Partners in UK offshore wind

MONA OFFSHORE WIND PROJECT

Preliminary Environmental Information Report

Volume 2, chapter 6: Physical processes

Image of an offshore wind farm

April 2023
FINAL

Document status

Version	Purpose of document	Authored by	Reviewed by	Approved by	Review date
Rev01	Draft for Client review	RPS	bp/EnBW		18/08/2022
Rev02	Addressing client comments	RPS	bp/EnBW		12/10/2022
Rev03	Addressing client comments	RPS	bp/EnBW		18/11/2022
Rev04	Final	RPS	bp/EnBW	bp/EnBW	03/02/2023

Prepared by:	Prepared for:
RPS	**Mona Offshore Wind Ltd.**

Contents

Tables

Figures

List of Annexes

Volume 6, Annex 6.1: Physical processes technical report of the PEIR

Glossary

Term	Meaning
Bathymetry	The measurement of depth of water in oceans, seas, or lakes.
Ebb tide	The tidal phase during which the water level is falling.
Erosion	Depletion of sediment in the intertidal region.
Fetch	Length in the wind direction of the marine area where water waves are generated by wind.
Flood tide	The tidal phase during which the water level is rising.
High Water Mark	The level reached by the sea at high tide.
Highest Astronomical Tide	The highest tidal height predicted to occur under average meteorological conditions and any combination of astronomical conditions.
Hydrodynamic boundary conditions	The conditions used in a model boundary which can included surface elevation and velocity which will affect the rest of the model domain. The boundary condition can vary with time and along the boundary.
Intertidal region	An area of a shoreline that is covered at high tide and uncovered at low tide.
Lee	Shelter from wind or weather given by an object.
Littoral currents	Flow derived from tide and wave climate.
Low Water Mark	The level reached by the sea at low tide.
Lowest Astronomical Tide	The lowest tidal height predicted to occur under average meteorological conditions and any combination of astronomical conditions.
Mean High Water	The highest water level reached during and average tide.
Mean High Water Spring	The most inshore level location reached by the sea at high tide during mean high water spring tide. This is defined as the average throughout the year, of two successive high waters, during a 24-hour period in each month when the range of the tide is at its greatest.
Mean Low Water Spring	The most offshore location reached by the sea at low tide during low water spring tide. This is defined as the average throughout the year, of two successive low waters, during a 24-hour period in each month when the range of the tide is at its greatest.
Mean Sea Level	The average tidal height over a long period of time.
Metocean	Refers to the syllabic abbreviation of meteorology and (physical) oceanography.
Neap tide	Tide that occurs when the sun and moon are at right angles to each other and the gravitational pull of the sun partially cancels out the pull of the moon on the ocean.
Refraction	The change in direction of a wave passing from one medium to another caused by its change in speed.
Residual current	The net flow over the course of the tidal cycle. This is effectively the driving force of the sediment transport.
Sandwave	A lower regime sedimentary structure that forms across from tidal currents.
Scour protection	Measures to prevent loss of seabed sediment around any structure placed in or on the seabed (e.g. by use of protective aprons, mattresses, rock and gravel placement)
Sedimentation	The process of settling or being deposited as a sediment.
Significant wave height	Mean wave height (trough to crest) of the highest third of the waves.
Slack tide	Tidal phase at which the current turns from flood to ebb (high-water slack tide) or from ebb to flood (low-water slack tide).
Spectral waves	Describes the distribution of wave energy with frequency (1/period) and direction.
Spring tide	Tide that occurs when the sun and moon are directly in line with the Earth and their gravitational pulls on the ocean reinforce each other.
Suspended Particulate Matter	Particles that are suspended in the water column.
Turbidity	The quality of being cloudy, opaque, or thick with suspended matter.
Wave height	The distance from trough to crest of a wave.
Wave period	The time it takes for two successive crests (one wavelength) to pass a specified point.

Acronyms

Acronym	Description
2D UHRS	2D Ultra High Resolution Seismic
BODC	British Oceanographic Data Centre
CEA	Cumulative Effect Assessment
Cefas	Centre for Environment Fisheries and Aquaculture Science
CIRIA	Construction Industry Research and Information Association
COWRIE	Collaborative Offshore Wind Energy Research into the Environment
CPT	Core Penetration Test
DSV	Digital Sound Velocity
ECMWF	European Centre for Medium-range Weather Forecast
EIA	Environmental Impact Assessment
EMODnet	European Marine Observation and Data Network
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
MBES	Multi-Beam Echo Sounder
MEDIN	Marine Environmental Data Information Network
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MPA	Marine Protected Area
NIS	Natura Impact Statement
NRW	Natural Resources Wales

Acronym	Description
OSP	Offshore Substation Platforms
SAC	Special Areas of Conservation
SBP	Sub-Bottom Profiler
SPA	Special Protection Area
SPM	Suspended Particulate Matter
SSC	Suspended sediment concentrations
SSS	Side Scan Sonar
SSSI	Site of Special Scientific Interest
UK	United Kingdom
UKHO	United Kingdom Hydrographic Office
ZOI	Zone of Influence

Units

Unit	Description
º	Degrees (angle from true North)
%	Percentage
cm/s	Centimetres per second (speed)
km	Kilometres (distance)
km^2	Square kilometres (distance)
m	Metres (distance)
m^2	Square metres (area)
m^3/h	Cubic metres per hour (discharge rate)
mg/l	Milligrams per litre (concentration)
mm	Millimetres (distance)
m/hour	Metres per hour (rate)
m/s	Metres per second (speed)
$m^3/s/m$	Cubic metres per second per metre (total load)

6 Physical processes

6.1 Introduction

6.1.1 Overview

6.1.1.1 This chapter of the Preliminary Environmental Information Report (PEIR) presents the assessment of the potential impact of the Mona Offshore Wind Project on physical processes. Specifically, this chapter considered the potential impact of the Mona Offshore Wind Project seaward of Mean High Water Springs (MHWS) during the construction, operational and maintenance, and decommissioning phases. The impacts of the Mona Offshore Wind Project landward of MHWS are addressed in volume 3: Onshore chapters of the PEIR. Specifically, volume 3, chapter 16: Geology, hydrogeology and ground conditions and volume 3, chapter 17: Hydrology and flood risk of the PEIR.

6.1.1.2 The assessment presented also informs and is informed by the following technical chapters:

- Volume 2, chapter 7: Benthic subtidal and intertidal ecology of the PEIR
- Volume 2, chapter 8: Fish and shellfish ecology of the PEIR
- Volume 2, chapter 9: Marine mammals of the PEIR
- Volume 2, chapter 13: Marine archaeology of the PEIR
- Volume 2, chapter 14: Other sea users of the PEIR.

6.1.1.3 This chapter also draws upon information contained within volume 6, annex 6.1: Physical processes technical report of the PEIR. Previous experience in offshore wind developments has indicated that changes in physical processes are generally limited in magnitude and scale. For the purposes of identifying significant impacts a comparative study was undertaken - assessing potential changes in physical process drivers (i.e. tidal currents and waves using numerical modelling techniques). These changes were not found to be significant therefore further detailed studies were not required. An exhaustive detailed study was not undertaken from the outset rather reference made to published characteristics and noted sensitivities.

6.1.1.4 The preparation of a PEIR and subsequent application is a live process with refinements being made to the project description throughout this period, as information is acquired from a range studies and assessments undertaken. For this reason, the modelled scenarios presented in volume 6, annex 6.1: Physical processes technical report of the PEIR will, inevitably, vary by a small degree from those ultimately assessed. However, due to the limited nature of these refinements, the modelling study remains a legitimate resource for supporting information. Where variations occur between the modelled parameters and those assessed they are cited within the relevant sections with reference to the applicability of the modelled data to the specific assessment.

6.1.2 Purpose of chapter

6.1.2.1 The primary purpose of the PEIR is outlined in volume 1, chapter 1: Introduction of the PEIR. In summary, the primary purpose of an Environmental Statement is to support the Development Consent Order (DCO) application for Mona Offshore Wind Project under the Planning Act 2008 (the 2008 Act). The PEIR constitutes the Preliminary Environmental Information for Mona Offshore Wind Project and sets out the findings of the EIA to date to support the pre-application consultation activities required under the 2008 Act. The EIA will be finalised following completion of pre-application consultation and the Environmental Statement will accompany the application to the Secretary of State for Development Consent.

6.1.2.2 The PEIR forms the basis for statutory consultation which will last for 47 days and conclude on 4 June 2023 as outlined in volume 1, chapter 2: Policy and legislation of the PEIR. At this point, comments received on the PEIR will be reviewed and incorporated (where appropriate) into the Environmental Statement, which will be submitted in support of the application for Development Consent scheduled for quarter one of 2024.

6.1.2.3 In particular, this PEIR chapter:

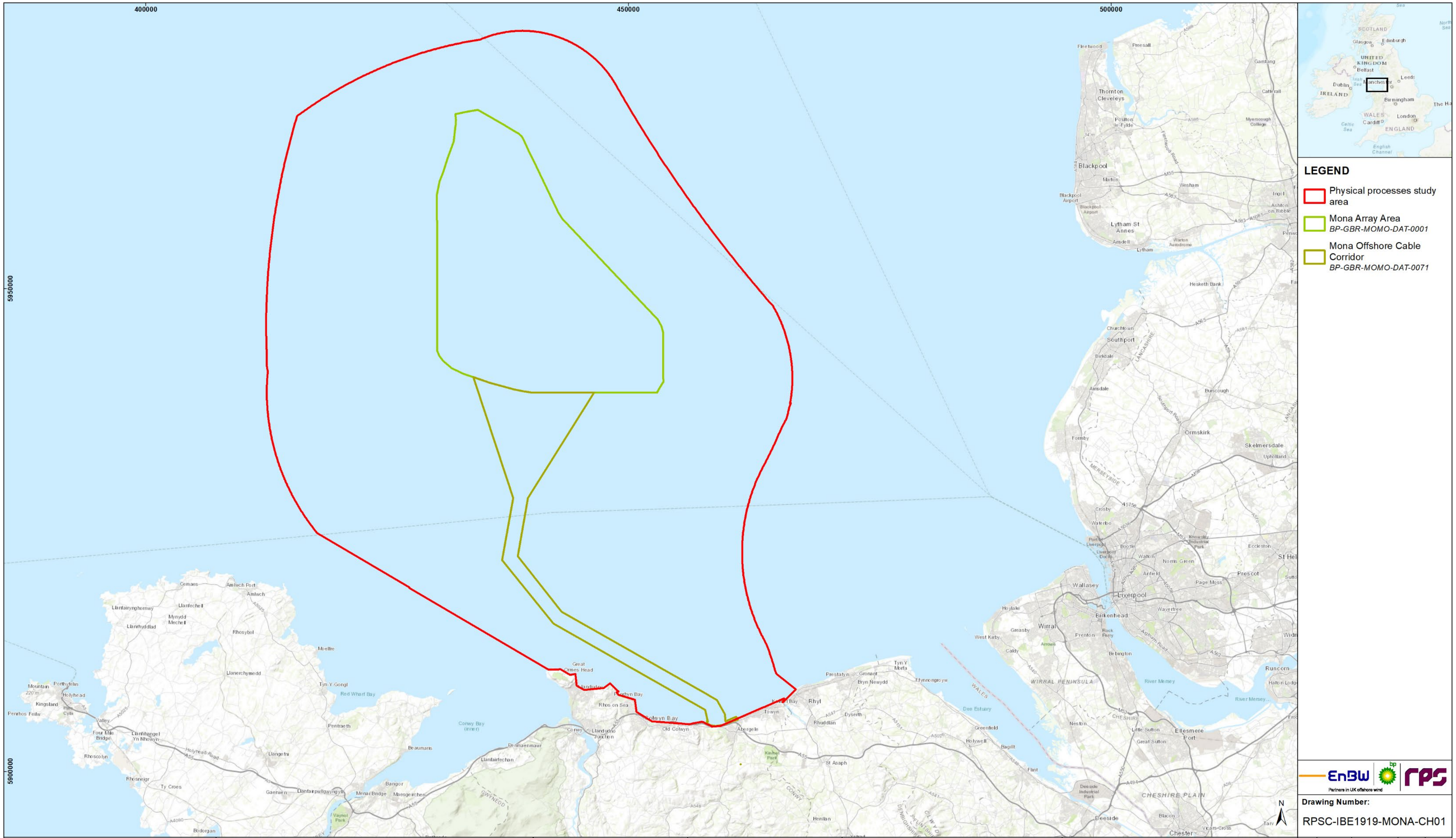
- Presents the existing environmental baseline established from desk studies and site-specific surveys
- Identifies any assumptions and limitations encountered in compiling the environmental information
- Presents the potential environmental effects on physical processes arising from the Mona Offshore Wind Project, based on the information gathered and the analysis and assessments undertaken
- Highlights any necessary monitoring and/or mitigation measures which could prevent, minimise, reduce or offset the possible environmental effects of the Mona Offshore Wind Project on physical processes.

6.1.3 Study area

6.1.3.1 The Mona physical processes study area is illustrated in Figure 6.1 and encompasses the:

- Mona Array Area (i.e. the area within which the wind turbines, foundations, inter-array cables, interconnector cables, offshore export cables and Offshore Substation Platforms (OSPs) forming part of the Mona Offshore Wind Project will be located)
- Mona Offshore Cable Corridor (i.e. the corridor located between the Mona Array Area and the landfall up to MHWS, in which the offshore export cables will be located)
- Landfall area
- Seabed and coastal areas that may be influenced by changes to physical processes due to the Mona Offshore Wind Project defined as one spring tidal excursion which is the distance suspended sediment is transported prior to being carried back on the returning tide.

6.1.3.2 It is however noted that the Mona physical processes study area forms the focus for the assessment and that the numerical modelling study undertaken to support the assessment is not limited to this region, as detailed in volume 6, annex 6.1: Physical processes technical report of the PEIR. The physical processes modelling study therefore also identifies any potential impacts beyond the physical processes study area. The Mona physical processes study area for the Cumulative Effects Assessment (CEA) presented in section 6.9 is defined as two spring tidal excursions which represents where study areas for adjacent projects and developments, defined in a similar way, may intersect.



Project Name:	Drawing Title:		Geodetic Information:	Data Sources:	Service Layer Credits:	VER	DATE	DETAILS	BY	CHECK
MONA OFFSHORE WIND PROJECT	PHYSICAL PROCESSES STUDY AREA	0 1 2 4 6 nm 0 2.5 5 10 km	Datum: ETRS 1989 Projection: ETRS 1989 UTM Zone 30N Scale@379mmx231mm: 1:400,000		Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community	00	16/09/22	Final	NRS	RM
						01	16/11/22	Final	NRS	CN

Figure 6.1: Mona Offshore Wind Project physical processes study area.

6.2 Policy context

6.2.1.1 The policy context for the Mona Offshore Wind Project is set out in volume 1, chapter 2: Policy and legislation of the PEIR. A summary of the policy provisions relevant to physical processes are provided in Table 6.1, with other relevant policy on decision making is set out in Table 6.2.

6.2.2 National Policy Statements

6.2.2.1 Planning policy on renewable energy infrastructure is presented in volume 1, chapter 2: Policy and legislation of the PEIR. Planning policy on offshore renewable energy Nationally Significant Infrastructure Projects (NSIPs), specifically in relation to physical processes, is contained in the Overarching National Policy Statement (NPS) for Energy (EN-1; DECC, 2011a).

6.2.2.2 NPS EN-1 and NPS EN-3 include guidance on what matters are to be considered in the assessment. These are summarised in Table 6.1 below. NPS EN-1 and NPS EN-3 also highlight a number of factors relating to the determination of an application and in relation to mitigation. These are summarised in Table 6.2 below.

6.2.2.3 Table 6.1 refers to the current NPSs, specifically NPS EN-1 (DECC, 2011a) and NPS EN-3 (DECC, 2011b). If the NPSs are updated prior to the application for Development Consent, the revised NPSs will be fully considered in relation to physical processes within the Environmental Statement.

Table 6.1: Summary of the NPS EN-1 and EN-3 provisions relevant to physical processes.

Summary of NPS EN-1 and EN-3 provision	How and where considered in the PEIR
NPS EN-1	
Applicants should undertake coastal geomorphological and sediment transfer modelling to predict and understand impacts and help identify relevant mitigating or compensatory measures (paragraph 5.5.6).	Assessment of sediment dynamics undertaken using the hydrodynamic and spectral wave modelling, together with an understanding of the sediment regime. Refer to volume 6, annex 6.1: Physical processes technical report of the PEIR.
The ES should include an assessment of the effects on the coast. In particular, applicants should assess: • The impact of the proposed project on coastal processes and geomorphology, including by taking account of potential impacts from climate change. If the development will have an impact on coastal processes the applicant must demonstrate how the impacts will be managed to minimise adverse impacts on other parts of the coast; • The effects of the proposed project on maintaining coastal recreation sites and features; and • The effects of the proposed project on marine ecology, biodiversity and protected sites (paragraph 5.5.7).	Baseline and post-construction physical processes were compared alongside extreme storm conditions to consider the wave climate detailed in volume 6, annex 6.1: Physical processes technical report of the PEIR, whilst climate change is discussed in section 6.4.16. A CEA has been undertaken and is outlined in section 6.10.
For any projects involving dredging or disposal into the sea, the applicant should consult the Marine Management Organisation (MMO) at an early stage. Where the project has the potential to have a major impact in this respect, this is covered in the technology-specific NPSs (paragraph 5.5.8).	The procedures are considered within volume 1, chapter 3: Project description of the PEIR. Best practice techniques will be employed to ensure sediment mobilisation is minimised. Assessment of sediment dynamics undertaken using the hydrodynamic and spectral wave modelling, together with an understanding of the sediment regime. Refer to volume 6, annex 6.1: Physical processes technical report of the PEIR. Predicted changes to the tidal current, wave climate, littoral currents and sediment transport are quantified in volume 6, annex 6.1: Physical processes technical report of the PEIR.
The applicant should be particularly careful to identify any effects of physical changes on the integrity and special features of Marine Conservation Zones, candidate marine Special Areas of Conservation (SACs), coastal SACs and candidate coastal SACs, coastal Special Protection Areas (SPAs) and potential coastal SPAs, Ramsar sites, Sites of Community Importance (SCIs) and potential SCIs and Sites of Special Scientific Interest (paragraph 5.5.9).	Designated sites and features of importance within and surrounding the physical processes study area have been identified in section 6.4.15. Further information is also provided in the Information to support the Appropriate Assessment. Potential impacts have also been identified and the significance of the effects on physical processes receptors has been assessed in section 6.8.
NPS EN-3	
Where necessary, assessment of the effects on the subtidal environment should include: • loss of habitat due to foundation type including associated seabed preparation, predicted scour, scour protection and altered sedimentary processes; • environmental appraisal of inter-array and cable routes and installation methods; • habitat disturbance from construction vessels' extendible legs and anchors; • increased suspended sediment loads during construction; and • predicted rates at which the subtidal zone might recover from temporary effects (paragraph 2.6.113).	Assessment of the significance of effects during installation of foundations and site preparation (construction phase) on physical processes receptors is detailed in section 6.8. The procedures are considered within volume 1, chapter 3: Project description of the PEIR. Best practice techniques will be employed to ensure sediment mobilisation is minimised. Assessment of sediment dynamics undertaken using the hydrodynamic and spectral wave modelling, together with an understanding of the sediment regime. Refer to volume 6, annex 6.1: Physical processes technical report of the PEIR.
If it is proposed to install offshore cables to a depth of at least 1.5m below the seabed, the applicant should not have to assess the effect of the cables on subtidal habitat during the operational phase of the offshore wind farm (paragraph 2.6.114).	The installation of cable is considered within volume 1, chapter 3: Project description of the PEIR.
Where a potential offshore wind farm is proposed close to existing operational offshore infrastructure or has the potential to affect activities for which a licence has been issued by Government, the applicant should undertake an assessment of the potential effect of the proposed development on such existing or permitted infrastructure or activities. The assessment should be undertaken for all stages of the lifespan of the proposed wind farm in accordance with the appropriate policy for offshore wind farm EIAs (paragraph 2.6.179).	Baseline and post-construction physical processes were compared under the MDS as described in Table 6.12 and a CEA has been undertaken and is outlined in section 6.10 which includes operational offshore wind farm within the physical processes CEA study area. Legislative requirements for offshore wind farms are considered within volume 1, chapter 2: Policy and legislation of the PEIR.

Summary of NPS EN-1 and EN-3 provision	How and where considered in the PEIR
Applicants should engage with interested parties in the potentially affected offshore sectors early in the development phase of the proposed offshore wind farm, with an aim to resolve as many issues as possible prior to the submission of an application to the [Secretary of State] (paragraph 2.6.180). Such stakeholder engagement should continue throughout the life of the development including construction, operation, and decommissioning phases where necessary. As many of these offshore industries are regulated by Government, the relevant Secretary of State should also be a consultee where necessary. Such engagement should be taken to ensure that solutions are sought that allow offshore wind farms and other uses of the sea to successfully co-exist (paragraph 2.6.181).	Key issues have been raised and discussed during consultation activities and engagement specific to physical processes. A summary of the key issues and responses have been provided in Table 6.5 below. A Consultation Report detailing the pre-application consultation will be submitted alongside the application.
Assessment should be undertaken for all stages of the lifespan of the proposed wind farm in accordance with the appropriate policy for offshore wind farm EIAs (paragraph 2.6.190). The Environment Agency (EA) regulates emissions to land, air and water out to 3nm. Where any element of the wind farm or any associated development included in the application to the [Secretary of State] is located within 3nm of the coast, the EA should be consulted at the pre-application stage on the assessment methodology for impacts on the physical environment (paragraph 2.6.191). Beyond 3nm, the MMO is the regulator. The applicant should consult the MMO and the Centre for Environment, Fisheries & Aquaculture Science (CEFAS) on the assessment methodology for impacts on the physical environment at the pre-application stage (paragraph 2.6.192). Geotechnical investigations should form part of the assessment as this will enable design of appropriate construction techniques to minimise any adverse effects (paragraph 2.6.193). The assessment should include predictions of the physical effect that will result from the construction and operation of the required infrastructure and include effects such as the scouring that may result from the proposed development (paragraph 2.6.194).	Hydrodynamic modelling undertaken for physical processes assessment (refer to volume 6, annex 6.1: Physical processes technical report of the PEIR.) Scour protection is included within the assessment as defined by the project description outlined in volume 1, chapter 3: Project description of the PEIR. Legislative requirements for offshore wind farms are considered within volume 1, chapter 2: Policy and legislation of the PEIR. Key issues have been raised and discussed during consultation activities and engagement specific to physical processes. A summary of the key issues and responses have been provided in Table 6.5 below. A Consultation Report detailing the pre-application consultation will be submitted alongside the application. Geophysical surveys and other site specific surveying has been carried out to support modelling and assessment, as described in Table 6.7.

Table 6.2: Summary of NPS EN-1 and NPS EN-3 policy on decision making relevant to physical processes.

Summary of NPS EN-1 and EN-3 policy	How and where considered in the PEIR
NPS EN-1	
The [Secretary of State] should be satisfied that the proposed development will be resilient to coastal erosion and deposition, taking account of climate change, during the project's operational life and any decommissioning period (section 5.5.10).	Details of the project design criteria are detailed in volume 1, chapter 3: Project description of the PEIR, whilst climate change is discussed in section 6.4.16.
The [Secretary of State] should not normally consent new development in areas of dynamic shorelines where the proposal could inhibit sediment flow or have an adverse impact on coastal processes at other locations. Impacts on coastal processes must be managed to minimise adverse impacts on other parts of the coast. Where such proposals are brought forward consent should only be granted where the [Secretary of State] is satisfied that the benefits (including need) of the development outweigh the adverse impacts (section 5.5.11).	Assessment of sediment dynamics undertaken using the hydrodynamic and spectral wave modelling, together with an understanding of the sediment regime. Refer to volume 6, annex 6.1: Physical processes technical report of the PEIR. Predicted changes to the tidal current, wave climate, littoral currents and sediment transport are assessed in volume 6, annex 6.1: Physical processes technical report of the PEIR. Potential impacts have also been identified and the significance of the effects on physical processes receptors has been assessed in section 6.8.
In addition to this NPS the [Secretary of State] must have regard to the appropriate marine policy documents, as provided for in the Marine and Coastal Access Act 2009. The [Secretary of State] may also have regard to any relevant SMPs (paragraph 5.5.15).	Legislative requirements for offshore wind farms are considered within volume 1, chapter 2: Policy and legislation of the PEIR.
The [Secretary of State] should examine the broader context of coastal protection around the proposed site, and the influence in both directions, i.e coast on site, and site on coast (paragraph 5.5.13).	The project design detailed in volume 1, chapter 3: Project description of the PEIR takes consideration of the impacts of physical processes on the infrastructure whilst this chapter considers the effect of the Mona Offshore Wind Project on physical processes.
NPS EN-3	
The conservation status of subtidal habitat is of relevance to the [Secretary of State] (section 2.6.115).	Potential impacts have also been identified and the significance of the effects on physical processes receptors has been assessed in section 6.8. Designated sites and features of importance within and surrounding the physical processes study area have been identified in section 6.4.15.
Where adverse effects are predicted, in coming to a judgement, the [Secretary of State] should consider the extent to which the effects are temporary or reversible (section 2.6.117).	Potential impacts have also been identified and the significance of the effects on physical processes receptors has been assessed in section 6.8.
As set out above, the direct effects on the physical environment can have indirect effects on a number of other receptors. Where indirect effects are predicted, the [Secretary of State] should refer to relevant sections of this NPS and EN-1 (paragraph 2.6.195).	Potential impacts have also been identified and the significance of the effects on physical processes receptors has been assessed in section 6.8.

Summary of NPS EN-1 and EN-3 policy	How and where considered in the PEIR
The [Secretary of State] should be satisfied that the methods of construction, including use of materials, are such as to reasonably minimise the potential for impact on the physical environment. This could involve, for instance, the exclusion of certain foundations on the basis of their impacts or minimising quantities of rock that are used to protect cables whilst taking into account other relevant considerations such as safety (paragraph 2.6.196).	The procedures are considered within volume 1, chapter 3: Project description of the PEIR. Best practice techniques will be employed to ensure sediment mobilisation is minimised.

6.2.1 Welsh National Marine Plan (WNMP)

6.2.1.1 The assessment of potential changes to physical processes has also been made with consideration to the specific policies set out in the Welsh National Marine Plan (Welsh Government, 2019). Key provisions are set out in Table 6.3 along with details as to how these have been addressed within the assessment.

Table 6.3: Welsh National Marine Plan policies of relevance to physical processes.

Policy	Key provisions	How and where considered in the PEIR
ENV_01	Proposals should demonstrate how potential impacts on marine ecosystems have been taken into consideration and should, in order of preference: a. avoid adverse impacts; and/or b. minimise impacts where they cannot be avoided; and/or c. mitigate impacts where they cannot be minimised. If significant adverse impacts cannot be avoided, minimised or mitigated, proposals must present a clear and convincing case for proceeding. Proposals that contribute to the protection, restoration and/or enhancement of marine ecosystems are encouraged.	Designated sites and sites of interest due to geological importance within the physical processes study area have been identified in section 6.4.15. Potential impacts have also been identified and the significance of the effects on physical processes receptors has been assessed in section 6.8.
ENV_02	Proposals should demonstrate how they: • avoid adverse impacts on individual Marine Protected Areas (MPAs) and the coherence of the network as a whole; • have regard to the measures to manage MPAs; and • avoid adverse impacts on designated sites that are not part of the MPA network.	Designated sites and sites of interest due to geological importance within the physical processes study area have been identified in section 6.4.15.
SOC_09	Proposals should demonstrate how they: • avoid significant adverse impacts upon coastal processes; and • minimise the risk of coastal change and flooding; Proposals that align with the relevant Shoreline Management Plan(s) and its policies are encouraged.	Assessment of sediment dynamics undertaken using the hydrodynamic and spectral wave modelling, together with an understanding of the sediment regime. Refer to volume 6, annex 6.1: Physical processes technical report of the PEIR.
GOV_01	Proposals should demonstrate that they have assessed potential cumulative effects and should, in order of preference: a. avoid adverse effects; and/or b. minimise effects where they cannot be avoided; and/or c. mitigate effects where they cannot be minimised. If significant adverse effects cannot be avoided, minimised or mitigated, proposals must present a clear and convincing case for proceeding. Proposals that contribute to positive cumulative effects are encouraged.	A CEA has been undertaken and is outlined in section 6.10. Potential impacts from the CEA have also been identified and the significance of the effects on physical processes receptors has been assessed in 6.10.

6.2.2 North West Inshore and North West Offshore Coast Marine Plans

6.2.2.1 The assessment of potential changes to physical processes has also been made with consideration to the specific policies set out in the North West Inshore and North West Offshore Coast Marine Plans (MMO, 2021). Key provisions are set out in Table 6.4 along with details as to how these have been addressed within the assessment.

Table 6.4: North West Inshore and North West Offshore Marine Plan policies of relevant to physical processes.

Policy	Key provisions	How and where considered in the PEIR
NW-CAB-1	Preference should be given to proposals for cable installation where the method of protection is burial. Where burial is not achievable, decisions should take account of protection measures for the cable that may be proposed by the applicant. Where burial or protection measures are not appropriate, proposals should state the case for proceeding without those measures.	Details of the project design criteria are detailed in volume 1 chapter 3: Project description of the PEIR.

Policy	Key provisions	How and where considered in the PEIR
NW-MPA-1	Proposals that may have adverse impacts on the objectives of marine protected areas must demonstrate that they will, in order of preference: a) avoid b) minimise c) mitigate - adverse impacts, with due regard given to statutory advice on an ecologically coherent network.	Designated sites and features of importance within the physical processes study area have been identified in section 6.4.15. Potential impacts have also been identified and the significance of the effects on physical processes receptors has been assessed in section 6.8.
NW-MPA-4	Proposals that may have significant adverse impacts on designated geodiversity must demonstrate that they will, in order of preference: a) avoid b) minimise c) mitigate - adverse impacts so they are no longer significant.	Designated sites and sites of interest due to geological importance within the physical processes study area have been identified in section 6.4.15. Potential impacts have also been identified and the significance of the effects on physical processes receptors has been assessed in section 6.8.
NW-BIO-1	Proposals that may have significant adverse impacts on the distribution of priority habitats and priority species must demonstrate that they will, in order of preference: a) avoid b) minimise c) mitigate - adverse impacts so they are no longer significant d) compensate for significant adverse impacts that cannot be mitigated.	Sites identified as habitat directive annex 1 habitats within the physical processes study area have been identified in section 6.4.15. Potential impacts have also been identified and the significance of the effects on physical processes receptors has been assessed in section 6.8.
NW-CE-1	Proposals which may have adverse cumulative effects with other existing, authorised, or reasonably foreseeable proposals must demonstrate that they will, in order of preference: a) avoid b) minimise c) mitigate - adverse cumulative and/or in-combination effects so they are no longer significant.	A CEA has been undertaken and is outlined in section 6.10. Potential impacts from the CEA have also been identified and the significance of the effects on physical processes receptors has been assessed in 6.10.

6.3 Consultation

6.3.1.1 A summary of the key issues raised during consultation activities undertaken to date specific to physical processes is presented in Table 6.5 below, together with how these issues have been considered in the production of this PEIR chapter.

6.3.2 Evidence plan

6.3.2.1 The purpose of the Evidence Plan process is to agree the information the Mona Offshore Wind Project needs to supply to the Secretary of State, as part of a DCO application for Mona Offshore Wind Project, with Natural Resources Wales (NRW), MMO, Natural England, Joint Nature Conservation Committee (JNCC), CEFAS, TWT and the Environment Agency. The Evidence Plan seeks to ensure compliance with the Habitat Regulations Assessment (HRA) and EIA.

6.3.2.2 In February 2022, the first Benthic Ecology, Fish and Shellfish and Physical Processes Expert Working Group (EWG) meeting was undertaken. In terms of physical processes an overview of the supporting study objectives, methodology and datasets was presented.

Table 6.5: Summary of key consultation issues raised during consultation activities undertaken for the Mona Offshore Wind Project relevant to physical processes.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or were considered in this chapter
February 2022	Natural resources Wales: EWG	Has there been a gap analysis done for characterisation of bathymetry and sandwave fields in the area?	Bathymetry data has been sourced from a number of resources as detailed in Table 6.6 and project specific datasets as detailed in Table 6.7 with seabed features illustrated in Figure 6.6. Further detail is provided in volume 6, annex 6.1: Physical processes technical report of the PEIR.
February 2022	Natural resources Wales: EWG	Will the model be high resolution (i.e. capable of modelling cable and scour protection)?	The model will have high enough resolution to account for scour protection as detailed in volume 6, annex 6.1: Physical processes technical report of the PEIR.
February 2022	Natural resources Wales: EWG	What model are you using? Will the model be 2D or 3D? Would the model be updated to be 3D if impacts extended into the Dee Estuary?	The study was undertaken in 2D, as anticipated impacts have been quantified as localised and of negligible magnitude therefore further detailed modelling was not necessary. The MIKE modelling software utilised is described in volume 6, annex 6.1: Physical processes technical report of the PEIR.
May 2022	Natural resources Wales: Scoping opinion	Suggested that seabed levelling; potential of dredge and disposal activities; removal of sediment through seabed clearance; secondary scour; and impacts to sediment transport and sediment pathways at the export cable landfall, are scoped into the project assessment. NRW advised that impacts on Habitats Directive Annex 1 habitats outside of protected sites should be considered as far as reasonably possible. In addition, NRW strongly encouraged the use of Horizontal Directional Drilling where feasible, to minimise the environmental impact of trenching on conservation features.	Seabed levelling, dredging, disposal activities and seabed clearance/secondary scour is included within the assessment as defined by the project description outlined in volume 1, chapter 3: Project description of the PEIR. Designated sites have been collated and sites protected based on the Habitats Directive Annex 1 have been listed below in Table 6.8 Information relating to the potential range of cable installation activities in the intertidal region are detailed volume 1, chapter 3: Project description of the PEIR.
May 2022	Natural resources Wales: Scoping opinion	Require more information about the nature and extent of the ground preparation and the potential impact from dredging and disposal at an appointed dredge disposal site.	Ground preparation such as sandwave clearance involves movement of material along pathway, no material will be disposed of beyond the Mona Array Area or Mona Cable Corridor.
May 2022	Natural resources Wales: Scoping opinion	NRW do not agree that temperature effects from cabling, or contaminated sediments should be scoped out of the project assessment.	These aspects will be covered under water quality within volume 6; annex 6.2: Water Framework Directive Coastal Waters Assessment with the support of physical processes as appropriate.
May 2022	Natural resources Wales: Scoping opinion	Seek clarification on what was used to define one tidal excursion for the Zone of Influence that defined the study boundary for physical processes.	Physical processes area has been informed by the outcome of the supporting study and extended to circa one spring tidal excursion which is defined as the distance travelled on the flood tide before returning when the tide turns on the ebb.
May 2022	Natural resources Wales: Scoping opinion	Assessment of the scales and magnitudes of processes controlling sediment transport rates and pathways. Clarification as to whether there are any mobile or stable sand wave features present within the area.	Previous experience in offshore wind developments has indicated that changes in physical processes are generally limited in magnitude and scale. For the purposes of identifying significant impacts a comparative study is undertaken - assessing potential changes in physical process drivers (i.e. tidal currents and waves). If these changes are found to be significant then further detailed studies will be required however an exhaustive baseline study will not be undertaken from the outset rather reference made to published characteristics (i.e. Brooks *et al.*, 2018) and noted sensitivities.
May 2022	Natural resources Wales: Scoping opinion	Include a map showing the location of the metocean buoys. To better understand the current flood and ebb tide patterns. It would also be useful if tidal stream current vectors are produced to describe the baseline hydrodynamics for the Mona study area using the numerical model proposed and using up to date high resolution bathymetric coverage.	This data is provided within the volume 6, annex 6.1: Physical processes technical report of the PEIR. The supporting study simulates the tidal flow field, calibrated to field data and presents flow patterns during both ebb and flood tides.
May 2022	Natural resources Wales: Scoping opinion	NRW advise that a thorough baseline understanding is required to inform any potential impacts to the seabed morpho dynamics, and the sediment transport processes caused by the project activities offshore, nearshore and across the intertidal. Particular reference is made to Constable Bank, which is an Annex 1 habitat that supports a wide range of species upon which the conservation objectives of a Special Area of Conservation SAC may be based, all of which can be sensitive to disturbance and changes in morphology.	A representative sediment map (derived from seabed classification and sediment data from BGS) will be implemented in the modelling to illustrate transport patterns. A comparative study will then be undertaken to quantify the impact of wind turbine structures and scour protection on these routes as detailed in volume 6, annex 6.1: Physical processes technical report of the PEIR. Seabed material disturbed in the process of seabed preparation will not be removed from the sediment cell. Sandwave clearance will involve relocation of material from sand wave crests to troughs with graded slopes (along pathway). Therefore, reducing the amount of levelling required, maintaining sediment source and minimising bathymetric changes.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or were considered in this chapter
May 2022	Natural resources Wales: Scoping opinion	NRW advise that seabed levelling is scoped in for both the construction and operational phase and for both Generation and Transmission Assets.	Supporting studies include the dredging and fate of material mobilised in sandwave clearance operations undertaken during the construction phase of the project; with no seabed levelling being undertaken during the operational phase. Secondary impacts due to seabed preparation are not included in the modelling (i.e. with post seabed preparation bathymetry prior to the installation of the infrastructure) for two reasons, principally because in areas of active sediment transport this is a temporary condition and sandwaves will recover and secondly the precise location of preparation activities would be determined during detailed design stages and micro-siting. The Habitats Directive Annex 1 habitats outside of protected sites are considered where relevant to physical processes, in Table 6.8.
May 2022	Natural resources Wales: Scoping opinion	NRW seek further clarification on which methods will be employed to quantitatively determine the depth of secondary scour that may arise around the cable protection on the seabed.	Cable protection, particularly in the Mona Array Area and at cable crossings, is included within the supporting studies and impacts on physical processes is included in volume 6, annex 6.1: Physical processes technical report of the PEIR.
May 2022	Natural resources Wales: Scoping opinion	Impacts to sediment transport and sediment pathways at the export cable landfall. The cable and/or cable protection measures may not only disturb or disrupt the intertidal sediment transport at the seabed through blockage effects, but cable protection on the seabed will also reduce the water depth locally, and whether located in the nearshore or intertidal can potentially alter the hydrodynamics (wave approach and currents) and sediment transport, with potential for associated morphological impacts.	In line with best practice cable burial depths are such that beach levels are maintained as detailed in volume 1, chapter 3: Project description of the PEIR. Cable installation in the intertidal region will be undertaken such that no additional material will be placed above the surface in the intertidal region so as not to disrupt sediment transport pathways or impede tidal flow.
June 2022	Conwy County Borough Council: Scoping opinion	The ES should address the impact of the construction, operations and decommissioning phases on coastal defence works, including the proposed Llanddulas to Kinmel Bay coastal defence scheme.	A cumulative impact assessment is undertaken for physical process with screening for all relevant projects in section 6.9.
June 2022	JNCC: Scoping opinion	Overall JNCC agree with the potential impacts that will be scoped in and will require further assessment at the EIA stage. However, we would like to highlight that impacts resulting from scour should be considered here.	Scour protection is provided within the project infrastructure. The project description, volume 1, chapter 3: Project description of the PEIR, details that the provision made is adequate/proportionate The physical processes assessment includes provision of scour protection as an integral part of the design.
June 2022	JNCC: Scoping opinion	JNCC are of the opinion that projects which are built and operational and have residual impacts would need to be considered in CEA.	A cumulative impact assessment is undertaken for physical process with screening for all relevant projects in section 6.9. This includes operational projects with ongoing impacts such as those related to maintenance activities. In accordance with The Planning Inspectorate advice, where other projects are expected to be completed before construction of the proposed NSIP and the effects of those projects are fully determined, effects arising from them should be considered as part of the baseline and may be considered as part of both the construction and operational assessment.
June 2022	Natural England: Scoping opinion	We advise that there may be additional data available from, Channel Coast Observatory, North West and North Wales Shoreline Management Plan, and Environment Agency LiDAR data. Review and include in ES.	These datasets have indeed been used in the supporting study to supplement those cited in the scoping report, outlined in Table 6.6.
June 2022	The Planning Inspectorate: Scoping opinion	The Scoping Report also proposes to scope out impacts from jack-up vessel spud-cans and jack-up vessel footprints on the sedimentary regime. No explicit justification for this conclusion has been provided in the Scoping Report and there is no evidence that additional scour from the depressions would not give rise to significant effects. The Inspectorate therefore does not agree this matter can be scoped out.	The bathymetry and sediment transport parameters are intrinsically linked, and further information is provided to justify scoping out of effects of depression on sediment regime in Table 6.13.
June 2022	The Planning Inspectorate: Scoping opinion	The Environmental Statement should assess any likely significant secondary effects that this may have on changes to the current/flow regime, wave regime and sediment transport regime and any morphological changes. Impacts from dredging and disposal of material should also be assessed, where significant effects are likely to occur.	Supporting studies, volume 6, annex 6.1: Physical processes technical report of the PEIR, include the dredging and fate of material mobilised in sandwave clearance. Secondary impacts due to seabed preparation are not currently included in the modelling post construction bathymetry for two reasons, firstly in areas of active sediment transport this is a temporary condition and sandwaves will recover, and secondly the uncertainty on scale & location of preparation activities. If this additional scenario is required there is a potential impact on programme. Sandwaves will recover quickly because it is a dynamic environment.

6.4 Baseline environment

6.4.1 Methodology to inform baseline

6.4.1.1 The baseline environment was established by undertaking a desktop study utilising existing studies and datasets as described in the following section.

6.4.2 Desktop study

6.4.2.1 Information on physical processes within the physical processes study area was collected through a detailed desktop review of existing studies and datasets. These are summarised at Table 6.6 below. The baseline was characterised by a combination of literature review of the reports and numerical modelling using the datasets. Full details of the analysis undertaken to develop the physical processes baseline is provided in the volume 6, annex 6.1: Physical processes technical report of the PEIR.

Table 6.6: Summary of key desktop reports.

Title	Source	Year	Author
European Marine Observation and Data Network (EMODnet) – Seabed classification	https://www.emodnet-geology.eu/	2022	EMODnet
European Marine Observation and Data Network (EMODnet) – Bathymetry data	https://www.emodnet-bathymetry.eu/	2022	EMODnet
European Marine Observation and Data Network (EMODnet) – Metocean data	https://map.emodnet-physics.eu/	2022	EMODnet
Department for Environment Food and Rural Affairs – Bathymetry data	https://environment.data.gov.uk/DefraDataDownload	2022	DEFRA
The Environment Agency National LiDAR Programme	National LIDAR Programme - data.gov.uk	2022	Environment Agency
National Oceanic and Atmospheric Administration (NOAA) –Atmospheric data	DHI Metocean Data Portal	2022	NOAA
National Network of Regional Coastal Monitoring Programmes	https://coastalmonitoring.org/cco/	2022	Coastal Channel Observatory
Centre for Environment, Fisheries and Aquaculture Science (CEFAS) – wave data	https://wavenet.cefas.co.uk/map	2022	CEFAS
ABPmer Data explorer	https://www.seastates.net/explore-data/	2022	ABPmer
Hydrography of the Irish Sea, SEA6 Technical Report	UK Government	2005	Howarth M.J.
Atlas of UK Marine Renewable Energy Resources	https://www.renewables-atlas.info/	2022	ABPmer
Geology of the seabed and shallow subsurface: The Irish Sea.	British Geological Survey	2015	Mellett *et al.*
British Geological Survey – sediment sample data	https://mapapps2.bgs.ac.uk/geoindex_offshore	2022	BGS
Suspended Sediment Climatologies around the UK.	Department for Business, Energy & Industrial Strategy (BEIS)	2016	Cefas
Metocean Data collection for the Ormonde offshore wind project.	Marine Data Exchange	2011	Geotechnical Engineering and Marine Surveys (GEMS)
Irish Sea Zone Hydrodynamic measurement campaign	Marine Data Exchange	2010 to 2013	EMU Ltd (now Fugro Ltd)
Admiralty Tide Tables	United Kingdom Hydrographic Office (UKHO)	2022	UKHO
Marine Environmental Data Information Network (MEDIN) Seabed Mapping Programme	Admiralty Marine Data Portal	2022	MEDIN
Integrated Mapping for the Sustainable Developments of Ireland's Marine Resource (INFOMAR) Seabed Mapping Programme	Geological Survey Ireland (GSI) and Marine Institute	2022	INFOMAR
Long term wind and wave datasets	European Centre for Medium-range Weather Forecast (ECMWF)	2022	ECMWF
UK tide gauge network and database of current observation	British Oceanographic Data Centre (BODC)	2021	BODC
UK Climate Projections (UKCP)	Met Office	2018	Met Office
A user-friendly database of coastal flooding in the UK from 1915-2014	Scientific Data (journal)	2015	Haigh *et al.*
British Oceanographic Data Centre	National Oceanography Centre	various	National Oceanography Centre
Review of aggregate dredging off the Welsh coast	HR Wallingford	2016	HR Wallingford
Designated sites (SPAs and SACs)	JNCC mapping data (https://jncc.gov.uk/mpa-mapper/)	2022	JNCC
Designated sites (SSSIs)	Defra Spatial Data Download	2022	DEFRA
Designated Ramsar sites	Map (ramsar.org)	2022	Ramsar

6.4.3 Identification of designated sites

6.4.3.1 All designated sites within the physical processes study area and qualifying interest features that could be affected by the construction, operations and maintenance, and decommissioning phases of the Mona Offshore Wind Project were identified using the three-step process described below:

- Step 1: All designated sites of international, national and local importance within the physical processes study area were identified using a number of sources. These sources included JNCC website (https://jncc.gov.uk/mpa-mapper/), the Ramsar website (ramsar.org) and DEFRA website (https://environment.data.gov.uk/)
- Step 2: Information was compiled on the relevant geomorphological/coastal features for each of these sites.
- Step 3: Using the above information and expert judgement, sites were included for further consideration if:
  - A designated site directly overlaps with the Mona Array Area or Offshore Cable Corridor and therefore has the potential to be directly affected by the Mona Offshore Wind Project; or
  - Sites and associated qualifying interests were located within the potential Zone Of Influence (ZOI) for impacts associated with the Mona Offshore Wind Project.

6.4.4 Site specific surveys

6.4.4.1 In order to inform the PEIR, offshore site-specific surveys were undertaken, and the survey plan was discussed and agreed with the Natural Resources Wales, JNCC and Natural England. A summary of the surveys undertaken to inform the physical processes impact assessment is outlined in Table 6.7 below.

Table 6.7: Summary of site-specific survey data.

Title	Extent of survey	Overview of survey	Survey contractor	Date	Reference to further information
Environmental Baseline Surveys and Habitat Assessments	Mona Array Area	Geophysical survey to determine characteristics of seabed sediment, characterise benthic communities (infauna and epifauna) and identification of any environmentally significant habitats (e.g. potential Habitats Directive Annex I and priority marine features). Deployment included multi-beam echo sounder (MBES), digital sound velocity (DSV) sensor, side scan sonar system (SSS), Sub-Bottom Profiler (SBP) & 2D Ultra High Resolution Seismic (2D UHRS) sensor. Additionally, seabed imagery was collected along with grab samples and cone penetration testing (CPT).	Gardline Ltd	2021	Gardline (2022)
Geophysical survey	Mona Array Area	Geophysical survey to establish bathymetry, seabed sediment and identify seabed features. Deployment included MBES with multibeam backscatter.	XOCEAN Ltd	2022	XOcean (2022)
Geophysical survey	Mona Offshore Cable Corridor – south section	Geophysical survey to establish bathymetry, seabed sediment and identify seabed features. Deployment included MBES.	Gardline Ltd	2022	Gardline (2022)
Geophysical survey	Mona Offshore Cable Corridor – north section	Geophysical survey to establish bathymetry, seabed sediment and identify seabed features. Deployment included MBES.	XOCEAN Ltd	2022	XOcean (2022)
Metocean survey	Morgan and Mona Array Area	Metocean and FLidar deployments to ascertain wind, wave and tidal currents.	Fugro	2022	Fugro (2022)

6.4.5 Baseline environment

6.4.5.1 A summary of the physical processes baseline environment is provided in the following sections. Full details of the analysis undertaken to develop the physical processes baseline for the supporting modelling study is provided in volume 6, annex 6.1: Physical processes technical report of the PEIR, which includes information on model development, resolution, calibration, and the modelling techniques implemented to develop the baseline characteristics.

6.4.6 Bathymetry

6.4.6.1 Seabed levels across the Mona Array Area vary from a minimum depth of 36m below Mean Sea Level (MSL) on the southeast of the Mona Array Area to a maximum depth of circa 53m below MSL in the north of the Mona Array Area, as illustrated in Figure 6.2. The Mona Offshore Cable Corridor has a relatively variable bathymetry ranging from the low water mark to a depth of 53m below MSL. With shallower depths observed on the east of the Mona Array Area which is closest to the shoreline.

6.4.7 Constable Bank

6.4.7.1 The Constable Bank is a sandbank of geomorphological and geological importance on the outskirts of Liverpool Bay. Although Constable Bank is not a designated site, it is however a site of importance as it is a sandbank which meets the Annex 1 habitat criteria of the EC Habitats Directive highlighted in Table 6.8. The main body of the sandbank is located to the east of the Mona Offshore Cable Corridor as shown in Figure 6.3. The figure presents survey data from 2019-2020, derived from UKHO data portal, overlaid with data collected in 2022 for this project. The 2022 survey was undertaken over the extent of the cable corridor. It indicates that although the Mona offshore corridor does not pass through the main body of the bank it crosses the 'tail' of the bank feature to the west. Resembling a storm generated ridge, long and narrow extending to the coast, Constable Bank is the outermost part of the embayment that forms the approach to Liverpool (Kenyon and Cooper, 2005). Constable bank is over 20km in length and 2km wide which increases progressively towards the coast, at a height of 10m. All of the seafloor is covered in sand apart from the west corner where coarser sediment is found (Kenyon and Cooper, 2005).

6.4.7.2 Sandbanks can be highly mobile driven by tides rather than waves and the formation is reliant on the availability of sediment. Active sandwaves were being transported east over a sedimentary layer of basal conglomerate. The Constable Bank is understood to influence the exchange of sediments with the adjacent coastline and the wave climate approaching the coastline (subsequent flood risk).

6.4.7.3 Kenyon and Cooper (2005) found that there was an unusual pattern of bedload movement in the same direction on both sides of the bank which would result in the shortening of the bank and eventual disappearance if maintained. However, it is not known whether a change in sand transport occurs at other stages of the tide. If there is no opposing transport path to maintain the sandbank it is estimated that it may not survive more than a few hundred years.

6.4.7.4 As part of the physical processes baseline study a rudimentary assessment was undertaken to investigate the stability of Constable Bank using the available bathymetric data. Three sets of data were available for the assessment:

- Mona Offshore Cable Corridor survey at 1m resolution, Gardline 2022
- Three surveys from MEDIN at 2m resolution, data logs indicated data was collected 2019
  - HI1571 Red Wharf Bay to Gwynt y Mor
  - HI1572 Little Ormes Head Hilbre Point
  - HI1573 Point Lynas Little Ormes Head
- A further survey from MEDIN at irregular spacing dated 1987
  - HI357 Skerries to the River Dee.

6.4.7.5 The first comparison was made between the most recent datasets across the intersection of Constable Bank with the Mona Offshore Cable Corridor. Figure 6.4 shows the 2019 data in the background (using a colour palette to accentuate the sandwaves) with the change to 2022 in the corridor area overlaid. The inset figures show regions at the survey boundaries in order that the progress of specific sandwave features may be quantified. The sandwaves, both north and south, appear to have migrated approximately 15m to the east over the three year period. This corroborates the observations of Kenyon and Cooper (2005).

6.4.7.6 In a similar manner, the changes between 1987 and 2019 were investigated. As previously, Figure 6.5 shows the 2019 dataset in the background and the change from the 1987 data to this point is overlaid, therefore the offset of features due to migration is in the opposite sense. The inset figure shows the comparison through specific sandwave features and, although it is more difficult to compare individual sandwave features, the migration is apparent. The 1987 dataset is sparser, however it is sufficient to indicate that, over this prolonged period, the changes in bed level (both increases and decreases) correlate with the height of the sandwave features. This indicates that although the waves migrate along the bank the underlying bank is stable over this timeframe. This theory is supported by the average change in level over the bank area which is approximately 0m.

6.4.8 Hydrography

6.4.8.1 The Mona Array Area has an average tidal range of 5.4m as published by Admiralty (United Kingdom Hydrographic Office (UKHO)) at Llandudno. This port is one of a number in the proximity of the study area and was used as a calibration point alongside several other reference points taken across the model domain, as detailed in volume 6, annex 6.1: Physical processes technical report of the PEIR.

6.4.8.2 Semi-diurnal tides are the dominant physical process in the Irish Sea coming from the Atlantic Ocean through both the North Channel and St Georges Channel. The tidal range in the Irish Sea is highly variable with a range greater than 10m on the largest spring tides, second largest in Britain.

6.4.8.3 Across the Mona Array Area, the tidal current floods to the east and ebbs to the west. The flows are relatively strong during spring tides with tidal current speeds typically between 1.0 – 1.1m/s during flood and ebb currents between 0.8 – 0.9m/s. Tidal flow fields for the east Irish Sea are presented in volume 6, annex 6.1: Physical processes technical report of the PEIR.

6.4.9 Wave climate

6.4.9.1 Characteristic of the east Irish Sea, waves are generated by either local winds or from remote winds (swell waves). At the centre of the Mona Array Area, the largest proportion of waves approach from the westerly sectors, typically combined wind and swell for the Irish Sea. However, a wave field can also develop from the east of the Mona Array Area as there is a sufficient fetch length.

6.4.9.2 The highest mean annual significant wave height of 1.39m was recorded between the Isle of Man and Anglesey with the significant wave height reducing closer to the coast with a low of 0.73m recorded to the west of the Dee Estuary (ABPmer, 2008).

6.4.9.3 Within the Mona Offshore Wind Project mean annual wave height ranges from 1.1m to 1.3m. Over 40% of waves arise from the southwest and all significant wave heights greater than 4m originate from the southwest or west (ABPmer, 2018).

6.4.9.4 Further detail on the wave climate analysis is provided in volume 6, annex 6.1: Physical processes technical report of the PEIR.

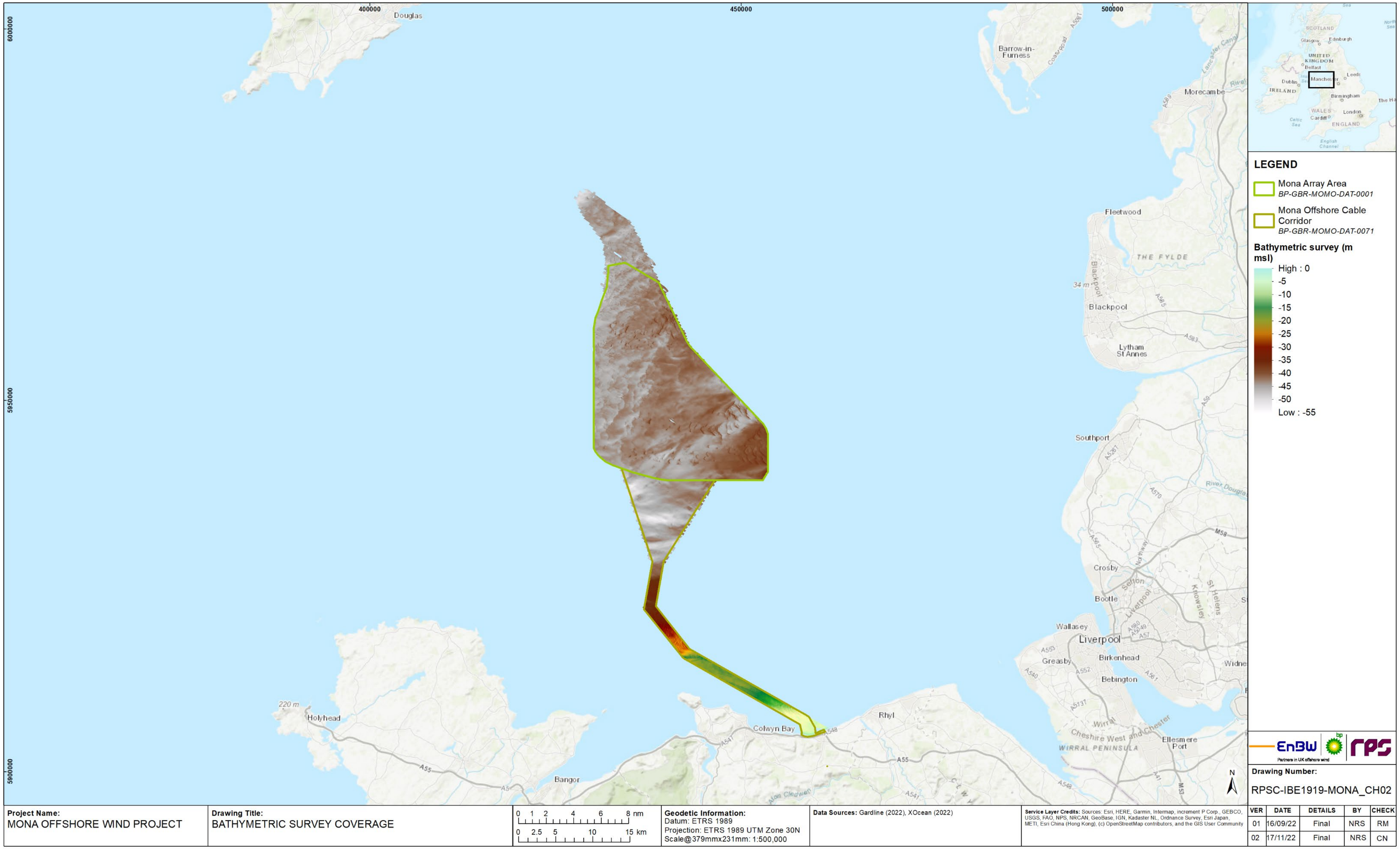
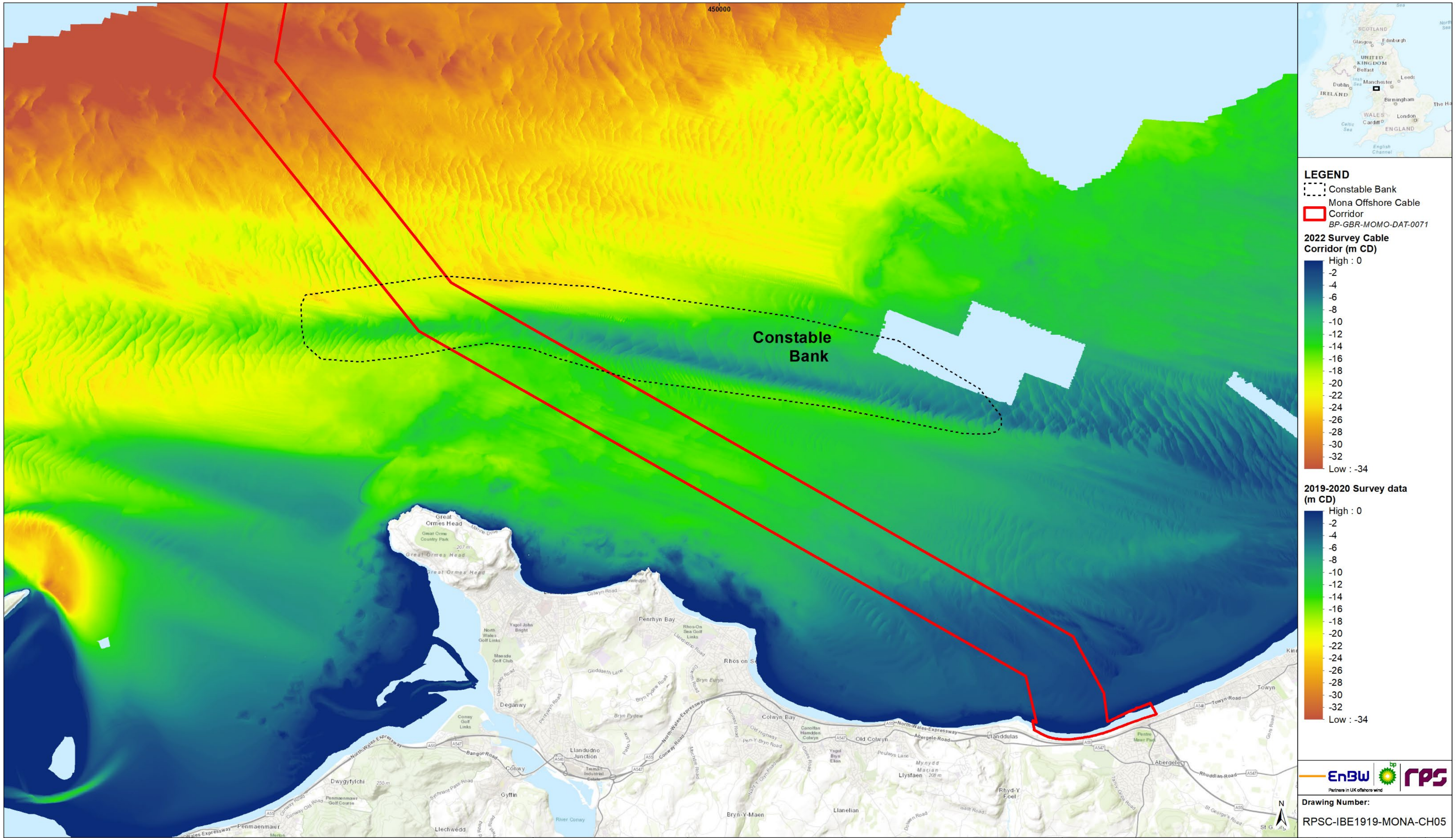


Figure 6.2: Mona Offshore Wind Project bathymetric surveys undertaken by Gardline 2022 and XOCEAN 2022.



Project Name:	Drawing Title:	Geodetic Information:	Data Sources:	Service Layer Credits:
MONA OFFSHORE WIND PROJECT	BATHYMETRY OF CONSTABLE BANK	Datum: ETRS 1989 Projection: ETRS 1989 UTM Zone 30N Scale@379mmx231mm: 1:100,000	UKHO Marine Data Portal, XOcean (2022), JNCC	Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

VER	DATE	DETAILS	BY	CHECK
03	17/11/22	Final_ss	NRS	CN
04	30/11/22	Final	NRS	CN

Figure 6.3: Location of Constable Bank sandbank in relation to the Mona Offshore Cable Corridor.

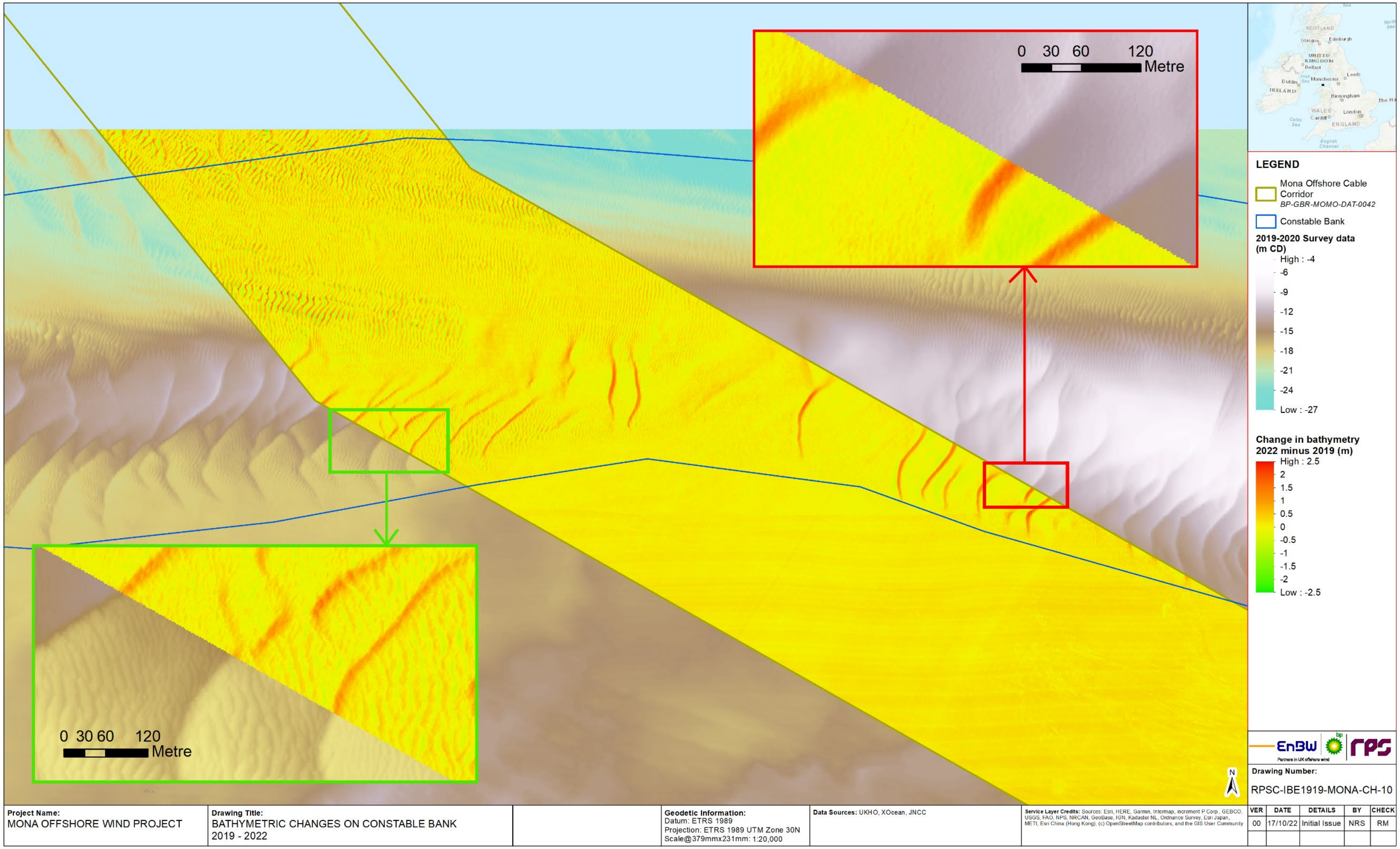


Figure 6.4: Bathymetric changes on Constable Bank 2019 - 2022.

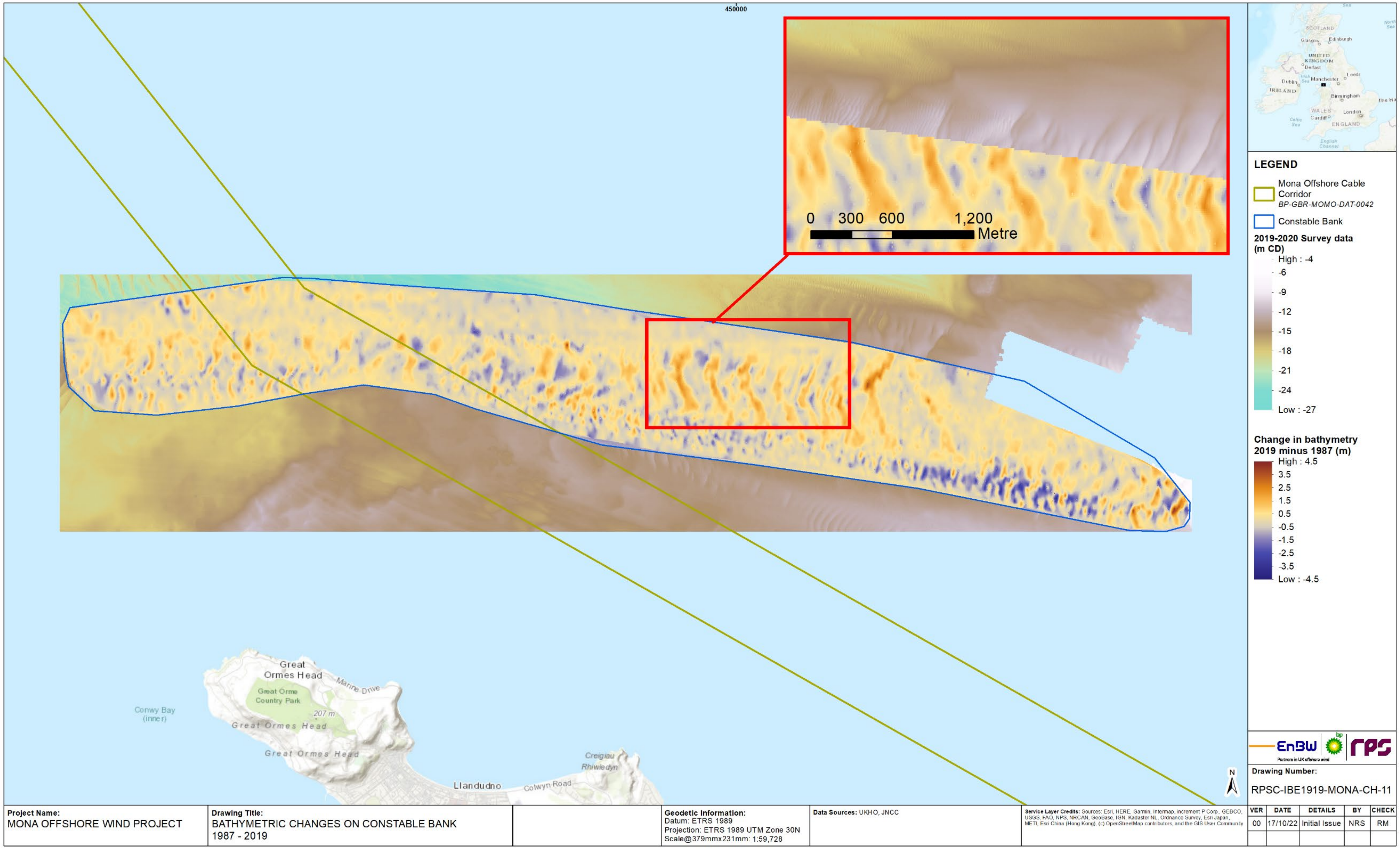


Figure 6.5: Bathymetric changes on Constable Bank 1987 - 2019.

6.4.10 Littoral currents

6.4.10.1 Littoral currents are driven by tides, waves, and meteorological events. The littoral currents were modelled from the westerly sector during a 1in1 year storm event, resulting in the increase of currents on the peak flood tide to circa 1.1-1.2m/s and reducing to 0.9-1m/s during the peak ebb within the Mona Array Area. With the largest and most prevalent waves approaching from the west, these waves cause an increase in currents during the flood tide and a decrease on the ebb tide.

6.4.11 Sedimentology

6.4.11.1 Across the Mona Array Area, the underlying geology consists of bedrock lithologies in the region are Triassic and Carboniferous sandstone and mudstone (Mellett *et al*., 2015). The bedrock of sandstone and mudstone are covered by sediments from the Quaternary age with small areas exposed (Mellett *et al.,* 2015). Potential weathering during the last glacial period may have weakened the uppermost surface of underlying bedrock (Mellett *et al.,* 2015). Quaternary sediment thickness in the central Irish Sea is <20m although in short distances this can increase to >100m due to the presence of glacial valleys. However, in the east and west of the Irish Sea sediment thickness is circa 50m (Mellett *et al.,* 2015).

6.4.11.2 In the Irish Sea, there is a high variability in the bedforms ranging from very small ripples (5cm high) to very large sediment waves (>10m high). The seafloor morphology of the Mona Array Area also includes several distinct features such as sandwaves, megaripples, sediment waveforms and outcrops (XOCEAN, 2022). Seabed substrate within the Mona Array Area ranged from sand, sandy gravel, and gravelly sand, as illustrated in Figure 6.6.

6.4.11.3 Across the Mona Array Area, the north section is described as mainly flat and featureless however the presence of sandwaves and megaripples was observed on the south section (Gardline, 2022).

6.4.11.4 In the east and west Irish Sea seabed sediments are subdivided into regions of soft mud (clay and silt) and rich sediment. However, Mona Array Area lies within the central gravel belt in the Irish Sea containing coarse sand and gravel (Mellett *et al.,* 2015). Although, small areas of bedrock outcrop at the seabed have been observed.

6.4.11.5 The Mona Offshore Cable Corridor is dominated by circalittoral course sediments, circalittoral mixed sediments, circalittoral rock and circalittoral sand. To the west of the Mona Offshore Cable Corridor is an important sandbank feature Constable Bank. Further towards the North Wales coast and the landfall site Bodelwyddan the composition of sediment is predominantly fine sand and muddy sand (EMODnet, 2022).

6.4.11.6 A section of the intertidal zone along the proposed landfall location is designated as a SSSI (Traeth Pensarn) of botanical interest for its vegetated shingle beach. The shingle ridges are mostly composed of locally derived Carboniferous Limestone together with a mixture of calcareous sand within the shingle and non-limestone material from the Irish Sea glacial till. Seaward of the shingle bank the intertidal is predominantly composed of medium to coarse sand with the presence of parallel sand banks in the nearshore.

6.4.12 Stratification

6.4.12.1 In the east Irish Sea, the temperature distribution is dominated by vertical exchanges and the input of heat at the sea surface leading to seasonal cycle resulting in the coolest waters in February to March (Howarth, 2005). Temperature decreases from the deeper channels towards the coast sea temperature is below 5°C between the Solway Firth and Liverpool Bay (Howarth, 2005). During the month of August water temperatures close to the coast can exceed 16°C in Liverpool Bay (Howarth, 2005).

6.4.12.2 There is often a substantial change in salinity travelling from north to south on the east Irish Sea on the west side of Isle of Man (Foster *et al.,* 1985). Seasonal changes in salinity are much less defined than for temperature away from the coast (Howarth, 2005).

6.4.12.3 Across the east side of the Irish Sea region most of the water column remains thoroughly mixed due to the occurrence of sufficiently intense tidal mixing throughout the year (Howarth, 2005). To the east of Isle of Man marginal stratification occurs only during hot, calm conditions yet can be mixed away with easily by storms or spring tides (Howarth, 2005). Stratification of the water column can occur in estuaries and especially in Liverpool Bay and the Dee Estuary as fresh water is lighter than salty with conditions are mostly characteristic at neap tides with calm conditions and river discharges (Howarth, 2005).

6.4.13 Sediment Transport

6.4.13.1 Within the Mona Array Area, the residual current speeds are several orders of magnitude smaller than those along the coastline. Residual currents are the net flow over a full tidal cycle and drive the sediment transport. Residual current flow into the east Irish Sea from the north of the Isle of Man and west around Anglesey correlates with this region being a sediment sink. In the Mona Array Area, sediment transport rates are highest during springs, peak flood tide with total sediment loads of up to 0.001m^3/s/m and 0.0005m^3/s/m on the peak of the ebb tide. Net sediment transport rates are circa 0.2-1.0m^3/d/m within the Mona Array Area.

6.4.13.2 There are strong circulatory currents where tidal flows interact with headlands and embayments. With the greatest sediment transport rates in estuaries and at headlands where finer sand fractions are present and where tidal currents are strongest. The littoral currents and dominant flood tide significantly increase easterly residual currents particularly along the Welsh coastline. Subsequently increasing sediment transport during storm conditions.

6.4.13.3 The physical processes study area largely coincides with Solway Firth sediment cell and sub-cell 11a Great Orme's Head to Southport Pier. In the sub-cell 11a the general direction of sediment transport is west to east. This direction of travel supplies the southeast shoreline with sediment (Price *et al.,* 2010).

6.4.14 Suspended Sediments

6.4.14.1 Suspended sediment concentrations (SSC) are regulated by tidal currents and intensify during wind-driven storm events throughout the water column. SSC levels have a seasonal pattern due to the seasonality of storm events. Offshore monitoring to the north of Mona Array Area within the proposed Morgan Generation Assets recorded typical SSC levels of <5mg/l, however as expected during storm events this increased to circa 20mg/l corresponding with increased wave heights *(*Fugro (2022)).

6.4.14.2 Within the Mona Array Area, the non-algal suspended particulate matter (SPM) was estimated to be on average 0.9 – 3mg/l between 1998 and 2015 (Cefas, 2016). As for the SSC, the SPM levels display a seasonal pattern with heightened levels during winter months and are regulated by tidal currents.

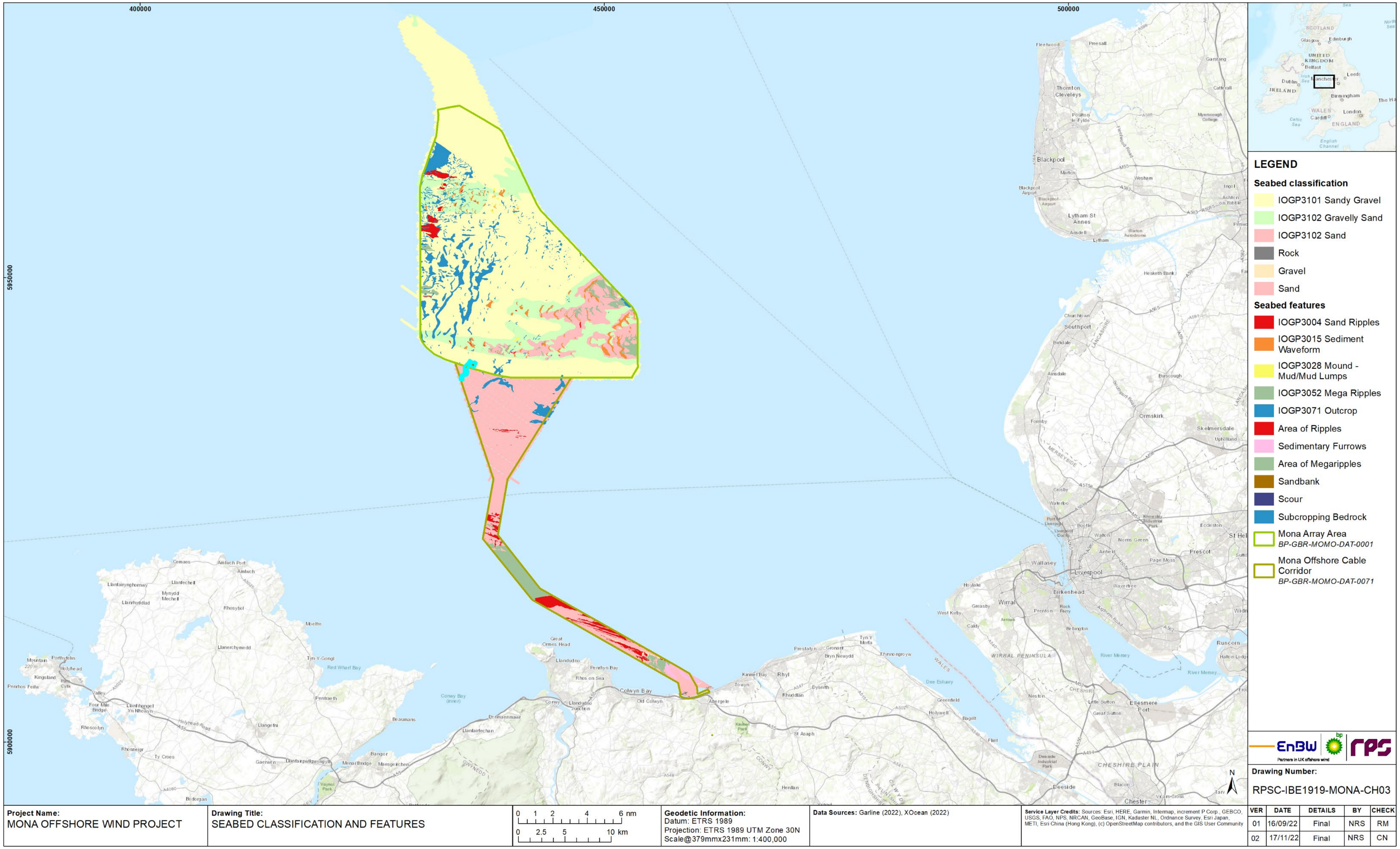


Figure 6.6: Mona Offshore Wind Project sediment classification and seabed features characterised by Gardline Ltd. (2022) and XOCEAN (2022).

6.4.15 Designated sites

6.4.15.1 Using the JNCC database (https://jncc.gov.uk/mpa-mapper/), Ramsar and DEFRA databases, designated sites identified for the physical processes chapter are described in Table 6.8 and illustrated in Figure 6.7.

Table 6.8: Designated sites and relevant qualifying interests for the physical processes chapter.

Designated site	Closest distance to the Mona array area (km)	Closest distance to the Mona Offshore Cable Corridor (km)	Relevant qualifying interest
Designated Sites			
Menai Strait and Conwy Bay SAC (UK0030202)	25.7	0	Protected Features: • Large shallow inlets and bays • Mudflats and sandflats not covered by seawater at low tide • Reefs • Sandbanks which are slightly covered by sea water all the time • Submerged or partially submerged sea caves.
Traeth Pensarn SSSI	34.7	0	Habitat: • Coastal vegetated shingle beach
Little Ormes Head SSSI	30.2	2.3	Habitats: • Reefs • Maritime cliff & slope • Lowland calcareous grassland • Calcareous grassland • Improved grassland • Broadleaved, mixed and yew woodland • Bracken • Inland rock • Species: • Lesser horseshoe bat • Lichens (Leptogium diffractum and Catapyyrenium pilosellum) • Veronica spicata ssp. Hybrida.
Great Ormes Head SSSI	28.5	3.2	Habitats: • Reefs • European Dry Heath • Semi-Natural Dry Grassland • Vegetated Sea Cliff Species: • Wild cotoneaster • Spiked speedwell • Goldilocks aster • Hairy-fruited cornsalad • Welsh hawkweed • Spotted cat's-ear • Lichens (Collema fragile and Synalissa symphorea) • Grayling • Silver-studded blue • Silky wave moth • Horehound plume moth • Weevil Helianthemapion aciculare • Pollen beetle Meligethes brevis.
Site of Importance			
Constable Bank	23.8	0	Habitat: • Sandbank.
Bathing Water Locations			
Abergele (Pensarn)	34.5	0	Sufficient
Colwyn Bay	32.6	3.2	Excellent
Colwyn Bay Porth Eirias	33.5	3.4	Excellent
Llandudno North Shore	30.4	4.3	Sufficient
Kinmel Bay (Sandy Cove)	34.0	4.6	Good

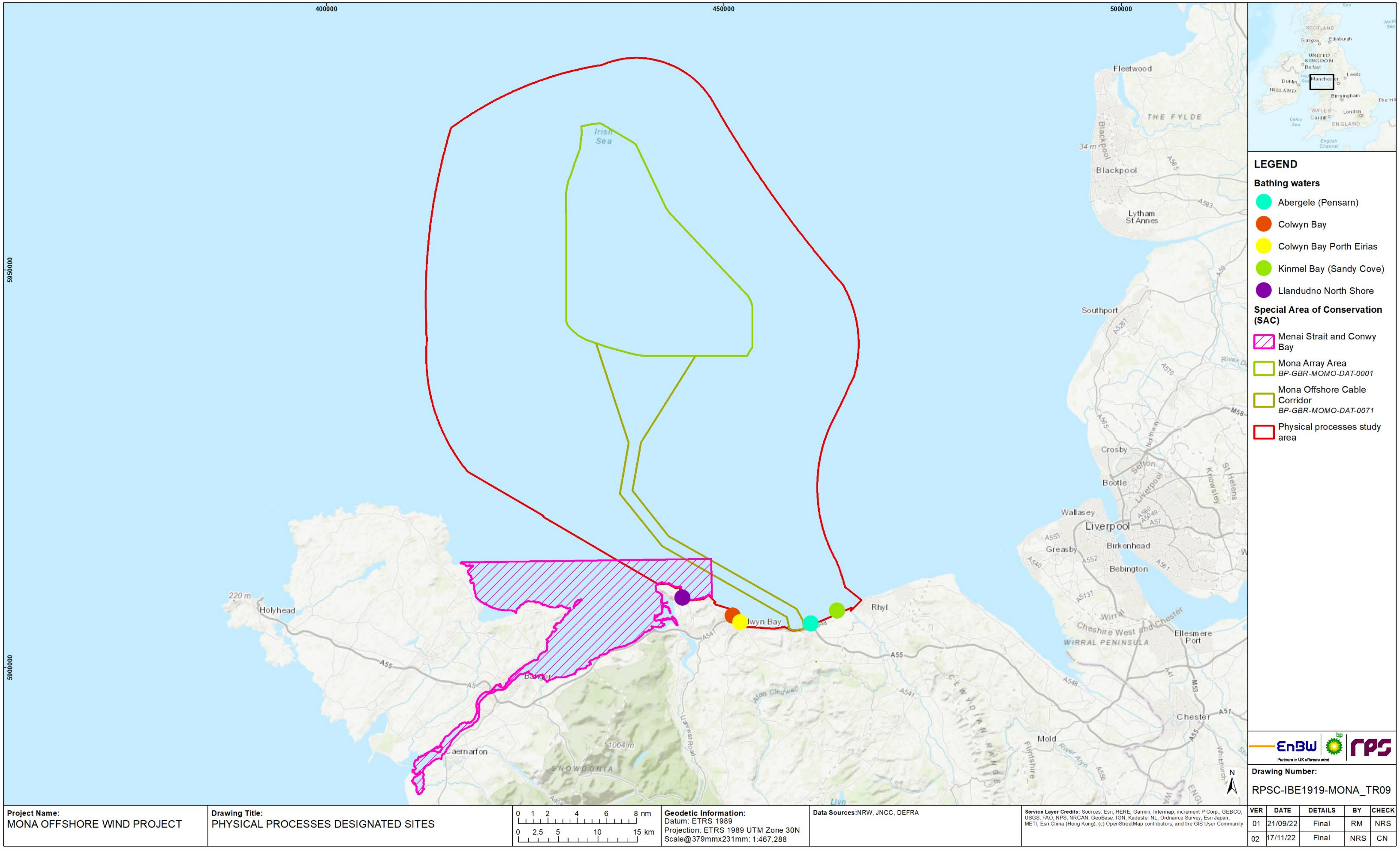


Figure 6.7: Designated sites for the Mona Offshore Wind Project physical processes chapter.

6.4.16 Future baseline scenario

6.4.16.1 Schedule 4 of the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (EIA Regulations), require that a "a description of the relevant aspects of the current state of the environment (baseline scenario) and an outline of the likely evolution thereof without implementation of the project as far as natural changes from the baseline scenario can be assessed with reasonable effort, on the basis of the availability of environmental information and scientific knowledge" is included within the Environmental Statement. In the event that the Mona Offshore Wind Project does not come forward, an assessment of the future baseline conditions has been carried out and is described within this section.

6.4.16.2 The baseline environment for physical processes is not static and will exhibit a degree of natural change over time. Such changes will occur with or without the Mona Offshore Wind Project in place due to natural variability. Future baseline conditions would be altered by climate change resulting in sea level rise and increased storminess. This is unlikely to have the effect of significantly altering tidal patterns and sediment transport regimes offshore at the Mona Array Area. The return period of the wave climates would be altered (e.g. what is currently defined as a 1in50 year event may become a 1in20 year event) as deeper water would allow larger waves to develop. Although increased water depth would potentially increase the wave climate, sandbank development is driven by tides and sediment source rather than waves (Kenyon and Cooper,2005). Therefore features, such as Constable bank would continue to develop regardless of wave climate. There is, however, a notable degree of uncertainty regarding how future climate change will impact prevailing wave climates within the Irish Sea and beyond.

6.4.17 Data limitations

6.4.17.1 The physical processes study area has been the focus of study for both academic and government institutions. Additionally, significant data collection campaigns have been undertaken by the Applicant and other offshore wind farm developers in the locality. Although some physical processes are complex and inter-related, there is a significant amount of data available. It is therefore considered that the data used in this assessment are robust and sufficient for the purposes of the impact assessment presented.

6.4.17.2 The geophysical survey for the Mona Offshore Cable Corridor was undertaken in summer 2022 and preliminary data is included in the physical processes PEIR chapter. The detailed results of the site-specific 2022 geophysical surveys, such as grab sample data, will feed into the physical processes chapter within the Environmental Statement.

6.5 Impact assessment methodology

6.5.1 Overview

6.5.1.1 The physical processes impact assessment has followed the methodology set out in volume 1, chapter 5: EIA methodology of the PEIR. Specific to the physical processes impact assessment, the following guidance documents have also been considered.

- Guidelines in the use of metocean data through the lifecycle of a marine renewable's development (Cooper et al., 2008)
- Physical processes guidance to inform EIA baseline survey, monitoring and numerical modelling requirements for major development projects with respect to marine, coastal and estuarine environments, GN041, Natural Resources Wales, Marine Programming Planning and Delivery Group (NRW, 2020)
- Guidance on EIS and NIS Preparation for Offshore Renewable Energy Projects, Department of Communications, Climate Action and Environment, (Barnes, 2017)
- Guidance on Marine Baseline Ecological Assessments and Monitoring Activities for Offshore Renewable Energy Projects Parts 1 and 2, Department of the Environment, Climate and Communications, (DECC, 2018)
- Collaborative Offshore Wind Energy Research into the Environment (COWRIE) - Coastal Process Modelling for Offshore Wind Farm Environmental Impact Assessment (Lambkin et al.,2009)
- Advice to Inform Development of Guidance on Marine, Coastal and Estuarine Physical Processes Numerical Modelling Assessments. NRW Report No 208, 139pp, Natural Resources Wales. (Pye et al., 2017)
- Guidance on Best Practice for Marine and Coastal Physical Processes Baseline Survey and Monitoring Requirements to inform EIA of Major Development Projects, NRW Report No: 243, 119 pp, Natural Resources Wales, Cardiff. (Brooks *et al*., 2018).

6.5.1.2 In addition, the physical processes impact assessment has considered the legislative framework as defined by:

- Overarching National Policy Statement (NPS) for Energy (EN-1; DECC, 2011a)
- NPS for Renewable Energy Infrastructure (EN-3, DECC, 2011b)
- Welsh National Marine Plan (Welsh Government, 2019)
- North West Inshore and North West Offshore Coast Marine Plans (MMO, 2021).

6.5.2 Impact assessment criteria

6.5.2.1 Physical processes are not generally receptors in themselves; they may be a pathway by which coastal features may be impacted or form a pathway for indirect impacts on other receptors. For example, increases in suspended sediments during the construction phase may lead to the deposit of these sediments and smothering of benthic habitats. For this impact, the magnitude of the potential changes has been assessed, with the sensitivity of the receptors to these changes and the significance of effects assessed within volume 2, chapter 7: Benthic Subtidal and Intertidal Ecology of the PEIR.

6.5.2.2 A full impact assessment has however been provided within this chapter, section 6.8, for the hydrodynamic regime and the sediment transport regime, which have been identified as potentially sensitive physical processes receptors.

6.5.2.3 The criteria for determining the significance of effects is a two-stage process that involves defining the magnitude of the impacts and the sensitivity of the receptors. This section describes the criteria applied in this chapter to assign values to the magnitude of potential impacts and the sensitivity of the receptors. The terms used to define magnitude and sensitivity are based on those which are described in further detail in volume 1, chapter 5: EIA methodology of the PEIR.

6.5.2.4 The criteria for defining magnitude in this chapter are outlined in Table 6.9 below.

Table 6.9: Definition of terms relating to the magnitude of an impact.

Magnitude of impact	Definition
High	Change in physical processes which results in the loss of a coastal feature (e.g. blockage of sediment pathway resulting in loss of spit (Adverse)).
	Change in physical processes which results in the creation of a coastal feature (e.g. reduction in wave climate giving rise to dune formation (Beneficial)).
Medium	Alteration of physical processes which effects the rate at which a coastal feature is maintained (e.g. reduction in accretion rate (Adverse)).
	Alteration of physical processes which effects the rate at which a coastal feature is developing (e.g. reduction in erosion rate (Beneficial)).
Low	Variation in physical processes which maintains the coastal feature (e.g. localised change in sediment pathway which does not destabilise bank).
Negligible	Imperceptible variation in physical process (e.g. in the order of natural variability).
No change	No loss or alteration of characteristics, features or elements; no observable impact either adverse or beneficial.

6.5.2.5 The criteria for defining sensitivity in this chapter are outlined in Table 6.10 below.

Table 6.10: Definition of terms relating to the sensitivity of the receptor.

Sensitivity	Definition
Very High	Coastal feature forms vital part of a wider scale system which is scarce and non-recoverable.
High	Coastal feature forms part of a wider scale system and is non-recoverable.
Medium	Coastal feature has limited potential for re-creation.
Low	Coastal features of local scale and recoverable.
Negligible	Coastal feature adaptable to changes in physical processes.

6.5.2.6 The significance of the effect upon physical processes is determined by correlating the magnitude of the impact and the sensitivity of the receptor. The particular method employed for this assessment is presented in Table 6.11. Where a range of significance of effect is presented in Table 6.11, the final assessment for each effect is based upon expert judgement.

6.5.2.7 For the purposes of this assessment, any effects with a significance level of minor or less have been concluded to be not significant in terms of The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017.

Table 6.11: Matrix used for the assessment of the significance of the effect.

Sensitivity of Receptor	Magnitude of Impact				
	No Change	Negligible	Low	Medium	High
Negligible	No change	Negligible	Negligible or Minor	Negligible or Minor	Minor
Low	No change	Negligible or Minor	Negligible or Minor	Minor	Minor or Moderate
Medium	No change	Negligible or Minor	Minor	Moderate	Moderate or Major
High	No change	Minor	Minor or Moderate	Moderate or Major	Major
Very High	No change	Minor	Moderate or Major	Major	Major

6.6 Key parameters for assessment

6.6.1 Maximum design scenario

6.6.1.1 The maximum design scenarios (MDS) identified in Table 6.12 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. These scenarios have been selected from the project description provided in volume 1, chapter 3: Project description of the PEIR. Effects of greater adverse significance are not predicted to arise should any other development scenario, (e.g. different infrastructure layout), to that assessed here be taken forward in the final design scheme.

6.6.1.2 The results of the physical processes study, particularly the numerical modelling output detailed in volume 6, annex 6.1: Physical processes technical report of the PEIR, will be used to support and inform the following PEIR chapters:

- volume 2, chapter 7: Benthic subtidal and intertidal ecology of the PEIR
- volume 2, chapter 8: Fish and shellfish ecology of the PEIR
- volume 2, chapter 9: Marine mammals of the PEIR
- Volume 2, chapter 13: Marine archaeology of the PEIR
- volume 2, chapter 14: Other sea users of the PEIR.

Table 6.12: Maximum design scenario considered for the assessment of potential impacts on physical processes.

[a] C=construction, O=operations and maintenance, D=decommissioning

Potential impact	Phase[a]			Maximum Design Scenario	Justification
	C	O	D		
Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features.	✓	✓	✓	**Construction phase** Site preparation: Sandwave clearance: • Sandwave clearance activities undertaken over an approximate 12-month duration within the wider four-year construction programme • Wind turbines and Offshore Substation Platform (OSP) foundations: sandwave clearance has been calculated on the basis of wind turbine generator foundations and an assumption of clearance at up to 50% of locations. Spoil volume per location has been calculated on the basis of 34 locations supporting the largest suction bucket four legged jacket foundation with an associated base diameter of 205m to an average depth of 7.5m. This equates to a total spoil volume of 8,416,621m^3 and a volume of 247,548m^3 per location • Inter-array cables: sandwave clearance along 250km of cable length, with a width of 104m, to an average depth of 5.1m. Total spoil volume of 9,542,806m^3 • Interconnector cables: sandwave clearance along 30km of cable length, with a width of 104m, to an average depth of 5.1m. Total spoil volume of 3,060,814m^3 • Offshore export cables: sandwave clearance along 252km of export cable, with a width of 104m, to an average depth of 5.1m. Total spoil volume of 12,051,955m^3 • Removal of up to 46km of disused cables. Foundation installation: • Undertaken over an approximate 12-month duration • Wind turbines: installation of up to 68 monopiles of 16m diameter, drilled to a depth of 60m at a rate of up to 0.89m/h. Two monopiles installed concurrently. Spoil volume of 13,460m^3 per pile • OSPs: installation of one OSP with foundations consisting of two 16m monopiles, drilled to a depth of 60m at a rate of up to 0.89m/h. Two monopiles installed concurrently. Spoil volume of 13,460m^3 per pile. Cable installation: • Inter-array cables: Installation via trenching of up to 500km of cable, with a trench width of up to 3m and a depth of up to 3m. Total spoil volume of 2,250,000m^3. Installed over a period of approximately 12-months • Interconnector cables: installation via trenching of up to 50km of cable, with a trench width of up to 3m and a depth of up to 3m. Total spoil volume of 225,000m^3. Installed over a period of approximately four-months • Offshore export cables: installation via trenching of up to 360km of cable, with a trench width of up to 3m and a depth of up to 3m. Total spoil volume of 1,620,000m^3. Installed over a period of 15-months • Intertidal export cable: installation via open trenching of up to 6km of cable, with a trench width of 1m and a depth of up to 3m. Total spoil volume of 18,000m^3. Installed over a period of approximately nine-months.	**Construction phase** Site preparation: • The volume of material to be cleared from individual sandwaves will vary according to the local dimensions of the sandwave (height, length, and shape) and the level to which the sandwave must be reduced. These details are not fully known at this stage, however based on the available data, it is anticipated that the sandwaves requiring clearance in the array area are likely to be in the range 15m in height • Site clearance activities may be undertaken using a range of techniques, the suction hopper dredger will result in the greatest increase in suspended sediment and largest plume extent as material is released near the water surface during the disposal of material • Boulder clearance activities will result in minimal increases in suspended sediment concentrations and have therefore not been considered in the assessment. Foundation installation: • Installation of foundations via augured (drilled) operations results in the release of the largest volume of sediment. The greatest volume of sediment disturbance by drilling at individual foundation locations and across the site as a whole is associated with the largest diameter monopile for wind turbines. The selected OSP scenario represents the greatest volume of sediment to be released for a drilling event • The greatest drilling rate represents the maximum level of increase in suspended sediment concentration. Cable installation: • Cable routes inevitably include a variety of seabed material and in some areas 3m depth may not be achieved or may be of a coarser nature which settles in the vicinity of the cable route. The assessment therefore considers the upper bound in terms of suspended sediment and dispersion potential • Cables may be buried by ploughing, trenching or jetting with jetting mobilising the greatest volume of material to increase suspended sediment concentrations • The use of open trenching in the intertidal zone releases the greatest volume of material into the water column and therefore provides the upper bound of impacts as compared with horizontal directional drilling (HDD) installation. **Operation and maintenance phase** • The greatest foreseeable number of cable reburial and repair events is considered to the MDS for sediment dispersion. **Decommissioning phase** • The removal of cables may be undertaken using similar techniques to those employed during installation, therefore the potential increases in SSC and deposition would be in-line with the construction phase.

Potential impact	Phase[a] C	O	D	Maximum Design Scenario	Justification
				Operational and maintenance phase Project lifetime of 35-years • Inter-array cables: repair of up 10km of cable in one event every three years. Reburial of up to 20km of cable in one event every five years • Interconnector cables: repair of up to 16km of cable in each of three events every 10 years. Reburial of up to 2km of cable in one event every five years • Offshore export cables: repair of up to 32km of cable in eight events every five years. Reburial of up to 15km of cable in one event every five years • Intertidal export cables: Repair of up to 1.6km of intertidal cable every five years. **Decommissioning phase** • Scour and cable protection will remain *in situ*. If suction caissons are removed using the overpressure to release them then suspended sediment concentration will be temporarily increased • Inter-array and interconnector cables will be removed and disposed of onshore • Offshore export cables will be removed up to the HDD or trenchless exit pits in the intertidal zone and disposed of onshore.	
Impacts to the tidal regime due to presence of infrastructure and the associated potential impacts along adjacent shorelines. Impacts to the wave regime due to presence of infrastructure and the associated potential impacts along adjacent shorelines. Impacts to sediment transport and sediment transport pathways due to presence of infrastructure and associated potential impacts to physical features and bathymetry. Impacts to temperature and salinity stratification due to the presence of infrastructure.	✓	✓	✓	**Construction phase** • During the construction phase the potential changes to the receptor will be gradual as the presence of infrastructure increases reaching the MDS outlined below in the operations and maintenance phase. The MDS in terms of the presence of infrastructure would be on the completion of construction, during the operations and maintenance phase. **Operation and maintenance phase** • Wind turbines: 68 installations with four-legged suction bucket foundations, each jacket leg with a diameter of 5m, spaced 48m apart, and each bucket with a diameter of 16m. Scour protection to a height of 2.5m. Total footprint of 10,816m^2 per wind turbine • OSPs: four installations with gravity base foundations, each with a 14m diameter at the surface, a slab base diameter of 52.5m and with scour protection to a height of 2.6m. Total footprint of 6,236m^2 per OSP. • Inter-array cables: cable protection along 50km of the cable, with a height of up to 3m and up to 10m width. Up to 67 cable crossings, each crossing has a height of up to 4m, a width of up to 32m and a length of up to 60m • Interconnector cables: cable protection along 10km of the cable, with a height of up to 3m and up to 10m width. Up to ten cable crossings, each crossing has a height of up to 3m, a width of up to 20m and a length of up to 50m • Export cables: cable protection along 72km of the cable, with a height of up to 3m and up to 10m width. Up to 24 cable crossings, each crossing has a height of up to 3m, a width of up to 30m and a length of up to 50m. **Decommissioning phase** • During the decommissioning phase the potential changes to the receptor would gradually decrease from the operational MDS as structures are removed and cut below the seabed. • Scour and cable protection will remain in situ and continue to influence tidal regime.	Physical processes are comprised of tides, waves and sediment transport and these aspects are integrated (i.e. without the influence of tides and waves there would be no sediment transport) as outlined below: • The tidal regime is influenced by changes in bathymetry due to the placement of scour protection and the obstruction of tidal flow due to foundation structures within the water column • The wave climate is influenced by obstruction within the water column however changes in bathymetry would only cause effects in shallow water • The sediment transport regime is affected by obstructions in the sediment transport pathways and also potential changes to the littoral currents which drive this process (i.e. those factors which also affect tide and wave climate) • Stratification is governed by the factors controlling mixing therefore the effects on tide and wave climate are common to stratification A holistic approach has therefore been applied to assessing the MDS. The greatest surface blockage to influence wave climate is from the wind turbines with the largest four-legged suction bucket foundations. The four legs provide a slightly smaller obstruction to tidal flows at each wind turbine site than gravity base foundations however the gravity base obstruction is concentrated towards to the lower section of the water column where tidal currents are weaker and influence of conveyance is therefore reduced. Suction bucket foundations have the largest footprint at each wind turbine in terms of scour protection and provide the greatest influence on bathymetry. The devices also have a greater footprint over the site as a whole rather than the more numerous smaller design options. The greatest overall in-water column blockage to influence tidal flow and wave climate from the OSPs is the maximum number of OSPs (four) with gravity base foundations. These parameters also present the largest overall footprints to affect changes in bathymetry and sediment transport pathways.

6.6.2 Impacts scoped out of the assessment

6.6.2.1 On the basis of the baseline environment and the description of development outlined in volume 1, chapter 3: Project description of the PEIR, a number of impacts are proposed to be scoped out of the assessment for physical processes. These impacts are outlined, together with a justification for scoping them out, in Table 6.13.

Table 6.13: Impacts scoped out of the assessment for physical processes.

Potential impact	Justification
Changes to bathymetry due to depressions left by jack-up vessels.	The potential for jack-up vessel spud-cans to affect the sediment regime has been scoped out of the assessment. Jack-up footprint depressions would likely only persist temporarily after jack-up operations have been completed and these would infill over time. Monitoring at the Barrow offshore wind farm showed depressions were almost entirely infilled 12 months after construction (BOWind, 2008).
Changes to sediment transport due to depressions left by jack-up vessels.	Changes to bathymetry and hydrography are intrinsically linked to sediment transport. When jack-up barges are removed the source of scour is also eradicated. The gradual infilling is not anticipated to significant implications for the sediment regime, due to the scale and nature.
Scour of seabed sediments during the construction, operations and maintenance phases.	Interaction between the waves and current and the Mona Offshore Wind Project generation infrastructure has the potential to cause localised scouring of seabed sediment. Scour protection will be a measure adopted as part of the project to prevent scour from occurring. The scour protection measures will be subject to engineering design to ensure they prevent scour from occurring and will be installed in concert with infrastructure. Therefore, it is proposed that scour of seabed sediments is scoped out of the Physical processes Environmental Statement chapter.

6.7 Measures adopted as part of the Mona Offshore Wind Project

6.7.1.1 For the purposes of the EIA process, the term 'measures adopted as part of the project' is used to include the following proposed measures (adapted from IEMA, 2016):

- Measures included as part of the project design. These include modifications to the location or design of the Mona Offshore Wind Project which are integrated into the application for consent. These proposed measures are secured through the consent itself through the description of the development and the parameters secured in the DCO and/or marine licences (referred to as primary mitigation in IEMA, 2016)
- Measures required to meet legislative requirements, or actions that are generally standard practice used to manage commonly occurring environmental effects and are secured through the DCO requirements and/or the conditions of the marine licences (referred to as tertiary mitigation in IEMA, 2016).

6.7.1.2 A number of measures (primary and tertiary) have been proposed to be adopted as part of the Mona Offshore Wind Project to reduce the potential for impacts on physical processes. These are outlined in Table 6.14 below. As there is a commitment to implementing these measures, they are considered inherently part of the design of the Mona Offshore Wind Project and have therefore been considered in the assessment presented in section 6.8 below (i.e. the determination of magnitude and therefore significance assumes implementation of these measures).

Table 6.14: Measures adopted as part of the Mona Offshore Wind Project.

Measures adopted as part of the Mona Offshore Wind Project	Justification	How the measure will be secured
Primary measures: Measures included as part of the project design		
Scour protection	There is the potential for scouring of seabed sediments to occur due to interactions between metocean regime (waves and currents) and foundations or other seabed structures. This scouring can develop into depressions around the structure. The use of scour protection around offshore structures and foundations will be employed, as described in detail in volume 1, chapter 3: Project description of the PEIR. The scour protection has been included in the modelled scenarios used within the impact assessment.	Committed with the project design (see volume 1, chapter 3: Project description of the PEIR).
Cable burial	Development and adherence to a Cable Specification and Installation Plan which will include cable burial where possible and cable protection. To minimise potential impact from the cables and removal of cables a commitment to bury cables where possible has been made in accordance with the specific policies set out in the North West Inshore and North West Offshore Coast Marine Plans (MMO, 2021).	Committed with the project design (see volume 1, chapter 3: Project description of the PEIR).
To minimise sandwave clearance on the Constable Bank and within the Menai Strait and Conwy Bay SAC	To minimise potential impacts on Annex I species habitat and designated SAC.	To be addressed for the application. Investigations will be undertaken to identify opportunities to limit sandwave clearance on the Constable Bank and within the Menai Strait and Conwy Bay SAC. This will be guided by survey data and when all cable route results have been evaluated this will inform the assessment within the Environmental Statement.

Measures adopted as part of the Mona Offshore Wind Project	Justification	How the measure will be secured
To minimise cable protection placed on the Constable Bank and within the Menai Strait and Conwy Bay SAC	To minimise potential impacts on Annex I species habitat and designated SAC.	To be addressed for the application. Investigations will be undertaken to identify opportunities to limit cable protection on the Constable Bank and within the Menai Strait and Conwy Bay SAC. This will be guided by survey data and when all cable route results have been evaluated this will inform the assessment within the ES.
Material arising from drilling and/or sandwave clearance will be deposited in close proximity to the works	To retain material within sediment cell and maintain sediment transport regimes.	Committed with the project design (see volume 1, chapter 3: Project description of the PEIR).

6.7.1.3 Where significant effects have been identified, further mitigation measures (referred to as secondary mitigation in IEMA 2016) have been identified to reduce the significance of effect to acceptable levels following the initial assessment. These are proposed measures that could further prevent, reduce and, where possible, offset any adverse effects on the environment. These proposed measures are set out, where relevant, in section 6.8 below.

6.8 Assessment of significant effects

6.8.1.1 The impacts of the construction, operations and maintenance, and decommissioning phases of the Mona Offshore Wind Project have been assessed on physical processes. The potential impacts arising from the construction, operations and maintenance and decommissioning phases of the Mona Offshore Wind Project are listed in Table 6.12, along with the MDS against which each impact has been assessed.

6.8.1.2 A description of the potential effect on physical processes receptors caused by each identified impact is given below.

6.8.2 Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features.

6.8.2.1 Increased suspended sediment concentrations may arise due to seabed preparation involving sandwave clearance, the installation of the wind turbines and OSP foundations, the installation and/or maintenance of cables and associated decommissioning activities. This impact is relevant to the construction, operations and maintenance, and decommissioning phases of the Mona Offshore Wind Farm and may cause indirect impacts to receptors.

6.8.2.2 The following scenarios were investigated:

- Site preparation activities – sand wave clearance to facilitate wind turbine, OSP and cable installation
- Drilled pile installation – across the range of hydrodynamic conditions
- Inter-array cable installation – for a zone of sandy seabed sediment
- Offshore export cable installation – through sandy seabed sediment.

6.8.2.3 Modelling was undertaken related to the MDS as outlined in Table 6.12 with the detail of the assessment provided in volume 6, annex 6.1: Physical processes technical report of the PEIR.

Construction phase

Magnitude of impact

6.8.2.4 The preparation of the seabed involves sandwave clearance activities within the Mona Offshore Array Area and Mona Offshore Cable Corridor which may lead to suspended sediment concentrations and associated deposition. The MDS for sandwave clearance was along 250km length of the inter array cable and width of 104m, to an average depth of 5.1m. Similarly, sandwave clearance at the same depth and width was modelled along the interconnector cable (30km) and the export cable (252km).

6.8.2.5 The installation of infrastructure within the Mona Offshore Array Area and Mona Offshore Cable Corridor may lead to increased suspended sediment concentrations and associated deposition. The MDS is for the drilled installation of up to 68 monopiles of 16m diameter. Included is the installation of one OSP with foundations consisting of two 16m monopiles, drilled to a depth of 60m. Up to two monopiles may be installed concurrently. For the installation of inter-array cables (500km), interconnector cables (50km) export cables (360km) a trench of up to 3m in width and 3m in depth with a triangular cross section may be excavated. Open trenching is required for the installation of the intertidal export cable of 6km of 1m in width and excavated to a depth of 3m.

6.8.2.6 The modelled scenarios examined a range of locations across the Mona Array Area with two concurrent drilling operations at adjacent locations. The drilled pile installations are anticipated to generate plumes with a suspended sediment level of <50mg/l. These levels would be localised and only persist for a short period. Concentrations within the plume envelope are much lower, typically <1mg/l a short distance from the discharge locations. Following the cessation of drilling the turbidity levels reduce within a few hours as tidal currents reduce. Some of the finer material associated with the drilling process is re-suspended during successive tides as it is redistributed but turbidity levels remain low. The sedimentation beyond the immediate drilling location is indiscernible (less than 1mm). This is due to the relatively slow drilling rate (0.89m/hour), allowing the fine sediment to be widely dispersed while the larger material settles at the release point due to the limited current speed.

6.8.2.7 For the inter-array cable installation, the sediment plumes are much larger than those for the pile installation. The reason for this is twofold, firstly there is a large amount of sediment mobilised (220,500m^3 of material was mobilised during the 4 day simulation along the 49km modelled route) and secondly there was elevated tidal currents on successive tides which remobilised material over the extended period of installation. Peak plume concentrations are highest at around 500mg/l (at the release site) with the sediment settling during slack water becoming resuspended in the form of an amalgamated plume. Sedimentation of 30mm depth occurs at the trench site, with sediment depths reducing moving away from the trench but remaining in the sediment cell and retained in the sediment transport system.

6.8.2.8 Following the completion of the works the turbidity levels return to baseline within a couple of tidal cycles. It would however be anticipated that spring tides following the works may mobilise and redistribute unconsolidated seabed material deposited at the end of the construction phase; this material will therefore be incorporated into the existing transport regime. Following installation, the native seabed material settles close to where it is mobilised and remains in-situ. This would be expected as the baseline modelling indicated that sediment transport potential is limited across the offshore wind farm area. The sedimentation is concentrated along the installation route as material effectively returns to the site from where it was disturbed. Sedimentation depths of <30mm arise beyond the immediate vicinity of the trench the day after drilling cessation and therefore would be indiscernible from the existing seabed sediment.

6.8.2.9 Export cable installation shows a higher variability in suspended sediment concentration due to the change in hydrography along the export cable corridor and, as anticipated, SSC increased in limited water depth. Average levels of suspended sediment concentrations of <300mg/l are noted along the cable path, with the level dropping to background levels on the slack tide. For cable trenching in the intertidal area material released may migrate within the sediment cell but it would be insufficient to impact the beach morphology, increasing baseline levels of sediment by circa 5-10mm along the coast and typically far less along the shoreline which is redistributed on successive tides flowing cable installation. In reality, the use of cofferdams during installation at the Bodelwyddan landfall site may provide a reduction in suspended sediment released from the modelled scenario as the movement of material is undertaken in a more controlled and enclosed environment.

6.8.2.10 The project design includes the provision of site preparation/sandwave clearance activities which have the potential to increase suspended sediment concentrations in the construction phase with associated sedimentation. Sandwave clearance was calculated for 50% of the wind turbine and OSP foundations at a width of 205m and a depth of 7.5m. The clearance width would be 104m wide corridor to facilitate cable installation with an average depth of 5.1m, with modelling assuming a clearance dredging rate of 10,000m^3/h and a 3% spill of material during the dredging phase.

6.8.2.11 In practice, plough dredging which mobilises a much smaller amount of sediment into suspension at the seabed and has reduced sediment plume concentrations and extents compared to other types of dredging activities may be undertaken. However, the modelling simulated the use of a suction hopper dredger with a phasing representative of the scale of the sandwaves; dredging, and then depositing material within the cable corridor as it progressed along the route, resulting in higher quantification of sedimentation compared to the plough dredging.

6.8.2.12 The impact is predicted to be of local spatial extent, short term duration, intermittent and with high reversibility. It is predicted that the impact will affect the Menai Strait & Conwy Bay SAC, Traeth Pensarn SSSI and Constable Bank features directly whilst affecting the remainder receptors indirectly. The magnitude is therefore, considered to be **low** for the receptors within the SAC and Constable Bank with a **negligible** magnitude for other receptor groups.

Sensitivity of the receptor

6.8.2.13 The Mona Offshore Wind Project partially overlaps with the Menai Strait & Conwy Bay SAC, Figure 6.7. The Menai Strait & Conwy Bay SAC is designated for multiple qualifying features under Annex 1 of the EC Habitats Directive; sandbanks which are slightly covered by sea water all the time, mudflats and sandflats not covered by seawater at low tide and reefs. The Menai Strait & Conwy Bay includes the Four Fathom Banks complex which is a rare subtidal sandbank. The sandbanks support relatively species-rich sandy communities of polychaetes such as *Spio filicornis* and internationally important flocks of common scoter *Melanitta nigra* feed on them when bivalve numbers are high. The mudflats and sandflats of the SAC are fully marine with a broad range of animal species and support the nationally scarce and important biotope, dwarf eelgrass *Zostera noltei*. Rocky reefs are situated in the strait and during spring tides the tidal current can reach 4m/s these turbid waters contain high levels of suspended material supporting many species of filter feeders. Other Annex 1 habitats such as large shallow inlets and bays and submerged or partially submerged sea caves found in the Menai Strait & Conwy Bay SAC are qualifying features but not the primary purpose for designation. The sedimentation identified is localised and composed of native material therefore the structure and function of the designated features is of low vulnerability and recoverable. The sensitivity of the receptor to changes as a result of seabed preparation, foundation installation and cable installation is therefore considered to be **low**.

6.8.2.14 Constable Bank is not a designated site but supports sandbanks which are an Annex 1 habitat of the EC Habitats Directive. Constable Bank is an area of shallow water creating rougher areas of wave stress, shifting sand creating sandbanks. The sedimentation identified is localised and composed of native material therefore the structure and function of sandbanks is of low vulnerability and recoverable. The sensitivity of the receptor to changes as a result of seabed preparation, foundation installation and cable installation is therefore considered to be **low**.

6.8.2.15 Traeth Pensarn SSSI is designated on vegetated shingle beach and associated plant communities. Shingle ridges are primarily derived of local Carboniferous Limestone together with calcareous sands, shingle and non-limestone material from the Irish Sea glacial till. Shingle ridges would recover from sedimentation as the sedimentation identified is localised and composed of native material therefore the structure and function of the designated features is of low vulnerability and recoverable. The sensitivity of the receptor to changes as a result of seabed preparation, foundation installation and cable installation is therefore considered to be **low**.

6.8.2.16 The Great Ormes Head SSSI is comprised of features such as reefs (intertidal) and terrestrial habitats, vegetated sea cliffs, European dry heath, and semi-natural dry grassland. These rocky reefs would recover from sedimentation as typically no material reaches the intertidal zone from nearshore cabling. The sensitivity of the receptor to changes as a result of seabed preparation, foundation installation and cable installation is therefore considered to be **low**.

6.8.2.17 Similarly, Little Ormes Head SSSI is primarily designated on terrestrial habitats such as lowland calcareous grassland, calcareous grassland and improved grassland (see Table 6.8). However, the reef at Little Ormes Head is described as geologically important for its Carboniferous stratigraphy. Special interest is given to the intertidal area due to scarce and specialised biotopes of hard vertical limestone rock off the headland and sand-scoured caves. Associated reefs and intertidal area would recover from sedimentation as no material reaches the intertidal zone from nearshore cabling. The sensitivity of the receptor to changes as a result of seabed preparation, foundation installation and cable installation is therefore considered to be **low**.

6.8.2.18 Bathing water quality is measured in terms of biological levels and due to the low potential influx of native sediment into the bathing waters of the intertidal zone the level of vulnerability would be low and recoverable. It is expected that the sensitivity of the receptor to changes because of seabed preparation, foundation installation and cable installation is therefore considered to be **low**.

Significance of the effect

6.8.2.19 During the installation of the wind turbines in the Mona Array Area, the peak sediment plumes are <50mg/l and do not persist or result in discernible sedimentation. However, these sediment concentrations do not extend as far south as Menai Strait & Conwy Bay SAC, Constable Bank, Great Ormes Head SSSI, Little Ormes Head SSSI and Traeth Pensarn SSSI.

6.8.2.20 Sediment plumes associated with the inter-array cable and inter-connector cable installation creates plumes on average <100-300mg/l, highest during the release (of material) phase however these plume concentrations do not persist in the designated sites. Sedimentation is typically <0.5mm beyond the immediate vicinity of the installation and less than one tenth of this value in the wider domain and would therefore not affect features beyond the development area (i.e. limited to the Mona Array Area). These plumes do not extend to any of the other designated sites with sediment concentrations settling to background levels within the Mona Offshore Wind Project.

6.8.2.21 In terms of the Constable Bank, the structure of the offshore subtidal sandbanks would remain unchanged as the deposition is of native material and the supporting hydrodynamic processes are not altered by the minimal level of bathymetric change as a result of the construction phase sediment releases. Similarly, reefs, mudflats and sandflats would remain stable and supporting hydrodynamics processes for communities of polychaetes such as *Spio filicornis*, bivalves and dwarf eelgrass *Zostera noltei* would remain unaffected.

6.8.2.22 Export cable trenching routes do not pass through either of the designated sites Great Ormes Head SSSI and Little Ormes Head SSSI therefore will have no impact on the geodiversity of these sites. Although plumes resulting from the offshore cable trenching may reach the outer extent of the Menai Strait & Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank. This increase in sediment entering the sediment cell causes sediment thickness of <0.5mm at the coast off Bodelwyddan adjacent to the export cable trenching operations, however this material is native to the sediment cell and will therefore not affect geodiversity.

6.8.2.23 The Mona Offshore Cable Corridor landfall site at the coast off Bodelwyddan intersects the Traeth Pensarn SSSI. Within the intertidal zone the export cable may be installed using open trench technology with the application of coffer dams. Therefore, similar to the other designated sites, the increased sedimentation from the export cable installation could causes a temporary increase in sedimentation in the intertidal zone, however it would be insufficient to affect beach morphology.

6.8.2.24 Overall, the magnitude of the impact is deemed to be **low,** and the sensitivity of the receptor is considered to be **low**. Considering both a low magnitude of impact combined with a low sensitivity of the receptor where impacts are limited in both temporal and spatial extent the effect will, therefore, be of **negligible** significance, which is not significant in EIA terms. For intertidal and coastal areas, the magnitude of impacts are negligible giving rise to effects of negligible significance.

Further mitigation and residual effect

6.8.2.25 No effects which are significant in EIA terms have been identified therefore further mitigation is not required.

Operation and maintenance

Magnitude of impact

6.8.2.26 Operation and maintenance activities within the Mona Array Area and Mona Offshore Cable Corridor may lead to increases in suspended sediment concentrations and associated sediment deposition.

6.8.2.27 The MDS is for up to 10km inter-array cable repair (one event every three years) and reburial event of up to 20km (once every five years). Including 16km export cable repair (three events every 10years) and reburial events of up to 2km of cable every one event in every five years. The repair of 32km of offshore export cables (eight events in every five years) and reburial of up to 15km once every five years as well as the repair of 1.6km of intertidal export cables every five years, over the 35-year lifetime of the project (Table 6.12). Using similar methods as those for cable installation activities (i.e. trenching/jetting, with trench width up to 3m and trench depth up to 3m).

6.8.2.28 In each case the length of the repair or reburial activity may be up to 20km; therefore, the magnitude of the impacts would be a fraction of those for the construction phase. In the case of the export cable the total length of works would be approximately 60% of the length of the construction phase with events being undertaken over the duration of the 35-year project lifetime. The sediment plumes and sedimentation footprints would be dependent on which section of the cable is being repaired however the entire length has been quantified under the construction phase scenario discussed above.

6.8.2.29 The impact is predicted to be of local spatial extent, short term duration, intermittent and with high reversibility. It is predicted that the impact will affect the Menai Strait & Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank directly whilst affecting other receptors indirectly to a much lesser degree than the construction phase. The magnitude is therefore, considered to be **negligible**.

Sensitivity of receptor

6.8.2.30 The sensitivity of receptors to changes in suspended sediments concentration and sedimentation remains the same as for all construction phases. The significance of the effects will however be reduced as the works are limited to intermittent, discrete repair activities.

6.8.2.31 The Menai Strait & Conwy Bay SAC, Traeth Pensarn SSSI and Constable Bank would recover from sedimentation as the material released is localised and native. The sensitivity of the receptor to changes as a result of seabed preparation, foundation installation and cable installation is therefore considered to be **low**. Other receptors that are indirectly impacted to a much lesser degree than the construction phase is therefore considered **low**.

Significance of effect

6.8.2.32 Overall, for all the physical processes receptors the magnitude of the impact is deemed to be **negligible**, and the sensitivity of the receptor is considered to be **low**. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Further mitigation and residual effects

6.8.2.33 No effects which are significant in EIA terms have been identified therefore further mitigation is not required.

Decommissioning

6.8.2.34 During decommissioning, increases in suspended sediments and potential impact on the physical features would be of lesser magnitude than both the construction phase and the operations and maintenance phase with scour and cable protection remaining *in situ*. In the case of piled foundations, there is no significant disturbance of the seabed during decommissioning as piles are cut off. SSC would increase temporarily if suction caissons were removed using overpressure to release. As per the MDS (Table 6.12), increases in SSC due to the removal of inter-array, interconnector and offshore export cables would be similar to those experienced during the construction phase, as retrieval would be undertaken using similar techniques to installation. The increase in suspended sediments and the potential impacts on physical features may persist during decommissioning, however they are temporary and localised in nature.

6.8.3 Impacts to the tidal regime due to presence of infrastructure and the associated potential impacts along adjacent shorelines.

6.8.3.1 The presence of infrastructure may lead to changes to the tidal regime and associated potential impacts along adjacent shorelines principally during the operations and maintenance phase of the Mona Offshore Wind Project. This impact is also relevant to the construction phase and following decommissioning associated with residual infrastructure. Modelling was undertaken using the MDS as outlined in Table 6.12 including the presence of scour protection as outlined in the project description (volume 1, chapter 3: Project description of the PEIR). The detail of the numerical modelling underpinning the assessment is provided in volume 6, annex 6.1: Physical processes technical report of the PEIR. The magnitude of the impact is detailed in this section along with the assessment of the effect of changes to physical processes on relevant receptors.

Construction phase

6.8.3.2 As the assessment was carried out with and without the presence of infrastructure, it can be inferred that during the construction phase there will be gradual changes to tidal regime as infrastructure is introduced into the environment. This would result in changes and therefore potential impacts, ranging from the baseline environment (no presence of infrastructure) to the operation phase (MDS), which are assessed in the following section.

Operation and maintenance

Magnitude of impact

6.8.3.3 The presence of infrastructure within the offshore wind farm area may lead to changes in tidal regime and the associated potential impacts along adjacent shorelines during the operations and maintenance phase of the Mona Offshore Wind Project. The MDS in terms of hydrographic impacts is for up to 68 wind turbines with 4-legged suction bucket foundations for each jacket leg at 5m diameter spaced 48m apart, and each bucket with a diameter of 16m. Scour protection at each bucket foundation of 2.5m in height and extending 20m covering a total footprint of 10,816m^2.

6.8.3.4 Additionally, the MDS includes four OSPs, with gravity base foundations each with a diameter of 14m at the surface and a slab base 52.5m diameter at the bed. Associated scour protection extends from the slab base by 18.3m at a height of 2.6m giving rise to 6,236m^2 footprint per unit. The modelled scenario presented in volume 6, annex 6.1: Physical processes technical report of the PEIR used an alternate arrangement for the inclusion of the OSPs within the modelled scenario.

6.8.3.5 The parameters in terms of seabed footprint and water column obstruction are similar between each wind turbine unit, as modelled, and each of the four OSP units. Therefore, it is appropriate to infer the impacts on tidal flows due to each of the OSPs would be of the same extent and order of magnitude as those modelled wind turbine sites and to occur at the OSP locations.

6.8.3.6 The results of the modelling indicated that peak tidal flows are redirected in the immediate proximity of structures by a maximum variation of 5cm/s which constitutes as less than 5% of the peak flow and reduces significantly with distance from the structures. These changes are also limited to the immediate Mona Offshore Array Area which may have a direct impact on the hydrodynamic regime and persist for the entire lifecycle of the Mona Offshore Wind Project. However, they would be imperceptible beyond the immediate vicinity of the offshore wind farm area and would be reversible on decommissioning. The limited nature of these changes would not influence the tidal regime which underpins sediment transport.

6.8.3.7 Cable installation in the intertidal region will be undertaken such that no additional material will be placed on the surface in the intertidal region and therefore will not disrupt sediment transport pathways or impede tidal flow. In line with best practice cable burial depths are such that beach levels are maintained as detailed in volume 1, chapter 3: Project description of the PEIR.

6.8.3.8 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the Menai Strait & Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank directly whilst affecting other receptors indirectly. The magnitude is therefore, considered to be **low** within the Menai Strait & Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank and **negligible** at coastal and intertidal receptors.

Sensitivity of the receptor

6.8.3.9 Overlapping with the Mona Offshore Wind Project cable corridor, the Menai Strait & Conwy Bay SAC is designated for multiple qualifying features under Annex 1 of the EC Habitats Directive; sandbanks which are slightly covered by sea water all the time, mudflats and sandflats not covered by seawater at low tide and reefs. Due to the localised and limited changes in tidal regime the Menai Strait & Conwy Bay SAC features are of low vulnerability and recoverable. The sensitivity of this is therefore considered to be **low**.

6.8.3.10 Also overlapping with the Mona Cable Corridor is the Constable Bank which is not a designated site but supports sandbanks which are an Annex 1 habitat of the EC Habitats Directive. The changes to tidal regime due to the presence of infrastructure identified is localised therefore the sandbank is of low vulnerability and recoverable. The sensitivity of the receptor to changes in tidal regime as a result of the presence of infrastructure is therefore considered to be **low**.

6.8.3.11 Traeth Pensarn SSSI is designated on vegetated shingle beach and associated plant communities. Shingle ridges would recover from the changes in tidal regime due to the presence of infrastructure identified as localised therefore the shingle beach is of low vulnerability and recoverable. The sensitivity of the receptor to changes in tidal regime because of the presence of infrastructure is therefore considered to be **low**.

6.8.3.12 Within the physical processes study area, Great Ormes Head SSSI is comprised of features such as reefs (intertidal) and terrestrial habitats, vegetated sea cliffs, European dry heath, and semi-natural dry grassland. These rocky intertidal reefs would recover from changes in tidal regime due to the presence of infrastructure. The sensitivity of the receptor to changes in tidal regime as a result of the presence of infrastructure is therefore considered to be **negligible**.

6.8.3.13 Similarly, Little Ormes Head SSSI is primarily designated on terrestrial habitats but the reef at Little Ormes Head is described as geologically important for its Carboniferous stratigraphy. Reefs and the intertidal area would recover from changes in tidal regime from infrastructure as no changes reach Little Ormes Head. The sensitivity of the receptor to changes in tidal regime as a result of the presence of infrastructure is therefore considered to be **negligible**.

6.8.3.14 Bathing water quality is measured in terms of biological levels and due to the distance from the Mona Offshore Wind Project, it is expected that the sensitivity of the receptor to changes in tidal regime is therefore considered to be **negligible.**

Significance of the effect

6.8.3.15 Overall, the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **low**. Considering both a low magnitude of impact combined with a low sensitivity of the receptor coupled with the limited spatial extent of the impact the effect will, therefore, be of **negligible** significance, which is not significant in EIA terms. For intertidal and coastal areas, the magnitude of impacts are **negligible** giving rise to effects of **negligible** significance.

Further mitigation and residual effect

6.8.3.16 No effects which are significant in EIA terms have been identified therefore further mitigation is not required.

Decommissioning

Magnitude of impact

6.8.3.17 Following decommissioning, changes to tidal regime would be of lesser magnitude than the operations and maintenance phase, as no structures would remain in the water column to influence tidal currents, with only the colonised scour and cable protection retained within the context of the MDS.

6.8.3.18 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the Menai Strait & Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank directly whilst affecting other receptors indirectly. The magnitude is therefore, considered to be **low**.

Sensitivity of receptor

6.8.3.19 As with the operations and maintenance phase, in response to localised changes in tides, the Menai Strait & Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank is deemed to be of low vulnerability and recoverable. The sensitivity of this is therefore, considered to be **low**.

Significance of effect

6.8.3.20 Overall, the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **low**. Considering both a low magnitude of impact combined with a low sensitivity of the receptor coupled with the limited spatial extent of the impact the effect will, therefore, be of **negligible** significance, which is not significant in EIA terms. For intertidal and coastal areas, the magnitude of impacts are **negligible** giving rise to effects of **negligible** significance.

Further mitigation and residual effects

6.8.3.21 No effects which are significant in EIA terms have been identified therefore further mitigation is not required.

6.8.4 Impacts to the wave regime due to presence of infrastructure and the associated potential impacts along adjacent shorelines.

6.8.4.1 Introducing infrastructure may lead to changes to the wave regime and the associated potential impacts along adjacent shorelines principally during the operations and maintenance phase of the Mona Offshore Wind Project. Also, relevant to a lesser degree is the construction phase and following decommissioning associated with residual infrastructure. Modelling was undertaken using the MDS as outlined in Table 6.12 including the presence of scour protection as outlined in the project description (volume 1, chapter 3: Project description of the PEIR). The detail of the numerical modelling underpinning the assessment is provided in volume 6, annex 6.1: Physical processes technical report of the PEIR. The magnitude of the impact is detailed in this section along with the assessment of the effect of changes to physical processes on relevant receptors.

Construction phase

6.8.4.2 Similar to the above assessment of tidal regime, modelling was carried out with and without the presence of infrastructure. During the construction phase there will be gradual changes to wave regime as infrastructure is introduced into the environment. This would result in changes and therefore potential impacts ranging from the baseline environment (no presence of infrastructure) to the operational phase MDS), which are assessed in the following section below.

Operation and maintenance

Magnitude of impact

6.8.4.3 Changes may occur in the wave regime due to the introduction of infrastructure with the Mona Offshore Wind Project and potential impacts along adjacent shorelines during the operations and maintenance phase. The MDS in terms of hydrographic impacts is for up to 68 wind turbines with 4-legged suction bucket foundations for each jacket leg at 5m diameter spaced 48m apart, and each bucket with a diameter of 16m. Scour protection at each bucket foundation of 2.5m in height and extending 20m covering a total footprint of 10,816 m^2.

6.8.4.4 Additionally, the MDS includes four OSPs with gravity base foundations, each with a diameter of 14m at the surface and a slab base 52.5m diameter at the bed. Associated scour protection extends from the slab base by 18.3m at a height of 2.6m giving rise to 6,236m^2 footprint per unit. The modelled scenario presented in volume 6, annex 6.1: Physical processes technical report of the PEIR used an alternate arrangement for the inclusion of the OSPs within the modelled scenario.

6.8.4.5 The modelled OSP parameters included three structures of 3m diameter at the water surface for each unit which is a reduction on the 14m diameter single structure proposed. Modelling at the wind turbine locations however included four structures each 16m in diameter therefore it may be inferred that the impact on wave climate at the OSP sites would be marginally larger than that modelled but much smaller than experienced at the wind turbine locations.

6.8.4.6 Examination of a 1in1 year storm from the west (of greatest influence of approaching storms) shows the deflection of waves by the structures result in a reduction in the lee and increases where the waves had been deflected either side of each structure. Changes in the wave height at the larger wind turbine structures were in the order of 3cm equating to <1% of the baseline significant wave height. For a 1in20 year storm event, the pattern is similar however the change in wave height at the structures is 3–4.5cm and due to the larger baseline associated with the return period the overall impact on the wave climate is less obvious.

6.8.4.7 The impact is predicted to be of local spatial extent, long term duration, continuous and of high reversibility. It is predicted that the impact will affect the Menai Strait & Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank directly whilst affecting other receptors indirectly. The magnitude is therefore, considered to be **low** within the Menai Strait & Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank and **negligible** at coastal and intertidal receptors.

Sensitivity of receptor

6.8.4.8 Overlapping with the Mona Offshore Wind Project cable corridor, the Menai Strait & Conwy Bay SAC is designated for multiple qualifying features under Annex 1 of the EC Habitats Directive; sandbanks which are slightly covered by sea water all the time, mudflats and sandflats not covered by seawater at low tide and reefs. Due to the localised and limited changes in wave regime the Menai Strait & Conwy Bay SAC features are of low vulnerability and recoverable. The sensitivity of this is therefore considered to be **low**.

6.8.4.9 Also overlapping with the Mona Cable Corridor is the Constable Bank which is not a designated site but supports sandbanks which are an Annex 1 habitat of the EC Habitats Directive. The changes to wave climate due to the presence of infrastructure identified is localised therefore the sandbank is of low vulnerability and recoverable. The sensitivity of the receptor to changes in wave regime as a result of the presence of infrastructure is therefore considered to be **low**.

6.8.4.10 Traeth Pensarn SSSI is designated on vegetated shingle beach and associated plant communities. Shingle ridges would recover from the changes in tidal regime due to the presence of infrastructure identified as localised therefore the shingle beach is of low vulnerability and recoverable. The sensitivity of the receptor to changes in wave regime because of the presence of infrastructure is therefore considered to be **low**.

6.8.4.11 Within the physical processes study area, Great Ormes Head SSSI is comprised of features such as reefs (intertidal) and terrestrial habitats, vegetated sea cliffs, European dry heath, and semi-natural dry grassland. These rocky intertidal reefs would recover from changes in wave regime due to the presence of infrastructure. The sensitivity of the receptor to changes in tidal regime as a result of the presence of infrastructure is therefore considered to be **negligible**.

6.8.4.12 Similarly, Little Ormes Head SSSI is primarily designated on terrestrial habitats but the reef at Little Ormes Head is described as geologically important for its Carboniferous stratigraphy. Reefs and the intertidal area would recover from changes in tidal regime from infrastructure as no changes reach Little Ormes Head. The sensitivity of the receptor to changes in wave regime as a result of the presence of infrastructure is therefore considered to be **negligible**.

6.8.4.13 Bathing water quality is measured in terms of biological levels and due to the distance from the Mona Offshore Wind Project, it is expected that the sensitivity of the receptor to changes in wave regime is therefore considered to be **negligible.**

Significance of effect

6.8.4.14 Overall, the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **low**. Considering both a low magnitude of impact combined with a low sensitivity of the receptor coupled with the limited spatial extent of the impact the effect will, therefore, be of **negligible** significance, which is not significant in EIA terms. For intertidal and coastal areas, the magnitude of impacts are **negligible** giving rise to effects of **negligible** significance.

Further mitigation and residual effects

6.8.4.15 No effects which are significant in EIA terms have been identified therefore further mitigation is not required.

Decommissioning

Magnitude of impact

6.8.4.16 Following decommissioning, changes to the wave regime would be of lesser magnitude than the operations and maintenance phase, as no structures would remain in the water column to influence the waves, with only the colonised scour and cable protection retained.

6.8.4.17 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the Menai Strait & Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank directly whilst affecting other receptors indirectly. The magnitude is therefore, considered to be **low**.

Sensitivity of receptor

6.8.4.18 As with the operations and maintenance phase, in response to localised changes in tides, the Menai Strait & Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank is deemed to be of low vulnerability and recoverable. The sensitivity of this is therefore, considered to be **low**.

Significance of effect

6.8.4.19 Overall, the magnitude of the impact is deemed to be l**ow** and the sensitivity of the receptor is considered to be **low**. Considering both a low magnitude of impact combined with a low sensitivity of the receptor coupled with the limited spatial extent of the impact the effect will, therefore, be of **negligible** significance, which is not significant in EIA terms. For intertidal and coastal areas, the magnitude of impacts are **negligible** giving rise to effects of **negligible** significance.

Further mitigation and residual effects

6.8.4.20 No effects which are significant in EIA terms have been identified therefore further mitigation is not required.

6.8.5 Impacts to sediment transport and sediment transport pathways due to presence of infrastructure and associated potential impacts to physical features and bathymetry.

6.8.5.1 During the operations and maintenance phase the presence of infrastructure may alter the sediment transport and sediment transport pathways leading to changes in the Mona Offshore Wind Project area and the associated potential impacts along adjacent shorelines. The construction phase and following decommissioning associated with residual infrastructure is relevant but changes are gradual and to a lesser extent in these phases. Modelling was undertaken using the MDS as outlined in Table 6.12 including the presence of scour protection as outlined in the project description (volume 1, chapter 3: Project description of the PEIR). The detail of the numerical modelling underpinning the assessment is provided in volume 6, annex 6.1: Physical processes technical report of the PEIR. The magnitude of the impact is detailed in this section along with the assessment of the effect of changes to physical processes on relevant receptors.

Construction phase

6.8.5.2 During the construction phase there will be gradual changes to sediment transport and sediment transport pathways as infrastructure is introduced into the environment. With changes and therefore potential impacts ranging from the baseline environment (no presence of infrastructure) to the operational phase (MDS) assessed in the following section below.

Operation and maintenance

Magnitude of impact

6.8.5.3 With the introduction of infrastructure during the operations and maintenance phase changes may occur in the sediment transport and sediment transport pathways in the Mona Offshore Wind Project area and potential impacts along adjacent shorelines. The MDS in terms of hydrographic impacts is for up to 68 wind turbines with 4-legged suction bucket foundations for each jacket leg at 5m diameter spaced 48m apart, and each bucket with a diameter of 16m. Scour protection at each bucket foundation of 2.5m in height and extending 20m covering a total footprint of 10,816 m^2.

6.8.5.4 Additionally, the MDS includes four OSPs each with gravity base foundations each with a diameter of 14m at the surface and a slab base 52.5m diameter at the bed. Associated scour protection extends from the slab base by 18.3m at a height of 2.6m giving rise to 6,236m^2 footprint per unit. The modelled scenario presented in volume 6, annex 6.1: Physical processes technical report of the PEIR used an alternate arrangement for the inclusion of the OSPs within the modelled scenario.

6.8.5.5 The parameters in terms of seabed footprint and water column obstruction are similar between each wind turbine unit, as modelled, and each of the four OSP units. Therefore, it is appropriate to infer the impacts on sediment transport due to each of the OSPs would be of the same extent and order of magnitude as those modelled wind turbine sites and to occur at the OSP locations.

6.8.5.6 Sediment transport is driven by a combination of tidal currents and wave conditions, the magnitude of these has been individually quantified as described above. For a 1in1 year storm from the north, during the flood tide the wave climate is in concert with tidal flow reducing the tidal flow on the lee side of the structure further. However, during the ebb flow, the wave climate and tidal flow are in opposition reducing the magnitude of the littoral current. With the presence of infrastructure, wave climate causes a small reduction in the magnitude of flow whilst there is little difference between the magnitude of littoral current flow and the tidal flows. Changes in magnitude compared to baseline current flow are ±5% which would not be sufficient to disrupt beach and offshore bank morphological processes or destabilise coastal features.

6.8.5.7 Residual currents are effectively the driver of sediment transport and therefore any changes to residual currents would have a direct impact on sediment transport which would persist for the lifecycle of the Mona Offshore Wind Project. However, if the presence of the foundation structures does not have a significant influence on either tide or wave conditions (see impact assessments presented above for changes in tidal and wave regime) they cannot therefore have a significant effect on the sediment transport regime. For completeness, the residual current and sediment transport was simulated with the foundations in place. The maximum change in residual current and sediment transport is circa ±10% which is largely sited within close proximity to the wind turbine foundation structures (i.e. as a result of the scour protection). Changes in the residual current and sediment transport reduce with increasing distance from the wind turbines towards baseline levels.

6.8.5.8 Cable installation in the intertidal region will be undertaken by trenching. This will be undertaken such that no additional material will be placed above the surface in this region which could potentially interfere with sediment transport pathways. In line with best practice cable burial depths are such that beach levels are maintained as detailed in volume 1, chapter 3: Project description of the PEIR. Similarly, it is anticipated that trenching to the required depth in areas of sandwaves and in the vicinity of sandbanks should achievable due to the nature of the sediment, with the reduced need for placement of material on the bed in these areas which may potentially reduce transport until pathways are re-established. Geophysical surveys have been carried out within the Mona Offshore Cable Corridor, and this additional data will be used to determine cable protection requirements, inform detailed design parameters and may be used to further validate numerical models.

6.8.5.9 The hydrodynamic regime is highly variable through tidal cycles and due to meteorological conditions, with the scale of the impact being well within the natural variation. The changes to tidal currents, wave climate, littoral currents, and sediment transport are insignificant in terms of the hydrodynamic regime and would not alter beach, sandbanks or reefs. Effects on tidal current and wave climate would be reversible on decommissioning (i.e. following removal of the wind turbine structures).

6.8.5.10 The impact is predicted to be of local spatial extent, long term duration, continuous and of high reversibility. It is predicted that the impact will affect the Menai Strait & Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank directly whilst affecting other receptors indirectly. The magnitude is therefore, considered to be **low** within the Menai Strait & Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank and **negligible** at coastal and intertidal receptors.

Sensitivity of receptor

6.8.5.11 Overlapping with the Mona Offshore Wind Project cable corridor, the Menai Strait & Conwy Bay SAC is designated for multiple qualifying features under Annex 1 of the EC Habitats Directive; sandbanks which are slightly covered by sea water all the time, mudflats and sandflats not covered by seawater at low tide and reefs. Due to the localised and limited changes in sediment transport the Menai Strait & Conwy Bay SAC features are of low vulnerability and recoverable. The sensitivity of this is therefore considered to be **low**.

6.8.5.12 Also overlapping with the Mona Offshore Cable Corridor is the Constable Bank which is not a designated site but supports sandbanks which are an Annex 1 habitat of the EC Habitats Directive. The changes to tidal regime due to the presence of infrastructure identified is localised therefore the sandbank is of low vulnerability and recoverable. The sensitivity of the receptor to changes in sediment transport as a result of the presence of infrastructure is therefore considered to be **low**.

6.8.5.13 Traeth Pensarn SSSI is designated on vegetated shingle beach and associated plant communities. Shingle ridges would recover from the changes in tidal regime due to the presence of infrastructure identified as localised therefore the shingle beach is of low vulnerability and recoverable. The sensitivity of the receptor to changes in sediment transport because of the presence of infrastructure is therefore considered to be **low**.

6.8.5.14 The Great Ormes Head SSSI contains a variety of features such as reefs (intertidal) and terrestrial habitats, vegetated sea cliffs, European dry heath, and semi-natural dry grassland. These rocky intertidal reefs would recover from changes in sediment transport due to the presence of infrastructure. The sensitivity of the receptor to changes in sediment transport due to the presence of infrastructure is therefore considered to be **negligible**.

6.8.5.15 Primarily designated on terrestrial habitats but the reef at the Little Ormes Head SSSI is described as geologically important for its Carboniferous stratigraphy. Reefs and the intertidal area would recover from changes in tidal regime from infrastructure as no changes reach Little Ormes Head. The sensitivity of the receptor to changes in sediment transport as a result of the presence of infrastructure is therefore considered to be **negligible**.

6.8.5.16 Bathing water quality is measured in terms of biological levels and due to the distance from the Mona Offshore Wind Project and potential influx of native sediment into the bathing waters of the intertidal zone the level of vulnerability would be low and recoverable. It is expected that the sensitivity of the receptor to changes in sediment transport is therefore considered to be **negligible.**

Significance of effect

6.8.5.17 Overall, the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **low**. Considering both a low magnitude of impact combined with a low sensitivity of the receptor coupled with the limited spatial extent of the effect will, therefore, be of **negligible** significance, which is not significant in EIA terms. For intertidal and coastal areas, the magnitude of impacts are **negligible** giving rise to effects of **negligible** significance.

Further mitigation and residual effects

6.8.5.18 No effects which are significant in EIA terms have been identified therefore further mitigation is not required.

Decommissioning

Magnitude of impact

6.8.5.19 Following decommissioning, changes to the sediment transport and sediment pathways would be of lesser magnitude than the operations and maintenance phase, as no structures would remain in the water column to influence the littoral currents above bed level, with only the colonised scour and cable protection remaining *in situ*.

6.8.5.20 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the Menai Strait & Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank directly whilst affecting other receptors indirectly. The magnitude is therefore, considered to be **low**.

Sensitivity of receptor

6.8.5.21 As with the reversal and removal of infrastructure, in response to localised changes in sediment transport, the Menai Strait & Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank is deemed to be of low vulnerability and recoverable. The sensitivity of this is therefore, considered to be **low**.

Significance of effect

6.8.5.22 Overall, the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **low**. Considering both a low magnitude of impact combined with a low sensitivity of the receptor coupled with the limited extent of the impact the effect will, therefore, be of **negligible** significance, which is not significant in EIA terms. For intertidal and coastal areas, the magnitude of impacts are **negligible** giving rise to effects of **negligible** significance.

Further mitigation and residual effects

6.8.5.23 No effects which are significant in EIA terms have been identified therefore further mitigation is not required.

6.8.6 Impacts to temperature and salinity stratification due to the presence of infrastructure.

6.8.6.1 Within the physical processes study area most of the water column remains thoroughly mixed due to the occurrence of sufficiently intense tidal mixing throughout the year. It has been noted that stratification of the water column can occur in estuaries and specifically in the Dee Estuary, as fresh water associated with river discharge is less dense than the saline offshore environment. In order to disrupt temperature and salinity stratification in the Dee Estuary a change in hydrography would be required in this region, an example being increased tidal currents or wave climate resulting in additional mixing.

6.8.6.2 The modelling studies undertaken for the Mona Offshore Wind Project detailed in volume 6, annex 6.1: Physical processes technical report of the PEIR demonstrated that potential changes in tidal currents and wave climate do not extend into these areas located beyond the physical processes study area therefore there will be no impact density and thermal stratification in the Dee estuary.

6.8.7 Future monitoring

6.8.7.1 No physical processes monitoring to test the predictions made within the impact assessment is considered necessary.

6.8.7.2 Overall, no effects which are significant in EIA terms have been identified therefore, in terms of physical processes, no specific monitoring is recommended beyond those related to undertaking maintenance activities outlined in the project description, volume 1, chapter 3: Project description of the PEIR. These include routine inspections of inter-array, interconnector and offshore export cables to ensure the cables are buried to an adequate depth and not exposed. We anticipate that geophysical surveys will be required as a condition of the marine licence(s).

6.9 Cumulative effect assessment methodology

6.9.1 Methodology

6.9.1.1 The CEA takes into account the impact associated with the Mona Offshore Wind Project together with other projects and plans. The projects and plans selected as relevant to the CEA presented within this chapter are based upon the results of a screening exercise (see volume 5, annex 5.1: CEA screening matrix of the PEIR). Each project has been considered on a case by case basis for screening in or out of this chapter's assessment based upon data confidence, effect-receptor pathways and the spatial/temporal scales involved.

6.9.1.2 The physical processes CEA methodology has followed the methodology set out in volume 1, chapter 5: EIA methodology of the PEIR. As part of the assessment, all projects and plans considered alongside the Mona Offshore Wind Project have been allocated into 'tiers' reflecting their current stage within the planning and development process, these are listed below.

6.9.1.3 A tiered approach to the assessment has been adopted, as follows:

- Tier 1
  - Under construction
  - Permitted application
  - Submitted application
  - Those currently operational that were not operational when baseline data were collected, and/or those that are operational but have an ongoing impact (for example, with associated maintenance activities)
- Tier 2
  - Scoping report has been submitted and is in the public domain
- Tier 3
  - Scoping report has not been submitted and is not in the public domain
  - Identified in the relevant Development Plan
  - Identified in other plans and programmes.

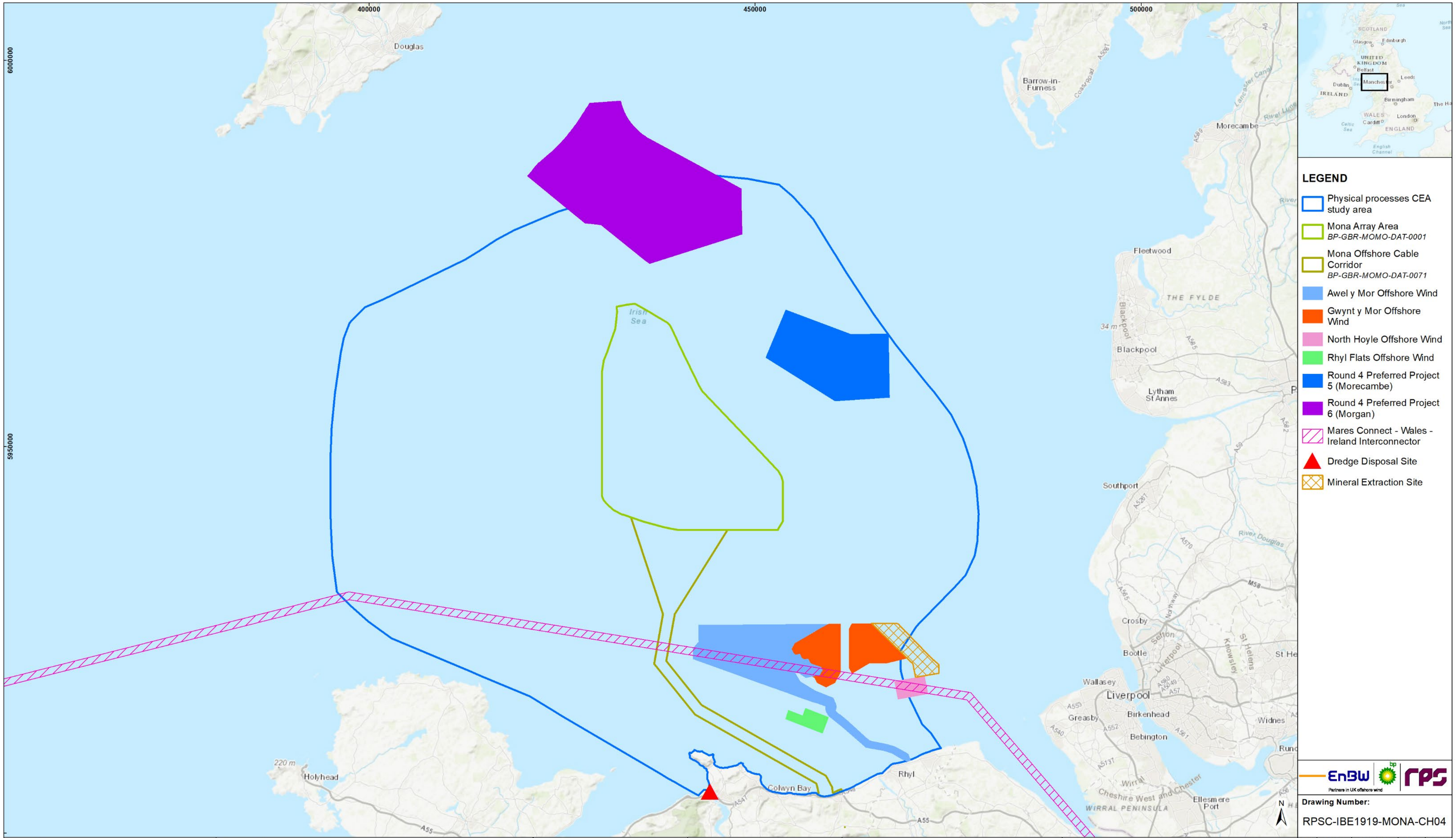
6.9.1.4 This tiered approach is adopted to provide a clear assessment of the Mona Offshore Wind Project alongside other projects, plans and activities.

6.9.1.5 The specific projects, plans and activities scoped into the CEA, are outline in Table 6.15. In accordance with The Planning Inspectorate advice, where other projects are expected to be completed before construction of the proposed NSIP and the effects of those projects are fully determined, effects arising from them are considered as part of the baseline and are considered as part of both the construction and operational assessment.

Table 6.15: List of other projects, plans and activities considered within the CEA.

Project/Plan	Status	Distance from the Mona array area (km)	Distance from the Mona Offshore Cable Corridor (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Mona Offshore Wind Project
Tier 1- Offshore Wind Projects and Associated Cables							
Awel y Môr offshore wind farm	Submitted	12.2	3.6	Awel y Môr Offshore Wind Farm	2026-2029	01/01/2030-01/01/2055	Project Construction Phase overlaps with Mona Offshore Wind Project Construction Phase. Project Operation and Maintenance Phase overlaps with Mona Offshore Wind Project Operation and Maintenance Phase.
Rhyl Flats offshore wind farm	Operational	23.3	3.8	Maintenance activities at Rhyl Flats Wind Farm Limited	N/A	04/06/2015-03/06/2034	Project Maintenance Phase overlaps with Mona Offshore Wind Project Construction and Operation and Maintenance Phases.
Gwynt y Môr offshore wind farm	Operational	13.8	9.9	Maintenance activities at Gwynt y Môr Offshore Wind Farm Limited	N/A	03/12/2008-03/12/2033	Project Maintenance Phase overlaps with Mona Offshore Wind Project Construction and Operation and Maintenance Phases.
North Hoyle offshore wind farm	Operational	24.7	13.6	Maintenance activities at North Hoyle Wind Farm Limited	N/A	01/01/2003-01/01/2028	Project Maintenance Phase overlaps with Mona Offshore Wind Project Construction Phase.
Subsea Cables (Telecommunications and Interlinks)							
MaresConnect	Permitted	14.7	0.0	MaresConnect is a proposed 750MW subsea and underground electricity interconnector system linking the electricity grids in Ireland and Great Britain.	2025-2027	2027 onwards	Project Construction Phase overlaps with Mona Offshore Wind Project Construction Phase.
Coastal Protection							
Llanddulas to Kinmel Bay coastal defence scheme	Pre-application	35.0	0.0	Coastal defence scheme	Unknown	Unknown	Unknown
Disposal Sites							
Conwy River	Operational	33.9	7.7	Dredging Activities and Dredge Disposal Sites	N/A	10/08/2022-10/08/2037	Project Operational Phase overlaps with Mona Offshore Wind Project Construction and Operation and Maintenance Phases.
Aggregate Extraction							
Hilbre Swash	Operational	14.5	20.1	Deposit and Removals	N/A	01/01/2015-31/12/2029	Project Operational Phase overlaps with Mona Offshore Wind Project Construction Phase.
Hilbre Swash marine minerals Area 393	Operational	17.1	17.2	Marine Aggregate Extraction	N/A	01/01/2014-01/01/2030	Project Operational Phase overlaps with Mona Offshore Wind Project Construction and Operation and Maintenance Phases.
Tier 2-Offshore Wind Projects and Associated Cables							
Morgan Generation Assets	Pre-application	5.5	33.0	Morgan Generation Assets	01/01/2028-31/12/2029	01/01/2030-31/12/2065	Project Construction Phase overlaps with Mona Offshore Wind Project Construction Phase. Project Operation and Maintenance Phase overlaps with Mona Offshore Wind Project Operation and Maintenance Phase.

Project/Plan	Status	Distance from the Mona array area (km)	Distance from the Mona Offshore Cable Corridor (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Mona Offshore Wind Project
Morgan/Morecambe Transmission Assets (scoping search area)	Pre-application	8.9	21.5	Morgan Transmission Assets	01/01/2028-31/12/2029	01/01/2030-31/12/2065	Project Construction Phase overlaps with Mona Offshore Wind Project Construction Phase. Project Operation and Maintenance Phase overlaps with Mona Offshore Wind Project Operation and Maintenance Phase.
Morecambe Offshore Wind Farm	Pre-application	8.9	21.5	Morecambe Offshore Wind Farm	01/01/2028-31/12/2029	01/01/2030-31/12/2065	Project Construction Phase overlaps with Mona Offshore Wind Project Construction Phase. Project Operation and Maintenance Phase overlaps with Mona Offshore Wind Project Operation and Maintenance Phase.



Project Name:	Drawing Title:	Geodetic Information:	Service Layer Credits:	VER	DATE	DETAILS	BY	CHECK
MONA OFFSHORE WIND PROJECT	PHYSICAL PROCESSES CEA STUDY AREA	Datum: ETRS 1989 Projection: ETRS 1989 UTM Zone 30N Scale@379mmx231mm: 1:500,000	Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community	02	17/11/22	Final ss	NRS	CN
				03	6/12/22	Final	NRS	CN

Figure 6.8: Other projects, plans and activities screened into the Mona Offshore Wind Project cumulative effects assessment for physical processes.

6.9.2 Maximum design scenario

6.9.2.1 The MDS identified in Table 6.16 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. The cumulative effects presented and assessed in this section have been selected from the Project Design Envelope provided in volume 1, chapter 3: Project description, of the PEIR as well as the information available on other projects and plans, in order to inform a ‘MDS’. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the Project Design Envelope (e.g. different wind turbine layout), to that assessed here, be taken forward in the final design scheme.

Table 6.16: Maximum design scenario considered for the assessment of potential cumulative effects on physical processes.

[a] C=construction, O=operations and maintenance, D=decommissioning

Potential cumulative effect	Phase[a]			Maximum Design Scenario	Justification
	C	O	D		
Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features.	✓	✓	✓	MDS as described for the Mona Offshore Wind Project Table 6.12 assessed cumulatively with the following other projects/plans: **Tier 1** **Construction Phase** • Proposed development of Awel y Môr Offshore Wind Farm • Maintenance of Rhyl Flats Wind Farm • Maintenance of Gwynt y Môr Offshore Wind Farm • Maintenance of North Hoyle Wind Farm • Construction of Mares Connect cable • Proposed development of Llanddulas to Kinmel Bay coastal defence scheme • Use of Conwy River disposal site • Operation of Hilbre Swash extraction • Operation of Hilbre Swash marine minerals Area 393. **Operations and Maintenance Phase** • Proposed development of Awel y Môr Offshore Wind Farm • Maintenance of Rhyl Flats Wind Farm • Maintenance of Gwynt y Môr Offshore Wind Farm • Proposed development of Llanddulas to Kinmel Bay coastal defence scheme • Use of Conwy River disposal site • Operation of Hilbre Swash marine minerals Area 393. **Decommissioning Phase** • Awel y Môr Offshore Wind Farm decommissioning structures • Rhyl Flats Wind Farm decommissioning structures • Gwynt y Môr Offshore Wind Farm decommissioning structures. **Tier 2** **Construction Phase** • Tier 1 Projects • Construction of Morgan Generation Assets • Construction of Morgan/Morecambe Transmission Assets • Construction of Morecambe Offshore Windfarm Generation Assets. **Operations and Maintenance Phase** • Tier 1 Projects • Operational and maintenance of Morgan Generation Assets • Operational and maintenance of Morgan/Morecambe Transmission Assets	Outcome of the CEA will be greatest when the greatest number of other schemes are considered in combination. Including schemes and developments within the CEA study area to capture the potential overlap of impacts during the construction, operations and maintenance and decommissioning phases. Activities from schemes that potentially increase suspended sediment concentrations during the temporal overlap with the Mona Offshore Wind Project phases have been included as these may create a cumulative impact on physical features/receptors.

Potential cumulative effect	Phase[a] C	O	D	Maximum Design Scenario	Justification
				• Operational and maintenance of Morecambe Offshore Windfarm Generation Assets. **Decommissioning Phase** • Morgan Generation Assets residual structures • Morecambe offshore wind farm residual structures.	
Impacts to the tidal regime due to presence of infrastructure and the associated potential impacts along adjacent shorelines.	✓	✓	✓	**Tier 1** **Construction Phase** • Proposed development of Awel y Môr Offshore Wind Farm. **Operations and Maintenance Phase** • Proposed development of Awel y Môr Offshore Wind Farm. **Decommissioning Phase** • Awel y Môr Offshore Wind Farm residual structures. **Tier 2** **Construction Phase** • Tier 1 Projects • Construction of Morgan Generation Assets • Construction of Morgan/Morecambe Transmission Assets • Construction of Morecambe Offshore Windfarm Generation Assets. **Operations and Maintenance Phase** • Tier 1 Projects • Operation and maintenance of Morgan Generation Assets • Operation and maintenance of Morgan/Morecambe Transmission Assets • Operation and maintenance of Morecambe Offshore Windfarm Generation Assets. **Decommissioning Phase** • Tier 1 Projects • Residual structures of Morgan Generation Assets • Residual structures of Morecambe Offshore Windfarm Generation Assets.	Outcome of the CEA will be greatest when the greatest number of other schemes are considered in combination. Including schemes and developments within the CEA study area to capture the potential overlap of impacts during the construction, operations and maintenance and decommissioning phases. Activities from schemes that potentially impact the tidal/wave regime and sediment transport during the temporal overlap with the Mona Offshore Wind Project phases have been included as these may create a cumulative impact on physical features/receptors.
Impacts to the wave regime due to presence of infrastructure and the associated potential impacts along adjacent shorelines.					
Impacts to sediment transport and sediment transport pathways due to presence of infrastructure and associated potential impacts to physical features and bathymetry.					

6.10 Cumulative effects assessment

6.10.1.1 A description of the significance of cumulative effects upon Physical Processes receptors arising from each identified impact is given below.

6.10.2 Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features.

6.10.2.1 Increased suspended sediment concentrations may arise due to seabed preparation involving sandwave clearance, the installation of the wind turbines and OSP foundations, the installation and/or maintenance of cables and associated decommissioning activities. Should the other projects cited take place concurrently with the Mona Offshore Wind Project (construction or operations and maintenance), there is potential for cumulative increased turbidity levels.

Construction phase

Magnitude of impact

6.10.2.2 The magnitude of the increase in suspended sediment concentrations arising from seabed preparation involving sandwave clearance, the installation of the wind turbines, OSP foundations and cables, has been assessed as low for the Mona Offshore Wind Project alone, as described in section 6.8. The greatest impacts are due to installation of the export cabling through the Constable Bank.

6.10.2.3 The construction phase of the Mona Offshore Wind Project may coincide with the maintenance activities associated with the Rhyl Flats Wind Farm, Gwynt y Môr Offshore Wind Farm and North Hoyle Wind Farm. Maintenance activities may result in increased suspended sediment concentration however, these activities would be of limited spatial extent and frequency and unlikely to interact with sediment plumes from the Mona Offshore Wind Project.

6.10.2.4 Also coinciding with the construction phase of the Mona Offshore Wind Project is the proposed development of Awel y Môr Offshore Wind Farm. Construction activities may result in increased suspended sediment concentration; however, these activities would be of limited spatial extent and frequency and unlikely to interact with sediment plumes from the Mona offshore array area. However, the Mona Offshore Cable Corridor runs adjacent to Awel y Môr array area and the cable corridors are parallel. Therefore, interaction of SSC plumes on spring tide events may occur should trenching activities be undertaken simultaneously however this is unlikely. SSC plumes would most likely reach background levels before overlapping with the Awel y Môr development area, when travelling on the flood tide as they would run in parallel. Resultant overlapping plumes may have increased suspended sediment concentrations between 2mg/l on the outer extent of the plume.

6.10.2.5 The cumulative impact assessment encompasses aggregate extraction at both Hilbre Swash licensed areas located within 14.5km of the Mona array area and 17.2km of the offshore cable corridor. Resultant plumes from the disposal of dredged material and extraction of aggregate would be advected on the tidal current running in parrallel and not coincide.

6.10.2.6 Similarly, the cumulative impact assessment considers sea disposal of dredged material at the Conwy River disposal site, located 33.9km and 7.7km from the Mona array area and Mona Offshore Cable Corridor respectively. If the offshore cable installation and dredge material dumping coincided both resultant plumes would be advected on the tidal currents, they would travel in parallel, and not towards one another, and are unlikely to interact if offshore cable installation coincides with the use of the licensed sea disposal site.

6.10.2.7 During the construction phase the Mares Connect cable will be in construction which may result in increased suspended sediment concentrations, the cable is located 14.7km from the Mona offshore array area and crosses the Mona Offshore Cable Corridor. As expected, the trenching activities for both projects will run concurrently and interaction of SSC plumes on spring tide events may occur. However, the concentration of suspended sediment reduces significantly moving further from the activity with levels of less than 10mg/l around 80km away therefore the potential overlap of resultant plumes would be low.

6.10.2.8 Construction phases may overlap between the Mona Offshore Wind Project and the proposed coastal defence scheme Llanddulas to Kinmel Bay. Construction activities coinciding would most likely not cause a cumulative increase in suspended sediment concentration as the coastal defence works are proposed to occur on the high water mark.

6.10.2.9 During the construction phase of the Mona Offshore Wind Project there is the potential for cumulative impacts with two proposed offshore wind farm installations (Morgan and Morecambe) including the transmission assets combined for Morgan/Morecambe wind farms. Construction activities may result in increased suspended sediment concentration; however, these activities would be of limited spatial extent and frequency and unlikely to interact with sediment plumes from the Mona Offshore Wind Project. As described in section 6.8.2, SSC plumes are localised to within the immediate vicinity of the construction activity and returning to background levels therefore travelling on the tide in parallel will most likely avoid interception of the most concentrated suspended sediment part of each plume.

6.10.2.10 The cumulative effect is predicted to be of local spatial extent, short term duration, intermittent and high reversibility. It is predicted that the impact will affect the Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

6.10.2.11 The Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank is deemed to be of low vulnerability and recoverable. The sensitivity of the receptor is therefore, considered to be low.

Significance of effect

6.10.2.12 Overall, the magnitude of the cumulative impact is deemed to be **low**, and the sensitivity of the receptor is considered to be **low**. The cumulative effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Operation and Maintenance phase

Magnitude of impact

6.10.2.13 The magnitude of the increase in suspended sediment concentrations arising from maintenance activities during operations and maintenance phase, has been assessed as negligible for the Mona Offshore Wind Project alone, as described in section 6.8.

6.10.2.14 The operations and maintenance phase of the Mona Offshore Wind Project may coincide with the maintenance activities associated with the Rhyl Flats Wind Farm and Gwynt y Môr Offshore Wind Farm. Maintenance activities may result in increased suspended sediment concentration however, these activities would be of limited spatial extent and frequency and unlikely to interact with sediment plumes from the Mona Offshore Wind Project maintenance activities. With resultant plumes from the Mona Offshore Wind Project being smaller in scale than during the construction phase potential cumulative impacts are less likely to occur during this operations and maintenance phase.

6.10.2.15 The cumulative impact assessment considers the proposed development of Awel y Môr Offshore Wind Farm potential maintanence for the wind farm coinciding with the operations and maintanence phase of Mona Offshore Wind Project. Maintenance activities are both intermittent and a smaller scale than that of the construction phase and therefore any potential cumulative impacts are less likely to occur and be on a smaller scale.

6.10.2.16 Potential cumulative impacts may relate to maintenance of offshore cables coinciding with the use of the Conwy River disposal site and aggregate extraction from Hilbre Swash. Maintenance activities are both intermittent and a smaller scale than that of the construction phase and therefore any potential cumulative impacts are less likely to occur and be on a smaller scale.

6.10.2.17 Operation and maintenance phase of the Mona Offshore Wind Project and the proposed construction of the coastal defence scheme Llanddulas to Kinmel Bay. Construction activities coinciding with the operations and maintenance phase of Mona Offshore Wind Project would most likely not cause a cumulative increase in suspended sediment concentration as the coastal defence works are proposed to occur on the high water mark.

6.10.2.18 The projects cited within the construction phase cumulative assessment will all be within the operational and maintenance phases therefore, as previously, maintenance activities may result in increased suspended sediment concentrations, however these activities would be of limited spatial extent and frequency. The cumulative impacts would therefore be of a lesser magnitude, (i.e. also negligible).

6.10.2.19 The cumulative effect is predicted to be of local spatial extent, short term duration, intermittent and high reversibility. It is predicted that the impact will affect the Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank directly. The magnitude is therefore, considered to be **negligible.**

Sensitivity of the receptor

6.10.2.20 The Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank is deemed to be of **low** vulnerability and recoverable. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

6.10.2.21 Overall, the magnitude of the cumulative impact is deemed to be **low**, and the sensitivity of the receptor is considered to be **low**. The cumulative effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Decommissioning phase

6.10.2.22 The magnitude of the increase in suspended sediment concentrations arising from decommissioning activities has been described in section 6.8 as having a lesser impact than the construction phase. The SSC would however increase temporarily as inter-array, interconnector and offshore export cables are retrieved and if suction caissons were removed using overpressure to release. The increase in suspended sediments and the potential impact on physical features may persist during decommissioning, however they are localised in nature.

6.10.2.23 Both the Rhyl Flats and Gwynt y Môr Offshore Wind Farms may be decommissioned on a similar time frame as the Mona Offshore Wind Project however as highlighted above any potential increase in SSC would be advected on tidal current running in parrallel and not overlap.

6.10.2.24 Residual structures remaining from the decommissioning of the Awel y Môr wind farm would not have a cumulative impact on suspended sediment concentrations.

6.10.2.25 Decommissioning of the Morecambe Offshore Wind Farm and Morgan Generation Assets will most likely occur on the same projected timeline as the Mona Offshore Wind Project. Decommissioning activity may result in increased suspended sediment concentrations however this would be localised and of a lesser magnitude than the construction phase.

6.10.2.26 If decommissioned prior to the Mona Offshore Wind Project, the residual infrastructure on the seabed would not cause a cumulative increase in suspended sediment concentration.

6.10.3 Impacts to the tidal regime due to presence of infrastructure and the associated potential impacts along adjacent shorelines.

6.10.3.1 The presence of infrastructure may lead to changes to the tidal regime and associated potential impacts along adjacent shorelines principally during the operations and maintenance phase of the Mona Offshore Wind Project. This impact is also relevant to the construction phase and following decommissioning associated with residual infrastructure.

Construction phase

6.10.3.2 Assessment of the Mona Offshore Wind Farm was carried out with and without the presence of infrastructure we can infer that during the construction phase there will be gradual changes to tidal regime. With changes occurring from the baseline environment (no presence of infrastructure) to the operational phase (MDS).

Operation and Maintenance phase

Magnitude of impact

6.10.3.3 The presence of infrastructure within the offshore wind farm area may lead to changes in tidal regime and the associated potential impacts along adjacent shorelines during the operations and maintenance phase of the Mona Offshore Wind Project. The magnitude of increased infrastructure leading to changes in the tidal regime during the operations and maintenance phase, has been assessed as low for the Mona Offshore Wind Project alone as described in section 6.8.

6.10.3.4 The proposed development of the Awel y Môr offshore wind farm comprising of 50 wind turbines may be in operation during the operations and maintenance phase of the Mona Offshore Wind Project. The Awel y Môr wind farm array is 12.2km from the Mona Array area and within the Mona offshore corridor (due to licensing permits). The modelling carried out for Mona Offshore Wind Project concluded that the impact on tidal regime was low when considering the development alone. Changes are observed in close proximity to the wind turbine structures with tides returning to baseline levels beyond the array area. Therefore, no overlap is expected to create cumulative changes in the tidal regime between the two wind farm developments.

6.10.3.5 The Mona Offshore Wind Project will not affect the proposed works at Llanddulas to Kinmel Bay and will not result in a cumulative impact on the tidal regime as the proposed rock revetment within the Mona Offshore Cable Corridor is to be constructed above the high water mark and there will be no changes the tide regime or water levels.

6.10.3.6 On similar project timelines, the construction and operation of both the Morecambe Offshore Windfarm Generation Assets and Morgan Generation Assets alongside the Morecambe/Morgan Transmission Assets are expected to coincide with the construction and operations and maintenance phase of the Mona Offshore Wind Project. The impact of Mona Offshore Wind Project on the tidal regime has been modelled on its own, with a low magnitude of impact discussed in section 6.8. As highlighted above the increase in infrastructure will not cause a cumulative change on the tidal regime as the impacts caused by the wind turbines are localised and return to baseline levels just beyond the infrastructure. An overlap of these changes in the tidal flow is not expected as they are limited to the array area.

6.10.3.7 The cumulative effect is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

6.10.3.8 The cumulative effects of the construction of the Awel y Môr offshore wind farm, operating and maintained concurrently does not further impact the Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank, more than a single development due to the impacts of infrastructure typically reserved to the vicinity of the developments.

6.10.3.9 The Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank is deemed to be of **low** vulnerability and recoverable. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

6.10.3.10 Overall, the magnitude of the cumulative impact is deemed to be **low**, and the sensitivity of the receptor is considered to be **low**. The cumulative effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

6.10.3.11 The presence of residual infrastructure within the offshore wind farm area may lead to changes in tidal regime the magnitude of which has been assessed as low for the Mona Offshore Wind Project alone as described in section 6.8.

6.10.3.12 With a similar lifespan to the Mona Offshore Wind Project, Awel y Môr wind farm may be or have been decommissioned during the decommissioning phase of Mona. Residual structures left on the seabed from decommissioning will not cause a cumulative impact on changes to the tidal regime and will result in a lesser magnitude of impact than that described in the operations and maintenance phase.

6.10.3.13 Morecambe Offshore Windfarm Generation Assets and Morgan Generation Assets have a similar lifespan to that of the Mona Offshore Wind Project therefore decommissioning activities could coincide. However, residual structures left on the seabed from decommissioning will not cause a cumulative impact on changes to the tidal regime and will result in a lesser magnitude of impact than that described in the operations and maintenance phase.

6.10.3.14 The cumulative effect is predicted to be of local spatial extent, long term duration and high reversibility. It is predicted that the impact will affect the Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank directly with a **low** magnitude and other receptors indirectly with **negligible** magnitude.

Sensitivity of the receptor

6.10.3.15 The cumulative effects of the decommissioning of the wind farm infrastructure from multiple offshore wind farm developments *in situ* does not further impact the Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank, more than a single development due to the impacts of decommissioning typically reserved to the vicinity of the developments.

6.10.3.16 The Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank is deemed to be of low vulnerability and recoverable. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

6.10.3.17 Overall, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

6.10.4 Impacts to the wave climate due to presence of infrastructure and the associated potential impacts along adjacent shorelines.

6.10.4.1 Introducing infrastructure may lead to changes to the wave regime and the associated potential impacts along adjacent shorelines principally during the operations and maintenance phase of the Mona Offshore Wind Project. Also, relevant to a lesser degree is the construction phase and following decommissioning associated with residual infrastructure.

Construction phase

6.10.4.2 Assessment of the Mona Offshore Wind Farm was carried out with and without the presence of infrastructure we can infer that during the construction phase there will be gradual changes to tidal regime. With changes occurring from the baseline environment (no presence of infrastructure) to the operational phase (MDS).

Operation and Maintenance phase

Magnitude of impact

6.10.4.3 The magnitude of changes in the wave regime has been assessed as low for the Mona Offshore Wind Project alone as described in section 6.8, with no influence on shoreline wave climate.

6.10.4.4 The proposed development of the Awel y Môr offshore wind farm comprising of 50 wind turbines may be in operation during the operations and maintenance phase of the Mona Offshore Wind Project. The Awel y Môr wind farm array is 12.2km from the Mona Array area. The modelling carried out for Mona Offshore Wind Project concluded that the impact on the wave regime was low when considering the development alone. Changes are observed in close proximity to the wind turbine structures with changes to wave climate decreasing rapidly with distance from the infrastructure. Under storm conditions from the north the change in wave climate due to the Mona Offshore Wind Project may extend to the limit of the Awel y Môr offshore wind farm however at this distance the change is diminutive (i.e. circa 0.2% reduction in significant wave height during a 1in20 storm from the north).

6.10.4.5 On similar project timelines, the construction and operation of both the Morecambe Offshore Windfarm Generation Assets and Morgan Generation Assets alongside the Morecambe/Morgan Transmission Assets are expected to coincide with the construction and operations and maintenance phase of the Mona Offshore Wind Project. The impact of Mona Offshore Wind Project on the wave regime has been modelled on its own, with a low magnitude of impact discussed in section 6.8. Morgan Generation Assets is located to the north of the Mona Offshore Wind Farm Project, whilst Morecambe Offshore Windfarm Generation Assets is located to the east.

6.10.4.6 Storms approaching from the south are limited in magnitude due to restricted fetch length therefore the changes in wave field do not extent to Morgan Generation Assets. However with storms approaching from the north Morgan offshore wind farm may influence the wave climate in the Mona Array Area to a small degree. The changes in wave climate due to storms from the southwest and west interacting with Mona Array infrastructure do not extend to the Morecambe site due to the influence Anglesea and the reduced number of wind turbine structures in the north of the Mona Array Area. The limited frequency and fetch length would reduce the likelihood of storms from the east giving rise to a change in wave climate in the Mona Array Area due to the presence of the Morecambe Offshore Windfarm Generation Assets.

6.10.4.7 The Mona Offshore Wind Project has no influence on shoreline wave climate therefore the proposed works at Llanddulas to Kinmel Bay will not result in a cumulative impact on the wave regime as the proposed rock revetment is to be constructed above the high water mark.

6.10.4.8 The cumulative effect is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank directly with a low magnitude and other receptors indirectly with **negligible** magnitude.

Sensitivity of the receptor

6.10.4.9 The cumulative effects of the presence of infrastructure from multiple offshore wind farm developments *in situ*, operating and maintained concurrently does not further impact the Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank, more than a single development due to the impacts of infrastructure typically reserved to the vicinity of the developments.

6.10.4.10 The Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank is deemed to be of **low** vulnerability and recoverable. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

6.10.4.11 Overall, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of negligible significance, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

6.10.4.12 With a similar lifespan to the Mona Offshore Wind Project, Awel y Môr wind farm may be or have been decommissioned during the decommissioning phase of Mona. Residual structures left on the seabed from decommissioning will not cause a cumulative impact on changes to the wave regime and will result in a lesser magnitude of impact than that described in the operations and maintenance phase.

6.10.4.13 Morecambe Offshore Windfarm Generation Assets and Morgan Generation Assets have a similar lifespan to that of the Mona Offshore Wind Project therefore decommissioning activities could coincide. However, residual structures left on the seabed from decommissioning will not cause a cumulative impact on changes to the wave regime and will result in a lesser magnitude of impact than that described in the operations and maintenance phase.

6.10.4.14 The cumulative effect is predicted to be of local spatial extent, long term duration and high reversibility. It is predicted that the impact will affect the Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank directly with a **low** magnitude and other receptors indirectly with **negligible** magnitude.

Sensitivity of the receptor

6.10.4.15 The cumulative effects of the decommissioning of the wind farm infrastructure from multiple offshore wind farm developments *in situ* does not further impact the designated sites or the adjacent shoreline, more than a single development due to the impacts of decommissioning typically reserved to the vicinity of the developments.

6.10.4.16 The Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank is deemed to be of **low** vulnerability and recoverable. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

6.10.4.17 Overall, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

6.10.5 Impacts to sediment transport and sediment transport pathways due to presence of infrastructure and associated potential impacts to physical features and bathymetry.

6.10.5.1 During the operations and maintenance phase the presence of infrastructure may alter the sediment transport and sediment transport pathways leading to changes in the Mona Offshore Wind Project area. The construction phase and following decommissioning associated with residual infrastructure is relevant but changes are gradual and to a lesser extent in these phases.

Construction phase

6.10.5.2 Assessment of the Mona Offshore Wind Farm was carried out with and without the presence of infrastructure we can infer that during the construction phase there will be gradual changes to sediment transport and sediment transport pathways. With changes occurring from the baseline environment (no presence of infrastructure) to the operational phase (MDS).

Operation and Maintenance phase

Magnitude of impact

6.10.5.3 The presence of Mona Offshore Wind Project infrastructure may lead to changes in sediment transport and sediment transport pathways during the operations and maintenance phase of the Mona Offshore Wind Project. The magnitude of changes in sediment transport and sediment transport pathways during the operations and maintenance phase, has been assessed as low for the Mona Offshore Wind Project alone as described in section 6.8.

6.10.5.4 The proposed development of the Awel y Môr offshore wind farm comprising of 50 wind turbines may be in operation during the operations and maintenance phase of the Mona Offshore Wind Project. The Awel y Môr wind farm array is 12.2km from the Mona Array area. The modelling carried out for Mona Offshore Wind Project concluded that the impact on sediment transport and sediment transport pathways was low when considering the development alone. Changes are observed in close proximity to the wind turbine structures with sediment transport returning to baseline levels beyond the array area. Therefore, no overlap is expected to create cumulative changes in the sediment transport and sediment transport pathways between the two wind farm developments.

6.10.5.5 The proposed works at Llanddulas to Kinmel Bay will not result in a cumulative impact on sediment transport and sediment transport pathways as the proposed rock revetment within the Mona Offshore Cable Corridor is to be constructed above the high water mark.

6.10.5.6 On similar project timelines, the construction and operation of both the Morecambe Offshore Windfarm Generation Assets and Morgan Generation Assets alongside the Morecambe/Morgan Transmission Assets are expected to coincide with the construction and operations and maintenance phase of the Mona Offshore Wind Project. The impact of Mona Offshore Wind Project on the sediment transport and sediment transport pathways has been modelled on its own, with a low magnitude of impact discussed in section 6.8. As highlighted above the increase in infrastructure will not cause a cumulative change on the sediment transport and sediment transport pathways as the impacts caused by the wind turbines are localised and return to baseline levels just beyond the infrastructure.

6.10.5.7 The cumulative effect is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank directly with a low magnitude and other receptors indirectly with **negligible** magnitude.

Sensitivity of the receptor

6.10.5.8 The cumulative effects of the presence of infrastructure from multiple offshore wind farm developments *in situ*, operating and maintained concurrently does not further impact the Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank, more than a single development due to the impacts of infrastructure typically reserved to the vicinity of the developments.

6.10.5.9 The Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank is deemed to be of **low** vulnerability and recoverable. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

6.10.5.10 Overall, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be **low**. The cumulative effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

6.10.5.11 With a similar lifespan to the Mona Offshore Wind Project, Awel y Môr wind farm may be or have been decommissioned during the decommissioning phase of Mona. Residual structures left on the seabed from decommissioning will not cause a cumulative impact on changes to the sediment transport and sediment transport pathways and will result in a lesser magnitude of impact than that described in the operations and maintenance phase.

6.10.5.12 Morecambe Offshore Windfarm Generation Assets and Morgan Generation Assets have a similar lifespan to that of the Mona Offshore Wind Project, however, residual structures left on the seabed from decommissioning will not cause a cumulative impact on changes to the sediment transport and sediment transport pathways and will result in a lesser magnitude of impact than that described in the operations and maintenance phase.

6.10.5.13 The cumulative effect is predicted to be of local spatial extent, long term duration and high reversibility. It is predicted that the impact will affect the Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank directly with a **low** magnitude and other receptors indirectly with **negligible** magnitude.

Sensitivity of the receptor

6.10.5.14 The cumulative effects of the decommissioning of the wind farm infrastructure from multiple offshore wind farm developments *in situ* does not further impact the Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank, more than a single development due to the impacts of decommissioning typically reserved to the vicinity of the developments.

6.10.5.15 The Menai Strait and Conwy Bay SAC features, Traeth Pensarn SSSI and Constable Bank is deemed to be of **low** vulnerability and recoverable. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

6.10.5.16 Overall, the magnitude of the cumulative impact is deemed to be **low**, and the sensitivity of the receptor is considered to be **low**. The cumulative effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

6.11 Transboundary effects

6.11.1.1 A screening of transboundary impacts has been carried out and has identified that there was no potential for significant transboundary effects with regard to physical processes from the Mona Offshore Wind Project upon the interests of other states.

6.12 Inter-related effects

6.12.1.1 Inter-relationships are considered to be the impacts and associated effects of different aspects of the proposal on the same receptor. These are considered to be:

- Project lifetime effects: Assessment of the scope for effects that occur throughout more than one phase of the Mona Offshore Wind Project (construction, operations and maintenance, and decommissioning), to interact to potentially create a more significant effect on a receptor than if just assessed in isolation in these three phases (e.g. subsea noise effects from piling, operational wind turbines, vessels and decommissioning)
- Receptor led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor. As an example, all effects on physical processes, such as sediment plumes, may interact to produce a different, or greater effect on this receptor than when the effects are considered in isolation. Receptor-led effects may be short term, temporary or transient effects, or incorporate longer term effects.

6.12.1.2 A description of the likely interactive effects arising from the Mona Offshore Wind Project on physical processes is provided in volume 2, chapter 15: Inter-related effects of the PEIR.

6.13 Summary of impacts, mitigation measures and monitoring

6.13.1.1 Information on physical processes within the physical processes study area was collected through detailed desktop review of existing studies and datasets and supported by numerical modelling.

- Table 6.17 presents a summary of the potential impacts, proposed measures adopted as part of the project and residual effects in respect to physical processes. The impacts assessed include:
  - Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features
  - Changes to tidal regime, wave climate and sediment transport due to presence of infrastructure and the associated potential impacts along adjacent shorelines.
- Overall, it is concluded that there will be no significant effects arising from the Mona Offshore Wind Project during the construction, operations and maintenance or decommissioning phases.
- Table 6.18 presents a summary of the potential cumulative impacts, proposed mitigation measures and residual effects. The cumulative impacts assessed include:
  - Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features
  - Changes to tidal currents, wave climate, littoral currents and sediment transport.
- Overall it is concluded that there will be no significant cumulative effects from the Mona Offshore Wind Project alongside other projects/plans
- No potential transboundary impacts have been identified in regard to effects of the Mona Offshore Wind Project.

Table 6.17: Summary of potential environmental effects, mitigation and monitoring.

[a] C=construction, O=operations and maintenance, D=decommissioning

Description of impact	Phase[a] C	O	D	Measures adopted as part of the project	Magnitude of impact	Sensitivity of the receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features.	✓	✓	✓	N/A	C: Low O: Negligible D: Low	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	Negligible	N/A
Impacts to the tidal regime due to presence of infrastructure and the associated potential impacts along adjacent shorelines.	✓	✓	✓	Scour Protection	C: Negligible O: Low D: Low	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	Negligible	N/A
Impacts to the wave regime due to presence of infrastructure and the associated potential impacts along adjacent shorelines.	✓	✓	✓	Scour Protection	C: Negligible O: Low D: Low	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	Negligible	N/A
Impacts to sediment transport and sediment transport pathways due to presence of infrastructure and associated potential impacts to physical features and bathymetry.	✓	✓	✓	Scour Protection	C: Negligible O: Low D: Low	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	Negligible	N/A

Table 6.18: Summary of potential cumulative environmental effects, mitigation and monitoring.

[a] C=construction, O=operations and maintenance, D=decommissioning

Description of effect	Phase[a]			Measures adopted as part of the project	Magnitude of impact	Sensitivity of the receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
	C	O	D							
Tier 1										
Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features.	✓	✓	✓	N/A	C: Low O: Negligible D: Low	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	Negligible	N/A
Impacts to the tidal regime due to presence of infrastructure and the associated potential impacts along adjacent shorelines.	✓	✓	✓	Scour Protection	C: Negligible O: Low D: Low	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	Negligible	N/A
Impacts to the wave regime due to presence of infrastructure and the associated potential impacts along adjacent shorelines.	✓	✓	✓	Scour Protection	C: Negligible O: Low D: Low	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	Negligible	N/A
Impacts to sediment transport and sediment transport pathways due to presence of infrastructure and associated potential impacts to physical features and bathymetry.	✓	✓	✓	Scour Protection	C: Negligible O: Low D: Low	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	Negligible	N/A
Tier 2										
Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features.	✓	✓	✓	N/A	C: Low O: Negligible D: Low	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	Negligible	N/A
Impacts to the tidal regime due to presence of infrastructure and the associated potential impacts along adjacent shorelines.	✓	✓	✓	Scour Protection	C: Negligible O: Low D: Low	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	Negligible	N/A
Impacts to the wave regime due to presence of infrastructure and the associated potential impacts along adjacent shorelines.	✓	✓	✓	Scour Protection	C: Negligible O: Low D: Low	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	Negligible	N/A
Impacts to sediment transport and sediment transport pathways due to presence of infrastructure and associated potential impacts to physical features and bathymetry.	✓	✓	✓	Scour Protection	C: Negligible O: Low D: Low	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	Negligible	N/A

6.14 Next steps

6.14.1.1 As part of the Mona Offshore Wind Project additional metocean monitoring and surveys are currently ongoing. These include further processing of geophysical surveys of the Mona Offshore Cable Corridor and particle size analysis of seabed sediment grab samples. Following completion of these surveys, the data collected will be reviewed to verify that assumptions made within the context of the physical process modelling and assessment are valid. For example, that seabed sediment classification and composition datasets derived from British Geological Survey geo-index applied in the desktop study are in line with survey samples collected. Similarly, any additional metocean data may be used to further validate numerical models.

6.14.1.2 The outcome of the analysis will be incorporated into the physical processes study and a revised assessment may be undertaken if necessary for the preparation of the physical processes chapter of the Environmental Statement.

6.15 References

ABPmer (2008) WebVision Atlas of UK Marine Renewable Energy Resources. Available: https://www.renewables-atlas.info/ Accessed June 2022.

ABPmer (2018) Data Explorer. Available: https://www.seastates.net/explore-data/ Accessed June 2022.

Barnes M.D. (2017) Guidance on EIS and NIS Preparation for Offshore Renewable Energy Projects, Report for the Environmental Working Group of the Offshore Renewable Energy Steering Group and the Department of Communications, Climate Action and Environment, Dublin: Department of Communications, Climate Action and Environment

BEIS (2021a) Draft overarching national policy statement for energy (EN-1), September 2021.

BEIS (2021b) Draft national policy statement for renewable energy infrastructure (EN-3), September 2021.

British Geological Survey (BGS) (2022). Sediment sample data. Available at https://mapapps2.bgs.ac.uk/geoindex_offshore. Accessed June 2022.

British Oceanographic Data Centre (BODC) (2021). UK tide gauge network. Available at: https://www.bodc.ac.uk/data/hosted_data_systems/sea_level/uk_tide_gauge_network/. Accessed 24 June 2022.

Brooks, AJ., Whitehead, PA. and Lambkin, DO. (2018). Guidance on Best Practice for Marine and Coastal Physical Processes Baseline Survey and Monitoring Requirements to inform EIA of Major Development Projects. NRW Report No: 243, 119 pp, Natural Resources Wales, Cardiff.

Centre for Environment, Fisheries and Aquaculture Science (Cefas) (2016). Suspended Sediment Climatologies around the UK, CEFAS. Available at: https://data.cefas.co.uk/view/18133. Accessed June 2022.

Centre for Environment, Fisheries and Aquaculture Science (Cefas) (2022). Wave data. Available at https://wavenet.cefas.co.uk/map. Accessed June 2022.

Cooper, W., Saulter, A. and Hodgetts, P. (2008). Guidelines in the use of metocean data through the lifecycle of a marine renewables development.

Department of Energy and Climate Change (DECC) (2011a) Overarching National Policy Statements for Energy (NPS EN-1). Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47854/1938-overarching-nps-for-energy-en1.pdf. Accessed June 2022

Department of Energy and Climate Change (DECC) (2011b) National Policy Statement for Renewable Energy Infrastructure. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47856/1940-nps-renewable-energy-en3.pdf. Accessed June 2022

Department of Energy and Climate Change (DECC) (2011c) National Policy Statements for Electricity Networks Infrastructure (NPS EN-5). Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47858/1942-national-policy-statement-electricity-networks.pdf. Accessed June 2022

Department of the Environment, Climate and Communications (2018). Guidance on Marine Baseline Ecological Assessments and Monitoring Activities for Offshore Renewable Energy Projects Parts 1 and 2. Available: https://www.gov.ie/en/publication/3d6efb-guidance-documents-for-offshore-renewable-energy-developers/ Accessed June 2022

Department for Environment Food and Rural Affairs (2022). Bathymetry and SSSI information. Available: https://environment.data.gov.uk/DefraDataDownload. Accessed June 2022.

European Centre for Medium-range Weather Forecast (ECMWF) (2022), Long term wind and wave datasets. Available: https://www.ecmwf.int/en/forecasts/datasets. Accessed April 2022

EMODnet (2022a). EODnet Bathymetry. Available: https://www.emodnet-bathymetry.eu/. Accessed June 2022.

EMODnet (2022b). EODnet Geology. Available: https://www.emodnet-geology.eu/. Accessed June 2022.

EMODnet (2022c). EODnet Geology. Available: https://www.emodnet-physics.eu/. Accessed June 2022.

EMU (2013) Irish Sea Zone, Hydrodynamic measurement campaign October 2010- October 2012. Data Marine Data Exchange Available: https://www.marinedataexchange.co.uk/ Report issued to Centrica Energy Renewable Investments. Accessed February 2022

Foster, P., Beardall, J., Voltolina, D., Savidge, G. (1985) The effects of wind, phytoplankton and density discontinuities upon ammonia distribution in Liverpool Bay. Estuarine, Coastal and Shelf Science, 20, 463-475.

Fugro (2022) Metocean Data Report, Morgan and Mona Offshore Wind Projects. Ref: 210674_190291-MDR-01 02

Gardline Ltd (2022) Integrated Offshore Wind Farm Site Survey. Document number: 11602.

GEMS (2011) Metocean data collection, Ormonde wind farm project. Report prepared for: Offshore Design Engineering Ltd Document number: GSL10108-FIN-001-01.

Haigh, I., Wadey, M., Gallop, S., Loehr, H., Nicholls, R., Horsburgh, K., Brown, J., Bradshaw, E. (2015) A user-friendly database of coastal flooding in the United Kingdom from 1915–2014, Scientific data 2 150021.

Highways England, Transport Scotland, Welsh Government, Department for Infrastructure (2019) Design Manual for Roads and Bridges (DMRB) LA 104, Environmental assessment and monitoring, Revision 1, Available: https://www.standardsforhighways.co.uk/prod/attachments/0f6e0b6a-d08e-4673-8691-cab564d4a60a?inline=true Accessed April 2022.

Howarth, M.J. (2005). Hydrography of the Irish Sea, SEA6 Technical Report, POLInternal document 174.

HR Wallingford, (2016). Review of aggregate dredging off the Welsh coast. Available: https://gov.wales/sites/default/files/publications/2018-05/review-of-aggregate-dredging-off-the-coast.pdf Accessed June 2022

Integrated Mapping for the Sustainable Developments of Ireland's Marine Resource (INFOMAR) (2022). Seabed mapping data Geological Survey Ireland (GSI) and Marine Institute. Available: http://www.infomar.ie/. Accessed February 2022.

JNCC (2022). Marine Protected Areas and Designations. Available: https://jncc.gov.uk/mpa-mapper/. Accessed June 2022.

Kenyon, N. and Cooper, B. (2005). Sand banks, sand transport and offshore wind farms.

Lambkin, D.O., Harris, J.M., Cooper, W.S. and Coates, T. (2009). Coastal Process Modelling for Offshore Wind Farm Environmental Impact Assessment. Collaborative Offshore Wind Energy Research into the Environment (COWRIE).

Marine Environmental Data Information Network (MEDIN) (2021). Bathymetry data. Available: https://data.admiralty.co.uk/portal/apps/sites/#/marine-data-portal. Accessed March 2022.

MMO, (2021). North West Inshore and North West Offshore Marine Plan, June 2021.

Mellett, C.L., Long, D. and Carter, G. (2015). Geology of the seabed and shallow subsurface: The Irish Sea. British Geological Survey. Available: https://nora.nerc.ac.uk/id/eprint/512352/ Accessed February 2022

Mona Offshore Wind Ltd (2023). Mona Offshore Wind Project: Consultation Report.

Natural Resources Wales, Marine Programming Planning and Delivery Group (20200.) Physical processes guidance to inform EIA baseline survey, monitoring and numerical modelling requirements for major development projects with respect to marine, coastal and estuarine environments, GN041.

National Network of Regional Coastal Monitoring Programmes (2022). Metocean data. Available at https://coastalmonitoring.org/cco/. Accessed June 2022.

National Oceanic and Atmospheric Administration (NOAA) (2022). Metocean data. Available at https://www.dhigroup.com/data-portals/metocean-data-portal. Accessed April 2022.

Price, D et al. (2010). Cell Eleven wave, tide and sediment study. Proceedings of the 2010 MIKE by DHI Modelling in a World of Change – Past Experiences & Future Challenges, Copenhagen.

Pye, K., Blott, S.J. and Brown, J. (2017). Advice to Inform Development of Guidance on Marine, Coastal and Estuarine Physical Processes Numerical Modelling Assessments. NRW Report No 208, 139pp, Natural Resources Wales.

Ramsar (2022). Designated sites. Available: https://rsis.ramsar.org/. Accessed July 2022.

The Environment Agency National LiDAR Programme (2022). LiDAR data. Available: https://www.data.gov.uk/dataset/f0db0249-f17b-4036-9e65-309148c97ce4/national-lidar-programmeAccessed May 2022.

The Planning Inspectorate (2022). Advice Note ten, Habitat Regulations Assessment relevant to Nationally Significant Infrastructure Projects. Version 8. Available: https://infrastructure.planninginspectorate.gov.uk/legislation-and-advice/advice-notes/advice-note-ten/. Accessed April 2022.

UKHO (2022). Admiralty Tide Tables – Volume 1B.

XOCEAN Ltd (2022). 00275-BPX-UKX-WIND bp Elizabeth Project Processing Report.