Treatment (Scotland) Amendment Regulations 2003.
International Convention for Prevention of Marine Pollution by Ships (MARPOL) (International Maritime Organisation [IMO], 1978[19])	MARPOL is the main international convention regarding prevention of pollution of the marine environment by ships from operational or accidental causes. The MARPOL Convention was adopted in 1973 and in response to numerous tanker accidents the Protocol of 1978 absorbed the 1973 Convention and has been updated by amendments through the years.
Policy	
Scotland's National Marine Plan (Scottish Government, 2015[20])	The following policies of Scotland's National Marine Plan, which was prepared in accordance with the United Kingdom (UK) Marine Policy Statement, apply to this water and sediment quality assessment: ▪ GEN 1: General planning principle; ▪ GEN 10: Invasive non-native species; ▪ GEN 12: Water quality and resource; and ▪ GEN 21: Cumulative impacts.
Sectoral Marine Plan for Offshore Wind Energy (Scottish Government, 2020[21])	The Sectoral Marine Plan for Offshore Wind Energy (Scottish Government, 2020) sets out a strategic framework for the sustainable development of offshore wind energy in Scotland's marine areas. The plan aims to guide the development of offshore wind farms to ensure they

Relevant Legislation, Policy and Guidance	Description
	contribute to renewable energy targets while minimizing environmental and social impacts.
The River Basin Management Plan (RBMP) for Scotland 2021 – 2027 (SEPA, 2021[22])	The RBMP for Scotland 2021-2027 outlines strategies and actions to protect and improve the water environment across Scotland. The plan aims to achieve good ecological and chemical status by 2027, in line with the WFD Legislation.
National Planning Framework 4 (NPF4) (Scottish Government, 2023[23])	The National Planning Framework 4 (NPF4), published by the Scottish Government in 2023, outlines strategic planning priorities and development policies for Scotland over the coming years. It serves as a guiding document for spatial planning, infrastructure development, and sustainable growth across various sectors, including housing, transportation, energy, and the environment. The NPF4 replaces both NPF3 and Scottish Planning Policy.
The Scotland River Basin District (Quality of Shellfish Water Protected Areas) (Scotland) Directions 2021 (Scottish Government, 2021[24])	The Scotland River Basin District (Quality of Shellfish Water Protected Areas) (Scotland) Directions 2021, and The Water Environment (Shellfish Water Protected Areas: Objectives and Classification etc.) (Solway Tweed) Directions 2021 establish requirements for monitoring and assessing water quality within SWPAs to ensure that environmental objectives are being met. This includes regular sampling and analysis of water samples for contaminants such as bacteria, toxins, and chemical pollutants that may pose risks to shellfish and human health.
Guidance	
The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended). A Practical Guide. (SEPA, 2021[25])	Provides detailed guidance on complying with regulations governing activities that affect Scotland's water environment. It aims to help individuals and organisations understand and adhere to the rules for activities such as discharges, abstractions, engineering works, and impoundments. The guide outlines the application process for necessary authorisations, explains regulatory requirements, and offers best practices for minimising environmental impacts, ensuring sustainable use and protection of water resources in Scotland.
Supporting Guidance (WAT-SG-53) Environmental Quality Standards and Standards for Discharges to Surface Waters (SEPA, 2020[26])	This guidance serves as a reference for understanding and implementing Environmental Quality Standards (EQS) and discharge standards in Scotland’s surface waters (including coastal and transitional). It outlines the criteria and thresholds for assessing and regulating the quality of surface waters, including rivers, lakes, and coastal areas. The guide provides clarity on compliance requirements, monitoring procedures, and strategies for managing discharges to ensure water quality protection and sustainable environmental management.

Relevant Legislation, Policy and Guidance	Description
Guidance for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater, Coastal and Marine (CEEIM, 2019[27])	This document provides comprehensive guidelines for conducting EIAs in various environments including terrestrial, freshwater, coastal, and marine ecosystems within the UK and Ireland. It aims to standardise the process and ensure high-quality, consistent assessments that support sustainable development and environmental protection.
Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Proposed Developments (Cefas, 2012[28])	These guidelines contain generic advice for the acquisition of data to support EIAs for offshore renewable energy developments. Guidance is provided on the design, review and implementation of environmental data collection and analytical activities associated with all stages of offshore renewable energy developments.
SEPA standing advice for the Department for Business, Energy and Industrial Strategy and The Scottish Government's Marine Directorate on marine consultations (SEPA, 2023[29])	This document aims to streamline the consultation process for marine developments by providing consistent and clear advice on environmental considerations. It is intended to help developers, planning authorities, and other stakeholders understand SEPA's position on various issues related to marine consenting processes, including developments requiring EIAs.
Guidance for Pollution Prevention (GPP) 5: Works and maintenance in or near water (NetRegs, 2017[30])	This document provides guidance on best practices for carrying out works and maintenance activities in or near waterbodies to minimise environmental impacts. It aims to prevent pollution and manage the environmental risks associated with such activities.
Review of cabling techniques and environmental effects applicable to the offshore wind farm industry, Technical Report (BERR, 2008[31])	This document aims to review the various cabling techniques employed in the offshore wind farm industry and assess their potential environmental effects. It provides guidance for developers, regulators, and other stakeholders involved in the planning and implementation of offshore wind farm projects.
Assessment of the Environmental Impact of Offshore Wind-Farms (OSPAR, 2008[32])	This assessment explores the status of offshore wind-farm development within the OSPAR area in terms of the current scale and planned potential schemes, and the environmental effects of this. Its conclusions relate to the effects that all offshore wind-farm developments under construction and operational within the OSPAR area have and how these affect the quality status of the OSPAR maritime area.
Use of Chemicals in Offshore Wind Farm Construction and Operation (Cefas, 2022[33])	This document provides a comprehensive overview of the chemicals used in the construction and O&M of OWFs. It assesses the potential environmental risks associated with these chemicals, considering their use, discharge, and potential impacts on marine ecosystems. The report also outlines regulatory frameworks and best practices for managing chemical use to minimise environmental harm.

3.2.2 Sediment Contamination Assessment Guidelines

3.2.2.1 Unlike water quality, formal EQS for UK statutory seabed sediment quality standards have yet to be established. Therefore, to assess potential contamination and pollution in offshore and nearshore seabed sediments, a number of published guidelines and assessment criteria have been considered. In situ values of physico-chemical variables are measured against background levels described in the guidelines, which are based on concentrations of compounds in undisturbed sediments. Those published guideline documents used in this MW&SQ assessment include:

- Action levels (ALs) for the Disposal of Dredged Material, as reported by Marine Management Organisation (2014[34]) and Scottish Government (2017[35]);
- Canadian Marine Sediment Quality Guidelines for PAHs, as reported by Canadian Council of Ministers of the environment (CCME, 1999[36]); and
- OSPAR Assessment Criteria for Polybrominated Diphenyl Ethers (PBDEs) in sediment, as reported on OSPAR (2020a[37]; 2020b[38]).

3.2.2.2 Further detail on the guidelines used in this MW&SQ assessment, including those forementioned threshold values, can be found in Volume 7B, Appendix 3-4: Sediment Contamination Baseline.

3.3 Stakeholder Engagement

3.3.1 Overview

3.3.1.1 The Offshore Scoping Report (Volume 7, Appendix 2) was submitted to Marine Directorate - Licensing Operations Team (MD-LOT)[i] in September 2022, who then circulated the report to relevant consultees. A Scoping Opinion (Volume 7, Appendix 3) was received from MD-LOT on 13 January 2023. Relevant comments from the Scoping Opinion specific to MW&SQ are provided in Table 3-2.

3.3.1.2 Further consultation has been undertaken throughout the pre-application stage. The consultation activities carried out relevant to MW&SQ are summarised in Table 3-3.

[i] In 2023, Marine Scotland was renamed Marine Directorate, and thus the marine licensing and consents team is now referred to as Marine Directorate - Licensing Operations Team (MD-LOT).

Table 3-2: Scoping Opinion Response.

Consultee	Comment	Response
MD-LOT	The Scottish Ministers are content with the baseline data sources regarding marine water and sediment quality used by the Developer in Table 7.1 of the Scoping Report. The Scottish Ministers advise in line with the NatureScot representation that a blue carbon assessment should be undertaken to expand on the information and assessment conducted for benthic ecology to focus on the potential impacts of the proposed development on marine sediments. The Developer must fully address the representation from NatureScot in the EIAR. The Scottish Ministers are otherwise content with the approach to the baseline environment.	Section 3.4.3 of this report provides an overview of blue carbon regarding sediments in the MW&SQ Study Area. For an overview of blue carbon regarding benthic ecology, the reader is directed to Volume 2, Chapter 4: Benthic Subtidal and Intertidal Ecology. The reader is referred to Volume 6, Chapter 3: Climate Change Resilience as part of the EIAR which looks to evaluate, where possible with the available data, the direct blue carbon habitat loss/disturbance from the placement of subsea infrastructure during the lifecycle of the Proposed Development (Offshore).
MD-LOT	In Table 7.7 of the Scoping Report the Developer summarises the potential impacts to marine water and sediment quality during the different phases of the Proposed Development. The Scottish Ministers agree with the impacts scoped in to and out of the EIAR and provide no further comments.	Section 3.7 of this report provides a full assessment of potential impacts scoped into the EIAR regarding MW&SQ.
NatureScot (4 November 2022)	In additional to the climate change assessments mentioned in the scoping report, we advise that a blue carbon assessment is undertaken. This should expand on the information and assessment conducted for benthic ecology to focus on the potential impacts of the proposed development on marine sediments.	Section 3.4.3 of this report provides an overview of blue carbon regarding sediments the MW&SQ Study Area. For an overview of blue carbon regarding benthic ecology, the reader is directed to Volume 2, Chapter 4: Benthic Subtidal and Intertidal Ecology. The reader is referred to Volume 6, Chapter 3: Climate Change and Resilience as part of the EIAR which looks to evaluate, where possible with the available data, the direct blue carbon habitat loss/disturbance from the placement of subsea infrastructure during the lifecycle of the Proposed Development (Offshore).

Consultee	Comment	Response
NatureScot (4 November 2022)	We agree that the only impact pathway scoped in for the cumulative impact assessment is the temporary increase in suspended sediment and sediment deposition. All other impacts on benthic and intertidal ecology are generally spatially restricted and within close proximity to the Caledonia OWF Array Area and offshore export cable corridor.	Section 3.8 of this chapters covers the potential cumulative impacts of increased suspended sediment on MW&SQ receptors which are linked to pathways of effect to benthic ecology. Volume 2: Chapter 4: Benthic Subtidal and Intertidal Ecology provides a full assessment of the potential cumulative impacts of increased suspended sediments and sediment deposition on benthic ecology.
NatureScot (4 November 2022)	The operational effect Modifications to the wave and tidal regime, & associated impacts to morphological features is scoped out "due to generally low tidal currents, as well as distance offshore". However no detail is provided to justify this. We advise that this effect should be scoped in. Alternatively the developer may wish to submit, for our consideration, further justification in terms of the significance of low tidal currents, any relevant evidence (observations or modelling results) from nearby and/or analogous offshore wind farms, and which if any receptors are being taken into account (w.r.t. paras 6.5.1.2 and 6.5.1.4).	Volume 2, Chapter 2: Marine and Coastal Processes offers a comprehensive assessment of potential impacts resulting from changes to the wave and tidal regimes, as well as the subsequent effects on morphological features from operational infrastructure.
NatureScot (4 November 2022)	The operational effect Impacts to seabed morphology is scoped in only for the export corridor, for potential impacts on the Southern Trench MPA. We advise that this effect should also be assessed for the other 'aspects' of the development (Table 6.2), in keeping with an approach of assessing effects as pathways. Alternatively the developer may wish to submit, for our consideration, further justification in terms of potential receptors (across all EIA topics).	Volume 2, Chapter 2: Marine and Coastal Processes offers a comprehensive assessment of potential impacts to seabed morphology across the Caledonia OWF and Caledonia OECC, including designated and undesignated areas of seabed.
NatureScot (4 November 2022)	The operational effect Cumulative modifications to the wave and tidal regime, & associated impacts to sediment	Volume 2, Chapter 2: Marine and Coastal Processes offers a comprehensive assessment of potential cumulative

Consultee	Comment	Response
	transport is scoped out because there is "no likelihood of local or regional changes in sediment transport regime". However no detail is provided to justify this. We advise that this effect should be scoped in. Alternatively the developer may wish to submit, for our consideration, further justification in terms of any relevant evidence (observations or modelling results) from nearby and/or analogous offshore wind farms.	impacts resulting from changes to the wave and tidal regimes, as well as the subsequent impacts to sediment transport, when evaluated with other projects.
The Highland Council (22 November 2022)	The description of development for an EIAR is often much more than would be set out in any planning application. An EIAR must include: ▪ A description of the main characteristics of the construction processes, for instance, nature and quantity of the materials used; ▪ The risk of accidents, having regard in particular to substances or technologies used; ▪ An estimate, by type and quantity, of expected residues and emissions (water, air and soil pollution, noise, vibration, light, heat, radiation, etc.) resulting from the operation of the development; ▪ The estimated cumulative impact of the project with other consented or operation development; and ▪ A detailed schedule of mitigation	Volume 1, Chapter 3: Proposed Development Description (Offshore) provides a full overview of the main characteristics of the construction processes and estimates of required materials. Section 3.7 of this report provides a full assessment of potential impacts scoped into the EIAR regarding MW&SQ. Section 3.8 provides a full assessment of potential cumulative impacts regarding any projects/plans that have potential to temporally and spatially overlap with the construction, Operation and Maintenance (O&M) or decommissioning of the Proposed Development (Offshore). Table 3-13 outlines mitigation relevant to the MW&SQ assessment.

Table 3-3: Stakeholder Engagement Activities.

Date	Consultee and Type of Consultation	Summary
7 June 2023	NatureScot; Meeting	NatureScot stated that a blue carbon assessment should be undertaken. This should expand on the information and assessment conducted for benthic ecology to focus on the potential impacts of the Proposed Development (Offshore) on marine sediments. NatureScot agreed to provide details of suggested references and guidance regarding the preparation of a blue carbon assessment. Communication of selected references received via email 4 July 2023.

3.4 Baseline Characterisation

3.4.1 Study Area

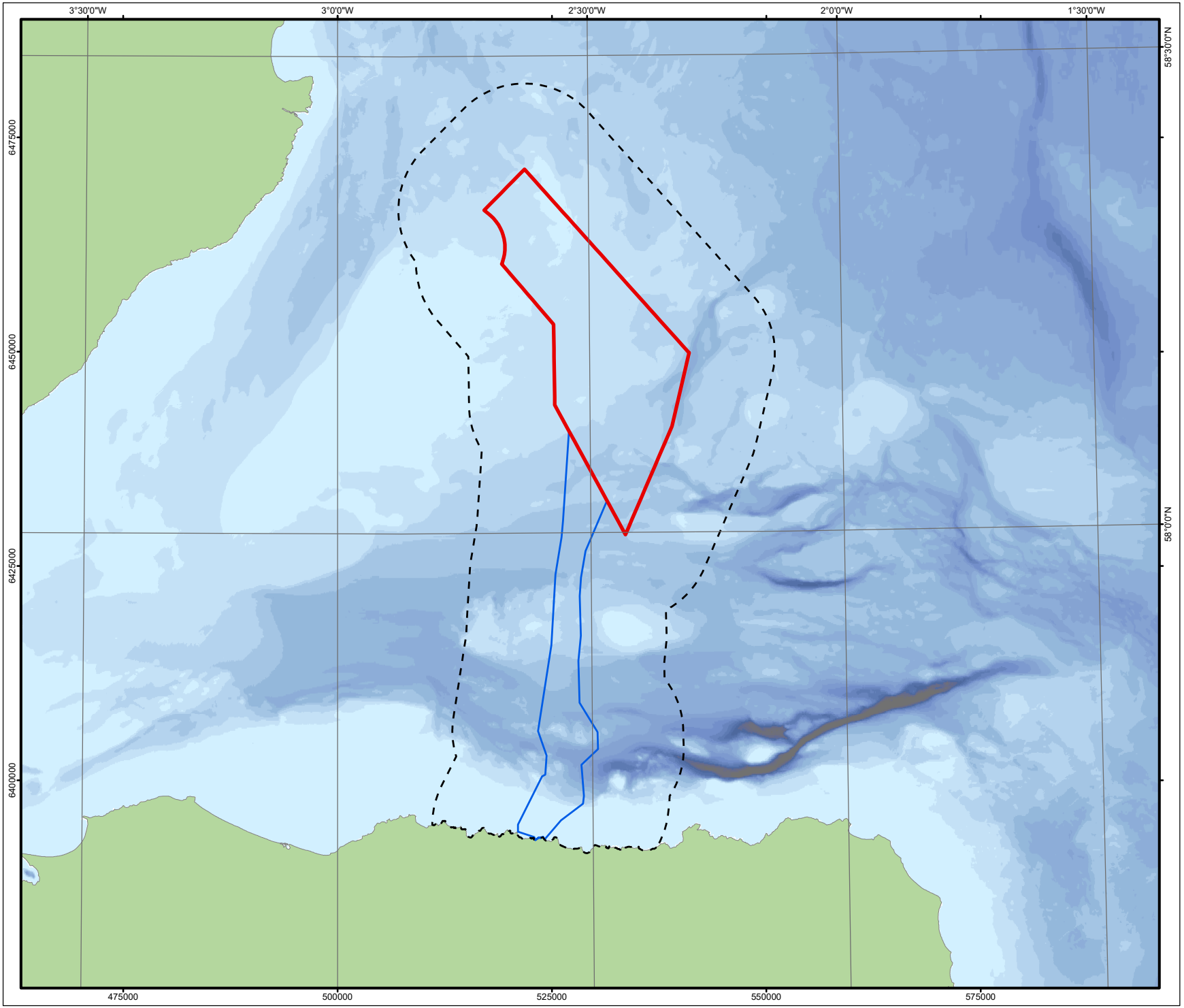
3.4.1.1 The MW&SQ Study Area (Figure 3-1), contains all elements of the Proposed Development (Offshore) up to and including the intertidal zone at landfall, defined as ending at MHWS. The comprising areas are characterised as:

- Near-field:
  - Caledonia OWF (including Wind Turbine Generators (WTGs), Offshore Substation Platforms (OSPs), interconnector and inter-array cables); and
  - Caledonia Offshore Export Cable Corridor (OECC; including offshore export cables) and Landfall Site.
- Far-field:
  - The seabed and water column surrounding those areas that may be influenced by changes to MW&SQ due to the potential impacts of the Proposed Development (Offshore).

3.4.1.2 A Zone of Influence (ZoI), illustrated in Figure 3-1, has been used to identify MW&SQ receptors which have the potential to be affected by the Proposed Development (Offshore) infrastructure and associated activities. The ZoI has been defined using the outputs from site-specific numerical modelling (Volume 7B, Appendix 2-2: Marine and Coastal Processes Numerical Modelling Report) and is scaled to conservatively represent the equivalent distance of tidal excursion on a mean spring tide. Consequently, the ZoI comprises a distance of 10 kilometres (km) from the limit of the Proposed Development (Offshore), encapsulating the maximum extent of measurable sediment plumes predicted by the modelling (Volume 7B, Appendix 2-2: Marine and Coastal Processes Numerical Modelling Report).

3.4.1.3 In this report, MW&SQ includes the following elements:

- Water quality (including physical parameters), WFD Legislation Protected Areas, BWs, SWPAs, Nutrient Sensitive Areas;
- Sediment quality (including Particle Size Analysis (PSA) and Total Organic Carbon (TOC)); and
- Sediment contamination (including Total Hydrocarbon Content (THC), Polycyclic Aromatic Hydrocarbons (PAHs), Polychlorinated Biphenyl (PCBs), PBDEs, Organochloropesticides (OCPs), organotins and metals).



Caledonia OWF

Offshore Export Cable Corridor

10km Zone of Influence

Depth (m)

0 - 50	120 - 130
50 - 60	130 - 140
60 - 70	140 - 150
70 - 80	150 - 160
80 - 90	160 - 170
90 - 100	170 - 180
100 - 110	180 - 190
110 - 120	190 - 200
	>200

0 5 10 15 20 km

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CALEDONIA Offshore Wind Farm

GoBe APEM Group

CONTRACTOR DRAWING NO: UKCAL1_GO_WNF_MWS_MAP_0010	CONTRACTOR REV: 01
GEODETIC PARAMETERS: WGS 84 / UTM zone 30N (EPSG: 32630)	
DRAWING TITLE: Figure 3-1: The Marine Water and Sediment Quality Study Area	
STATUS: Approved	SCALE: 1:600,000
DRAWING NUMBER: N/A	SHEET NO: 01 of 01 / REV: N/A

3.4.2 Data Sources

Desk Study

3.4.2.1 The data sources that have been used to inform this MW&SQ chapter of the EIAR are presented within Table 3-4.

Table 3-4: Summary of key publicly available datasets for MW&SQ.

Title	Author	Year
Atlantic – European North West Shelf – Ocean Biogeochemistry Analysis and Forecast	Copernicus Marine Service[39]	2024
Shellfish safety and sanitation	Food Standards Scotland[40]	2024
Bathing Water Profiles	SEPA[41]	2023
Water Classification Hub	SEPA[42]	2022
The River Basin Management Plan for Scotland 2021 – 2027	Scottish Government and SEPA, [22]	2021
Contaminant and biological effect data 1999-2017 for the 2018 CSEMP assessment	Marine Scotland[43]	2019
Shellfish Water Protected Area: Maps	Scottish Government[44]	2019
Urban Waste Water Treatment Directive Areas 2019	SEPA[45]	2019
Beatrice O&G Field Decommissioning EIA	Repsol Sinopec Resources UK Limited[46]	2018
Moray West OWF EIAR	Moray Offshore Windfarm (West) Limited[47]	2018
Hazardous substances – UK Marine Environment Monitoring and Assessment National (MERMAN)[48]	MERMAN[49]	2017
Intermediate Assessment 2017 – Contaminants	OSPAR[50]	2017
Mean monthly sea surface temperature and salinity (Scotland's National Marine Plan Interactive (NMPi))	Marine Scotland[51]	2017
Suspended Sediment Climatologies around the UK	Cefas[52]	2016
Nitrate Vulnerable Zones: maps	Scottish Government[53]	2015

Title	Author	Year
Moray East OWF EIAR	Moray Offshore Renewables Limited[54]	2012
Waste water treatment in the United Kingdom – 2012. Implementation of the European Union Urban Waste Water Treatment Directive - 91/271/EEC	Department for Environment, Food and Rural Affairs (DEFRA)[55]	2012
Charting Progress 2	United Kingdom Marine and Monitoring Assessment Strategy (UKMMAS)[56]	2010

Site Specific Surveys

3.4.2.2 Site-specific surveys have been carried out across the Proposed Development (Offshore) to appropriately inform the impact assessment. The surveys of specific relevance to this MW&SQ chapter are summarised here.

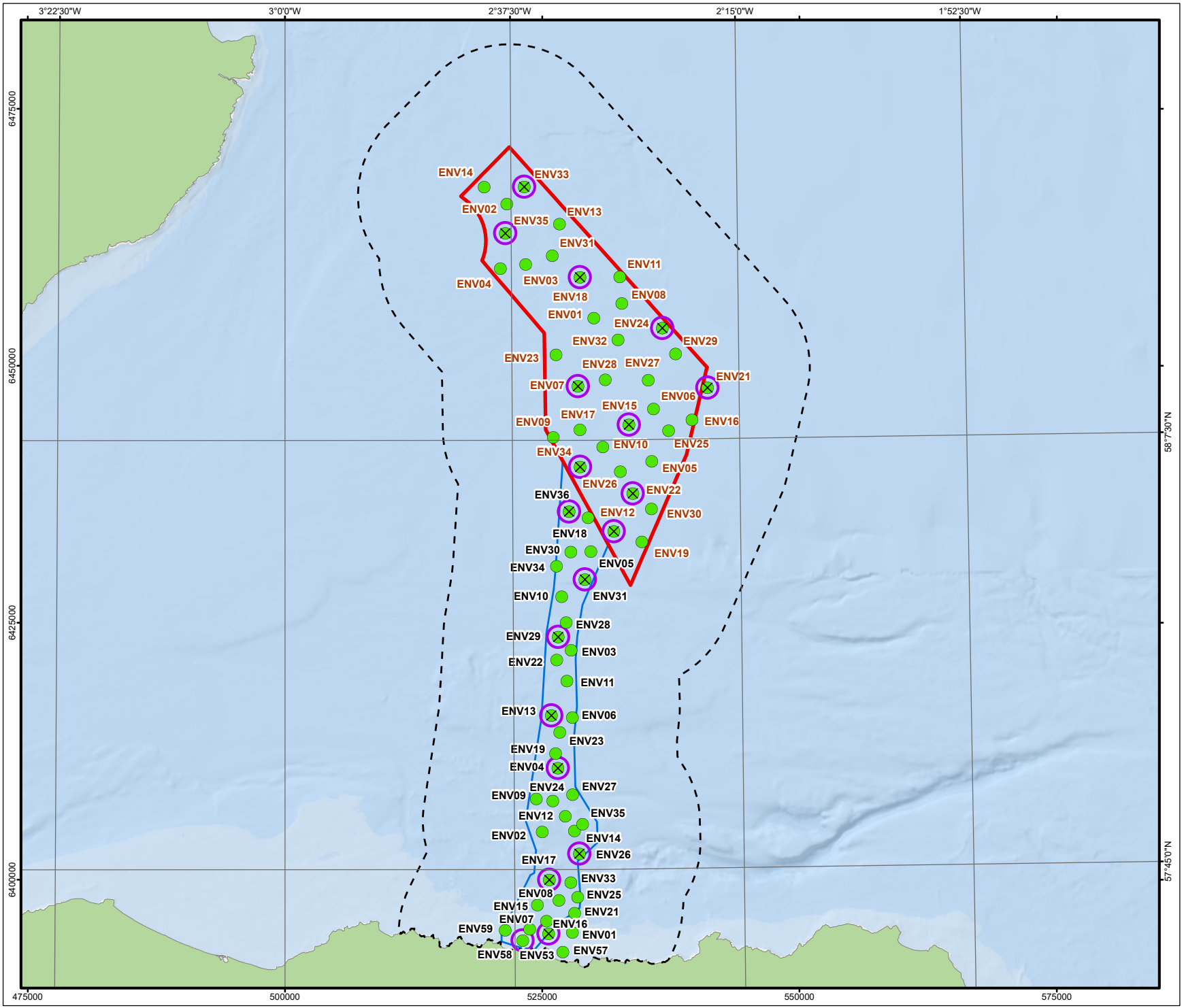
Environmental Baseline Report

3.4.2.3 Between March and June 2023, Gardline conducted an integrated survey on behalf of Caledonia Offshore Windfarm Limited (the Applicant). This included sediment sampling for PSA, macrofauna, eDNA, and various contaminants, along with Conductivity, Temperature and Depth (CTD) profiles to assess water column properties like temperature, salinity, turbidity, dissolved oxygen, and pH.

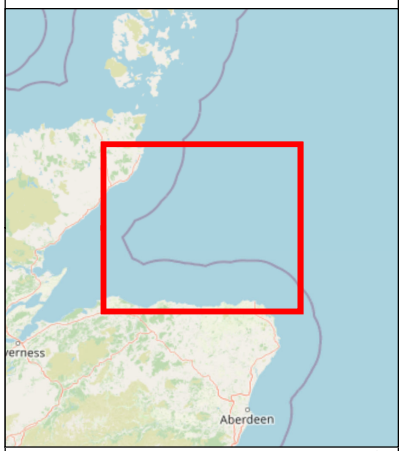
3.4.2.4 All sample stations are displayed in Figure 3-2, illustrating both the location and type of samples collected. Detailed methodology and findings are available in Volume 7B, Appendix 4-1: Environmental Baseline Report (Array Area) and Volume 7B, Appendix 4-2: Environmental Baseline Report (Offshore Export Cable Corridor).

Geophysical Survey

3.4.2.5 Geophysical survey data were successfully acquired across the Caledonia OWF and Caledonia OECC. The output of this survey detailed information on bathymetry, seabed features (including locations of anthropogenic features such as shipwrecks, cables and Oil and Gas wells) and sub-seabed data. Detailed methodology and findings are available in Volume 7B, Appendix 4-6: Reconnaissance Geophysical Survey Interpretation Report.



Caledonia OWF
Offshore Export Cable Corridor
10km Zone of Influence
PSA Sample
Chemistry Sample
Water Sample



0 5 10 15 20 km

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GoBe APEM Group

CONTRACTOR DRAWING NO: UKCAL1_GO_WNF_MWS_MAP_0014	CONTRACTOR REV: 01
GEODETIC PARAMETERS: WGS 84 / UTM zone 30N (EPSG: 32630)	

DRAWING TITLE

Figure 3-2: Site-Specific Survey Locations in the Array Area and Export Cable Corridor

STATUS: Approved	SCALE: 1:500,000	
DRAWING NUMBER: N/A	SHEET NO: 01 of 01	REV: N/A

3.4.3 Baseline Description

3.4.3.1 The baseline (or existing) environment has been assessed in terms of MW&SQ characteristics across the Study Area (see Section 3.1). Where applicable, the Caledonia OWF and OECC baseline environment has been evaluated individually.

3.4.3.2 A comprehensive review of the existing MW&SQ baseline environment is provided in the following documents:

- Volume 7B, Appendix 3-2: Marine Water Quality Baseline;
- Volume 7B, Appendix 3-3: Sediment Quality Baseline; and
- Volume 7B, Appendix 3-4: Sediment Contamination Baseline.

3.4.3.3 The following section offers a concise summary; the reader is referred to the aforementioned documents for further details.

Water Quality

Temperature and Salinity

3.4.3.4 Climatology data from Scotland's NMPi covering a 30-year period (1971-2000) was used to calculate mean monthly surface temperature and salinity across the MW&SQ Study Area (Marine Scotland, 2017[51]). This data was compared with recent site-specific survey data to ensure robust characterisation of temperature and salinity profiles (see Volume 7B, Appendix 4-1: Environmental Baseline Report (Array Area); Volume 7B, Appendix 4-2: Environmental Baseline Report (Offshore Export Cable Corridor)).

Caledonia OWF

3.4.3.5 The annual mean surface salinity (parts per thousand; ‰) within the Caledonia OWF was reported to remain fully marine at around 34.78‰ with minimal fluctuations throughout the year (ranging from 34.70‰ in April to 34.99‰ in October) (Marine Scotland, 2017[51]). A site-specific survey undertaken in April 2023 observed similar results, ranging from 34.10psu to 34.60psu, indicating stable salinity profiles with the exception of Station ENV12 which showed a localised halocline at 10 metres (m) to 25m depth (which is likely due to freshwater input from river catchments which flow into the Moray Firth) (see Volume 7B, Appendix 4-1: Environmental Baseline Report (Array Area)).

3.4.3.6 Temperature values across the Caledonia OWF showed a strong seasonal signal with highs of 12.69 degrees celsius (°C) in September and lows of 5.76°C in March. Moreover, during the summer months (May, June, July, August, and September), a slight temperature variation was observed in throughout the water column with ranges of up to 1.8°C (in June) between mean surface and bottom temperatures (Marine Scotland, 2017[51]). A site-specific survey conducted in April observed surface temperatures between

7.8°C to 9.7°C, indicating well-mixed upper layers with a distinct thermocline forming below 10m (see Volume 7B, Appendix 4-1: Environmental Baseline Report (Array Area)).

Caledonia OECC

3.4.3.7 The annual mean surface salinity (‰) within the OECC was reported to remain full marine at around 34.74‰ with minimal fluctuations throughout the year (ranging from 34.63‰ in April to 34.89‰ in October) (Marine Scotland, 2017[51]). A site-specific survey conducted in April observed similar sea surface salinity ranging from 33.8psu to 34.40psu across sample stations. Compared to the Caledonia OWF, the OECC showed slightly decreased salinity in surface waters which is consistent with freshwater input from river catchments which flow into the Moray Firth (Volume 7B, Appendix 4-2: Environmental Baseline Report (Offshore Export Cable Corridor)).

3.4.3.8 Temperature across the OECC showed a strong seasonal signal with highs of 12.88°C in September and lows of 5.58°C in March. Moreover, during the summer months (May, June, July, and August), a slight temperature variation was observed in the depth of the water column with variations of up to 2.04°C in June between mean surface and mean bottom temperatures (Marine Scotland, 2017[51]). The site-specific survey data reported a general increase in sea surface temperature associated with distance from shore, ranging from 6.9°C at nearshore Station ENV17 to 8.1°C at the furthest offshore Station ENV36. In addition, a clear thermocline was observed at depths ranging from c. 10 to 15m in the offshore environment, whereas nearshore stations recorded a well-mixed profile throughout (Volume 7B, Appendix 4-2: Environmental Baseline Report (Offshore Export Cable Corridor)).

3.4.3.9 In summary, these values reported for temperature and salinity of both the Caledonia OWF and Caledonia OECC are characteristic of a typical coastal environment throughout an annual cycle with inputs from freshwater sources.

Dissolved Oxygen

3.4.3.10 Dissolved oxygen levels are indicative of oxygen sufficiency, with concentrations below 6 milligrams per litre (mg/l) considered oxygen deficient and below 2mg/l as hypoxic. Typical dissolved oxygen concentrations in the North Sea range from 6mg/l to 10mg/l (Mahaffey *et al.*, 2020[57]). In the OSPAR Quality Status Report (2023), a dissolved oxygen concentration of >6mg/l near the seafloor is used as an indicator of a healthy marine environment.

Caledonia OWF

3.4.3.11 A site-specific survey of the Caledonia OWF found all dissolved oxygen concentrations above 6mg/l, ranging from 9.1mg/l to 11.4mg/l (Volume 7B, Appendix 4-1: Environmental Baseline Report (Array Area)) The highest dissolved oxygen concentrations were reported in surface samples within the top 10m of the water column, suggesting surface mixing contributing to air-sea gas exchange. An observed decline in dissolved oxygen was evident below

the well mixed upper layer down to, approximately, 30m. These data are characteristic of a typical offshore coastal region of the North Sea (Mahaffey *et al*., 2020[57]).

Caledonia OECC

3.4.3.12 A site-specific survey of the Caledonia OECC found all dissolved oxygen concentrations above 6mg/l, ranging from 9.0mg/l to 10.7mg/l (Volume 7B, Appendix 4-2: Environmental Baseline Report (Offshore Export Cable Corridor)). The highest dissolved oxygen concentrations were reported in surface samples within the top 5m to 10m of the water column, suggesting surface mixing contributing to air-sea gas exchange. These data are characteristic of typical dissolved oxygen concentrations in offshore coastal region of the North Sea (Mahaffey *et al*., 2020[57]).

Turbidity and Suspended Particulate Matter

3.4.3.13 Baseline Suspended Particulate Matter (SPM) values in the Study Area are expected to be relatively low (approximately < 5mg/l) (Cefas, 2016[52]). However, during storm events, near seabed SPM can be significantly increased in the short-term due to the influence of waves stirring the seabed.

3.4.3.14 The normal turbidity levels for seawater in the North Sea can vary depending on factors such as location, season, weather conditions, and anthropogenic influences. However, typical turbidity levels in the North Sea are generally low to moderate whereas coastal or estuarine environments are more turbid. In relatively clear offshore waters of the North Sea, turbidity levels may range from around 1 to 5 Formazin Turbidity Units (FTU) under normal conditions.

Caledonia OWF

3.4.3.15 Turbidity profiles of water samples within the Caledonia OWF revealed that the water turbidity remained relatively consistent throughout the water column, within that expected of Noth Sea conditions (Volume 7B, Appendix 4-1: Environmental Baseline Report (Array Area)).

Caledonia OECC

3.4.3.16 Turbidity profiles of water samples within the OECC revealed that the water turbidity remained relatively consistent throughout the water column. There were slight increases in turbidity observed at the deepest 5 to 10m at most stations. Nearshore Station ENV53 exhibited higher turbidity (6.7FTU), likely due to a plankton bloom observed in the seabed imagery (Volume 7B, Appendix 4-2: Environmental Baseline Report (Offshore Export Cable Corridor)).

pH

3.4.3.17 Data extracted from Copernicus for pH levels between 2021 and 2024, focusing on a central data point within the Caledonia OWF, indicates an annual average pH of 8.06 (Copernicus Marine Service, 2024[39]). The typical pH of seawater in the Moray Firth varies based on location, season, and environmental influences. Air-sea interaction with carbon dioxide generally

keeps seawater pH within a range of 7.5 to 8.5, aligning with the survey results.

Caledonia OWF

3.4.3.18 A site-specific survey measured pH at various depths in April, with results indicating relatively stable pH levels throughout the water column (ranging from a minimum pH of 7.9 to a maximum pH of 8.3) (Volume 7B, Appendix 4-1: Environmental Baseline Report (Array Area)). Slight increases in pH were observed at thermoclines (see Volume 7B, Appendix 3-2: Marine Water Quality Baseline), likely due to changes in water chemistry or biological activity influenced by stratification during spring/summer.

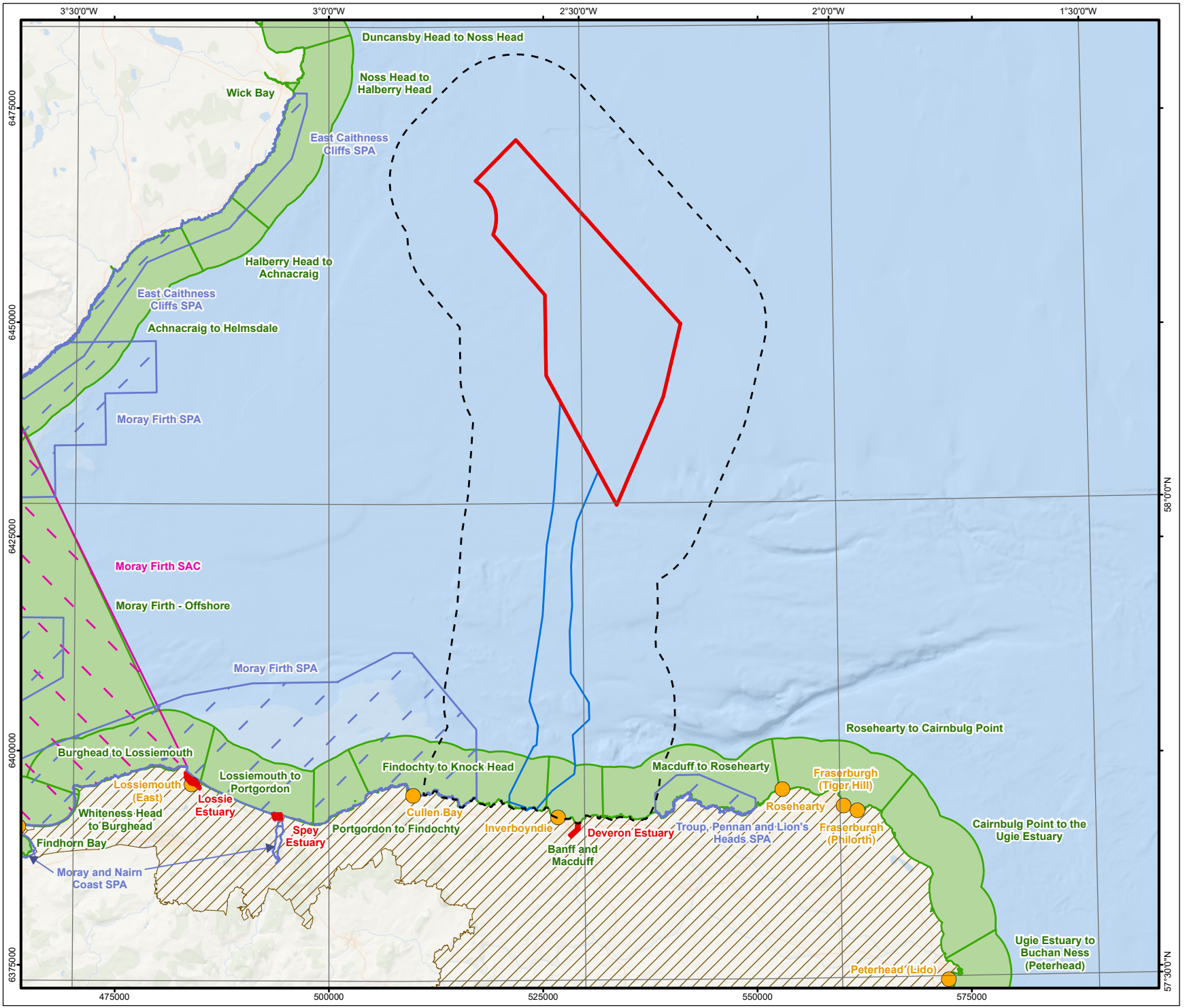
Caledonia OECC

3.4.3.19 Similar to the Caledonia OWF, the OECC survey showed stable pH levels throughout the water column (ranging from a minimum pH of 7.9 to a maximum pH of 8.1) (Volume 7B, Appendix 4-2: Environmental Baseline Report (Offshore Export Cable Corridor)). Slight increases in pH were also noted at thermoclines.

Water Framework Directive Legislation

3.4.3.20 As specified in the WFD Legislation (see Table 3-1), there is a requirement to characterise coastal waters, as part of River Basin districts, within the area extending landward from three nautical miles up to the limit of the highest tide or, where appropriate, the seaward limits of any bodies of transitional water. This MW&SQ chapter further characterises the MW&SQ Study Area based on the expected maximum distance that water from within the Caledonia OWF or Caledonia OECC might be transported on a single mean spring tide, in either flood and/or ebb direction. All sites designated in accordance with the WFD Legislation that fall within the 10km Study Area (Figure 3-3) are potentially assessed as receptors within this EIAR and include:

- One transitional and three coastal waterbodies;
- One BW;
- No SWPAs; and
- One Nutrient Sensitive Area.



- Caledonia OWF
- Offshore Export Cable Corridor
- 10km Zone of influence
- Special Protection Area (SPA)
- Special Area of Conservation (SAC)
- Coastal Waterbodies
- Transitional Waterbodies
- Bathing Water Locations
- Aberdeenshire, Banff, Buchan and Moray Nitrate Vulnerable Zone

0 5 10 15 20 km

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CALEDONIA Offshore Wind Farm

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GEODETIC PARAMETERS: WGS 84 / UTM zone 30N (EPSG: 32630)	

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Figure 3-3: Designated Sites in Relation to the MW&SQ Study Area

STATUS: Approved	SCALE: 1:600,000	
DRAWING NUMBER: N/A	SHEET NO: 01 of 01	REV: N/A

Coastal and Transitional Waterbodies

3.4.3.21 One transitional and three coastal waterbodies wholly or partially overlap with the MW&SQ Study Area. A detailed summary of the latest (2022/23) classification status of these four waterbodies is shown in Table 3-5. The one transitional waterbody within the Study Area was identified as Deveron Estuary (ID: 200138) which maintained an overall status of 'High' in 2022, indicating a healthy and resilient environment. The three coastal waterbodies were Findochty to Knock Head (ID: 200497), Banff and Macduff (ID:200498) and Macduff to Rosehearty (ID: 200499) which were all classified with an overall 'Good' status with many indications of a healthy and resilient environment (Table 3-5). All waterbodies passed the chemical status assessment indicating lower pollution levels. Moreover, both dissolved inorganic nitrogen and dissolved oxygen status was reported as 'High' for all coastal waters suggesting eutrophication is not a problem in these waterbodies. Overall, these classifications provide high confidence that the MW&SQ Study Area is characteristic of what is expected of a healthy coastal environment within the Moray Firth.

Table 3-5: Summary of latest classification status (2022/23) for WFD coastal and transitional waterbodies in the MW&SQ Study Area.

Parameter	Coastal and Transitional Water Bodies			
Water body name	Findochty to Knock Head	Banff and Macduff	Macduff to Rosehearty	Deveron Estuary
Water body ID	200497	200498	200499	200138
Water body type	Coastal	Coastal	Coastal	Transitional
Water body size (surface area)	135.3km^2	41.3km^2	130.9km^2	0.1km^2
Overall status	Good	Good	Good	High
Overall ecology	Good	Good	Good	High
Physico-chemical	High	High	High	-
Dissolved oxygen	High	High	High	-
Dissolved inorganic nitrogen	High	High	High	-
Biological elements	Good	Good	Good	-
Invertebrate animals	Good	Good	Good	-
Imposex assessment	-	Good	-	-

Parameter	Coastal and Transitional Water Bodies			
Benthic invertebrates (IQI)	Good	Good	Good	-
Macroalgae	High	High	High	-
Macroalgae (FSL)	High	High	High	-
Macroalgae (RSL)	High	High	High	-
Phytoplankton	High	High	High	-
Specific pollutants	Pass	Pass	Pass	-
Copper	-	-	-	-
Zinc	-	-	-	-
Unionised ammonia	Pass	Pass	Pass	-
Hydromorphology	High	High	High	High
Morphology	High	High	High	High
Water quality	Good	Good	Good	-
Chemical status	Pass	Pass	Pass	Pass
Distance from the Caledonia OWF (km)	30.39	30.25	28.97	37.38
Distance from the Caledonia OECC (km)	0	0	3.14	4.63

Bathing Waters

3.4.3.22 The Bathing Water Legislation has four different classifications of performance according to the levels of certain types of bacteria (intestinal enterococci and *Escherichia coli [E.coli]*) in samples obtained during the bathing season, as follows:

- Excellent – the highest, cleanest class;
- Good – generally good water quality;
- Sufficient – water quality meets minimum required standards; and
- Poor – water quality does not meet the minimum required standards.

3.4.3.23 There are currently 11 BWs in the Moray Firth, of which only one wholly overlaps with the MW&SQ Study Area of the Proposed Development (Offshore) (Table 3-6). Inverboyndie BW is situated within the MW&SQ Study Area, located 2.55km from the OECC and 37.09km from the Caledonia OWF.

Inverboyndie was reported as 'Excellent' in the year 2022/23, with a history of increasing overall status.

Table 3-6: Summary of latest classification status (2022/23) for designated BWs in the MW&SQ Study Area.

Bathing Water	Classification Season					
	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
Inverboyndie	Sufficient	Sufficient	-	Good	Good	Excellent

Shellfish Water Protected Areas

3.4.3.24 SWPAs are areas of water designated to support the sustainable growth of the shellfish sector. Within the Moray Firth there are two SWPAs, namely Cromarty Bay and Dornoch Firth. However, both areas are located within the Inner Moray Firth, greater than 70km to the west of the Proposed Development (Offshore) and subsequently outside of the Study Area (Scottish Government, 2019[45]). Furthermore, Production Areas for Cromarty Bay (Pacific oyster) and Dornoch Firth (common mussels) were declassified as part of the 2017/18 season and have not been classified since (FSS, 2024[40]). Therefore, there are no identified pathways for significant effects on the Moray Firth's SWPAs.

Urban Wastewater Treatment Legislation Sensitive Areas

3.4.3.25 The UWWTD (91/271/EEC) aims to protect the environment from the adverse effects of urban wastewater by requiring tertiary treatment at sewage treatment plants that impact sensitive waters. Outside but flowing towards the MW&SQ Study Area, three sensitive rivers (eutrophic and freshwater fish areas) and one sensitive BW area (Inverboyndie BW) are designated for protection. These rivers, classified as heavily modified waterbodies due to unavoidable physical alterations for agricultural drainage, include the River Deveron (Turriff to tidal limit); Boyne Burn/Corncairn Burn; and Fordyce Burn (SEPA, 2019[45]). The rivers do not extend past the MHWS and therefore do not form part of the Study Area.

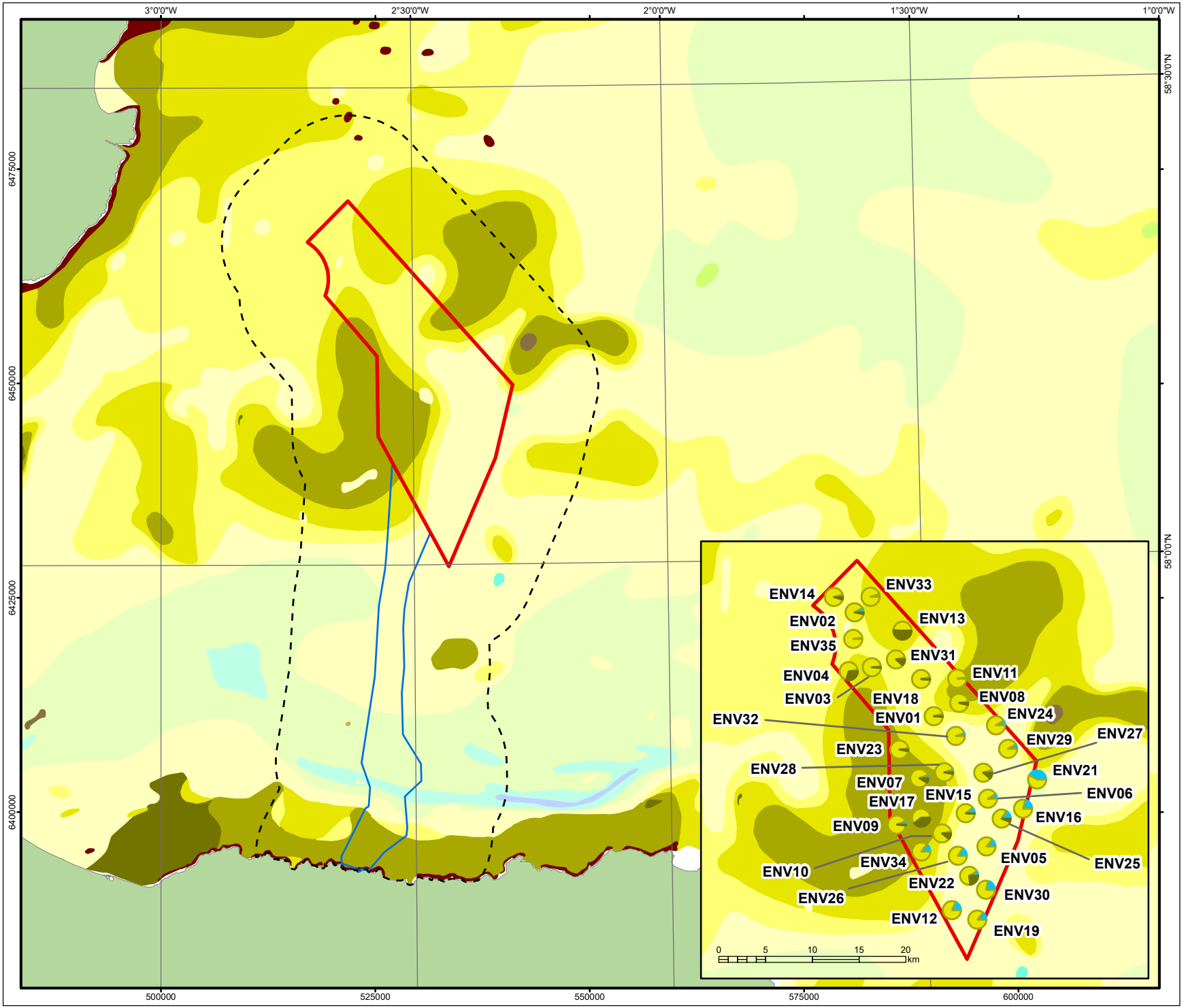
Nitrate Vulnerable Zones

3.4.3.26 Of the five NVZs in Scotland, one falls in the MW&SQ Study Area, referred to as the Moray, Aberdeenshire/Banff and Buchanan NVZ (Scottish Government, 2015[53]). This means that farms in the NVZ must comply with the Action Programme for Nitrate Vulnerable Zones (Scotland) Regulations 2008. The Caledonia OECC and Caledonia OWF are located 0km and 34.57km, respectively, from the border of the NVZ. The Proposed Development (Offshore) is not anticipated to effect or be affected by the NVZ. Moreover, the coastal and transitional waterbodies along the MW&SQ Study Area hold an overall classification of 'Good' or 'Excellent', with a high classification in regard to dissolved inorganic nitrogen concentration.

Sediment Quality

Sediment Characterisation

3.4.3.27 Diversity and composition of macro and meio benthic communities, organic carbon (OC) storage and contaminant storage/distribution are strongly conditioned by sediment grain size. Sediments with a finer particle size, such as clays and muds, can act as adsorption surfaces for contaminants that may be released into the water column if the sediment is disturbed. This is due to their larger surface area to volume ratios and higher organic carbon content. Sediments consisting of coarser sand and gravel are accepted to carry a much lower contamination risk. Information regarding particle sizes is an important step in assessing the contamination risk to the marine environment. Figure 3-4 illustrates the anticipated sediment characterisation across the Study Area.



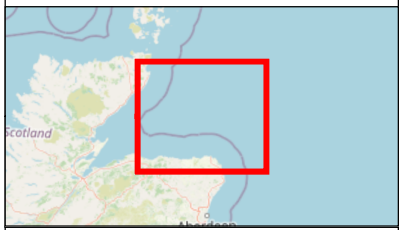
Caledonia OWF
Offshore Export Cable Corridor
10km Zone of Influence

Seabed Sediments (Folk, 1954)

- 1.1.1 Mud
- 1.2.1 sandy Mud
- 1.2.2 (gravelly) sandy Mud
- 1.3.1 muddy Sand
- 1.3.2 (gravelly) muddy Sand
- 2.1.1 Sand
- 2.1.2 (gravelly) Sand
- 3.1.1 gravelly Sand
- 3.2.1 sandy Gravel
- 3.3.1 Gravel
- 4.3.1 gravelly muddy Sand
- 4.4.1 muddy sandy Gravel
- 5. Rock and Boulders

PSA Results (%)

- Fines
- Sand
- Gravel



0 5 10 15 20 km

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CALEDONIA Offshore Wind Farm

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GEODETIC PARAMETERS: WGS 84 / UTM zone 30N (EPSG: 32630)	

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Figure 3-4: Existing Surficial Sediment Characterisation Combined with Site-Specific Sampling

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DRAWING NUMBER: N/A	SHEET NO: 01 of 01	REV: N/A

Caledonia OWF

3.4.3.28 Regional sediment maps sourced from EMODnet (2020[58]) and British Geological Society (BGS) datasets for the Caledonia OWF reveal predominantly Holocene sediments such as sand, gravelly sand, sandy gravel, and slightly gravelly sand, classified by Folk (1954) (Folk, 1954[59]). These sediments are reported to contain only a small proportion of fines, less than 10%.

3.4.3.29 A site-specific survey observed mean particle size ranging from 45 micrometres (µm) at Station ENV21 to 2881µm at Station ENV13, with an average mean grain diameter of 439µm (±613SD). The dominant fraction, accounting for between 49.0% and 97.1% of the sediment was sand (with a particle size range of ≥63µm and <2 millimetres (mm)). These data support the BGS sediment maps (reporting of less than 10% fines), where there was 8.8% of fines present in the survey samples. Surveys conducted across Moray East OWF found levels of fine (silt / clay) particles were generally low across the survey area (<3%) but increased (around 4% and 5%) with increased water depth to the south (Moray Offshore Renewables Limited, 2012[54]). This is further validated by comparison with Moray West surveys that found seabed sediments across the Moray West site generally consist of Holocene gravelly sand and sand with only a minor proportion of fines (<5 to 10% silt and clay sized) (Moray Offshore Windfarm (Est) Limited, 2018[47]).

3.4.3.30 When survey results were classified under the modified Folk 16 classification (1954[59]), stations ranged from muddy sand to sandy gravel. These classifications were validated by the analysis of the relative proportions of fines, sand and gravel. Similar results as seen reported from Moray East survey samples are observed in the Caledonia OWF where samples indicate a particle size distribution ranging from very poorly sorted[ii] to moderately sorted[iii] (Folk and Ward, 1957[60]).

Caledonia OECC

3.4.3.31 Regional-scale sediment maps from EMODnet (2020[58]), sourced from BGS datasets, indicate that within the OECC of the Proposed Development (Offshore) the surficial seabed sediments are characterised by Holocene sediments of sand and gravels close to the Caledonia OWF, with mud content increasing towards the shore. Sediments generally appear to become progressively finer as water depth increases, with isolated patches of coarser sediment associated with bathymetric highs. Between approximately 8km and 20km offshore, the surficial sediments are classified as muddy sand, with a band of sandy mud approximately 10km offshore.

[ii] "Very poorly sorted" indicates that the sediment contains a wide range of particle sizes, with no dominant size fraction. This suggests a lack of uniformity in the particle sizes present.
[iii] "Moderately sorted" suggests that there is some degree of uniformity in the particle sizes, but there is still noticeable variability present.

3.4.3.32 A site-specific survey across the OECC observed mean particle size ranging from 41µm (Station ENV27) to 1813µm (Station ENV11). Shallow stations (<35m depth) were mostly sandy (>95%) and moderate to moderately well sorted with minimal fines and gravel. Deeper stations (>70m depth) had poorly to very poorly sorted, muddy sands with higher fines content (11-45%) and low gravel content (<1%). There is a positive correlation between fines and water depth. There was a clear positive correlation between fines and water depth, where finer sediment was observed in areas of deeper water.

Total Organic Carbon

3.4.3.33 TOC is expressed as a percentage of the total weight and represents the carbon constituent of organic matter. In general, for continental shelf sediment there is a close relationship between OC content and the surface area of the mineral matrix (Mayer, 1994[61]). Increased TOC is expected with the presence of fine sediment, as it adsorbs to the increased surface area provided by the fine grain particles.

Caledonia OWF

3.4.3.34 A site-specific survey found that across the Caledonia OWF, the highest TOC concentration of 1.10% was recorded at Station ENV21 which was identified as a statistically high outlier. All remaining stations reported relatively uniform TOC concentrations from 0.21% at Station ENV18 to 0.45% at Station ENV34. In the Caledonia OWF, these TOC values were expected considering the general predominant sand component of the sediment. This was supported by results where TOC concentration was positively correlated with the volume of fines across the Caledonia OWF.

Caledonia OECC

3.4.3.35 A site-specific survey found that across the OECC, TOC concentrations ranged from 0.16% at Station ENV58 to 0.77% at Station ENV26, where the mean TOC value was 0.39% and there was a positive correlation with water depth. Similar to the Caledonia OWF, these TOC values were expected in the OECC considering the general predominant sand and muddy sand components of the sediment. This was supported by results where TOC concentration was positively correlated with the volume of fines across the OECC.

Sediment Contamination

3.4.3.36 Unlike water quality, there are no formal quantitative EQS for sediments. In the absence of any quantified UK standards, common practice for characterising baseline sediment quality conditions is to compare against ALs for the disposal of dredged material as defined by the Scottish Government (2017[35]) and the MMO (2014[34]). Where ALs do not provide comprehensive guidance, other sediment quality guidelines are used in place (CCME, 1999[36]; OSPAR, 2020a[37]; OSPAR, 2020b[38]).

3.4.3.37 The Intermediate Assessment 2017 prepared by OSPAR (2017[62]) reviewed and compared mercury, cadmium, lead, organotins (limited data), PCBs, PAHs and PBDE concentrations in sediments between OSPAR contaminant assessment areas. The four monitoring stations in the Moray Firth form part of the Northern North Sea region. The main conclusions drawn from the data for the Northern North Sea are as follows:

- Metals:
  - Mercury and lead concentrations in sediment are at or above the Background Assessment Concentration (BAC).
  - Lead concentrations are also at or above the Effect Range-Low (ERL) value.
  - Mean concentrations of cadmium are below the BAC.
- PCBs:
  - Trend analysis shows PCB concentrations are reducing.
  - PCB congener 118 concentrations in sediments are below the EAC and above the BAC.
- PAHs:
  - Mean PAH concentrations in sediment were statistically significantly below the ERL but not below the BAC.
- PBDEs:
  - PBDE concentrations in sediment are low and often below detection levels.

3.4.3.38 EIARs for Moray West, Moray East and Beatrice OWFs, located in the Moray Firth, all reported low levels of metals and/or organic contaminants with majority below the Limit of Detection (LOD) or otherwise below relevant threshold guidelines (e.g., ALs), suggesting no significant contamination (BOWL, 2012[63]; Moray Offshore Renewables Limited, 2012[54]; Moray Offshore Windfarm (West) Limited, 2018[47]). Although there is some historical oil and gas activity surrounding Beatrice OWF, contamination levels generally align with expected background levels for the Central North Sea, indicating a lack of gross contamination (Repsol Sinopec Resources UK Limited, 2018[64]).

Total Hydrocarbons

3.4.3.39 THC concentration gives an indication of the total hydrocarbon present within a sediment sample; it does not give an indication of the source of contamination. It has previously been shown that benthic macrofauna suffer adverse effects when THC is in excess of 50 micrograms per gram (µg/g) (Kjeilen-Eilertsen *et al*., 2004[65]; UKOOA, 2002[66]; 2005[67]) and as such, this value represents a threshold above which hydrocarbons can be expected to present a 'significant environmental impact'. In addition, Kingston (Kingston, 1992[68]) previously reported that benthic macrofauna suffer adverse effects (e.g., reduced diversity), when THC is more than 50µg/g to 60µg/g, where

specific sensitive species can experience impacts at levels greater than 10µg/g.

Caledonia OWF

3.4.3.40 The site-specific survey (Volume 7B, Appendix 4-1: Environmental Baseline Report (Array Area)) analysed sediment samples from the Caledonia OWF using a Gas Chromatography-Flame Ionisation Detector (GC-FID) to measure THC. THC ranged from 2.1µg/g at Station ENV35 to 20.7µg/g at Station ENV21, with an average of 7.0µg/g (± 5.4 SD). However, the high outlier at ENV21 was a statistically high outlier. THC levels correlated negatively with particle size and positively with depth and fines, with the highest concentrations observed in the south of the Caledonia OWF. THC levels measured by Ultraviolet Fluorescence (UVF) were lower, with only three stations above the LOD.

3.4.3.41 Station ENV21 exceeded the 10µg/g threshold, potentially impacting sensitive benthic macrofauna. The hydrocarbon profile of samples indicated low-level, high molecular weight n-alkanes typical of the North Sea, with origins likely from terrestrial plants or weathered petrogenic materials. Overall, THC values were below harmful thresholds, and the faunal community is not expected to be significantly influenced by THC concentrations.

Caledonia OECC

3.4.3.42 The site-specific survey (Volume 7B, Appendix 4-2: Environmental Baseline Report (Offshore Export Cable Corridor)) analysed samples from the OECC using a GC-FID to measure THC. THC levels ranged from 2.8µg/g at the shallowest station (ENV58) up to 18.7µg/g at the deepest station (ENV26) with a mean of 10.7µg/g (± 4.6SD). THC concentrations were positively correlated with fines and TOC. Similar to findings in the Caledonia OWF, THC levels measured by UVF were lower, with only three stations above the LOD. Six stations (ENV04, ENV17, ENV26, ENV29 ENV36 and ENV53) had THC marginally above the 10µg/g threshold, however, when measured through UVF, all concentrations were below the 10µg/g threshold.

3.4.3.43 The hydrocarbon profile of samples showed low-level, high molecular weight n-alkanes and unresolved comnplex mixtures (UCM), typical of background hydrocarbon inputs in the North Sea. The UCM accounted for 62% to 94% of THC, indicating weathered hydrocarbons with some fresher inputs. Overall, THC in the OECC were below harmful levels and faunal community is not expected to be significantly influenced by THC concentrations.

Polycyclic Aromatic Hydrocarbons

3.4.3.44 PAHs are priority hazardous substances under the WFD (2000/60/EC)[15] in the related EQSD (2008/105/EC amended by 2013/39/EU)[14] due to their persistence, bioaccumulation, and toxicity. The Canadian Marine Sediment Quality Guidelines (Threshold Effect Levels (TELs) and Probable Effect Levels (PELs)) provide reliable standards for assessing PAH toxicity in marine sediments (CCME, 1999[36]).

3.4.3.45 PAH toxicity varies based on type and bioavailability, and individual PAH toxicity values can be misleading as PAHs are rarely found alone. More sensitive toxicity estimates use ERL and Effects Range-Median (ERM) concentrations: 0.55 µg/g and 3.16 µg/g for low molecular weight PAHs, 1.70 µg/g and 9.60 µg/g for high molecular weight PAHs (Long *et al*., 1995[69]). These concentrations are not actual thresholds of toxicity but delineate concentration ranges with associated probabilities of toxicity.

Caledonia OWF

3.4.3.46 Total PAH concentration in the Caledonia OWF ranged from 0.001µg/g to 0.275µg/g, with Station ENV33 and ENV35 below the LOD. Molecular mass indices identified pyrogenic sources like grass, wood, or coal combustion and petrogenic sources like petroleum. Overall, PAH concentrations were very low, not exceeding Canadian or USEPA guidelines for sediment PAHs, and were below ERL values (Long *et al*., 1995[69]), further indicating that toxic effects on fauna are unlikely.

Caledonia OECC

3.4.3.47 Total PAH concentrations in the Caledonia OECC ranged from 0.009µg/g to 0.146µg/g, with Stations ENV53 and ENV58 below the LOD. Molecular mass indices identified pyrogenic PAHs from sources like grass, wood or coal combustions at all stations, and low concentrations of petrogenic PAHs from petroleum sources. Overall, PAH concentrations were very low and did not exceed Canadian or USEPA guidelines for sediment PAHs. Total PAH concentrations were also below ERL values, indicating that toxic effects on fauna are unlikely.

Polychlorinated Biphenyls

3.4.3.48 A report published by Marine Scotland (Marine Scotland, 2020[70]) found PCB concentrations in biota (fish and shellfish) and sediment in the four Scottish biogeographic regions generally remain below the threshold at which adverse effects occur in marine life, but above the BAC. Mean concentrations were stable or decreasing in the assessed areas over the assessment period (1999 – 2018).

Caledonia OWF

3.4.3.49 PCB concentrations from sediment samples collected from the Caledonia OWF were all below the LOD, indicating that toxic effects to fauna by PCBs are unlikely (Volume 7B, Appendix 4-1: Environmental Baseline Report (Array Area)).

Caledonia OECC

3.4.3.50 PCB concentrations from sediment samples collected from the Caledonia OECC were all below the LOD, indicating that toxic effects to fauna by PCBs are unlikely (Volume 7B, Appendix 4-2: Environmental Baseline Report (Offshore Export Cable Corridor)).

Polybrominated Diphenyl Ethers

3.4.3.51 PBDEs adsorb easily to solid matrices due to their lipophilicity and hydrophobicity thus sediments are becoming known as major reservoirs for this pollutant (Ohoro *et al*., 2021[71]). PBDE concentrations in sediment are compared to OSPAR BACs and Environmental Assessment Criteria (EACs). BACs indicate thresholds near natural background levels, particularly for man-made substances like PBDEs. EACs assess whether PBDE concentrations might harm marine organisms. For PBDEs, the Canadian Federal Environmental Quality Guidelines (FEQGs) are used as EAC equivalents. Hence, adverse effects on marine organisms are rarely observed when concentrations are below the FEQG.

Caledonia OWF

3.4.3.52 Concentrations of PBDEs in sediment collected across the Caledonia OWF were recorded below the LOD with the exception of PBDE 209 which ranged from 0.31 nanograms per gram (ng/g) to 2.01ng/g. The results of the survey highlighted that PBDE 209 concentrations exceeded OSPAR (2020a[37]) BAC values at three Stations. However, all concentrations were below the FEQG guidelines (OSPAR, 2020b[38]). Therefore, toxic effects to fauna by PBDEs in the Caledonia OWF are unlikely, even with the disturbance of sediment.

Caledonia OECC

3.4.3.53 Contamination of PBDEs in sediment collected across the OECC were recorded below the LOD with the exception of PBDE 209 which ranged from below the LOD at Station ENV58 to 1.86ng/g at Station ENV31. Analysis of survey results showed that PBDE 209 at all but Station ENV58 exceeded the OSPAR (2020[37]) BAC. However, concentrations were all well below the FEQGs. Therefore, toxic effects to fauna by PBDEs in the OECC are unlikely, even with the disturbance of sediment.

Organochloropesticides

3.4.3.54 OCPs belong to the group of chlorinated hydrocarbon derivatives, which have vast application in the chemical industry and in agriculture. These compounds are known for their high toxicity, slow degradation, and bioaccumulation (Jayaraj *et al*., 2017[72]).

Caledonia OWF

3.4.3.55 OCPs present in sediment samples collected across the Caledonia OWF were generally below the LOD, with the exception of dieldrin at Station ENV15 (0.1ng/g) and p,p'-Dichlorodiphenyldichloroethane at Station ENV33 (0.1ng/g). Dieldrin concentration at Station ENV15 did not exceed the AL1 concentration of 0.5ng/g. Therefore, toxic effects to fauna by OCPs in the Caledonia OWF are not anticipated.

Caledonia OECC

3.4.3.56 OCPs present in sediment samples collected across the Caledonia OECC were generally below the LOD, with the exception of dieldrin at Station ENV04. Dieldrin concentration at Station ENV04 of 0.1ng/g did not exceed the AL1

concentration of 0.5ng/g. Therefore, toxic effects to fauna by OCPs in the OECC are not anticipated.

Organotins

3.4.3.57 Organotin compounds are man-made metallic tin complexes with hydrocarbon substituents with historical applications in food packages, pesticides, wood preservatives, antifouling, and anticorrosion paints. According to the OSPAR Intermediate assessment, mean concentrations of tributyltin have measurably reduced in the Southern North Sea and are very low or undetectable elsewhere (OSPAR, 2017[50]).

Caledonia OWF

3.4.3.58 Organotins found in sediment samples collected across the Caledonia OWF were all below the LOD at all sampled stations. Therefore, toxic effects to fauna by organotins in the Caledonia OWF are not anticipated.

Caledonia OECC

3.4.3.59 Organotins found in sediment samples across the Caledonia OECC were all below the LOD at all sampled stations. Therefore, toxic effects to fauna by organotins in the OECC are not anticipated.

Metals

3.4.3.60 Metals constitute a significant source of pollution in marine environments, originating from both natural and anthropogenic sources. Within the water column, biogeochemical processes govern the existence of heavy metals in particulate or dissolved form. In the EIA conducted for Moray East OWF, located directly adjacent to the Caledonia OWF, sediment samples were analysed for various metals, including arsenic, cadmium, chromium, copper, mercury, nickel, lead, tin, barium, and aluminium. The results showed that all metal concentrations were below ALs, indicating no anticipated adverse environmental effects.

Caledonia OWF

3.4.3.61 The survey of the Caledonia OWF found that chromium, copper, nickel, and zinc concentrations correlated positively with fines and negatively with sands, meaning that fluctuations in metal concentrations were influenced by variations in sediment particle size and the resultant adsorption properties. These metals also showed positive correlations with TOC and N-alkanes. Mercury was generally below the LOD except at Station ENV12 (0.02ug/g). All metal concentrations were below respective ALs and Canadian Sediment Quality Guideline standards. These findings align with those of the Moray East and Moray West OWF EIAs, confirming metals were within acceptable guidelines without exceeding ALs.

Caledonia OECC

3.4.3.62 The results of the site-specific survey of the Caledonia OECC showed that arsenic, cadmium, chromium, copper, mercury, nickel, lead and zinc were positively correlated with depth and finer sediment, indicating that

fluctuations in metal concentrations were influenced by variations in sediment particle size and resultant adsorption properties. These five metals also demonstrated positive correlations with TOC and low molecular weight n-alkanes. Concentrations of metals were all well below their respective ALs, indicating that toxic impacts are unlikely to occur.

Blue Carbon

3.4.3.63 Surficial sediments with a high mud fraction generally store more organic carbon (OC) compared to coarser sediments. Anthropogenic disturbance of sediment (i.e., OWF developments) risk increasing the release of OC through remilitarisation. Inorganic carbon (IC), such as carbonate ions, in seabed sediments is less vulnerable to disturbance because it is not easily digested by marine microbes when suspended in the water column. However, IC release can become problematic in areas affected by ocean acidification, potentially harming marine organisms reliant on calcium carbonates. Site-specific sampling in the study area indicates that current pH levels are within expected limits, but uncertainty remains regarding how regional seas like the North Sea will respond to global pH decreases.

3.4.3.64 Scotland's Exclusive Economic Zone (EEZ) covers an area of 554,755km^2 (an area six times larger than Scotland's land area). According to Smeaton *et al.* (2021[73]), the Scottish sector of the UK EEZ hold the majority of the carbon stock estimated at 356.5 (± 72.2) Mt OC and 2,264.8 (± 156.3) Mt IC totalling 2,622 Mt C is held within the top 10 cm of seabed sediments (Smeaton *et al.,* 2021[73]). OC densities (the quantity of OC held per square metre (m^2)) are highest in muddy sediments within fjords and coastal zones, gradually decreasing offshore due to factors like higher dissolved oxygen, longer sediment transport times, and increased sediment resuspension, which accelerate OC degradation. In the Caledonia OWF, sample analysis found concentrations of TOC were relatively uniform, ranging from 0.21% to 1.10% (identified as a statistically high outlier), with a mean TOC value of 0.41%. In the OECC, concentrations of TOC ranged from 0.16% to 0.77%, with a mean TOC value of 0.39%. Overall, organic material is considered to be reasonably low across Caledonia OWF, which is located in the coastal and offshore region.

3.4.3.65 Recent research has highlighted differences in the stability or reactivity of sedimentary OC as a function of location; OC reactivity decreases with distance from the coast (i.e., is more resistant to degradation) (Smeaton and Austin, 2022[74]). Sedimentary OC on the Scottish continental shelf appears to be relatively stable to degradation (Smeaton and Austin, 2022[74]). This stability is crucial as it prevents rapid release of carbon dioxide into the environment, thereby enhancing long-term carbon storage in sediments. Understanding OC stability helps predict how activities like dredging or construction can affect carbon cycling and the overall carbon balance in coastal and marine ecosystems.

3.4.3.66 Sedimentary carbon burial rates in Scottish coastal and marine sediments vary significantly by sediment type and location (Cunningham and Hunt, 2023[75]). Certain sediment types, particularly OC-rich muds found in areas like fjords and muddy coastal regions, are more vulnerable to disturbance and may require management or protection for their carbon resources (Luisetti *et al.*, 2019[76]). In contrast, offshore environments, dominated by sandy sediments according to sediment maps, appear less susceptible to sedimentary carbon disturbances. Site-specific grab samples were interpreted in combination with regional scale sediment maps (EMODnet, 2020[58]) which showed the sediment was dominated by sand fractions, where under the Folk 16 classification (Folk, 1954[59]), sediment ranged from muddy sand to sandy gravel.

3.4.3.67 Given the small proportion of the Scottish EEZ disturbed by the Proposed Development (Offshore), there is limited potential for measurable release of carbon from sediment into the marine environment as a result of the Proposed Development (Offshore). The reader is referred to Volume 6, Chapter 3: Climate Change Resilience as part of the EIAR which looks to evaluate, where possible with the available data, the direct blue carbon habitat loss/disturbance from the placement of subsea infrastructure during the lifecycle of the Proposed Development (Offshore).

3.4.4 Do Nothing Baseline

3.4.4.1 If the Proposed Development (Offshore) does not come forward, an assessment of the future baseline conditions has also been carried out and is described within this section.

3.4.4.2 In the absence of the Proposed Development (Offshore) being constructed, the characterisation of the baseline environment, as presented above, is anticipated to remain valid (i.e., no alterations to the evolving baseline environment out with any natural responses to climate change, in respect of MW&SQ, are anticipated to occur). Regarding the wider marine environment, a deterioration in water quality and in particular biological characteristics and nutrient loads may occur as a result from climate change, and in particular in response to an increased frequency of extreme weather events, increased water flows and temperature fluctuations (IPCC, 2014[77]; Tinker and Howes, 2020[78]).

3.4.4.3 Anticipated changes in the future receiving environment, irrespective of the Proposed Development (Offshore), are multifaceted and driven by various factors relating to climate change. Evidence suggests that climate change is driving fluctuations in the physical, chemical, and biological conditions of marine environments globally, although the extent of these impacts at regional scales, such as the Moray Firth, remains challenging to ascertain due to limitations in data coverage and the complex linkages of climate change impacts in the marine environment (ClimateXChange, 2024[79]). Climate

models indicate that changes in air temperature will likely cause earlier onset of stratification in spring and later breakdown in autumn by the end of the century. This prediction is based on comparing present-day conditions with projected future scenarios under a business-as-usual scenario (SRES A1B) (Sharples *et al*., 2020[80]). In terms of the lifetime of the Proposed Development (Offfshore), climate change is not yet expected to have any notable effect on the range of natural variability in the location or strength of stratification and front, nor any measurable influence on the disturbance of seabed sediments. Coastal areas reliant on freshwater inputs face additional uncertainty due to unpredictable rainfall, which may increase in intensity and frequency, further affecting stratification dynamics. Changes in stratification could have an impact on other properties, such as dissolved oxygen concentration due to longer periods of reduced air-sea exchange and productivity from phytoplankton and lower trophic levels due to reduced upward mixing of nutrients from the deeper layer.

3.4.4.4 Out with the indeterminate changes brought on by climate change, there are few anticipated changes to MW&SQ beyond the natural variations. Site-specific surveys revealed that majority contaminants were either below the limits of detection or relevant guideline levels (e.g., Canadian Guidelines). Trend assessments carried out for the OSPAR intermediate Assessment (OSPAR, 2017[50]), with high confidence in the assessment, found that PCB concentrations were decreasing in the Northern North Sea. These reductions were assessed from the 10 years of monitoring data (2005–2015), where the trend is determined from the last 5 years of data. Meanwhile, no statistically significant decrease (or increases) in PBDEs or PAHs were reported. Finally, in the northern North Sea, cadmium and lead sediment contamination were not significantly found to reduce where mercury was observed to have a statistically significant reduction. In summary, contaminant levels within the sediments and biota of the North Sea have generally shown to be declining, or alternatively, not inclining (OSPAR, 2017). Contaminant release into the North Sea from both land-based sources and the Oil and Gas Industry has been observed to reduce since 2010; this is expected to continue due to improved regulation and diffuse pollution control initiatives (OSPAR, 2017[50]).

3.4.4.5 The proportion of Scottish coastal waters meeting 'Good' ecological status under the WFD Legislation has increased, from 93% in 2008 to 97% in 2014. This previous increase is reflected presently within the MW&SQ Study Area where all designated coastal waterbodies were 'Good' and transitional waterbodies were 'Excellent' denoting the high water quality in these areas. Reflecting on the history of BW classifications within the Study Area, an overall increase from 'Sufficient' to 'Excellent' has been observed, suggesting a reduction in levels of harmful bacteria. Due to the ongoing effort to keep coastal areas and BWs of a higher quality, with the enforcement of relevant legislation and guidelines, the future baseline environment is anticipated to continue to improve. The Water Environment and Water Services (Scotland) Act 2003 (Scottish Parliament, 2003[2]), which implements the requirements of

the WFD in Scotland, subjects many previously unregulated activities to regulation, ensuring Scotland meets the long-term quality objectives that were first identified under the WFD.

3.4.5 Data Gaps and Limitations

3.4.5.1 Whilst many of the baseline characteristics are well understood, as described above, some data sources or assumptions are less well studied and/or quantified for the Study Area. This section seeks to identify areas of uncertainty and potential data gaps.

3.4.5.2 Grab sampling, while providing detailed information on the sediment types (and contaminants) present at collection sites, cannot cover wide swaths of the seabed and individually represent point samples that can then be interpreted in combination together and with the other appropriate datasets, such as the regional scale sediment maps sourced from EMODnet (2020[58]). Data confidence is considered high since comprehensive site-specific surveys undertaking numerous grab samples across both the Caledonia OWF and Caledonia OECC have been conducted, which additionally show good validation against EMODnet predictive substrate model. Moreover, the survey output was compared to existing surveys collected from the receiving environment of nearby OWFs like Beatrice, Moray East, and most recently, Moray West, demonstrating greater validation of the findings. The seabed morphology, sediment types and potential contaminants are well-studied and are considered sufficient to characterise the study (and wider) area. As such, the available evidence base is sufficiently robust to underpin the assessment presented here and an overall high confidence is placed in the characterisation of the sediment baseline.

3.4.5.3 The most recent WFD Legislation classifications, published by SEPA, are anticipated to be released towards the end of 2024, with the latest classification available from the period 2022/23. At the time of writing, this presents a limitation due to the potential for a changed overall classification of relevant coastal and transitional waterbodies. However, there is public access to the history of designated waterbody status, alongside performance in specific biological, chemical and physical parameters, so an informed assumption can be made on the likelihood of the classification maintaining, increasing, or decreasing from that shown in Table 3-5. Moreover, the in-depth site-specific surveys collected data on various water parameters (i.e., temperature, salinity, dissolved oxygen, turbidity and pH) all indicate a stable healthy coastal environment. The most recent classification for designated BWs has been published from the 2023 bathing season, so there is an up-to-date understanding on levels of harmful bacteria currently present in the BWs included in the current assessment.

3.4.5.4 There is some uncertainty associated with the sediment plume assessment due to activities of the Proposed Development (Offshore) and/or activities of

potential other projects. This arises due to the uncertainty regarding how the seabed geology will respond to drilling and jetting. There are several factors which determine the exact volume of material that is entrained into the water column; including the exact type of drilling/cable installation equipment used, the variability of the forcing conditions at the installation time (i.e., the waves and tidal conditions) and the mechanical properties of the geological units. To minimise this limitation, a series of potential release scenarios have been considered in Volume 2, Chapter 2: Marine and Coastal Processes. Together, these scenarios capture the potential impacts in terms of the highest concentration and persistent suspended sediment plumes and the greatest spatial extent of changes in bed level elevation.

3.4.5.5 The availability of data relevant for the characterisation and assessment of MW&SQ is such that, despite some minor data limitations, it is considered that a thorough and meaningful characterisation for the purposes of EIA has been undertaken. As such, the available evidence base is sufficiently robust to underpin the assessment presented here and an overall high confidence is placed on the assessment.

3.5 EIA Approach and Methodology

3.5.1 Overview

3.5.1.1 This section outlines the methodology for assessing the likely significant effects on MW&SQ from the construction, operation and decommissioning of the Proposed Development (Offshore).

3.5.2 Impacts Scoped in to the Assessment

3.5.2.1 The Offshore Scoping Report (Volume 7, Appendix 2) was submitted to MD-LOT in September 2022. The Offshore Scoping Report set out the overall approach to assessment and allowed for the refinement of the Proposed Development (Offshore) over the course of the assessment. The proposed scope of the assessment is set out in Table 3-7.

Table 3-7: MW&SQ Scope of Assessment.

Potential Impact	Phase	Nature of Impact
Deterioration in water quality due to suspension of sediments	Construction, O&M and decommissioning	Direct
Release of sediment-bound contaminants from disturbed sediments	Construction and decommissioning	Direct

Potential Impact	Phase	Nature of Impact
Deterioration in water clarity due to the release of drilling mud	Construction	Direct
Deterioration in status of WFD Legislation transitional and/or coastal waterbody	Construction, O&M and decommissioning	Indirect
Deterioration in Bathing Water quality	Construction, O&M and decommissioning	Indirect

3.5.3 Impacts Scoped out of the Assessment

3.5.3.1 The impacts scoped out of the assessment during EIA scoping, and the justification for this, are listed in Table 3-8.

Table 3-8: Impacts Scoped Out for MW&SQ

Potential Impact	Justification
Accidental releases or spills of materials or chemicals	Substances such as grease, oil, fuel, anti-fouling paints and grouting materials may be accidentally released or spilt into the marine environment. No discharges (continuous or intermittent) of chemicals or construction materials are proposed during the construction phase of the Proposed Development (Offshore) which may be toxic or persistent within the marine environment. Nevertheless, the impacts are likely to be short-lived and localised. In the event of an accidental chemical or oil spill, hydrocarbons would rapidly be dispersed or diluted. As well as this, all vessels on the Proposed Development (Offshore) will be required to comply with strict environmental controls set out in the Environmental Monitoring Programme (EMP) and Marine Pollution Contingency Plan (MPCP) which will minimise the risk and set out provisions for responding to spills during construction or decommissioning. Due to the implementation of control measures and small quantities of hydrocarbons and chemicals, it is proposed to scope this impact out of further consideration within the EIA.
Deterioration in water quality due to resuspension and deposit of sediments from scour	There is the potential that sediment could be re-suspended as a result of scour around infrastructure (including foundations and cable protection). Given that the volume of suspended sediment released during operation via scour would be much lower than during construction or repair works, it is proposed that this impact will be scoped out from further consideration within the EIA. Furthermore, the effect will be highly localised and associated volumes of mobilised sediment (and associated contaminants) are considered to be within the range of natural variability.

Potential Impact	Justification
Changes in water and sediment quality associated with cleaning of infrastructure	Routine maintenance activities (such as the removal/cleaning of biofouling) on infrastructure may potentially result in reduced water and sediment quality in the immediate vicinity of the activity. Such operational cleaning may also release paints used on the infrastructure. Any impacts are likely to be small scale, temporary, short-lived and highly localised. Risks will also be adequately managed through the embedded mitigation measures, including using anti-biofouling paints suitable for the marine environment and fauna.

3.5.4 Assessment Methodology

3.5.4.1 The project-wide generic approach to assessment is set out in Volume 1, Chapter 7: EIA Methodology. The assessment methodology for MW&SQ for the EIAR is consistent with that provided in the Offshore Scoping Report (Volume 7, Appendix 2).

3.5.4.2 The baseline and assessment works have been undertaken using an evidence-based approach, supported by site-specific surveys and numerical modelling undertaken as part of the Marine and Coastal Processes study (Volume 7B, Appendix 2-1: Marine and Coastal Processes Baseline Technical Report and Volume 7B, Appendix 2-2: Marine and Coastal Processes Numerical Modelling Report), as appropriate.

3.5.4.3 Contaminants may be released into the water column from the sediments as a result of the activities associated with the Proposed Development (Offshore). This has the potential to reduce the water quality in the locality of the release. Consequently, the potential for a reduction in water quality will be assessed in terms of the contaminants present in the sediment.

3.5.4.4 The assessment undertaken here has been used to inform the WFD Legislation Compliance Assessment (Volume 7B, Appendix 3-1: Water Framework Directive (WFD) Regulatory Compliance Assessment).

Marine Water and Sediment Quality Receptors

3.5.4.5 Various designated waterbodies were identified within the MW&SQ Study Area. The quality of these designated waterbodies (e.g., BWs) are considered against the baseline performance of each site relative to the WFD Legislation or Bathing Water Legislation. As well as the designated receptors, the wider marine environment will also be assessed due to its local importance. The MW&SQ receptors that will be considered in the current assessment include:

- The wider marine environment;
- Designated BWs; and
- Designated coastal and transitional waterbodies.

3.5.4.6 SWPAs are not considered further in this assessment. The closest SWPA was measured over 70km away from the Proposed Development (Offshore) offering no spatial effect-receptor overlap. As such, no likely significant effect is anticipated in relation to SWPAs.

3.5.4.7 NVZs are not considered further in this assessment. NVZs are predominantly associated with risk of nitrated inputs from agricultural activities, it is considered that offshore works for the Proposed Development (Offshore) do not involve such activities. As such, no likely significant effect is anticipated in relation to NVZs.

3.5.4.8 Sensitive areas identified within the MW&SQ Study Area were predominantly freshwater river catchments where main concerns were regarding diffuse pollution sources from agricultural practices. It is not considered that the Proposed Development (Offshore) offshore works will result in the introduction, release, or disturbances of nitrates. As such, no likely significant effect is anticipated in relation to sensitive areas. The Inverboyndie sensitive area and BW is considered in this assessment in terms of effect-receptor pathways as a designated BW.

3.5.4.9 The Southern Trench Nature Conservation Marine Protected Area (MPA) was not identified as having any features directly relevant to this MW&SQ assessment. However, the MPA Assessment (Application Document 19) comprehensively addresses all qualifying features of the Southern Trench, including burrowed mud, minke whales, oceanic fronts, shelf deeps, Quaternary of Scotland, and submarine mass movement.

Sensitivity Criteria

3.5.4.10 This section describes the criteria applied in this chapter to assign values to the sensitivity of the receptors. The terms used to define sensitivity are based on those which are described in further detail in Volume 1, Chapter 7: EIA Methodology.

3.5.4.11 A receptor's sensitivity is a function of its capacity to accommodate change and indicates its ability to recover if it is affected. The identification of sensitivity is via a consideration of adaptability, tolerance, recoverability, and value.

3.5.4.12 The criteria used in defining the sensitivity of the MW&SQ receptor is provided in Table 3-9. Where a receptor could reasonably be assigned more than one level of sensitivity, professional judgement has been used to determine which level is applicable. The inclusion of internationally or nationally important features within the high sensitivity definition provides the opportunity to

increase the sensitivity of the receptor if required, even if capacity for dilution exists.

Table 3-9: Definitions of sensitivity of the receptor.

Receptor Sensitivity	Definition
High	Adaptability: The receptor cannot avoid or adapt to an impact. Tolerance: The environment has no capacity to accommodate the proposed form of change. Recoverability: The effect on the receptor is anticipated to be permanent (over 60 years) or long-lasting (15 to 60 years). Value: The water quality of the receptor supports or contributes towards the designation of an internationally or nationally important feature.
Medium	Adaptability: The receptor has a limited capacity to avoid or adapt to an impact Tolerance: The environment has a moderate to low capacity to accommodate the proposed form of change. Recoverability: The receptor is anticipated to recover fully within the medium term (i.e., seven to 15 years). Value: The water quality of the receptor supports or contributes towards the designation of a nationally important feature.
Low	Adaptability: The receptor has a reasonable capacity to avoid or adapt to an impact. Tolerance: The environment has a high capacity to accommodate the proposed form of change. Recoverability: The receptor is anticipated to recover fully within the short-term (i.e., one to seven years). Value: The water quality of the receptor supports or contributes towards the designation of a nationally important feature.
Negligible	Adaptability: The receptor has a high capacity to avoid or adapt to an impact. Tolerance: The environment has a high capacity to accommodate the proposed form of change. Specific water quality conditions of the receptor are likely to be able to tolerate change with very little or no impact upon the baseline conditions detectable. Recoverability: The receptor is anticipated to recover fully and will be temporary (i.e., lasting less than one year). Value: The receptor is not designated but may be of local importance and/ or local socio-economic value.

Magnitude Criteria

3.5.4.13 This section described 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 7: EIA Methodology.

3.5.4.14 The definition of magnitude specific to MW&SQ is provided in Table 3-10. Where a range of magnitude criteria are met, the final assessment for each impact is based upon expert judgement.

Table 3-10: Definition of terms relating to the magnitude of an impact.

Magnitude	Definition
High	Extent: Impact across the near-field and far-field areas beyond the Study Area. Duration: The impact is anticipated to be permanent (i.e., over 60 years). Frequency: The impact will occur constantly throughout the relevant project phase. Consequences: Permanent changes across the near-field and far-field environment to key characteristics or features of the particular environmental aspects character or distinctiveness.
Medium	Extent: The maximum extent of the impact is restricted to the far-field (i.e., the defined Study Area) Duration: The impact is anticipated to medium-term (i.e., seven to 15 years) to long-term (i.e., 15 to 60 years). Frequency: The impact will occur constantly throughout a relevant project phase. Consequences: Notable change to key characteristics or features of the particular environmental aspect's character or distinctiveness
Low	Extent: The maximum extent is restricted to the near-field and adjacent far-field areas. Duration: The impact is anticipated to be temporary (i.e., lasting less than one year) to short-term (i.e., one to seven years). Frequency: The impact will occur frequently throughout a relevant project phase. Consequences: Barely discernible/ noticeable change to key characteristics or features of the particular environmental aspect's character or distinctiveness.
Negligible	Extent: The maximum extent of the impact is restricted to the near-field and immediately adjacent far-field areas. Duration: The impact is anticipated to be momentary (i.e., minutes) to brief (i.e., days). Frequency: The impact will occur once or infrequently throughout a relevant project phase. Consequences: No discernible/ barely discernible change to key characteristics or features of the particular environmental aspects or distinctiveness.

Significance of Effect

3.5.4.15 The consideration of the magnitude of a potential impact and sensitivity of the receptor determines an expression for the overall significance of the adverse or positive effect. This determination may be quantitative or qualitative and is often informed by expert judgement. Table 3-11 below sets out how impact magnitude and receptor sensitivity interact to facilitate a judgement of significance of effect.

Table 3-11: Significance of effect matrix.

Significance of Effect		Sensitivity of Receptor			
		Negligible	Low	Medium	High
Impact Magnitude	Negligible	Negligible	Negligible	Negligible	Negligible
	Low	Negligible	Negligible	Minor	Minor
	Medium	Negligible	Minor	Moderate	Moderate
	High	Negligible	Minor	Moderate	Major

3.5.4.16 Major or moderate effects are categorised as 'significant' in EIA terms, as highlighted in grey in Table 3-11. A typical categorisation for effect significance is provided in Table 3-12.

Table 3-12: Categorisation for effect significance.

Expression	Definition	Significance
Major	A fundamental change to the environment or receptor, resulting in a significant effect.	Significant
Moderate	A material but non-fundamental change to the environment or receptor, resulting in a possible significant effect.	Significant
Minor	A detectable but non-material change to the environment or receptor resulting in no significant effect or small-scale temporary changes.	Not Significant
Negligible	No detectable change to the environment or receptor resulting in no significant effect.	Not Significant

3.5.4.17 By applying professional judgement and by taking into account the Guidelines for Environmental Impact Assessment (IEMA, 2004[81]), the assessments within the EIAR will consider moderate or major effects to be significant, and minor or negligible effects to be not significant.

3.5.5 Approach to Cumulative Effects

3.5.5.1 The Cumulative Impact Assessment (CIA) assesses the impact associated with the Proposed Development (Offshore) together with other relevant plans, projects and activities. Cumulative effects are therefore the combined effect of the Proposed Development (Offshore) in combination with the effects from a number of different projects, on the same receptor or resource.

3.5.5.2 The approach to the CIA for MW&SQ follows the process outlined in Volume 1, Chapter 7: EIA Methodology.

3.5.5.3 The list of relevant developments for inclusion within the CIA is outlined in Volume 7A, Appendix 7-1, Annex 2: CIA short list for the Proposed Development (Onshore) and the Proposed Development (Offshore).

3.5.5.4 Developments which are located within 10km of the MW&SQ Study Area have the potential to result in a cumulative effect. Developments which are either operational or in the decommissioning stage are considered to be part of the baseline and are not considered within the assessment.

3.5.6 Embedded Mitigation

3.5.6.1 Where possible, mitigation measures will be embedded into the design of the Proposed Development (Offshore) applications, specifically Caledonia North and Caledonia South.

3.5.6.2 Where embedded mitigation measures have been developed into the design of the Proposed Development (Offshore) with specific regard to MW&SQ, these are described in Table 3-13. The impact assessment presented in Sections 3.7 to 3.8 take into account this embedded mitigation.

Table 3-13: Embedded Mitigation.

Code	Mitigation Measure	Securing Mechanism
M-1	Development of and adherence to a Cable Plan (CaP). The CaP will confirm planned cable routing, burial and any additional protection and will set out methods for post-installation cable monitoring.	To be secured as a condition of the Generation Asset and Transmission Asset Marine Licences for both Caledonia North and Caledonia South.
M-3	Development of and adherence to a Construction Method Statement (CMS). The CMS will confirm construction methods and the roles and responsibilities of parties engaged in construction.	To be secured as a condition of the Generation Asset and Transmission Asset Marine Licences for both Caledonia North and Caledonia South.
M-4	Scour protection where there is potential for scour to develop around infrastructure (foundations and cables).	To be secured as a condition of the Generation Asset and Transmission Asset Marine Licences for both Caledonia North and Caledonia South.
M-8	Development of and adherence to an Environmental Management Plan (EMP). The EMP will set out mitigation measures and procedures relevant to environmental management, including but not limited to the following topics: Chemical usage, invasive non-native marine species, dropped objects, pollution prevention and contingency planning and waste management.	To be secured as a condition of the Generation Asset and Transmission Asset Marine Licences for both Caledonia North and Caledonia South.
M-9	Development of and adherence to a Marine Pollution Contingency Plan (MPCP). The MPCP will identify potential sources of pollution and associated spill response and reporting procedure.	To be secured as a condition of the Generation Asset and Transmission Asset Marine Licences for both Caledonia North and Caledonia South.
M-10	Development of and adherence to a Decommissioning Programme (DP). The DP will outline measures for the decommissioning of the Proposed Development (Offshore).	To be secured as a condition of the Generation Asset and Transmission Asset Marine Licences for both Caledonia North and Caledonia South.

Code	Mitigation Measure	Securing Mechanism
M-12	Development of and adherence to a Project Environmental Monitoring Programme (PEMP). The PEMP will set out commitments to environmental monitoring in pre-, during and post- construction phases of the Proposed Development (Offshore).	To be secured as a condition of the Generation Asset and Transmission Asset Marine Licences for both Caledonia North and Caledonia South.
M-13	Development of and adherence to a Vessel Management Plan (VMP). The VMP will confirm the types and numbers of vessels that will be engaged on the Proposed Development (Offshore) and consider vessel coordination including indicative transit route planning.	To be secured as a condition of the Generation Asset and Transmission Asset Marine Licences for both Caledonia North and Caledonia South.
M-24	Any object dropped on the seabed during works associated with the Proposed Development (Offshore) will be reported and objects will be recovered where they pose a hazard to other marine users and where recovery is possible.	To be secured as a condition of the Generation Asset and Transmission Asset Marine Licences for both Caledonia North and Caledonia South.
M-26	Marine coordination and communication to manage project vessel movements.	To be secured as a condition of the Generation Asset and Transmission Asset Marine Licences for both Caledonia North and Caledonia South.
M-106	Trenchless techniques (Horizontal Directional Drilling) will be used as installation methodology at landfall to avoid direct impacts to the intertidal area.	To be secured as a condition of the Transmission Asset Marine Licence for both Caledonia North and Caledonia South.

3.6 Key Parameters for Assessment

3.6.1.1 Volume 1, Chapter 3: Proposed Development Description (Offshore) details the parameters of the Proposed Development (Offshore) using the Rochdale Envelope approach. This section identifies those parameters during construction, operation and decommissioning relevant to potential impacts on MW&SQ.

3.6.1.2 The worst-case assumptions with regard to MW&SQ are summarised in Table 3-14.

Table 3-14: Worst Case Assessment Scenario Considered for Each Impact as Part of the Assessment of Likely Significant Effects.

Potential Impact	Assessment Parameter	Explanation
Construction		
Impact 1: Deterioration in water quality due to suspension of sediments	**Post-consent Surveys**: ▪ Geophysical and geotechnical surveying; and ▪ Post-consent survey activities (e.g., boreholes/ grab sampling) across the Caledonia OWF and Caledonia OECC. **Seabed Preparation**: ▪ The greatest volume of sediment disturbed and released is related to dredging and seabed levelling (i.e., sandwave flattening using trailing suction hopper dredger (TSHD)) of the Caledonia OWF to install jacket and suction caisson foundations: o 140 jacket with suction caissons WTG foundations, total sediment disturbed per WTG is estimated to be 90,750m^3, which results in a total of 12,705,000m^3; and o Four OSPs with suction caissons foundations, volume of sediment disturbed per OSP is estimated to be 90,750m^3, which results in a total of 363,000m^3; and o Overall total sediment disturbed by dredging (WTG and OSP foundations) = **13,068,000m^3**. **Construction/installation of:** ▪ 140 WTGs installed on monopiles foundations: o Maximum penetration depth per monopile of 50m; o Approximate drilling installation rate of 0.15m/hr; o Maximum spoil/drilled volume per monopile of 11,546m^3; and o Maximum spoil/drilled volume for all WTG monopile foundations = **1,616,440m^3**. ▪ Four OSPs installed on monopiles foundations:	Defining the worse-case-scenario for sediment disturbance activities is highly complex as the actual disturbance will be temporally and spatially variable (depending upon the metocean conditions at the time). For sediment plumes, the worse-case-scenario is intended to be representative in terms of peak concentration, plume extent and plume duration but will not correspond to a single sediment disturbance activity. This proposed design scenario anticipates in the greatest sediment volumes being disturbed for all construction activities. Site investigation activities may disturb the seabed, on a short-term and localised basis, due to the placement of an instrument and its mooring system on the seabed to sediment removal (as boreholes/grabs). Sediment disturbance resulting from site investigation activities will typically be of shorter duration (hours to days), lesser magnitude and localised when compared to those resulting from site preparation, foundation and cable installation works. Site clearance activities may be undertaken using a range of techniques,

Potential Impact	Assessment Parameter	Explanation
	o Maximum penetration depth per monopile of 50m; o Approximate drilling installation rate of 0.15m/hr; o Maximum spoil/drilled volume per monopile of 11,546m^3; and o Maximum spoil/drilled volume for all OSP monopile foundations = **46,184m^3**. ▪ 140 inter-array cables; o Cable length of 655km combined total; o Seabed trench width of 2m, with affected seabed disturbance width of 15m and burial depth of up to 3m; o Total area of seabed disturbance of 9,825,000m^2; o Cable laying rate of 700m/hr; and o Total estimated volume of sediment disturbance (inter-array cables) = **29,475,000m^3**. ▪ Two interconnector cables; o Cable length of 60km combined total; o Seabed trench width of 2m, with affected seabed disturbance width of 15m and burial depth of 3m; o Total area of seabed disturbance: 900,000m^2; and o Cable laying rate: 700m/hr. ▪ Total estimated volume of sediment disturbance (interconnector cables) = **2,700,000m^3**. ▪ Four offshore export cables; o Cable length of 330km combined total; o Seabed trench width of 2m, with affected seabed disturbance width of 15m and burial depth of up to 3m; o Total area of seabed disturbance: 4,950,000m^2; and o Cable laying rate: 700m/hr. ▪ Total estimated volume of sediment disturbance (offshore export cables) = **14,850,000m^3**.	where the use of a TSHD has the potential to cause the greatest increase in suspended sediment and largest plume extent as material is released near the water surface. The fate and transport of this material will be largely dependent on the tidal current at the time of works and the nature of the material. Drilling the foundation for monopile structures (14m diameter on the bed) results in the highest sediment disturbance rate and longest duration. Cable installation may require some combination of jetting, ploughing, trenching and/or cutting type installation techniques. The realistic worst-case-scenario option is represented by jet trenching methods, which develop the largest trench cross-section with the greatest potential to displace fine sediments into the water column to the same height as the depth of the trench. The fastest trenching rate of 700m/hr represents the highest release rate of sediments operating in locations with the largest contribution of fine sediments. Sediment disturbances arising from worst case assumptions of construction activities have the potential to result in direct impacts on water quality (i.e., water clarity and resuspension of nutrients and bacteria) as a result of temporary increases in SSCs and associated

Potential Impact	Assessment Parameter	Explanation
		deposition. Increased SSC can lead to various direct impacts (e.g., decreased bacterial mortality) and indirect impacts to the quality status of relevant designated waterbodies (e.g., BWs).
Impact 2: Release of sediment-bound contaminants from disturbed sediments	Refer to Impact 1.	Refer to Impact 1. The described design scenarios anticipate the greatest sediment volumes being disturbed for all potential construction activities. The greater the volume of sediment disturbed, the greater the potential for release of sediment bound contaminants.
Impact 3: Deterioration in water clarity due to the release of drilling mud	**Horizontal Directional Drilling fluid release**: ▪ Punch-out location for HDD will be shallow subtidal (10m to 40m water depth); ▪ Four HDD exit pits; ▪ HDD pit dimensions of 15m x 6m x 1.2m; ▪ Diameter of each HDD bore of 860mm; ▪ Anticipated HDD length per offshore export cable of 1.2km; ▪ Volume of sediment released per HDD pit of 47m^3 (mass of 70,500kg to 117,500kg per cut, depending on sediment density); ▪ Volume of drilling fluid released per HDD pit of 450m^3 (sediment mass of 867,000kg dry weight); and ▪ HDD operations per duct over an estimated 56 days, 12 hours of operation per day (672 total hours per HDD).	HDD activities may cause localised, short-term effects on SSC due to bentonite release during punch-out at the exit pits. HDD works are estimated to take 672 hours for HDD ducting for a single line. However, the release of sediment is only expected to occur at the exit pit and as such the sediment release would occur over a short period of time. Assuming all sediment is released in one hour and adopting a conservative assumption that all sediment is bedrock which is completely broken down to fines by the drilling would yield a source term of 32.6kg/s for the cuttings and an additional 240.9kg/s for the drilling muds. Resultant sediment plumes caused by HDD have been fully assessed in Volume

Potential Impact	Assessment Parameter	Explanation
		2, Chapter 2: Marine and Coastal Processes.
Operation and Maintenance		
Impact 4: Deterioration in water quality due to suspension of sediments	**Operation of:** ▪ 140 WTGs; ▪ Four OSPs; ▪ 140 inter-array cables; ▪ Two interconnector cables; and ▪ Four offshore export cables **Maintenance:** ▪ Routine, preventative and corrective maintenance; ▪ For unplanned major component replacement, one JUV campaign annually is the expected worst case scenario with up to three interventions in each campaign; and ▪ Preventative cable maintenance every 1-5 years for offshore export cables, interconnector cables and inter-array cables.	Minimal (if any) sediment disturbance is expected from annual inspection of bottom-fixed or floating foundations, cables, protection and exit pits. Corrective maintenance of fixed foundations and cables (if required) has potential to disturb sediment in a way that may lead to effects on water quality (e.g., reduced water clarity). However, it is not anticipated that this will be required throughout the lifespan of Caledonia North, unless an incident is to occur. Statistically reliable statements are not possible at this stage in regard to maintenance requirements of flexible cable systems. An approximate figure of 0.1 stationkeeping replacements per year is assumed for the assessment.
Decommissioning		
Impact 5: Deterioration in water quality due to suspension of sediments	The worst-case scenario will be equal to (or less than) that of the construction phase. Refer to Impact 1.	As with the construction phase, decommissioning activities have the potential to affect MWSQ receptors either directly or indirectly. If the Proposed Development (Offshore) structures are left *in-situ* any likely significant effects from decommissioning will be avoided. If the

Potential Impact	Assessment Parameter	Explanation
		Proposed Development (Offshore) structures are to be removed at decommissioning this appraisal assumes that impacts from decommissioning activities are of similar nature to construction activities and would be of a similar or lesser scale, assuming the impact footprint is the same. In the absence of detailed information regarding decommissioning works, the worst case design scenario for decommissioning would be the same or less than during construction, assuming the impact footprint is the same.
Impact 6: Release of sediment-bound contaminants from disturbed sediment	The worst-case scenario will be equal to (or less than) that of the construction phase. Refer to Impact 1.	Refer to Impact 5.

3.7 Potential Effects

3.7.1 Construction

Impact 1: Deterioration in Water Quality Due to Suspension of Sediments

Conceptual Understanding of Potential Change

3.7.1.1 During the construction of the Proposed Development (Offshore), sediment will be disturbed and released into the water column. This will give rise to suspended sediment plumes and localised changes in water clarity due to the increased SSC. Increases in SSC, and consequently turbidity, may result in a decrease in the depth to which natural light can penetrate into the water column. Increased turbidity/artificial reduction of natural light may result in a reduction of primary productivity (such as the production of organic compounds through the biological process of photosynthesis by phytoplankton) and/or an increase in bacterial growth. Moreover, the disturbance of seabed sediments may result in the release of additional nutrients (for example nitrogen and phosphorus) that were sediment bound. This anthropogenic cause of increased SSC can lead to an unnatural surge of nutrient availability in the water column for aquatic plants (e.g., seaweeds). The temporary influx of nutrients (known as nutrient loading) can cause phytoplankton and/or seaweed to bloom and then die, in a process referred to as eutrophication. Where nutrients are released, phytoplankton and seaweed can begin to utilise these nutrients within a few days. However, the duration of this stage depends largely on the concentration of nutrients available and conditions such as light (e.g., effected by water clarity) and temperature. Once the nutrients are depleted, the bloom will begin to decline. Subsequently, bacteria and other decomposer organisms then take up oxygen as they decompose materials (e.g., dead seaweeds).

3.7.1.2 There are a range of factors which will influence both the magnitude and extent of change in SSC. These include, but are not limited to, the actual total volumes and rates of sediment disturbance, the local water depth and current speed at the time of the activity, the local sediment type and grain size distribution in addition to the local seabed topography and slopes. Due to the wide range of possible combinations of these factors it is not possible to predict specific dimensions with complete certainty. To provide a robust assessment, a range of realistic combinations have been considered within Volume 2, Chapter 2: Marine and Coastal Processes based on conservatively representative location (environmental) and site-specific information, including a range of water depths, sediment ejection/initial resuspension heights, and sediment types.

3.7.1.3 In addition to the output from the numerical modelling undertaken for the marine and coastal processes assessment (Volume 7B, Appendix 2-2: Marine and Coastal Processes Numerical Modelling Report), the understanding of the potential increase in suspended sediments due to Proposed Development (Offshore) installation activities can be informed by the evidence base regarding marine dredging impacts, specifically sediment plumes (e.g., Cooper and Brew, 2013[82]). Highly concentrated sediment plumes formed of coarser material (sands) will only occur for short-time periods and in the immediate vicinity of the seabed disturbance. The output of this modelling has been used to comprehend a realistic magnitude of impact upon MW&SQ receptors. It should be noted that the effect of increased SSC on MW&SQ can act as an impact pathway for other EIAR receptors that are sensitive to changes in water quality, in particular:

- Volume 2, Chapter 4: Benthic Subtidal and Intertidal Ecology; and
- Volume 2, Chapter 5: Fish and Shellfish Ecology.

3.7.1.4 Those construction activities presented in Table 3-14 which will result in the greatest disturbance of seabed sediments are:

- Seabed preparation (including both seabed levelling for WTG and OSP foundations and sandwave clearance) including spoil disposal via a TSHD;
- Pre-lay cable trenching using a jet trencher tool at the seabed; and
- Foundation installation using drilling techniques.

3.7.1.5 These construction activities have been reported in Volume 7B, Appendix 2-2: Marine and Coastal Processes Numerical Modelling Report) and assessed fully in Volume 2, Chapter 2: Marine and Coastal Processes, where findings are concisely summarised in Table 3-15 to assist in the understanding of the likelihood and potential of effects to MW&SQ receptors.

Table 3-15: Extent of sediment plumes modelled from worst-case scenario construction activities.

Proposed Activity	Extent of Sediment Plumes
Seabed Preparation (TSHD)	▪ Maximum sediment volume likely to be removed for seabed levelling within the Caledonia OWF is of the order of 49,680,000m^3, to be excavated using a TSHD. ▪ Geophysical survey indicates only small ripples (50cm high), minimal volume removal needed. ▪ Sediment plumes restricted to near-field and adjacent far-field areas (low). ▪ Unlikely to affect designated waterbodies significantly.
Pre-lay Cable Trenching (Jet Trencher)	▪ A jet trencher works by fluidising the bed layer by injecting water into the seabed (i.e., displacing sediment into the water column). ▪ Peak SSC (>50mg/l) localised to area of activity.

Proposed Activity	Extent of Sediment Plumes
	▪ SSC >50mg/l expected only within approximately 2.5km of installation zone. ▪ Maximum sediment dispersion: approximately 15km southward, approximately 5km northward in Caledonia OWF. ▪ Elevated SSC >25mg/l observed for no more than 7.2 hours. ▪ SSC normalises (<5mg/l) within a week. ▪ Sediment plumes restricted to near-field and adjacent far-field areas (low). ▪ Unlikely to affect designated waterbodies significantly.
Foundation Installation (Drilling)	▪ Drilling may suspend and re-deposit sediment. ▪ SSC >5mg/l within a 5km radius north-south and 1km east-west. ▪ SSC >1mg/l above background up to 30km southeast. ▪ Significant SSC decrease below 4mg/l after 6 days, extending to 20km southeast. ▪ Background SSC approximately 5mg/l, making changes barely discernible. ▪ Plumes restricted to near-field and adjacent far-field areas (low). ▪ Unlikely to affect designated waterbodies significantly.
Overall	▪ No significant impact on MW&SQ receptors. ▪ Plumes restricted to near-field and adjacent far-field areas (low). ▪ Unlikely to affect designated waterbodies significantly.

Magnitude of Impact

3.7.1.6 Given that no nutrients are anticipated to be released in concentrations significantly greater than those released during storm events, it is considered that the proposed activities are unlikely to affect phytoplankton abundance or dissolved oxygen levels. The short-term nature of the proposed construction activities is such that any effects will also be temporary in nature.

3.7.1.7 As there are no outfalls or discharges associated with the Proposed Development (Offshore), the proposed activities are not expected to cause a reduction in the dissolved oxygen within the water column. Consequently, no source-receptor-pathways are identified for a deterioration of dissolved oxygen, phytoplankton blooms or eutrophication as a result of the proposed construction activities.

3.7.1.8 Bacterial mortality, including *E.coli* and Intestinal Enterococci, within the water column is strongly influenced by the amount of ultra-violet (UV) light which penetrates the water column; under higher UV scenarios, bacterial mortality is higher. Therefore, any Proposed Development (Offshore) activities in the coastal zone which reduce water clarity could result in temporary increases in bacterial counts within the water column due to the decreased bacterial mortality and UV light within the water column. Further, it could result in the potential release of sediment bound bacteria

(including *E.coli* and Intestinal enterococci). In theory, elevated bacterial counts could cause a deterioration in the water quality and if present at the identified BWs during the designated bathing season, could theoretically cause a deterioration in their performance classifications (reported in Table 3-6).

3.7.1.9 The maximum SSC immediately adjacent to the Proposed Development (Offshore) activities typically remain below 5mg/l within one week following the cessation of activity for the most intensive construction activities. In accordance with the UKTAG water turbidity ranking (see Tyler-Walters *et al*., 2018[83]), this is classified as clear (Tyler-Walters *et al*., 2018[83]). Given that Proposed Development (Offshore) construction activities are temporary and short-lived, and that following cessation of activities the SSC levels return to background levels, it is expected that any bacterial increases in the water column would be in the order of days (occurring for the plume duration only). Following the sediment plume dispersion, and subsequent increases in UV light, the bacterial counts in the water column will return to the "do-nothing" baseline conditions.

3.7.1.10 Overall, any resultant decrease in water clarity would be analogous to storm events (See Volume 7B, Appendix 2-2: Marine and Coastal Processes Numerical Modelling Report). These potential changes are within the natural variation of the marine environment in the Study Area during high energy, low frequency events. Moreover, Proposed Development (Offshore) activities which result in sediment disturbance within the Caledonia OWF and Caledonia OECC are not anticipated to impact on the designated WFD Legislation waterbodies (Figure 3-3). In conclusion, the SSC elevation and associated decrease in bacterial mortality, would be localised, within the range of natural variability and temporary. The magnitude of deterioration in water quality due to suspension of sediments from construction activities are considered to be Low (Table 3-16).

Table 3-16: Determination of the magnitude of Impact 1 during the construction phase.

Magnitude	Definition
Extent	The maximum extent is restricted to the near-field and adjacent far-field areas (low).
Duration	Construction works in any given discrete location within the boundary will be classified as brief (negligible).
Frequency	The impact will occur frequently throughout the construction phase (low).
Consequences	Barely discernible changes to key characteristics or features of the particular environmental aspects (low).
Overall Magnitude	The potential magnitude of the predicted changes is rated as low.

Sensitivity of Receptor

3.7.1.11 The Proposed Development (Offshore) activities are not expected to cause a measurable reduction in dissolved oxygen availability in the water column. Moreover, dissolved oxygen concentrations of the baseline environment were characteristic of a normal coastal marine environment. Therefore, no source receptor pathways are identified for a deterioration of dissolved oxygen or eutrophication. On this basis, no likely substantial effects are predicted in either the wider environment, designated coastal waters or BW's.

3.7.1.12 The potential for sediment disturbance to decrease water clarity (and bacterial mortality) have been considered against MW&SQ receptors split into three categories: the wider marine environment, designated coastal and transitional waterbodies and designated BWs, to accurately identify their sensitivity (Table 3-17).

Table 3-17: Sensitivity of MW&SQ receptors to Impact 1.

Sensitivity Criteria	MW&SQ Receptors		
	Wider Marine Environment	Designated Coastal and Transitional Waterbodies	Designated BWs
Background Information	The MW&SQ Study Area, and wider regional environment, has been considered in Section 3.4.3. All reports indicated a healthy baseline environment characteristic of coastal areas connecting to the Moray Firth and wider North Sea.	All designated coastal waterbodies were classified as 'Good' and transitional waterbodies were classified as 'High' under the WFD Legislation classifications. The physical, chemical, and biological analysis which influence the classification decision (Table 3-5) indicated stable, healthy, and resilient baseline conditions.	Under the most recent reports (i.e., 2022/23 season), all designated BWs were classified as 'Excellent', indicating stable, healthy, and resilient baseline conditions.
Adaptability	High capacity to avoid or adapt (Negligible)	Reasonable capacity to avoid or adapt (Low)	Limited capacity to avoid or adapt (Medium)
Tolerance	Very little or no impact upon the baseline conditions detectable (Negligible)	High capacity to accommodate the proposed form of change (Low)	Moderate capacity to accommodate the proposed form of change (Medium)
Recoverability	Will recover fully and effect will be temporary (Negligible)	Will recover fully and effect will be temporary (Negligible)	Will recover fully and effect will be temporary (Negligible)

Sensitivity Criteria	MW&SQ Receptors		
	Wider Marine Environment	Designated Coastal and Transitional Waterbodies	Designated BWs
Value	Not designated (Negligible)	Nationally important feature (Low)	Nationally important feature (Low)
Overall Sensitivity	Negligible	Low	Medium

Significance of Effects

3.7.1.13 Taking the **Negligible** sensitivity of the wider marine environment and the **Low** magnitude of impact, the overall effect of deterioration in water quality due to the suspension of sediments during construction is considered to be **Negligible and Not Significant in EIA terms**.

3.7.1.14 Taking the **Low** sensitivity of designated coastal and transitional waterbodies and the **Low** magnitude of impact, the overall effect of deterioration in water quality due to the suspension of sediments during construction is considered to be **Negligible and** N**ot Significant in EIA terms**.

3.7.1.15 Taking the **Medium** sensitivity of designated BWs and the **Low** magnitude of impact, the overall effect of deterioration in water quality due to the suspension of sediments during construction is considered to be **Minor and Not Significant in EIA terms**.

3.7.1.16 Overall, no additional mitigation relating to MW&SQ to that already identified in Table 3-13 is considered necessary. Therefore, no significant adverse residual effects have been predicted in respect to MW&SQ receptors.

Impact 2: Release of Sediment-bound Contaminants from Disturbed Sediments

Conceptual Understanding of Potential Change

3.7.1.17 The construction activities associated with the Proposed Development (Offshore) have the potential to increase SSC in the marine environment through the generation of sediment plumes (see Impact 1). Whilst in suspension, there is potential for sediment bound contaminants (e.g., THC, PAHs, PCBs, PBDEs, OCPs, organotins and metals) to be released into the water column which may lead to an adverse effect on water quality. The outcome of such impact depends upon the existing volume and nature of contaminants present within the sediment. The magnitude of impact will be contingent upon the baseline level of sediment contamination, with lower

contamination levels yielding lesser effects compared to areas categorised by higher contamination levels.

Magnitude of Impact

3.7.1.18 Details relating to the sediment contamination levels within the Caledonia OWF and Caledonia OECC are presented in Section 3.4. In summary, site-specific surveys of sediment contamination indicate that contamination levels are generally very low across the Caledonia OWF and OECC. The following contaminants are believed to exist in concentrations that are not expected to result in notable ecotoxicological impacts:

- Metals: no exceedance of ALs;
- Organotins: below LOD at all stations;
- OCPs: generally below LOD, no exceedance of ALs;
- PBDEs: slight exceedances of the BAC, all concentrations below the FEQGs;
- PCBs: below LOD at all stations;
- PAHs: no exceedances of respective ERL/ERM or TEL/PEL values; and
- THCs: below published threshold values with exception of Station ENV21 which was marginally (0.7ug/g) above a level which some sensitive species might be impacted. However, analysis by UVF reported below the same Station ENV21 below the (10µg/g) threshold.

3.7.1.19 None of the above contaminants were present in concentrations that would notably affect surrounding faunal communities. Therefore, regardless of the volume of sediment disturbance, the low presence of contaminants limits their potential to become bioavailable.

3.7.1.20 Typically, whilst very small concentrations of contaminants enter the dissolved phase, the vast majority will adhere to sediment particles when temporarily entering suspension in the water column. Partition coefficients may be applied to estimate the concentration of the contaminants entering the dissolves phase, which typically result in a reduction of several orders of magnitude than the concentrations associated with suspended sediments. As such, it is considered highly unlikely that the maximum allowable concentration (EQS) threshold will be exceeded for any of the substances as a result of disturbing sediment from the proposed activities, given both the low presence of contaminants and the fates of the sediment plumes. Although it is unforeseen, should there be an unanticipated increase in water concentrations of EQS substances, they would likely return to background concentrations very quickly (thus not materially impact any annual average EQS threshold). Therefore, it is not anticipated that disturbance of sediment-bound contaminants would affect a waterbody's performance against its EQSs as the potential impacts will be temporary in nature.

3.7.1.21 An assessment of sediment plumes (see Volume 2, Chapter 2: Marine and Coastal Processes) as previously summarised (see Table 3-15), indicated the rapid dispersion of suspended sediment following the cessation of construction activities. To reiterate, all sediment plumes caused by Proposed Development (Offshore) construction activities are to be concentrated at the site of activity, rapidly dispersing and reducing in overall SSC until they quickly return to normal background concentrations. As such, any suspended sediment-bound contaminants are also likely to be rapidly dispersed with the tidal currents and therefore, increased bioavailability resulting in adverse ecotoxicological effects is not expected.

3.7.1.22 Any activities resulting in disturbed sediments within either the Caledonia OWF or Caledonia OECC are not anticipated to have an impact on WFD Legislation or Bathing Water Legislation waterbodies. All site-specific modelling indicates that no works undertaken in the Caledonia OWF or the Caledonia OECC have measurable changes in SSC within designated WFD Legislation waterbodies (Volume 7B, Appendix 2-2: Marine and Coastal Processes Numerical Modelling Report).

3.7.1.23 The magnitude of this potential impact is conservatively considered to be low when compared against the magnitude criteria (Table 3-18).

Table 3-18: Determination of the magnitude of Impact 2 during the construction phase.

Magnitude	Definition
Extent	The maximum extent is restricted to the near-field and adjacent far-field areas (low).
Duration	Construction works in any given discrete location within the boundary will be classified as brief (negligible).
Frequency	The impact will occur frequently throughout the construction phase (low).
Consequences	No discernible changes to key characteristics or features of the particular environmental aspects or distinctiveness (Negligible)
Overall Magnitude	The potential magnitude of the predicted changes is rated as low.

Sensitivity of Receptor

3.7.1.24 The potential for the release of sediment bound contaminants from disturbed sediments has been considered against MW&SQ receptors split into three categories: the wider marine environment, designated coastal and transitional waterbodies and designated BWs, to accurately identify their sensitivity (Table 3-19).

Table 3-19: Sensitivity of MW&SQ receptors to Impact 2.

Sensitivity Criteria	MW&SQ Receptors		
	Wider Marine Environment	Designated Coastal and Transitional Waterbodies	Designated BWs
Background Information	The MW&SQ Study Area, and wider marine environment, has been considered in Section 3.4.3. All reports indicated a healthy baseline environment characteristic of coastal areas connecting to the Moray Firth and wider North Sea.	All designated coastal waterbodies were classified as 'Good' and transitional waterbodies were classified as 'High' under the WFD Legislation classifications. The physical, chemical, and biological analysis which influence the classification decision (Table 3-5) indicated stable, healthy, and resilient baseline conditions.	Under the most recent reports (i.e., 2022/23 season), all designated BWs were classified as 'Excellent', indicating stable, healthy, and resilient baseline conditions.
Adaptability	High capacity to avoid or adapt (Negligible)	Reasonable capacity to avoid or adapt (Low)	High capacity to avoid or adapt (Negligible)
Tolerance	Very little or no impact upon the baseline conditions detectable (Negligible)	High capacity to accommodate the proposed form of change (Low)	Very little or no impact upon the baseline conditions detectable (Negligible)
Recoverability	Will recover fully and effect will be temporary (Negligible)	Will recover fully and effect will be temporary (Negligible)	Will recover fully and effect will be temporary (Negligible)
Value	Not designated (Negligible)	Nationally important feature (Low)	Nationally important feature (Low)
Overall Sensitivity	Negligible	Low	Negligible (no notable pathway of effect to the classification of BWs)

Significance of Effects

3.7.1.25 Taking the **Negligible** sensitivity of the wider marine environment and the **Low** magnitude of impact, the overall effect of the release of sediment bound contaminants from disturbed sediments during construction is considered to be **Negligible and Not Significant in EIA terms**.

3.7.1.26 Taking the **Low** sensitivity of designated coastal and transitional waters and the **Low** magnitude of impact, the overall effect of the release of

sediment bound contaminants from disturbed sediments during construction is considered to be **Negligible and Not Significant in EIA terms**.

3.7.1.27 Taking the **Negligible** sensitivity of designated BWs and the **Low** magnitude of impact, the overall effect of the release of sediment bound contaminants from disturbed sediments during construction is considered to be **Negligible and Not Significant in EIA terms**.

3.7.1.28 Overall, no additional mitigation relating to MW&SQ to that already identified in Table 3-13 is considered necessary. Therefore, no significant adverse residual effects have been predicted in respect to MW&SQ receptors.

Impact 3: Deterioration in Water Clarity Due to the Release of Drilling Mud

Conceptual Understanding of Potential Change

3.7.1.29 In order to undertake trenchless technique activities and make landfall, there will be a requirement to use drilling mud, such as bentonite (or another inert mud). This in turn will result in the release of drilling mud within the subtidal area at the punch out point under the WCS assessment (Table 3-14).

3.7.1.30 Bentonite is a non-toxic, inert, natural clay material with a particle size less than 63µm. It is included in the List of Notified Chemicals approved for use and discharge into the marine environment and is classified as a Group E substance under the Offshore Chemical Notification Scheme. Substances in Group E are defined as the group least likely to cause environmental harm and are "*readily biodegradable and non-bioaccumulative*". This is further supported by bentonite being included on the OSPAR List of Substances Used and Discharged Offshore which are considered to pose little or no risk to the environment.

3.7.1.31 With respect to bentonite release into the water column for MW&SQ receptors, the principal concern relates to the potential for an increase in SSC (and so turbidity) within the water column and potential reduction in bacterial mortality. With the exception of the potential for increased turbidity from a bentonite release, no other potential deterioration in water and/ or sediment quality, such as the introduction of contaminants or nutrients, is considered as a consequence of bentonite release.

Magnitude of Impact

3.7.1.32 Bentonite is a clay-based substance and as such may remain in suspension for hours to days following its release, becoming diluted to very low concentrations (indistinguishable from natural background levels and variability). As discussed in Volume 2, Chapter 2: Marine and Coastal Processes, the maximum SSC that would occur over the 15-day period

over which the statistics were calculated for the HDD model simulation. The numerical modelling results show the resultant plume is to be up to 6km long (east-west) and 2.5km width (north-south). The highest SSC (measuring above 50mg/l) is simulated to occur over an area of less than 1km long (east-west) and 500m width (north-south). It is estimated that SSC might reduce to 15mg/l withing 3km east to west and approximately 700m north to south. With these estimations it is not predicted that SSC is to be advected along the coastline, primarily aligning with the tidal direction, extending up to 8km eastward and 6km westward. However, concentrations beyond these distances remain low, typically below 1mg/l. Any measurable SSC is anticipated to have dispersed after 3 days. Considering generally higher background SSC conditions along the coast, these changes are likely to be indiscernible from background conditions.

3.7.1.33 As previously described (Impact 1), there is a relationship between increased turbidity and decreased bacterial mortality within the water column. However, given the predicted dilution levels, punch-out in the subtidal, the temporary nature of the Proposed Development (Offshore) (Offshore) activities, and tidal dispersion of the released bentonite, it is expected that any bacterial increases within the water column would be in the order of days. Following the bentonite plume dispersion, and subsequent UV increases, the bacterial counts in the water column will return to "do-nothing" baseline conditions. The resultant decrease in water clarity would be analogous to storm events. Therefore, these potential changes are considered to remain within the natural variation of the marine environment.

3.7.1.34 The increased SSC and potential decrease in bacterial mortality which may result from the release of inert drilling mud, such as bentonite, is expected to be localised, within the range of natural variability and temporary. The magnitude of these elevated concentrations and potential bacterial counts on water quality receptors are considered to be low (Table 3-20).

Table 3-20: Determination of the magnitude of Impact 3 during the construction phase.

Magnitude	Definition
Extent	The maximum extent of increased SSC from HDD drilling is restricted to the near-field and immediately adjacent far-field areas (negligible).
Duration	The impact is anticipated to be brief (negligible).
Frequency	The impact will occur once or infrequently throughout a relevant project phase (negligible).
Consequences	Barely discernible change to key characteristics or features of the particular environmental aspect’s character or distinctiveness (low).
Overall	The potential magnitude of the predicted changes is rated as low.

Sensitivity of Receptor

3.7.1.35 The potential for the release of drilling mud to decrease water clarity (and bacterial mortality) have been considered against MW&SQ receptors split into three categories: the wider marine environment, designated coastal and transitional waterbodies and designated BWs, to accurately identify their sensitivity (Table 3-21).

Table 3-21: Sensitivity of MW&SQ receptors to Impact 3.

Sensitivity Criteria	MW&SQ Receptors		
	Wider Marine Environment	Designated Coastal and Transitional Waterbodies	Designated BWs
Background Information	The MW&SQ Study Area, and wider regional environment, has been considered in Section 3.4.3. All reports indicated a healthy baseline environment characteristic of coastal areas connecting to the Moray Firth and wider North Sea.	All designated coastal waterbodies were classified as 'Good' and transitional waterbodies were classified as 'High' under the WFD Legislation classifications. The physical, chemical, and biological analysis which influence the classification decision (Table 3-5) indicated stable, healthy, and resilient baseline conditions.	Under the most recent reports (i.e., 2022/23 season), all designated BWs were classified as 'Excellent', indicating stable, healthy, and resilient baseline conditions.
Adaptability	High capacity to avoid or adapt (Negligible)	Reasonable capacity to avoid or adapt (Low)	Limited capacity to avoid or adapt (Medium)
Tolerance	Very little or no impact upon the baseline conditions detectable (Negligible)	High capacity to accommodate the proposed form of change (Low)	Moderate capacity to accommodate the proposed form of change (Medium)
Recoverability	Will recover fully and effect will be temporary (Negligible)	Will recover fully and effect will be temporary (Negligible)	Will recover fully and effect will be temporary (Negligible)
Value	Not designated (Negligible)	Nationally important feature (Low)	Nationally important feature (Low)
Overall Sensitivity	Negligible	Low	Medium

Significance of Effects

3.7.1.36 Taking the **Negligible** sensitivity of the wider marine environment and the low magnitude of impact, the overall effect of the deterioration in water clarity due to the release of drilling mud during construction is considered to be **Negligible and Not Significant in EIA terms**.

3.7.1.37 Taking the **Low** sensitivity of designated coastal and transitional waters and the **Low** magnitude of impact, the overall effect of the deterioration in water clarity due to the release of drilling mud during construction is considered to be **Negligible and Not Significant in EIA terms**.

3.7.1.38 Taking the **Medium** sensitivity of designated BWs and the **Low** magnitude of impact, the overall effect of the deterioration in water clarity due to the release of drilling mud during construction is considered to be **Minor and Not Significant in EIA terms**.

3.7.1.39 Overall, no additional mitigation relating to MW&SQ to that already identified in Table 3-13 is considered necessary. Therefore, no significant adverse residual effects have been predicted in respect to MW&SQ receptors.

3.7.2 Operation

3.7.2.1 The potential impacts of anticipated O&M activities of the Proposed Development (Offshore) have been evaluated concerning MW&SQ receptors within the MW&SQ Study Area (as depicted in Figure 3-1). The environmental impacts scoped in for the Proposed Development's (Offshore) O&M phase are detailed in Table 3-7, along with the design parameters used to assess each impact during the O&M phase.

3.7.2.2 A description of the significance of effect upon MW&SQ receptors caused by each identified impact is also provided below.

Impact 4: Deterioration in Water Quality Due to Suspension of Sediments

Magnitude of Impact

3.7.2.3 During the O&M phase, fewer activities will disturb the sediment and raise SSCs compared to those proposed during the construction phase. Consideration has been afforded to those O&M activities which have created the greatest change (increase) in suspended sediments and are outlined in Table 3-14. The greatest sediment disturbance is likely to occur should a section of cable become exposed or damaged and would require reburial and/or replacement (see parameters in Table 3-14).

3.7.2.4 It is acknowledged that when subsea cables are not properly protected, they can be damaged, due to the seabed relief, ship anchors, industrial fishing activity etc. A statistical analysis conducted by the United States

Department of Energy on 1061 submarine cable faults and accidents in numerous sea areas revealed that 82% of cables were harmed due to external activities, while the remaining damaged portion (18%) was induced internally (Kordahi *et al*., 2016[84]). The Proposed Development (Offshore) aims for a cable burial depth of 1-3m as the primary form of protection. If a minimum burial depth of 1m cannot be achieved, additional protection will be implemented to reduce the risk of cable damage. Final cable protection(s) will be decided during the detailed design stage and following a cable burial risk-assessment. Potential protection measures may include concrete mattresses, rock placement, grout bags, iron cast, and engineered Cable Protection Systems, as needed. Therefore, it is predicted that the replacement of a cable section is unlikely. Major component replacement is not anticipated during the design lifetime.

3.7.2.5 If required, reburial (and/or replacement) would be undertaken using similar techniques to that set out in the assessment of SSC associated with cable installation activities. The length of exposed/ damaged cable would be shorter, and the potential impacts would consequently be more localised and occur over a shorter duration than those considered during the construction phase.

3.7.2.6 Although cable reburial and/or replacement are prescribed as corrective activities in response to cable damage (which is not expected to happen frequently), there are also some routine maintenance tasks that could cause minor disturbances to the seabed. Smaller scale O&M project activities including the use of jack-up vessels or geophysical surveys are considered to result in a smaller increase in suspended sediments over a shorter period of time.

3.7.2.7 Overall, any O&M activities (preventative or corrective), especially those undertaken in the Caledonia OWF where the majority of infrastructure sits, are not expected to impact on the designated waterbodies. Moreover, the magnitude of impact of effects on water quality resulting from O&M activities would be no greater than those assessed during the construction phase. Therefore, the magnitude of impact has been assessed as negligible (Table 3-22).

Table 3-22: Determination of the magnitude of Impact 4 during the O&M phase.

Magnitude	Definition
Extent	The maximum extent of the impact is restricted to the near-field and immediately adjacent far-field areas (negligible).
Duration	The impact is anticipated to be momentary to brief (negligible).
Frequency	The impact will occur once or infrequently throughout a relevant project phase (negligible).

Magnitude	Definition
Consequences	No discernible/ barely discernible change to key characteristics or features of the particular environmental aspects or distinctiveness (negligible).
Overall	The potential magnitude of the predicted changes is rated as negligible.

Sensitivity of Receptors

3.7.2.8 Temporary increases in SSC could potentially result in a reduction in water clarity, a reduction in primary production, an increase in bacterial growth, increased nutrients within the water column and a reduction in dissolved oxygen concentrations.

3.7.2.9 The potential sensitivity of the MW&SQ receptors are the same as outlined for the construction phase in Table 3-14. In summary, the sensitivity of the wider marine environment is rated as negligible. The sensitivity of designated and transitional waterbodies is rated as low. The sensitivity of designated BWs is rated as medium.

Significance of Effects

3.7.2.10 Taking the **Negligible** sensitivity of the wider marine environment and the **Negligible** magnitude of impact, the overall effect of deterioration in water quality due to the suspension of sediments during O&M is considered to be **Negligible and Not Significant in EIA terms**.

3.7.2.11 Taking the **Low** sensitivity of designated coastal and transitional waterbodies and the **Negligible** magnitude of impact, the overall effect of deterioration in water quality due to the suspension of sediments during O&M is considered to be **Negligible and Not Significant in EIA terms.**

3.7.2.12 Taking the **Medium** sensitivity of designated BWs and the **Negligible** magnitude of impact, the overall effect of deterioration in water quality due to the suspension of sediments during O&M is considered to be **Negligible and Not Significant in EIA terms**.

3.7.2.13 Overall, no additional mitigation relating to MW&SQ to that already identified in Table 3-13 is considered necessary. Therefore, no significant adverse residual effects have been predicted in respect to MW&SQ receptors.

3.7.3 Decommissioning

Impact 5: Deterioration in Water Quality Due to Suspension of Sediments

Magnitude of Impact

3.7.3.1 The effects of the Proposed Development's (Offshore) decommissioning activities have been assessed on MW&SQ receptors within the MW&SQ Study Area (Figure 3-1). As presented in Table 3-14, the nature and extent of the environmental impacts arising during decommissioning is assumed (for the purposes of this assessment) to be similar to that described for the equivalent activities during the construction phase. Therefore, these assumptions have been based on the worst-case construction impacts which provides a cautious approach to any potential effects from decommissioning activities.

3.7.3.2 Activities associated with the Proposed Development (Offshore) during the decommissioning phase will result in seabed sediment disturbance into the water column, the volumes of which are considered to be equal to, or less than, those disturbed during the construction phase. Given that the magnitude of effect during the construction phase has been assessed as Low, the magnitude of effect arising as a result of increased SSC during the decommissioning phase is also considered to be Low (see Table 3-16).

Sensitivity of Receptors

3.7.3.3 Temporary increases in SSC could potentially result in a reduction in water clarity, a reduction in primary production, an increase in bacterial growth, increased nutrients within the water column and a reduction in dissolved oxygen concentrations.

3.7.3.4 The potential sensitivity of the MW&SQ receptors are the same as outlined in Table 3-17. In summary, the sensitivity of the wider marine environment is rated as negligible. The sensitivity of designated and transitional waterbodies is rated as low. The sensitivity of designated BWs is rated as medium.

Significance of Effect

3.7.3.5 Taking the **Negligible** sensitivity of the wider marine environment and the **Low** magnitude of impact, the overall effect of deterioration in water quality due to the suspension of sediments during decommissioning is considered to be **Negligible and Not Significant in EIA terms**.

3.7.3.6 Taking the **Low** sensitivity of designated coastal and transitional waterbodies and the **Low** magnitude of impact, the overall effect of deterioration in water quality due to the suspension of sediments during decommissioning is considered to be **Negligible and Not Significant in EIA terms**.

3.7.3.7 Taking the **Medium** sensitivity of designated BWs and the **Low** magnitude of impact, the overall effect of deterioration in water quality due to the suspension of sediments during decommissioning is considered to be **Minor and Not Significant in EIA terms**.

3.7.3.8 Overall, no additional mitigation relating to MW&SQ to that already identified in Table 3-13 is considered necessary. Therefore, no significant adverse residual effects have been predicted in respect to MW&SQ receptors.

Impact 6: Release of Sediment-bound Contaminants from Disturbed Sediments

Magnitude of Impact

3.7.3.9 It is anticipated that activities associated with the decommissioning phase will result in seabed sediment (and associated contamination) disturbance into the water column in volumes considered to be equal to, or less than, those disturbed during the construction phase. Therefore, the magnitude (and so significance) of the effect on MW&SQ resulting from decommissioning activities would be no greater than those assessed in the construction phase (see Table 3-18). Therefore, the potential magnitude of the predicted changes is rated as low.

Sensitivity of Receptor

3.7.3.10 The release of sediment bound contaminants from activities disturbing the sediment could lead to an increased contaminant bioavailability with the potential for ecotoxicological effects.

3.7.3.11 The potential sensitivity of MW&SQ receptors will be the same as outlined for Impact 2 during the construction phase in Table 3-19. In summary, the sensitivity of the wider marine environment is rated as negligible. The sensitivity of designated and transitional waterbodies is rated as low. The sensitivity of designated BWs is rated as negligible.

Significance of Effect

3.7.3.12 Taking the **Negligible** sensitivity of the wider marine environment and the **Low** magnitude of impact, the overall effect of the release of sediment bound contaminants from disturbed sediments during decommissioning is considered to be **Negligible and Not Significant in EIA terms**.

3.7.3.13 Taking the **Low** sensitivity of designated coastal and transitional waters and the **Low** magnitude of impact, the overall effect of the release of sediment bound contaminants from disturbed sediments during decommissioning is considered to be **Negligible and Not Significant in EIA terms**.

3.7.3.14 Taking the **Negligible** sensitivity of designated BWs and the **Low** magnitude of impact, the overall effect of the release of sediment bound

contaminants from disturbed sediments during decommissioning is considered to be **Negligible and Not Significant in EIA terms**.

3.7.3.15 Overall, no additional mitigation relating to MW&SQ to that already identified in Table 3-13is considered necessary. Therefore, no significant adverse residual effects have been predicted in respect to MW&SQ receptors.

3.8 Cumulative Effects

3.8.1 Overview

3.8.1.1 The list of developments identified for assessing cumulative effects is presented in Volume 7A, Appendix 7-1: Cumulative Impact Assessment Methodology. In Table 3-23, the potential for cumulative effects with each of these developments is examined, and an assessment of the cumulative effects presented where appropriate.

Table 3-23: Projects considered within the MW&SQ cumulative assessment.

Development	Potential for Significant Cumulative Impact?	Comment
Moray West OWF OECC[iv]	Yes	If activities associated with this development activities overlap temporally with either the construction or O&M of the Proposed Development (Offshore), there is potential for cumulative SSC to occur within the modelled plume footprints resulting in deterioration of water quality from the cumulative suspension of sediments and the potential for sediment plumes acting cumulatively to release sediment bound contaminants which has potential for ecotoxicological effects.
Stromar OWF OECC (scoping)	Yes	If activities associated with this development activities overlap temporally with either the construction or O&M of the Proposed Development (Offshore), there is potential for cumulative SSC to occur within the modelled plume footprints resulting in deterioration of water quality from the cumulative suspension of sediments and the potential for sediment plumes acting cumulatively to release sediment bound contaminants which has potential for ecotoxicological effects.

[iv] Moray West Export Cable was commissioned after the CIA was undertaken, and therefore has been included as part of the longlist.

3.8.2 Construction

Impact 7: Deterioration in Water Quality from the Suspension of Sediments

Magnitude of Impact

3.8.2.1 Given the similarities in proposed activities and the proximity of identified OWFs, it is expected that resultant sediment plumes will behave similarly to that assessed for the Proposed Development (Offshore). Any OWFs and/ or associated cables that are not already operational (and therefore part of the baseline) identified within the cumulative ZoI (10km) are outlined here:

- Moray West OECC (under construction, operational by 2025); and
- Stromar OECC (Scoping, operational by 2030).

3.8.2.2 The Stromar export cables are estimated to be within 10km of the Proposed Development (Offshore) Caledonia OWF, although this cannot be confirmed due to the early stage of application (i.e., Scoping). Should Stromar proceed, there is a likelihood that the construction phase will coincide with that of the Proposed Development (Offshore). The potential overlap in construction periods means there is a chance for temporal overlap between the Stromar export cable installation and the Proposed Development (Offshore) export cable installation. Modelling for the Proposed Development (Offshore) alone indicated that HDD activity could generate a sediment plume extending up to 6km east to west and 2.5km north to south over a 15-day period. The highest SSC (above 50mg/l) would occur in an area less than 1 km long and 500m wide, reducing to 15 mg/l within 3km east to west and approximately 700m north to south within 3.6 hours. The SSC would be advected along the coast, following the tidal axis, up to 8km east and 6 km west, with concentrations below 1mg/l at these distances. All measurable SSC would disperse after 3 days.

3.8.2.3 For any cumulative effect to occur, the plumes generated by the two activities would need to meet and coalesce to form a larger plume. The likelihood of a temporal overlap occurring within this period is extremely low. However, if offshore export cable installations were to occur simultaneously, resulting sediment plumes would not travel towards each other as they are carried by the tide. Given the generally higher background SSC conditions along the coast, these changes are likely to be indistinguishable from background levels. Moreover, the concentrated SSCs are more localised, close to the site of activity. Therefore, considering the extent of sediment plumes carried by the tide, the potential increase in SSC is unlikely to be any more significant than during storm conditions and is not expected to cause a greater impact than when the Proposed Development (Offshore) is assessed alone.

The construction and O&M of analogous OWFs can be presumed to closely resemble those outlined for the Proposed Development (Offshore) due to similarities in anticipated activities (e.g., asset reburial/repair). Therefore, sediment plumes generated by other projects considered here, are anticipated to behave in a similar pattern as the sediments disturbed for the Proposed Development (Offshore) (activities and sediment are comparable).

3.8.2.4 Due to uncertainties associated with the exact (day/month) timings of other plans and projects, there is insufficient data on either project scale or timings on which to undertake a quantitative or semi-quantitative assessment. As such, the discussion presented here is qualitative. Although there is a possibility of temporal overlap with the construction of Stromar export cables, the exact dates remain uncertain. It should be noted that two resulting sediment plumes would not travel towards each other as they are carried by the tide. Moreover, given the low levels of sediment dispersion as demonstrated by site-specific sediment assessment (i.e., increased SSC restricted to the near-field only), there is not anticipated to be a notable spatial overlap with concentrated sediment plumes created during the installation of Stromar' export cables.

3.8.2.5 The comprehensive qualitative assessment of the Stromar OECC and Moray West OECC has determined through individual investigation that cumulative increase of SSC or subsequent degradation of water quality is not anticipated. Moreover, when evaluating all projects cumulatively with the Proposed Development (Offshore), they are not expected to generate additive SSC within the MW&SQ Study Area beyond those observed during natural storm events (see Volume 2, Chapter 2: Marine and Coastal Processes). This can be explained by the assessment undertaken for the Proposed Development (Offshore) alone which shows that in almost all cases, sediment plumes are rapidly indistinguishable from background levels and restricted to the near-field area. Consequently, the likelihood of two sediment-disturbance activities (e.g., the construction of the Proposed Development (Offshore) happening simultaneously to the construction of the Stromar OECC) occurring simultaneously and in close enough proximity that the tidal excursions and resultant sediment plumes overlap is considered highly unlikely. Given the short-lived nature of the sediment plumes and their highly localised behaviour, alongside the location of other infrastructure, there is not anticipated to be a notable overlap with concentrated sediment plumes created from other industry activities.

3.8.2.6 The potential increases in SSC, when considered cumulatively, are still anticipated to be within the natural variation of the MW&SQ Study Area, where no cumulative effect is expected to water clarity or bacterial mortality. Hence, even with the additional potential sediment disturbances introduced by other projects, the magnitude of the impact is considered to stay the same as the assessment of the Proposed Development (Offshore) alone. Therefore,

when assessed cumulatively the magnitude of the impact is considered to be low.

Sensitivity of Receptor

3.8.2.7 Temporary increases in SSC from constriction activities could potentially result in a reduction in water clarity, a reduction in primary production, an increase in bacterial growth, increased nutrients within the water column and a reduction in dissolved oxygen concentrations.

3.8.2.8 The potential sensitivity of the MW&SQ receptors are the same as outlined in the assessment of the Proposed Development (Offshore) alone during the construction phase (Table 3-17). In summary, the sensitivity of the wider marine environment is rated as Low. The sensitivity of designated coastal and transitional waterbodies is rated as Low. The sensitivity of designated BWs is rated as Medium.

Significance of Effects

3.8.2.9 The significance of effect on each MW&SQ receptor has been carefully assessed in accordance with the matrix provided in Table 3-11.

3.8.2.10 Taking the **Negligible** sensitivity of the wider marine environment and the **Low** magnitude of impact, the cumulative effect of deterioration in water quality from the suspension of sediments during construction is considered to be **Negligible and Not Significant in EIA terms**.

3.8.2.11 Taking the **Low** sensitivity of designated coastal and transitional waterbodies and the **Low** magnitude of impact, the cumulative effect of deterioration in water quality from the suspension of sediments during construction is considered to be **Negligible and Not Significant in EIA terms**.

3.8.2.12 Taking the **Medium** sensitivity of designated BWs and the **Low** magnitude of impact, the cumulative effect of deterioration in water quality from the suspension of sediments during construction is considered to be **Minor and Not Significant in EIA terms**.

Impact 8: Release of Sediment-bound Contaminants from Disturbed Sediments

Magnitude of Impact

3.8.2.13 The cumulative assessment of the release of sediment bound contaminants from disturbed sediments is heavily dependent on the volume of disruption coming from other projects within proximity to the Proposed Development (Offshore). The cumulative assessment of sediment disturbance projected that increased SSC would not occur out with the natural variation of the MW&SQ Study Area. Details relating to the sediment contamination levels within the Caledonia OWF and Caledonia OECC are summarised in paragraph 3.7.1.17 *et seq*. In summary, site-specific surveys of sediment contamination indicate that contamination levels are generally very low across the Caledonia

OWF and Caledonia OECC. No contaminants were reported to be present in concentrations that would notably affect surrounding faunal communities, and the low presence of contaminants limits their potential to become bioavailable. Consequently, it is not anticipated that sediment will be disturbed, and therefore the potential release of sediment bound contaminants, at a volume greater than assessed for the Proposed Development (Offshore) alone.

3.8.2.14 The sediment plumes generated by Moray West OECC and Stromar OECC, are anticipated to behave in a similar pattern as the sediments disturbed for the Proposed Development (Offshore) due to many similarities in operational design (such as cable installation techniques) combined with a similar environmental setting and sediment characteristics. Due to proximity, a generalised assumption can be made that contaminants present in sediment from the wider marine area will have followed a similar environmental fate to those in the MW&SQ Study Area of the Proposed Development (Offshore). Therefore, it is unlikely that any unaccounted-for contaminants would be introduced by the potential cumulative sediment plumes.

3.8.2.15 In term of potential contamination of sediment from 'other projects' over time, recently, Tornero and Hanke (2016[85]) presented a generic list of potential chemicals released from offshore wind energy facilities, which includes aluminium, copper, zinc, iron, diuran, irgarol, hydrocarbons (Benzene, toluene, ethylbenzene, and xylenes (BTEX), PAHs), silicon fluids, mineral oils, (bio-) diesel, vegetable oils, synthetic esters, ethylene glycol, propylene glycol, and sulfuric acid. There is no data available about the total amount of chemical emissions from OWFs, but they are likely to be very low compared to chemical emissions from fossil energy related offshore platforms (e.g., UK oil & gas industry reported 102,500t of chemical emissions in 2015 (Oil and Gas UK, 2016; Tornero and Hanke, 2016[85]). Beatrice and Moray East are both established OWFs in the MW&SQ Study Area (i.e., since 2019 and 2021 respectively). Despite this, site-specific surveys conveyed healthy baseline levels that were not indicative of established OWFs as sources of gross pollution.

3.8.2.16 In theory, if two plumes were to act cumulatively, this may have potential to increase the bioavailability of contaminants in the water column, increasing the likelihood of effect on identified receptors. However, the potential increases in SSC, when considered cumulatively, are still anticipated to be within the natural variation of the MW&SQ Study Area. Moreover, surveys from the Caledonia OWF and Caledonia OECC, have indicated that sediment contamination levels were all comparable to the wider regional background, not considered to be of low quality, and will not result in significant effect-receptor pathways if made bioavailable.

3.8.2.17 Typically, whilst very small sediment-bound contaminant concentrations enter to the dissolved phase, the vast majority remain adhered to the sediment particles when temporarily entering suspension in the water column. Similar

to the assessment of the Proposed Development (Offshore) alone, the sediment (and associated contaminants) from construction activities is expected to rapidly disperse with tidal currents. Therefore, any increase in contaminant bioavailability that could lead to ecotoxicological effects is not expected. When assessed cumulatively with the Proposed Development (Offshore), the magnitude of the impact is considered to be Negligible.

Sensitivity of Receptor

3.8.2.18 The release of sediment bound contaminant from construction activities disturbing the sediment could lead to an increased contaminant bioavailability with the potential for ecotoxicological effects.

3.8.2.19 The potential sensitivity of the MW&SQ receptors will be the same as outlined for the Proposed Development (Offshore) alone during the construction phase (Table 3-19). In summary, the sensitivity of the wider marine environment is rated as negligible. The sensitivity of designated coastal and transitional waters is rated as low. The sensitivity of designated BWs is rated as negligible.

Significance of Effect

3.8.2.20 The significance of effect on each MW&SQ receptor has been carefully assessed in accordance with the matrix provided in Table 3-11.

3.8.2.21 Taking the **Negligible** sensitivity of the wider marine environment and the **Negligible** magnitude of impact, the cumulative effect of release of sediment-bound contaminants from disturbed sediment during construction is considered to be **Negligible and Not Significant in EIA terms**.

3.8.2.22 Taking the **Low** sensitivity of designated coastal and transitional waterbodies and the **Negligible** magnitude of impact, the cumulative effect of release of sediment-bound contaminants from disturbed sediment during construction is considered to be **Negligible and Not Significant in EIA terms**.

3.8.2.23 Taking the **Negligible** sensitivity of designated BWs and the **Negligible** magnitude of impact, the cumulative effect of release of sediment-bound contaminants from disturbed sediment during construction is considered to be **Negligible and Not Significant in EIA terms**.

3.8.3 Operation

Impact 9: Deterioration in Water Quality from the Suspension of Sediments

Magnitude of Impact

3.8.3.1 Whilst activities associated with the Proposed Development (Offshore) during the O&M phase will result in seabed disturbances into the water column, primarily through cable protection and reburial works, if required, the volumes disturbed are much less than those disturbed during the construction phase.

Stromar OWF is projected to be operational by 2030, aligning with the anticipated O&M phase of the Proposed Development (Offshore). This suggests that both projects are likely to commence operations around the same timeframe. Moreover, Moray West OECC is anticipated to be fully operational by 2025.

3.8.3.2 Since all other projects are expected to be in the O&M phase, the overall probability of cumulative increases in SSC is substantially reduced compared to the potential overlaps assessed during the construction phase of the Proposed Development (Offshore). Therefore, the potential increases in SSC, when considered cumulatively, are still anticipated to be within the natural variation of the MW&SQ Study Area, where no additive effect is expected to water clarity or bacterial mortality. When assessed cumulatively with the O&M phase of the Proposed Development (Offshore), the magnitude of the impact is considered to be Negligible.

Sensitivity of Receptor

3.8.3.3 Temporary increases in SSC from O&M activities could potentially result in a reduction in water clarity, a reduction in primary production, an increase in bacterial growth, increased nutrients within the water column and a reduction in dissolved oxygen concentrations.

3.8.3.4 The potential sensitivity of the MW&SQ receptors are the same as outlined in the assessment of the Proposed Development (Offshore) alone (Table 3-17). In summary, the sensitivity of the wider marine environment is rated as Low. The sensitivity of designated coastal and transitional waterbodies is rated as Low. The sensitivity of designated BWs is rated as Medium.

Significance of Effect

3.8.3.5 The significance of effect on each MW&SQ receptor has been carefully assessed in accordance with the matrix provided in Table 3-11.

3.8.3.6 Taking the **Negligible** sensitivity of the wider marine environment and the **Negligible** magnitude of impact, the cumulative effect of deterioration in water quality from the suspension of sediments during O&M is considered to be **Negligible and Not Significant in EIA terms**.

3.8.3.7 Taking the low sensitivity of designated coastal and transitional waterbodies and the **Negligible** magnitude of impact, the cumulative effect of deterioration in water quality from the suspension of sediments during O&M is considered to be **Negligible and Not Significant in EIA terms**.

3.8.3.8 Taking the **Medium** sensitivity of designated BWs and the **Negligible** magnitude of impact, the cumulative effect of deterioration in water quality from the suspension of sediments during O&M is considered to be **Minor and Not Significant in EIA terms**.

3.8.4 Decommissioning

Impact 10: Deterioration in Water Quality from the Suspension of Sediments

Magnitude of Impact

3.8.4.1 Activities associated with the Proposed Development (Offshore) during the decommissioning phase will result in seabed sediment disturbance into the water column, the volumes of which are considered to be equal to, or less than, those disturbed during the construction phase. Additionally, all other projects are likely to be fully operational or decommissioned (i.e., dates are uncertain), in which case the cumulative effects are also considered to be equal to, or less than, those cumulatively assessed during the construction phase of the Proposed Development (Offshore).

3.8.4.2 Given that the cumulative magnitude of effect during the construction phase has been assessed as Low, impacts arising as a result of disturbed sediment during the decommissioning phase are also considered to be Low. Therefore, when considered cumulatively with the Proposed Development (Offshore), the magnitude of the impact is considered to be Low.

Sensitivity of Receptor

3.8.4.3 Temporary increases in SSC from decommissioning activities could potentially result in a reduction in water clarity, a reduction in primary production, an increase in bacterial growth, increased nutrients within the water column and a reduction in dissolved oxygen concentrations.

3.8.4.4 The potential sensitivity of the MW&SQ receptors are the same as outlined in the assessment of the Proposed Development (Offshore) alone (Table 3-16). In summary, the sensitivity of the wider marine environment is rated as Low. The sensitivity of designated coastal and transitional waterbodies is rated as Low. The sensitivity of designated BWs is rated as Medium.

Significance of Effect

3.8.4.5 The significance of effect on each MW&SQ receptor has been carefully assessed in accordance with the matrix provided in Table 3-11.

3.8.4.6 Taking the **Negligible** sensitivity of the wider marine environment and the **Low** magnitude of impact, the cumulative effect of deterioration in water quality from the suspension of sediments during decommissioning is considered to be **Negligible and Not Significant in EIA terms**.

3.8.4.7 Taking the **Low** sensitivity of designated coastal and transitional waterbodies and the **Low** magnitude of impact, the cumulative effect of deterioration in water quality from the suspension of sediments during decommissioning is considered to be **Negligible and Not Significant in EIA terms**.

3.8.4.8 Taking the **Medium** sensitivity of designated BWs and the **Low** magnitude of impact, the cumulative effect of deterioration in water quality from the

suspension of sediments during decommissioning is considered to be **Minor and Not Significant in EIA terms**.

Impact 11: Release of Sediment-bound Contaminants from Disturbed Sediments

3.8.4.9 Activities associated with the Proposed Development (Offshore) during the decommissioning phase have potential to result in the release of sediment bound contaminants from disturbed sediments, the volumes of which are considered to be equal to, or less than, those disturbed during the construction phase. Additionally, all other projects are likely to be fully operational or decommissioned (i.e., dates are uncertain), in which case the cumulative effects are also considered to be equal to, or less than, those cumulatively assessed during the construction phase of the Proposed Development (Offshore).

3.8.4.10 Given that the cumulative magnitude of effect during the construction phase has been assessed as Low, release of sediment bound contaminants arising as a result of disturbed sediment during the decommissioning phase are also considered to be Low. Therefore, when considered cumulatively with the Proposed Development (Offshore), the magnitude of the impact is considered to be Negligible.

Sensitivity of Receptor

3.8.4.11 The release of sediment bound contaminant from decommissioning activities disturbing the sediment could lead to an increased contaminant bioavailability with the potential for ecotoxicological effects.

3.8.4.12 The potential sensitivity of the MW&SQ receptors will be the same as outlined for the Proposed Development (Offshore) alone during the construction phase (Table 3-19). In summary, the sensitivity of the wider marine environment is rated as negligible. The sensitivity of designated coastal and transitional waters is rated as low. The sensitivity of designated BWs is rated as negligible.

Significance of Effect

3.8.4.13 The significance of effect on each MW&SQ receptor has been carefully assessed in accordance with the matrix provided in Table 3-11.

3.8.4.14 Taking the **Negligible** sensitivity of the wider marine environment and the **Negligible** magnitude of impact, the cumulative effect of release of sediment-bound contaminants from disturbed sediment during decommissioning is considered to be **Negligible and Not Significant in EIA terms**.

3.8.4.15 Taking the **Low** sensitivity of designated coastal and transitional waterbodies and the **Negligible** magnitude of impact, the cumulative effect of release of sediment-bound contaminants from disturbed sediment during

decommissioning is considered to be **Negligible and Not Significant in EIA terms**.

3.8.4.16 Taking the **Negligible** sensitivity of designated BWs and the **Negligible** magnitude of impact, the cumulative effect of release of sediment-bound contaminants from disturbed sediment during decommissioning is considered to be **Negligible and Not Significant in EIA terms**.

3.9 In-combination Effects

3.9.1.1 In-combination impacts may occur through the inter-relationship with another EIAR topic that may lead to different or greater environmental effects than in isolation. There is also the potential for in-combination impacts resulting from onshore and offshore works. These are identified within Volume 6, Chapter 5: Intertidal Assessment and are therefore not repeated here.

3.9.1.2 The potential in-combination effects for MW&SQ receptors resulting from effects between offshore Proposed Development (Offshore) works are described below:

Receptor-led Effects

3.9.1.3 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 benthic ecology such as direct habitat loss or disturbance, sediment plumes, scour, etc., 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 but may also incorporate longer term effects.

3.9.1.4 Effects on water quality (e.g., from disturbance of sediments) may have the potential to generate secondary effects on other receptors which have been fully assessed in the topic-specific chapters. These receptor pathways are outlined here:

Benthic Subtidal and Intertidal Ecology

3.9.1.5 Sediment disturbance caused by activities associated with the Proposed Development (Offshore) have the potential to alter water clarity (leading to reduced dissolved oxygen and increased bacterial counts). This reduced water clarity has potential to cause secondary effects on benthic ecology during construction or decommissioning of the Proposed Development (Offshore) of Minor significance, which is not significant in EIA terms (Volume 2, Chapter 4: Benthic Subtidal and Intertidal Ecology).

3.9.1.6 The release of sediment bound contaminant from activities disturbing the sediment could lead to an increased contaminant bioavailability with the potential for ecotoxicological effects. However, due to the lack of contaminants found in the site-specific survey, it was considered unlikely that there would be any pathways on benthic communities. Therefore, the

significance of effect was considered to be negligible which is not significant in EIA terms (Volume 2, Chapter 4: Benthic Subtidal and Intertidal Ecology).

Fish and Shellfish Ecology

3.9.1.7 Increased SSC caused by activities associated with the Proposed Development (Offshore) have the potential to alter water clarity (leading to reduced dissolved oxygen and increased bacterial counts). This reduced water clarity has potential to cause secondary effects on fish and shellfish ecology during construction or decommissioning of the Proposed Development (Offshore) of Minor adverse significance, which is not significant in EIA terms (Volume 2, Chapter 5: Fish and Shellfish Ecology).

3.9.1.8 The release of sediment bound contaminant from activities disturbing the sediment could lead to an increased contaminant bioavailability with the potential for ecotoxicological effects. However, due to the lack of contaminants found in the site-specific survey, it was considered unlikely that there would be any pathways on fish and shellfish communities. Therefore, the significance of effect was considered to be Negligible to Minor adverse, which is not significant in EIA terms (Volume 2, Chapter 5: Fish and Shellfish Ecology).

Marine Mammals

3.9.1.9 Sediment disturbances caused by activities associated with the Proposed Development (Offshore) have the potential to alter water clarity (leading to reduced dissolved oxygen and increased bacterial counts) and release sediment bound contaminants that could lead to increased contaminant bioavailability. Due to the lack of contaminants found in the site-specific survey, it was considered unlikely that there would be any pathways on marine mammals (including indirect effects from benthic or fish and shellfish communities as known food sources). Moreover, due to their biological adaptations, all marine mammal receptors are considered able to avoid the impacts associated with water quality mentioned in this chapter. Therefore, the significance of effect was considered to be Negligible, which is not significant in EIA terms (Volume 2, Chapter 7: Marine Mammals).

Project Lifetime Effects

3.9.1.10 Assessment of the scope for effects that occur throughout more than one phase of the project (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 key project stages (subsea noise effects from piling, operational WTGs, vessels and decommissioning). The potential interactive effects on MW&SQ receptors from project lifetime effects are detailed in Table 3-24.

Table 3-24: Potential interactive effects on MW&SQ receptors from project lifetime effects.

Impact Type	Significance of Effect			Interaction Assessment of Project Lifetime Effects
	Construction	Operation	Decommissioning	
Impact 1: Deterioration in water quality due to suspension of sediments	Negligible to Minor adverse	Negligible	Negligible to Minor adverse	The activities resulting in the highest sediment disturbance (i.e., increase of SSC levels within the coastal zone below the HWM) will occur during the construction phase, with any effects being of short-term duration and high reversibility. Due to this and the Negligible to Medium sensitivity of MW&SQ receptors to increased SSC, the interaction of these impacts across the stages of the project lifecycle is not predicted to result in an effect of any greater significance than those assessed in the individual project phases and presented here. During the construction and decommissioning phases, the Low magnitude of deterioration of water quality due to suspension of sediments is predicted to be of local spatial extent, short-term duration, intermittent and of high reversibility, with an even lower (Negligible) magnitude of impact on MW&SQ receptors predicted during the O&M phase. This dip in magnitude further prevents any interaction of these impacts to carry across the various stages of the Proposed Development (Offshore). For example, increased SSC (and potential elevated bacteria) from intensive construction activities is expected to dissipate no longer than 10 hours after cessation of activities. Therefore, it is not anticipated that any potential effects will remain into the O&M activities. Due to this the interaction of these impacts across the stages of the Proposed Development (Offshore) lifecycle is not predicted to result in an effect of any greater significance than those assessed in the individual project phases.

Impact Type	Significance of Effect			Interaction Assessment of Project Lifetime Effects
	Construction	Operation	Decommissioning	
Impact 2: Release of sediment-bound contaminants from disturbed sediments	Negligible	N/A	Negligible	The activities resulting in the highest sediment disturbance, and therefore release of sediment bound contaminants, will occur during the construction phase, with any effects being of short-term duration and high reversibility. Due to this and the Negligible to Low sensitivity of MW&SQ receptors to suspension of sediment bound contaminants, the interaction of these impacts across the stages of the project lifecycle is not predicted to result in an effect of any greater significance than those assessed in the individual project phases and presented here. During the construction and decommissioning phases, the magnitude of the release of sediment bound contaminants is predicted to be of local spatial extent, short-term duration, and intermittent frequency, with an even lower anticipated magnitude of impact on MW&SQ receptors during the O&M phase. This dip in magnitude further prevents any interaction of these impacts to carry across the various stages of the Proposed Development (Offshore). Majority of re-suspended sediments will remain with the sediment during deposition not becoming bioavailable in the water column, indicating that any impact will dissipate after cessation of activities. Moreover, there is no evidence of significant pollution within the sediment of the MW&SW Study Area. It is not anticipated that any potential effects from the construction phase will remain into the sequential phases of the Proposed Development (Offshore). Due to this the interaction of these impacts across the stages of the Proposed Development (Offshore) lifecycle is not predicted to result in an effect of any greater significance than those assessed in the individual project phases.

Impact Type	Significance of Effect			Interaction Assessment of Project Lifetime Effects
	Construction	Operation	Decommissioning	
Impact 3: Deterioration in water clarity due to the release of drilling mud	Negligible to Minor adverse	N/A	N/A	This impact pathway is in relation to cable installation using trenchless techniques in the construction phase only. Due to this there is no pathway for potential for interaction of impacts across the stages of the Proposed Development (Offshore) lifecycle.
Note, N/A - Impact not assessed for respective Proposed Development (Offshore) phase.				

3.10 Transboundary Effects

3.10.1.1 The Proposed Development (Offshore) is located wholly within the Outer Moray Firth. Any impacts on MW&SQ from the presence of the Proposed Development (Offshore) infrastructure and activities are anticipated to be localised and temporary in nature. As such, no transboundary effects are predicted to result from the construction, operation and maintenance and decommissioning phases of the Proposed Development (Offshore) in terms of MW&SQ receptors.

3.10.1.2 A screening of transboundary impacts has been carried out and has identified that there was no potential for significant transboundary effects with regard to MW&SQ from the Proposed Development (Offshore) upon the interests of other states.

3.11 Mitigation Measures and Monitoring

3.11.1.1 Based upon the assessment presented here which found no significant effects for both the Proposed Development (Offshore) alone or cumulatively with other projects, there are no secondary mitigations required for the construction, O&M and decommissioning phase of the Proposed Development (Offshore).

3.12 Residual Effects

3.12.1.1 There are no significant effects identified for either the Proposed Development (Offshore) alone or cumulatively with other projects. Therefore, no additional mitigation to that already identified in Table 3-13 are considered necessary. Therefore, no significant adverse residual effects have been predicted in respect of MW&SQ.

3.13 Summary of Effects

3.13.1.1 Table 3-25 presents a summary of the significant effects assessed within this EIAR, any mitigation required, and the residual effects are provided.

Table 3-25: Summary of Effects for MW&SQ.

Potential Impact	Magnitude	Sensitivity of Receptor	Significance	Mitigation Measure	Residual Effect
Construction					
Impact 1: Deterioration in water quality due to suspension of sediments	Low	Negligible to Medium	Negligible to Minor adverse (not significant)	N/A	Negligible to Minor adverse (not significant)
Impact 2: Release of sediment-bound contaminants from disturbed sediments	Low	Negligible to Low	Negligible (not significant)	N/A	Negligible (not significant)
Impact 3: Deterioration in water clarity due to the release of drilling mud	Low	Negligible to Medium	Negligible to Minor adverse (not significant)	N/A	Negligible to Minor adverse (not significant)
Operation and Maintenance					
Impact 4: Deterioration in water quality due to suspension of sediments	Negligible	Negligible to Medium	Negligible (not significant)	N/A	Negligible (not significant)

Potential Impact	Magnitude	Sensitivity of Receptor	Significance	Mitigation Measure	Residual Effect
Decommissioning					
Impact 5: Deterioration in water quality due to suspension of sediments	Low	Negligible to Medium	Negligible to Minor adverse (not significant)	N/A	Negligible to Minor adverse (not significant)
Impact 6: Release of sediment-bound contaminants from disturbed sediments	Low	Negligible to Low	Negligible (not significant)	N/A	Negligible (not significant)

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