Partners in UK offshore wind

MONA OFFSHORE WIND PROJECT

Preliminary Environmental Information Report

Volume 3, chapter 16: Geology, hydrogeology and ground conditions

Image of an offshore wind farm

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Final

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RPS	**Mona Offshore Wind Ltd.**

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Glossary

Term	Meaning
Abstraction licence	The authorisation granted by the Environment Agency to allow the removal of surface water or groundwater.
Aquifer	A water-bearing geological unit that can yield economically viable amounts of groundwater.
Groundwater	Water that is contained in underground rocks and sediments below the ground surface.
Mona Proposed Onshore Development Area	The area of land to be temporarily or permanently occupied during the construction, operations and maintenance and decommissioning of the Mona Offshore Wind Project.
Source Protection Zone	Groundwater catchment areas defined by travel time around important potable groundwater abstraction sites to safeguard drinking water quality. Certain land-uses are controlled or prohibited with certain source protection zone areas.

Acronyms

Acronym	Description
BGS	British Geological Survey
BSI	British Standards Institute
CCBC	Conwy County Borough Council
CEA	Cumulative Effects Assessment
CIRIA	Construction Industry Research and Information Association
CoCP	Code of Construction Practice
DCC	Denbighshire County Council
DCO	Development Consent Order
DMRB	Design Manual for Roads and Bridges
EHO	Environmental Health Officer
GCR	Geological Conservation Review
GHGC	Geology, Hydrogeology and Ground Conditions
GPP	Guidance for Pollution Prevention
HDD	Horizontal Directional Drilling
LCRM	Land contamination risk management
LDP	Local Development Plan
mAOD	Meters Above Ordnance Datum
MDS	Maximum design Scenario
MHWS	Mean High Water Springs
MSA	Mineral Safeguarded Area
NNR	National Nature Reserves
NORA	NERC Open Research Archive
NPS	National Policy Statement
NRW	Natural Resources Wales
NSIP	Nationally Significant Infrastructure Project
PEIR	Preliminary Environmental Information Report
RIGS	Regionally Important Geological Sites
SPZ	Source Protection Zone
SSSI	Sites of Special Scientific Interest
WLGA	Welsh Local Government Association

Units

Unit	Description
%	Percentage
km^2	Square kilometres
m	Metres

16 Geology, hydrogeology and ground conditions

16.1 Introduction

16.1.1 Overview

16.1.1.1 This chapter of the Preliminary Environmental Information Report (PEIR) presents the assessment of the potential impact of the Mona Offshore Wind Project on geology, hydrogeology and ground conditions. Specifically, this chapter considers the potential impact of the Mona Offshore Wind Project landward of Mean High Water Springs (MHWS) during the construction, operations and maintenance, and decommissioning phases.

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

- Volume 3, chapter 17: Hydrology and flood risk of the PEIR
- Volume 3, chapter 18: Onshore ecology of the PEIR
- Volume 3, chapter 20: Land use and recreation of the PEIR.

16.1.1.3 This chapter draws upon information contained within volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR, which presents the desk-based information regarding geology, hydrogeology and ground conditions. The chapter also draws upon information in volume 7, annex 17.4: Water Framework Directive surface water and groundwater assessment of the PEIR.

16.1.2 Purpose of chapter

16.1.2.1 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 the 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.

16.1.2.2 The PEIR forms the basis for statutory consultation which will last for 47 days and conclude on 04 June 2023 as outlined in volume 1, chapter 1: Introduction 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.

16.1.2.3 In particular, this PEIR chapter:

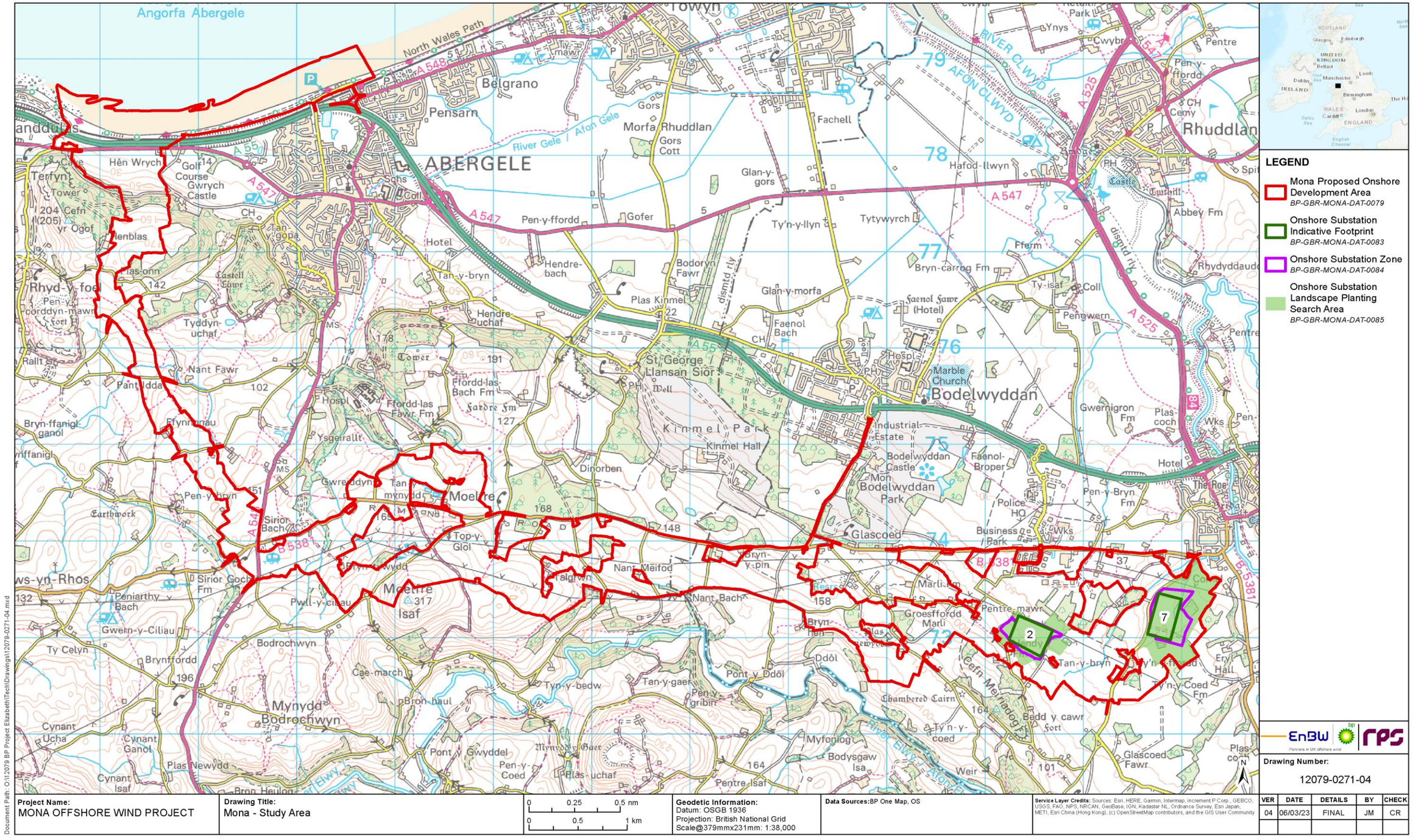
- Presents the existing environmental baseline established from desk studies, and consultation
- Identifies any assumptions and limitations encountered in compiling the environmental information
- Presents the potential environmental effects on geology, hydrogeology and ground conditions arising from the Mona Offshore Wind Project, based on the information gathered and the analysis and assessments undertaken.

16.1.3 Study area

16.1.3.1 The geology, hydrogeology and ground conditions study area, hereafter referred to as the GHGC study area, to be used for the assessment focuses on areas located above MHWS where potential impacts are most likely to occur on geological and hydrogeological receptors. As such, the GHGC study area includes:

- The area of land to be temporarily or permanently occupied during the construction, operations and maintenance and decommissioning of the Mona Offshore Wind Project (hereafter referred to as the Mona Proposed Onshore Development Area)
- Geological and hydrogeological receptors within 1km of the Mona Proposed Onshore Development Area. The 1km buffer was selected for the GHGC study area as potential impacts on hydrogeological receptors are likely to occur within this distance. Potential impacts on geological receptors may occur within a shorter distance, however a conservative approach has been followed and a consistent buffer has been applied for all receptors
- Ground condition constraints within the Mona Proposed Onshore Development Area.

16.1.3.2 The GHGC study area is shown in Figure 16.1. This area will be reviewed and modified in response to any refinements made to the Mona Proposed Onshore Development Area during the EIA process.



LEGEND

- Mona Proposed Onshore Development Area *BP-GBR-MONA-DAT-0079*
- Onshore Substation Indicative Footprint *BP-GBR-MONA-DAT-0083*
- Onshore Substation Zone *BP-GBR-MONA-DAT-0084*
- Onshore Substation Landscape Planting Search Area *BP-GBR-MONA-DAT-0085*

Project Name:	MONA OFFSHORE WIND PROJECT
Drawing Title:	Mona - Study Area
Drawing Number:	12079-0271-04
Geodetic Information:	Datum: OSGB 1936 Projection: British National Grid Scale@379mmx231mm: 1:38,000
Data Sources:	BP One Map, OS
Service Layer Credits:	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
04	06/03/23	FINAL	JM	CR

Figure 16.1: Mona GHGC study area.

16.2 Policy context

16.2.1 National Policy Statements

16.2.1.1 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 geology, hydrogeology and ground conditions, is contained in the Overarching National Policy Statement (NPS) for Energy (EN-1; DECC, 2011a), and the NPS for Electricity Networks Infrastructure (EN-5, DECC, 2011c).

16.2.1.2 NPS EN-1 includes guidance on what matters are to be considered in the assessment. These are summarised in Table 16.1 below. NPS EN-1 also highlights a number of factors relating to the determination of an application and in relation to mitigation. These are summarised in Table 16.2 below.

16.2.1.3 NPS-5 includes guidance on what matters are to be considered in the onshore assessment of electrical networks. These are summarised in Table 16.3 below. NPS EN-5 does not include any factors relating to the determination of an application and in relation to mitigation with regards to geology, hydrogeology or ground conditions.

16.2.1.4 Table 16.1 refers to the current NPSs, specifically NPS EN-1 (DECC, 2011a). If the NPSs are updated prior to the application for Development Consent, the revised NPSs will be fully considered in relation to geology, hydrogeology and ground conditions within the Environmental Statement.

Table 16.1: Summary of the NPS EN-1 provisions relevant to geology, hydrogeology and ground conditions.

Summary of NPS EN-1 provision	How and where considered in the PEIR
The Environmental Statement shall clearly set out any effects on internationally, nationally and locally designated sites of ecological or geological conservation importance (paragraph 5.3.3 of NPS EN-1).	The effects of the Mona Offshore Wind Project on designated geological sites are considered in section 16.8 of this chapter.
The Applicant should show how the project has taken advantage of opportunities to conserve and enhance biodiversity and geological conservation interest (paragraph 5.3.4 of NPS EN-1).	Mitigation measures relating to geology, hydrogeology and ground conditions are set out in section 16.7 of this chapter.
For developments on previously developed land, applicants should ensure that they have considered the risk posed by contamination (paragraph 5.10.8 of NPS EN-1).	The risks posed by land contamination are considered in qualitative assessment summarised in volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR, paragraph 16.4.5.69 to 16.4.5.80 of this chapter and Section 16.8.8 to Section 16.8.11 of this chapter.
Development should aim to avoid significant harm to biodiversity and geological conservation interests, including through mitigation and consideration of reasonable alternatives; where significant harm cannot be avoided, then appropriate compensation measures should be sought (paragraph 5.3.7 of NPS EN-1).	The Mona Proposed Onshore Development Area has been located to avoid significant harm to geological interests. The approach to site selection and consideration of alternatives is set out in volume 1, chapter 4: Site selection and consideration of alternatives of the PEIR.
The ES should describe: • the existing quality of waters affected by the proposed project and the impacts of the proposed project on water quality, noting any relevant existing discharges, proposed new discharges and proposed changes to discharges; • existing water resources affected by the proposed project and the impacts of the proposed project on water resources, noting any relevant existing abstraction rates, proposed new abstraction rates and proposed changes to abstraction rates (including any impact on or use of mains supplies and reference to Catchment Abstraction Management Strategies); • existing physical characteristics of the water environment (including quantity and dynamics of flow) affected by the proposed project and any impact of physical modifications to these characteristics; and • any impacts of the proposed project on water bodies or protected areas under the Water Framework Directive and source protection zones (SPZs) around potable groundwater abstractions (paragraph 5.15.3 of NPS EN-1)	Hydrogeological resources, groundwater abstractions and SPZs within the Mona GHGC study area are identified in volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR. Potential impacts on the environmental objectives of the Water Framework Directive are set out in volume 7, annex 17.4: Water Framework Directive surface water and groundwater assessment of the PEIR

Table 16.2: Summary of NPS EN-1 policy on decision making relevant to geology, hydrogeology and ground conditions.

Summary of NPS EN-1 and policy	How and where considered in the PEIR
"*In taking decisions, the [Secretary of State] should ensure that appropriate weight is attached to designated sites of international, national and local importance; protected species; habitats and other species of principal importance for the conservation of biodiversity; and to biodiversity and geological interests within the wider environment*." (paragraph 5.3.8 of NPS EN-1).	Designated sites and areas of geological interest are identified in volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR. The sensitivity assigned to these receptors is set out in Table 1.2 and Table 1.3 in volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR.
Development proposals provide many opportunities for building-in beneficial biodiversity or geological features as part of good design. When considering proposals, the Secretary of State should maximise such opportunities in and around developments, using requirements or planning obligations where appropriate (paragraph 5.3.15 of NPS EN-1)	Mitigation measures relating to geology, hydrogeology and ground conditions are set out in section 16.7 of this chapter.
Where a proposed development on land within or outside an Site of Scientific Interest (SSSI) is likely to have an adverse effect on an SSSI (either individually or in combination with other developments), development consent should not normally be granted. Where an adverse effect, after mitigation, on the site's notified special interest features is likely, an exception should only be made where the benefits (including need) of the development at this site, clearly outweigh both the impacts that it is likely to have on the features of the site that make it of special scientific interest and any broader impacts on the national network of SSSIs (paragraph 5.3.11 of NPS EN-1)	SSSIs of designated on the basis of geological, geomorphological interest or hydrogeological dependence are identified in volume 7, annex 16.1: Aquifer, groundwater abstractions and ground conditions of the PEIR and described in section 16.4.5. Potential impacts on those features are assessed in section 16.8 of this chapter.

Summary of NPS EN-1 and policy	How and where considered in the PEIR
The Secretary of State should give due consideration to such regional or local designations. However, given the need for new nationally significant infrastructure, these designations should not be used in themselves to refuse development consent (paragraph 5.3.13 of NPS EN-1).	Regionally designated sites of geological interest are identified in volume 7, annex 16.1: Aquifer, groundwater abstractions and ground conditions of the PEIR. Potential impacts on those features are assessed in section 16.8 of this chapter.
The Secretary of State should satisfy itself that a proposal has regard to the River Basin Management Plans and meets the requirements of the Water Framework Directive and its daughter directives, including those on priority substances and groundwater (paragraph 5.15.6 of NPS EN-1).	The potential adverse effects on groundwater as a result of the Mona Offshore Wind project (e.g. from an increased demand for water and discharges to water) are identified in section 16.8 of this chapter. The potential effects on surface watercourses and ecological habitats are set out in volume 3, chapter 17: Hydrology and flood risk, and chapter 18: Onshore ecology (respectively) of the PEIR. Potential impacts on the environmental objectives of the Water Framework Directive are set out in volume 7, annex 17.4: Water Framework Directive surface water and groundwater assessment of the PEIR.

Table 16.3: Summary of NPS EN-5 provisions relevant to geology, hydrogeology and ground conditions.

Summary of NPS EN-5 provision	How and where considered in the PEIR
Applicants should safeguard any mineral resources on the proposed site as far as possible, taking into account the long-term potential of the land use after any future decommissioning has taken place (paragraph 5.10.9 of NPS EN-1).	The Mona Proposed Onshore Development Area has been located to avoid significant harm to mineral resources where possible. The approach to site selection and consideration of alternatives is set out in volume 1, chapter 4: Site selection and consideration of alternatives of the PEIR.

16.2.2 Local Planning Policies

16.2.2.1 The assessment of potential changes to geology, hydrogeology and ground conditions has also been made with consideration to the specific policies set out in Adopted Local Development Plans (LDPs) of Conwy County Borough Council (CCBC) (adopted in October 2013) and Denbighshire County Council (DCC) (adopted in June 2013). Replacement LDPs are currently being drafted by CCBC and DCC and will be considered upon publication. Key provisions are set out in Table 16.4 along with details as to how these have been addressed within the assessment.

Table 16.4: Local Planning Policy of relevant to geology, hydrogeology and ground conditions.

Policy	Key provisions	How and where considered in the PEIR
Conwy County Borough Council: Adopted Local Development Plan (October 2013)		
Strategic Policy DP/1 – Sustainable Development Principles	Development will only be permitted where it is demonstrated that it is consistent with the principles of sustainable development. Development proposals should also where appropriate: h. Protect the quality of natural resources including water, air and soil in line with Strategic Policy NTE1.	Measures to protect groundwater resources from spillages and leakages during construction are defined within the Outline Code of Construction Practice (CoCP).
Strategic Policy NTE/1 – The Natural Environment	In seeking to support the wider economic and social needs of the Plan Area, the Council will seek to regulate development so as to conserve and, where possible, enhance the Plan Area's natural environment, countryside and coastline. This will be achieved by: a. Safeguarding the Plan Area's biodiversity, geology, habitats, history and landscapes through the protection and enhancement of sites of international, national, regional and local importance, in line with Policy DP/6 – National Planning Policy and Guidance' i. Preventing, reducing or remedying all forms of pollution including air, light, noise, soil and water, in line with Policy DP/6.	The Mona Proposed Onshore Development Area seeks to avoid harm to designated sites of geological interest. The approach to site selection and consideration of alternatives is set out in volume 1, chapter 4: Site selection and consideration of alternatives of the PEIR.
Strategic Policy MWS/1 – Minerals and Waste	The Council will ensure that there is sufficient provision of mineral resources and waste management facilities, while safeguarding the natural and built environment by: a. Safeguarding permitted reserves of hard rock at Penmaenmawr, Raynes (Llysfaen), Llanddulas and St George and additional resources of hard rock as identified on the proposals map in line with Policies MWS/2 – 'Minerals' and MWS/3 – 'Safeguarding Hard Rock and Sand and Gravel Resources' c. Designating buffer zones around quarries to protect amenity and ensuring that mineral operations are not unduly constrained by other land users in line with Policy MWS/4 – 'Quarry Buffer Zones' d. Safeguarding sand and gravel resources as identified on the proposals map in line with Policy MWS/3 h. Designating a landfill buffer zone around Llanddulas landfill site to ensure that only appropriate development in this location is	The location of the Mona Proposed Onshore Development Area seeks to avoid safeguarded mineral resources. The site selection process will continue to refine the area needed to support the construction of the Onshore Cable Corridor, 400kV Grid Connection Cable Corridor, Onshore Substation and associated infrastructure. The Llanddulas landfill site will be avoided by using trenchless cabling techniques as described in volume 1, chapter 3: Project description of the PEIR.

Policy	Key provisions	How and where considered in the PEIR
	permitted in line with Policy MWS/8 – 'Landfill Buffer Zone'.	
Denbighshire County Council: Adopted Local Development Plan (June 2013)		
Policy VOE 5 – Conservation of natural resources	Planning permission will not be granted for development proposals that are likely to cause significant harm to the qualifying features of internationally and nationally designated sites of nature conservation, priority habitats, priority species, regionally important geodiversity sites, or to species that are under threat.	The location of nationally and regionally important geological sites are identified in volume 7, annex 16.1: Aquifers, groundwater abstractions and conditions of the PEIR. The potential impacts to these sites of geological interest is set out section 16.8 of this chapter.
Policy PSE 15 - Safeguarding Minerals	High quality resources of minerals, including limestone, sand and gravel, Denbigh Gritstones, igneous and volcanic deposits will be safeguarded from development that would result in its permanent loss or hinder future extraction. Development will only be permitted where: 1. it can be demonstrated that the need for the development outweighs the need to protect the mineral resource; or 2. where such development would not have a significant impact on the viability of that mineral being worked; or 3. where the mineral is extracted prior to the development.	The location of the Mona Proposed Onshore Development Area seeks to avoid safeguarded mineral resources. The site selection process will continue to refine the area needed to support the construction of the Onshore Cable Corridor, 400kV Grid Connection Cable Corridor, Onshore Substation and associated infrastructure. The approach to site selection is set out in volume 1, chapter 4: Site selection and consideration of alternatives of the PEIR.
Policy PSE 16 - Mineral buffer zones	Sensitive development within buffer zones, as defined on the proposals map, will not be permitted unless it can be demonstrated that working has ceased and will not be resumed. Extensions to quarries will only be permitted where a suitable buffer can be retained, i.e. where such an extension would not cause other development to become part of a buffer, and where it can be demonstrated that there is no unacceptable impact on the environment or human health.	

16.3 Consultation

16.3.1.1 A summary of the key issues raised during consultation activities undertaken to date specific to geology, hydrogeology and ground conditions is presented in Table 16.5 below, together with how these issues have been considered in the production of this PEIR chapter.

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Table 16.5: Summary of key consultation issues raised during consultation activities undertaken for the Mona Offshore Wind Project relevant to geology, hydrogeology and ground conditions.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or were considered in this chapter
31 May 2022	Natural Resources Wales (NRW) Response to Scoping	NRW (A) note that there are Source Protection Zones (SPZs) at Trofarth Farm and Llannerch Park.	The location and extent of these SPZs have been identified. The SPZs do not fall within the Mona GHGC study area.
31 May 2022	NRW Response to Scoping	Contaminated land is mentioned within the Scoping Report. NRW (A) remind the applicant that both contaminated land as statutorily defined contaminated land under Part 2A of the Environmental Protection Act 1990, or land affected, and land affected by contamination (as often associated with brownfield sites) that needs to be dealt with through planning, should be scoped in. It should be noted that there is Wales specific guidance on land contamination. Please refer to Land Contamination: a guide for developers 9WLGA, 2017) for the type of information that NRW (A) required in order to assess risks to controlled waters from the site.	Potential areas of contaminated land have been considered in volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR, paragraphs 16.4.5.69 to 16.4.5.80 of this chapter and section 16.8.8 to section 16.8.10 of this chapter. The Wales-specific guidance has been considered throughout this chapter.
31 May 2022	NRW Response to Scoping	NRW (A) note that impacts proposed to be scoped out of the project include spillages. NRW (A) advise that further information with regards to the operational aspects should be provided to clarify how spillages have been ruled out, for example, will refuelling ever be necessary? Will the cable be fluid filled?	An CoCP will set out the measures for controlling spillages and leaks during construction. Further information will be provided post statutory consultation regarding the design of the Onshore Substation and operational measures that will be put in place.
31 May 2022	NRW Response to Scoping	NRW (A) agree with the proposed 1km receptor buffer [to be used in the assessments] based on the available information. NRW (A) concur that dependant on specific activities it is proposed the 1km receptor buffer may need to be changed, e.g. if a large groundwater abstraction or dewatering activity is proposed.	Noted. The buffer area will be kept under review until the requirements for abstractions and dewatering have been confirmed.
01 June 2022	CCBC Response to Scoping	The Environmental Statement should address the impact of the construction, operation and decommissioning phases on mineral resources, including permitted reserves and other mineral resources safeguarded in the Local Development Plan.	Mineral safeguarded areas are considered in section paragraphs 16.4.5.24 to 16.4.5.25 of this chapter and section 16.8.4 of this chapter
15 June 2022	Planning Inspectors Response to Scoping	The Inspectorate has queried the proposed methodology to rely on desk-based data. It considers that limiting the approach to desk study only may not provide sufficient baseline information to inform the assessment. The Applicant is advised to discuss and agree the need for intrusive site investigation with NRW and the relevant local authority.	The site selection process to refine the Mona Proposed Onshore Development Area is ongoing. Once the Onshore Cable Corridor and 400kV Grid Connection Cable Corridor have been refined and the location of the Onshore Substation has been confirmed, discussions will be held with NRW and the local Environmental Health Officers (EHOs) regarding any need for intrusive investigations.

16.4 Baseline environment

16.4.1 Methodology to inform baseline

16.4.1.1 The baseline environment for geology, hydrogeology and ground conditions has been principally defined through a desktop study that reviews the following:

- Publicly available data sources available from the following organisations:
  - British Geological Survey (BGS)
  - Natural Resources Wales (NRW)
  - Conwy County Borough Council (CCBC)
  - Denbighshire County Council (DCC)
  - Coal Mining Authority
- Information contained in a Groundsure Enviro-Geo Insights report for the GHGC study area. That report includes:
  - General information regarding geological, hydrogeological and hydrological setting
  - Groundwater abstraction licences
  - Current and historical landfill sites
  - Current and historical waste sites
  - Pollution incidents
  - Discharge consents
  - Current and historical land-use
  - Mining and ground working areas (coal and non-mining)
  - Geotechnical constraints
- Historical Ordnance Survey mapping and some aerial photography.

16.4.1.2 The key datasets obtained as part of the desktop study are presented in volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR. Following the refinement of the Mona Proposed Onshore Development Area post statutory consultation, this desk-based information will be augmented by information relating to private groundwater abstractions, site walkovers (where appropriate) and intrusive surveys (as required subject to consultation with NRW and the EHOs).

16.4.2 Desktop study

16.4.2.1 Information on geology, hydrogeology and ground conditions within the GHGC study area was collected through a detailed desktop review of existing studies and datasets. These are summarised in Table 16.6 below.

Table 16.6: Summary of key desktop reports.

Title	Source	Year	Author
Geological Viewer	BGS Map Viewers	-	British Geological Survey
Geoindex (Onshore)	BGS Map Viewers	-	British Geological Survey
Sheet 95, Rhyl, Solid alongside Drift, 1:63 360	BGS Maps Portal	1970	British Geological Survey
Sheet 107, Denbigh, Solid and Drift, 1:50 000	BGS Maps Portal	1985	British Geological Survey
Warren, P.T., Price, D., Nutt, M.J.C. and Smith, E.G. 1984. Geology of the country around Rhyl and Denbigh. Mem. Br. Geol. Surv., sheets 95 and 107.	BGS Memoir Portal	1984	British Geological Survey
Aquifer designation – bedrock	NRW interactive map of data about the natural environment	-	National Resources Wales
Aquifer designation – superficial deposits	NRW interactive map of data about the natural environment	-	Natural Resources Wales
The physical properties of major aquifers in England and Wales	NERC Open Research Archive (NORA)	1997	British Geological Survey (Allen, D J, Brewerton, L J, Coleby, L M, Gibbs, B R, Lewis, M A, MacDonald, A M, Wagstaff, S J, and Williams, A T.)
The physical properties of minor aquifers in England and Wales	NERC Open Research Archive (NORA)	2000	British Geological Survey (Jones, H K, Morris, B L, Cheney, C S, Brewerton, L J, Merrin, P D, Lewis, M A, MacDonald, A M, Coleby, L M, Talbot, J C, McKenzie, A A, Bird, M J, Cunningham, J, and Robinson, V K.)
Groundwater vulnerability	NRW interactive map of data about the natural environment and GeoIndex Onshore	-	Natural Resources Wales and BGS
Groundwater safeguard zones	NRW interactive map of data about the natural environment	-	Natural Resources Wales
BGS Hydrogeology Map: Map No. 19, Clwyd and Cheshire Basin, 1:100,000	BGS Scans Viewer	1989	British Geological Survey
WFD groundwater bodies (Cycle 2)	Lle Geo-Portal for Wales. Spatial Dataset	-	Partnership between Welsh Government and Natural Resources Wales
WFD river water bodies (Cycle 2)	Lle Geo-Portal for Wales. Spatial Dataset	-	Partnership between Welsh Government and Natural Resources Wales
Geological Conservation Review (GCR) sites	Lle Geo-Portal for Wales. Spatial Dataset	-	Partnership between Welsh Government and Natural Resources Wales

Title	Source	Year	Author
Regionally Important Geological and Geomorpholgical Sites (RIGS)	Lle Geo-Portal for Wales. Spatial Dataset	-	Partnership between Welsh Government and Natural Resources Wales
Protected Sites (Sites of Scientific Interest, Special Areas of Conservation)	Lle Geo-Portal for Wales. Spatial Dataset; NRW interactive map of data about the natural environment and Groundsure Enviro-Geo Insights Report	-	Partnership between Welsh Government and Natural Resources Wales
Main Rivers in Wales	Lle Geo-Portal for Wales. Spatial Dataset	-	Partnership between Welsh Government and Natural Resources Wales
Groundsure Enviro-Insights Report including historical maps	Groundsure	2022	Produced by Groundsure on the basis of dataset sets relevant to the Environment and Ground Conditions.

16.4.3 Identification of designated sites

16.4.3.1 All designated sites within the GHGC 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 GHGC study area were identified using a number of sources. These sources included the Lle Geo-Portal for Wales - Spatial Dataset; NRW interactive map of data about the natural environment and Groundsure Enviro-Geo Insights Report
- Step 2: Information was compiled on the relevant geology and hydrogeological qualifying interests 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 Proposed Onshore Development Area
  - A designated site was considered potentially to have hydraulic continuity with the Mona Proposed Onshore Development Area and could potentially be affected.

16.4.4 Site specific surveys

16.4.4.1 No site-specific surveys have been undertaken to inform the baseline conditions reported in the PEIR.

16.4.5 Baseline environment

Hydrology and topography

16.4.5.1 The Mona GHGC study area is situated in the surface water catchment of four NRW Main Rivers (see volume 7, annex 17.2: Surface watercourses and NRW flood zones of the PEIR):

- Afon Elwy, that defines the south and east boundary to the GHGC study area up to its confluence with Afon Clwyd
- Afon Clwyd, that flows north to its mouth at Rhyl
- Afon Dulas, that flows north to its mouth between Llanddulas and Abergele, defining the west boundary to the study area
- Afon Gele, a short watercourse that flows north onto the low-lying, drained, coastal marshes between Abergele and the mouth of Afon Clwyd.

16.4.5.2 There are also several small watercourses within the GHGC study area many of which discharge to the Main Rivers. Ordnance Survey mapping also identifies many small ponds and water bodies, most notably at low elevation at the east end of Mona Proposed Onshore Development Area. These hydraulically isolated ponds are situated upon low permeability glacial till. Further information on surface watercourses can be found within chapter 18: Hydrology and flood risk of the PEIR.

16.4.5.3 Topography within the GHGC study area is depicted in Figure 16.1 and is dominated by two areas of high ground. The north ridge of high ground that extends southeast away from the coast at Llanddulas up to Bryn-y-Pin on the B5381 to the south of Bodelwyydan. This ridge of high ground passes behind Abergele and forms the inland boundary of the low-lying land between Abergele and the mouth of Afon Clwyd. Elevations along this ridge are typically below 200m above Ordnance Datum (AOD) but include the pronounced peak of Cefn yr Ogof and local summits at Gopa Wood and Tower Hill.

16.4.5.4 To the south of this north ridge, there is an area of high ground that extends approximately west to east on either side of Afon Elwy. This south area of high ground is more elevated than the north ridge with peak elevations that commonly exceed 250m AOD and reaching a maximum height of 317m AOD at Moelfry Isaf.

16.4.5.5 The Mona Proposed Onshore Development Area rises over the north ridge high ground, from the point of coastal landfall. Topography rises steeply to a maximum height of 180m AOD.

16.4.5.6 South of the north ridge, the Mona Proposed Onshore Development Area crosses an undulating area with an elevation of between 120m AOD and 160m AOD. The Mona Proposed Onshore Development Area crosses the A548 at an elevation of approximately 155m AOD and travels east to the Mona Onshore Substation options and National Grid connection at Bodelwyddan. East of the A548, the Mona Proposed Onshore Development Area either follows lower lying land along the B5381 to Moelfre or ascends the north flank of Moelfre Isaf, reaching a maximum elevation of approximately 290m AOD. East of Bryn-y-pin the Mona Proposed Onshore Development Area follows a local ridge of high ground up to Glascoed. East of Glascoed, topography declines towards the east end of the Mona Proposed Onshore Development Area at 40m AOD. The east end of the Mona Proposed Onshore

Development Area is located approximately 475m west of the Afon Elwy which has an elevation of between 10 and 20m AOD.

Geology

16.4.5.7 A summary of the regional geological sequence is provided in Table 16.7 and presented in Figure 1.1 and Figure 1.2 of volume 7, annex 16.1: Aquifers, groundwater abstraction and ground conditions of the PEIR.

Bedrock

16.4.5.8 The bedrock in this area of North Wales gets progressively younger from the southwest to the northeast. The oldest bedrock comprises a thick sequence of silty mudstones and subordinate sandstones of the Elwy Formation. These rocks are often disturbed and are highly fractured and faulted. This Silurian bedrock dips to the northeast, becoming overlain by the Ffernant Formation (formerly Carboniferous Basement Beds).

16.4.5.9 The Ffernant Formation is of Carboniferous age and is composed of red and purple silty mudstones, siltstones and sandstones with conglomerates. The Ffernant Formation is overlain by a thick sequence of Carboniferous limestones of the Clwyd Limestone Group. This group comprises a diverse range of limestones, with subordinate sandstone and mudstone units. Further, to the northeast the Carboniferous limestones are overlain by predominantly red, brown or purple-grey sandstone, siltstone and mudstone sequence of the Warwickshire Group. The entire Carboniferous bedrock sequence is significantly fractured and faulted.

16.4.5.10 The youngest bedrock in the regional sequence is Permo-Triassic sandstone of the Kinnerton Sandstone Formation. This bedrock lies outside of the GHGC study area.

16.4.5.11 As shown in Figure 1.1 of volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR, the Mona Proposed Onshore Development Area travels south for approximately 1.7km across the Carboniferous limestones of the Clwyd Limestone Group. These limestones form the first ridge of high ground that passes behind Abergele. These limestones are karstic in nature, with cave development in many places, most notably around Cefn yr Ogof.

16.4.5.12 The GHGC study area then crosses a thin band of the Carboniferous Ffernant Formation before passing onto Silurian mudstones of the Elwy Formation. The Elwy Formation underlies the south area of high ground that includes Moelfre Isaf. The Mona Proposed Onshore Development Area is situated above the mudstones of the Elwy Formation for approximately 7km before crossing back on to the Clwyd Limestone Group in the east, at a point near Bryn-y-Pin Mawr on the B5381 where topography begins to decline.

16.4.5.13 Finally, the GHGC study area passes onto sandstones of the Carboniferous Warwickshire Group at a point near St Asaph business park. The Warwickshire Group underlies the final 2km of the GHGC study area including the Mona Onshore Substation options; with the southwest corner of Onshore Substation option 2 underlain by the Clwyd Limestone Group.

Table 16.7: Regional geology and hydrogeological classification for the GHGC study area.

Greyed out rows denote geological units that do not underlie the Mona GHGC study area but are part of the regional sequence.

***** Geological descriptions and indicative unit thicknesses have been taken from the BGS Lexicon of Named Units or the BGS Memoir for the area (Warren *et al*., 1983).

# Denotes superficial deposits of minor importance within the Mona GHGC study area

Era	Group	Formation	Description*	Thickness*	Aquifer designation (NRW)	BGS hydrogeological description
Superficial geology						
Quaternary	Tidal Flat Deposits		Tidal flat deposits, including mud flat and sand flat deposits. They consist of unconsolidated sediment, mainly mud and/or sand	-	Secondary Undifferentiated	Not described
	Marine Beach Deposits		Shingle, sand, silt and clay; may be bedded or chaotic; beach deposits may be in the form of dunes, sheets or banks; in association with the marine environment.	-	Secondary A	Not described
	Storm Beach Deposits		A low rounded ridge of coarse materials (gravels, cobbles and boulders) piled up by very powerful storm waves at the inland margin of a beach, above the level reached by normal spring tides.	-	Secondary A	Not described
	Glacial Till (Devensian)		Unconsolidated mixed deposit consisting of a heterogenous mixture of clay, sand, gravel, and boulders varying widely in size and shape	-	Secondary Undifferentiated	Not described
	Glaciofluvial Deposits#		Unconsolidated material by glacial river waters and consisting of boulders, gravel, sand, silt and clay from ice sheets or glaciers.	-	Secondary A	Not described
	Alluvium#		Sorted/Semi-sorted clay, silt, sand and gravel deposited by a river, stream or other body of running water.	-	Secondary A	Not described
	Head Deposits		Poorly sorted and poorly stratified, angular rock debris and/or clayey hillwash and soil creep. Can comprise gravel, sand and/or clay.	-	Secondary Undifferentiated	Not described
	River Terrace Deposits		Sand and gravel, locally with lenses of silt, clay or peat.		Secondary A	Not described
Bedrock geology						
Permo-Triassic	Sherwood Sandstone Group	Kinnerton Sandstone Formation	Sandstone, red-brown to yellow, generally pebble-free, fine- to medium-grained, cross-stratified.	Can be > 150m	Principal	Highly productive aquifer. Significant intergranular flow. Sandstone, with some conglomerates, aquifer yielding up to 25 L/s in Eden and Clwyd valleys
Carboniferous	Warwickshire Group		Predominantly red, brown or purple-grey sandstone, siltstone and mudstone, some grey strata, coals not common, local conglomerates, localised beds of limestone.	Up to 1200m	Secondary A	Not described
	Clwyd Limestone Group		Diverse range of limestone facies with subordinate sandstone and mudstone units.	Up to 900m	Principal	Moderately productive aquifer. Flow is virtually all through fractures and other discontinuities. Massive karstic limestone aquifer with rapid response to rainfall. Yields highly variable from dry to 40 L/s
	Not Applicable	Ffernant Formation (formerly the Carboniferous Basement Beds)	Red, purple and variegated silty mudstones, siltstones and sandstones with lenticular bodies of conglomerate.	Up to 330m	Secondary A	Not described
Silurian	Not Applicable	Elwy Formation	Silty mudstones and subordinate sandstones with lateral facies changes.	>1750m	Secondary B (Sandstones horizons Secondary A)	Low productivity aquifer. Flow is virtually all through fractures and other discontinuities. Highly indurated argillaceous rocks with limited groundwater.

Superficial deposits

Glacial till and glaciofluvial deposits

16.4.5.14 With the exception of the Mona Landfall, the superficial geology within the GHGC study area is dominated by glacial till. The BGS geological memoir for the area describes the glacial till in fresh exposures as consisting of '*a stiff, steel grey to blue black clay with numerous pebbles and boulders*' (Warren *et al*., 1984). Warren *et al*. (1984) also states there is evidence that the upper 2m to 3m of the till can occur as a friable yellow clay with angular stones more numerous pebbles on boulders. Geological logs for the area around Abergele and Bodelwyddan commonly describe the glacial till as a red clay that can exceed 4.4m in depth (Warren *et al*., 1984).

16.4.5.15 Glacial till occurs as either:

- Thin patches on relatively high ground
- Extensive till deposits with a relatively smooth surface filling low ground, with a thickness of up to 30m in the main valleys
- As 'drumlins' and associated glacial structures which have a height of up to 3m (see Figure 1.2 of volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR).

16.4.5.16 As can be seen in Figure 1.2 of volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR, almost the entire Mona Proposed Onshore Development Area is shown to be underlain by glacial till, except for:

- 'Windows' where superficial deposits are absent, most notably at summit of local high ground along the north ridge of high ground and Moelfre Isaf in the south
- Small areas of glaciofluvial deposits associated with the glacial till
- Localised areas alluvial deposits where the Mona Proposed Onshore Development Area crosses small surface watercourses.

16.4.5.17 Glacial till is most continuous and is likely to be thickest in the east half of the Mona Proposed Onshore Development Area where elevations decline towards the onshore substation sites. In general, the glacial till can be expected to be a relatively thick, cohesive, clay-rich deposit.

16.4.5.18 As shown in Figure 1.2 of volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR, several drumlin features are located partially or wholly within the GHGC study area. Drumlins are low, oval or elongated mounds or small hills consisting of compacted till that were formed by the movement of glacial ice. These glacial features have no formal designation.

16.4.5.19 Small areas of glaciofluvial deposits are found in association with the glacial till. Warren *et al*. (1984) describe the glaciofluvial deposits as being either:

- Irregular, mound-like patches of ill-sorted, poorly bedded or unbedded gravel (and sand) overlying bedrock or till
- Flattish spreads of generally cross-bedded sands and gravels.

16.4.5.20 It can be seen in Figure 1.2 of volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR, that glaciofluvial deposits are rare within the GHGC study area and of limited extent.

Marine beach deposits and storm beach deposits

16.4.5.21 Marine beach deposits are present along the coastline within the GHGC study area including the Mona Landfall site at Llanddulas. Warren *et al*. (1984) describes present day marine beach deposits as consisting of sand, with some mud and shingle.

16.4.5.22 Storm beach deposits fringe the marine beach deposits at the Mona Landfall, forming a raised bar along the beach with a height above MHWS. In this area the coarse beach gravels are described as being up to 10cm in diameter.

Local geological records

16.4.5.23 The expected geological sequence within the Mona GHGC study area has been corroborated using borehole records on the BGS GeoIndex Onshore platform. The geological logs for eleven boreholes and one mine audit identified within the Mona GHGC study area are provided in Appendix A of volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR, wherein their location is shown in Figure 1.1 and Figure 1.2. These logs demonstrate:

- There are no publicly available borehole records for the Silurian bedrock (Elwy Formation) within the Mona GHGC study area
- Glacial till is thick in the east and northeast where it is continuous and can exceed 30m in depth
- The glacial till is often red or reddish, particular in the east
- In the west, where elevations are highest, the composition and thickness of superficial deposits is more variable. Sand and gravel are more common and the superficial deposits are commonly thinner than seen in east.

Mineral safeguarding areas

16.4.5.24 The Carboniferous bedrock of the Clwyd Limestone Group is designated a Mineral Safeguarded Area (MSA) for limestone in the adopted Local Development Plans (LDPs) of CCBC and DCC. As shown in Figure 1.1 of volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR, the east and west ends of the Mona Proposed Onshore Development Area are situated above the Clwyd Limestone Group and associated MSA. In these areas the limestone is largely concealed beneath glacial till, except where windows in the glacial till expose the bedrock at high elevation.

16.4.5.25 River Terrace Deposits, principally present within the valley of the Afon Elwy are also designated a MSA for sand and gravel by CCBC and DCC. Given the Mona Proposed Onshore Development Area does not cross this MSA and it is located at a lower topographic elevation, these sand and gravel minerals resources are not considered further.

Quarrying and mining

Current operations

16.4.5.26 No active mining operations have been identified within the GHGC study area.

16.4.5.27 St George Quarry (also known as Parc-y-meirch Quarry) is an active limestone quarry located approximately 2.5km southeast of Abergele, Conwy. It is one of CCBC's three working quarries: it has planning permission until 2035 and predominantly serves northeast Wales. CCBC has defined a 200m buffer zone around the quarry to reduce potential conflicts between land uses.

16.4.5.28 The south tip of the quarry and the buffer zone extend into the GHGC study area, however, the Mona Proposed Onshore Development Area is located outside this buffer zone and is underlain by Silurian bedrock of the Elwy Formation. On this basis, St George Quarry is not considered further in this assessment.

16.4.5.29 No active quarries or quarry buffer zones were identified in the GHGC study area in the DCC planning area.

Historical operations

16.4.5.30 The Coal Authority confirmed the absence of coal mining in the GHGC study area in their response to the Mona Scoping Report (The Planning Inspectorate, 2022).

16.4.5.31 The BGS geological memoir for Rhyl and Denbigh does, however, identify widespread historical mining, most notably of lead, zinc, copper and iron ores (Warren *et al*., 1984). Further information regarding mining is also provided in *The Non-Ferrous Mines of Denbighshire* report (Foster-Smith, 1972). Within the GHGC study area this mineralisation is associated with the Carboniferous bedrock and is often closely related to faulting of the Carboniferous limestone and Carboniferous Basement Beds (i.e. the Ffernant Formation). Warren *et al*. (1984) identified the following historical mines within the GHGC study area:

- Cefn yr Ogof (NGR SH 917 773) lead and zinc mine
- Castell Cawr lead and zinc mines:
  - Extensive working of veins crossing the north end called Ffos-y-Bleiddiaid (NGR SH 936 766)
  - Workings on south edge, on the long abandoned Tyddyn Morgan Mine (NGR SH 937 764)
- Nant Uchaf Mine (NGR SH 934 760) - Southwest of Abergele (Lead, Zinc, Iron and Manganese)
- Bodelwyddan Mine (NGR SH 997 749) – A lead and zinc mine that was active between 1851 and 1858; it was abandoned in 1859
- Score Mine (NGR SH 993 737) also known as Cefn Mine. A lead and zinc mine that was abandoned in 1851
- Coed-Carreg-Dafydd lead mine (NGR SH 995 733)
- Pant y Celyn Lead Mine (NGR SJ 013 727) also known as Coed Celyn Mine.

16.4.5.32 The location of these historical mines are shown in Figure 1.6 of volume 7, annex 16.1: Aquifer, groundwater abstractions and ground conditions of the PEIR and are all associated with the limestone of the Clwyd Limestone Group or the underlying Ffernant Formation. These mines are all comparatively deep and are associated with the disused shafts commonly identified on Ordnance Survey mapping obtained for the area.

16.4.5.33 There is little detailed information regarding these historical mines, except for Bodelwyddan Mine that was obtained from BGS borehole records for borehole SJ07NW94. Although situated to the north of the Mona Proposed Onshore Development Area, those records confirm the extent and depth of the worked mineral veins and the location of historical shafts. The records also confirm that there has been historical monitoring of groundwater levels and groundwater discharge from the now flooded sections of the mine.

16.4.5.34 The mining dataset provided in the Groundsure Enviro-Geo report is presented Figure 1.6 of volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR. The dataset includes:

- Non-coal mining areas – Areas where there is the potential for historical non-coal mining to have affected an area, based on expert knowledge, literature and the Digital Geological Map of Britain. These zones are classified on the basis of the likelihood of mining and the following data has been presented:
  - Zone D, underground mining is known or considered likely to have occurred within or close to the area
  - Zone E, underground mining is known to have occurred within or very close to the area
- British Pits (BritPits) – BGS database of closed and active surface and underground mineral workings.

16.4.5.35 Based on the BGS reporting and the Groundsure Enviro-Geo Insights report dataset, four areas that may be affected by historical mining have been identified in the Mona Proposed Onshore Development Area. These areas are situated in the east and west, where the Mona Proposed Onshore Development Area is underlain by Carboniferous bedrock of the Clwyd Limestone Group or Ffernant Formation, and include:

- The area located within the Mona GHGC study area between Cefn yr Ogof and Gwrych Castle (approximately 0.75km south of the Mona Landfall). It includes disused shafts identified on Ordnance Mapping towards the top of the coastal high ground. These features are likely to relate to the Cefn yr Ogof mine and is situated above limestones of the Clwyd Limestone Group
- The area approximately 1km east of the GHGC study area around Castell Cawr and is the site of the Ffos-y-Bleiddiaid mine. This area is situated above limestones of the Clwyd Limestone Group
- An area 800m east of the GHGC study area and approximately 2.1km south of the Mona Landfall that includes many features associated with the Nant Uchaf Mine. This area is situated above the Ffernant Formation
- The area located around Glascoed and Cefn Meiriadog (approximately 2km south of Bodelwyddan and 3.5km from the east end of the GHGC study area).

This area includes the Score (Cefn) Mine and Coed-Carreg-Dafydd Mine and is situated above limestones of the Clwyd Limestone Group.

16.4.5.36 The presence of historical deep mining does have implications with respect to geotechnical considerations and may potentially affect soil quality principally through the disposal of mine wastes and tailings. Areas (1) and (4) are considered relevant to the GHGC study area.

16.4.5.37 In addition to the historical deep mining, many small surface quarries have been identified within the GHGC study area from historical mapping,. These sites are typically small, old and commonly associated with local limestone extraction. Although former quarries do represent potential sites for uncontrolled waste disposal, these sites are considered to represent a low risk given small size and old age. As such they have not be evaluated in any further detail for the PEIR but may examined further following the completion of site walkovers and as part of detailed design.

Hydrogeology

Aquifer units

16.4.5.38 Aquifers in Wales are classified by NRW and the BGS (British Geological Survey, 2022) on the following basis:

- Principal aquifer – the geological unit that provides significant quantities of water and can support water supply and/or baseflow to rivers, lakes and wetlands on a strategic scale. They typically have a high intergranular and/or fracture permeability meaning they usually provide a high level of water storage
- Secondary A aquifer – the geological unit that provides modest amounts of water, but the nature of the rock or the aquifer's structure limits their use. They support water supplies at a local rather than strategic scale (such as for private supplies) and remain important for rivers, wetlands and lakes
- Secondary B aquifer – Dominated by lower permeability layers that may store and yield limited amounts of groundwater
- Secondary (undifferentiated) aquifer - Where it is not possible to apply either a Secondary A or B definition because of the variable characteristics of the rock type, but generally have only a minor resource value
- Unproductive strata - These rocks have negligible significance for water supply or baseflow to rivers, lakes and wetlands. They consist of bedrock or superficial deposits with a low permeability that naturally offer protection to any aquifers that may be present beneath.

16.4.5.39 Aquifer classifications for bedrock and superficial geology within the GHGC study area are summarised in Table 16.7 and shown in Figure 1.3 and Figure 1.4 in volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions respectively. Table 16.7 also provides the BGS hydrogeological description for each bedrock unit.

16.4.5.40 With regards to superficial geology, the majority of the GHGC study area is underlain by glacial till which is classified a Secondary (Undifferentiated) aquifer unit. Given its clay-rich nature and low permeability, groundwater will be restricted to localised granular lenses or layers in the glacial till which do not typically form significant groundwater bodies. As its aquifer classification suggests, localised groundwater within the glacial till is not considered to be of significant resource value. The majority of the Mona Proposed Onshore Development Area and both of the Onshore Substation options are underlain by the Secondary (Undifferentiated) aquifer.

16.4.5.41 Granular glaciofluvial deposits, found in association with the glacial till in the west, can form locally important groundwater bodies and are classified as a Secondary A aquifer unit. The importance of these aquifers is, dependent on their thickness and the lateral extent of these deposits. The extent of these deposits in the GHGC study area is limited. The local geological records in Appendix A of volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR provide little detail regarding the glaciofluvial deposits, however BGS geological maps show these deposits extend to less than 0.07km^2 within the Mona Proposed Onshore Development Area.

16.4.5.42 The Silurian bedrock of the Elwy Formation is overlain by till in areas of high ground in the south and central areas of the GHGC study area. The mudstones and siltstones that dominate the Elwy Formation have little intergranular porosity or permeability. Groundwater in this formation is restricted to fractures and faults or associated with zones of weathering, typically at shallow depth. The possible presence of groundwater in shallow weathered Elwy Formation can be seen by shallow wells and springs on OS mapping, the latter commonly marking the contact between the exposed bedrock and glacial till. The Elwy Formation does contain some localised groundwater bearing sandstones units and these can support small domestic supplies (BGS, 1989), although these are located outside of the GHGC study area. The Elwy Formation is classified a Secondary B aquifer unit reflecting its low permeability and the fact groundwater is typically of little resource importance.

16.4.5.43 The most important aquifers within the GHGC study area are associated with the carboniferous bedrock that underlies the GHGC study area in the northwest and east. Limestones of the Clwyd Limestone Group are classified as a Principal Aquifer, suggesting significant groundwater can be obtained from this unit. However, these karstic limestones are unpredictable in terms of their permeability distribution with a low storage potential. As stated by Jones *et al*. (2000), these limestones have minimal primary porosity or permeability with groundwater storage and movement restricted to solution enlarged fractures. As these fractures are not regularly spaced, nor extensively interconnected, failure to intersect a water-bearing fracture commonly results in a dry or very low yielding borehole. Jones *et al*. (2000) also, state that discharge from the fractured limestone systems occurs at a small number of large springs with high (albeit seasonally variable) flow rates. No large springs have been identified in the Mona GHGC study area. It can be concluded that groundwater levels in the limestones will therefore, be variable, but are likely to be at considerable depth beneath areas of high ground.

16.4.5.44 The underlying mudstones, siltstones and sandstone of the Ffernant Formation are classified a Secondary A aquifer unit, reflecting their potential to be of local resource importance. Similarly, the overlying sandstones, siltstones and mudstones of the Warwickshire Group are classified a Secondary A aquifer unit. The sandstones of the Warwickshire Group are groundwater bearing, however Warren *et al*. (1984) state that these sandstones are well cemented giving them very low permeability. They also state the principal significance of the upper carboniferous bedrock sequence is to hydraulically separate the Carboniferous limestones from the overlying Permo-Triassic aquifers. The Mona Onshore Substation options are underlain by this

Secondary A aquifer unit; with the southwest corner of Onshore Substation option 2 underlain by a Principal Aquifer associated with the Clwyd Limestone Group

16.4.5.45 The BGS borehole records provided in Appendix A of volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR confirmed the following:

- Where present, groundwater in the limestone aquifer of the Clwyd Limestone Group is located at significant depth beneath areas of high ground
- The hydraulic properties of the limestone aquifer of the Clwyd Limestone Group are spatially variable and can be unproductive where groundwater bearing fissures and fractures are not present (See BGS Ref. SH97NW91)
- The absence of borehole records for Silurian bedrock (Elwy Formation) area suggests the Elwy Formation is not important with respect to water resources. This also reflects its designation as a Secondary B aquifer.

Groundwater occurrence across the GHGC study area

16.4.5.46 The west end of the GHGC study area crosses Marine Beach Deposits and a ridge of Storm Beach Deposits. These predominantly granular deposits will contain groundwater at shallow depth. The groundwater contained in the marine beach deposits will be saline and non-potable.

16.4.5.47 Groundwater will be situated at greater depth beneath the ridge of Storm Beach Deposits. Given its coastal setting, this groundwater is likely to brackish or saline in nature, although a small surface lens of fresher water may have developed above more saline waters beneath.

16.4.5.48 The west end of the GHGC study area passes onto low-lying glacial till immediately south of the A55. The till is likely to be thick in this low-lying area, with localised groundwater occurrence possible at shallow depth. In this area, the till conceals limestone of the Clwyd Limestone Formation. Groundwater levels in this limestone aquifer are uncertain, but likely to approach sea level.

16.4.5.49 On the north ridge of high ground between Cefn yr Ogof and Gopa wood, the GHGC study area is situated above glacial till except around the local summits that are formed of Carboniferous bedrock of the Clwyd Limestone Group. The till will be of a variable thickness, often shallow, and localised groundwater bodies may be encountered. BGS borehole records (in Appendix A of volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR) show unconfined groundwater to be present at considerable depth in the Clwyd Limestone Group aquifer in this area.

16.4.5.50 To the south, the Silurian bedrock may contain some groundwater in shallow fractures or a surface weathered zone. However, this groundwater will be of limited extent and little resource value. Much of the GHGC study area is underlain by glacial till, with small windows of exposed bedrock. Localised areas of groundwater may be present at shallow depth. Small areas of glaciofluvial deposits are present in association with the glacial till in this area. Although glaciofluvial deposits can contain groundwater, geological mapping suggests that these water bodies will be of small extent and limited resource value in the GHGC study area.

16.4.5.51 The south part of the GHGC study area, from the crossing of the A548 to the end of the Mona Proposed Onshore Development Area, is almost entirely underlain by glacial till. BGS borehole records confirm that the till thickens towards the east, becoming more continuous as topographic elevation declines. In the area to the north of Moelfre Isaf, the till within the GHGC study area includes multiple drumlins. These features form locally thicker mounds of glacial till.

16.4.5.52 Across the south and east parts of the GHGC study area, bedrock is concealed beneath glacial till potentially exceeding 30m in places. The bedrock aquifers include limestone of Clwyd Limestone Group and sandstones of the Warwickshire Group aquifer. In the east, at lower topographic elevation, groundwater in these bedrock aquifers is likely to be confined by the overlying till and would only be encountered at significant depth. Given that the bedrock aquifers in this area will ultimately discharge to low-lying local surface watercourses it is considered unlikely that artesian groundwater conditions will be encountered in these confined aquifer units.

Water Framework Directive Groundwater Bodies

16.4.5.53 The GHGC study area crosses three groundwater bodies defined for the Water Framework Directive (Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy) (WFD). These groundwater bodies and their status is summarised in Table 16.8 and shown within volume 7, annex 17.4: Water Framework Directive surface water and groundwater assessment of the PEIR.

Table 16.8: Summary of WFD groundwater bodies within the GHGC study area.

* Water Framework Directive (WFD) groundwater body status determined for Cycle 2 (2014-2019)

Reference	Name	Position in GHGC study area	Overall status*	Quantitative status*	Chemical status*
GB41001G202100	Clwyd Permo-Triassic Sandstone	Northeast of the first ridge of high ground immediately south of Llanddulas and Abergele	Good	Good	Good
GB41002G200100	Clwyd Silurian	Southwest of the first ridge of high ground immediately south of Llanddulas and Abergele. West of the A458.	Good	Good	Good
GB41002G203000	Conwy	Southwest of the first ridge of high ground immediately south of Llanddulas and Abergele. East of the A458.	Poor	Good	Poor

16.4.5.54 The Clwyd Permo-Triassic Sandstone and Clwyd Silurian groundwater bodies currently have good status (2019). The Conwy groundwater body has poor overall status, which relates to the assessment of its chemical status in relation to the 'groundwater impacts on surface water' test.

Licensed groundwater abstractions

16.4.5.55 Fourteen licensed groundwater abstraction sources were identified in the GHGC study area. Those abstractions are shown in Figure 1.3 and Figure 1.4. of volume 7, appendix 16.1: Aquifer, groundwater abstractions and ground conditions of the PEIR.

16.4.5.56 The licensed abstraction sources are situated above the Principal aquifer of the Clwyd Limestone Group or the Secondary A sandstone aquifer of the Warwickshire Group. All but one licensed abstraction source is situated 0.66km or more from the Mona Proposed Onshore Development Area. The only exception is source GWA_02 which is located within 50m of the Mona Proposed Onshore Development Area, although that borehole is recorded as being a historical abstraction source.

16.4.5.57 Only abstraction sources GWA_06 and GWA_07 are active. Both are situated in the north of St Asaph, approximately 950m northeast of the Mona Proposed Onshore Development Area and immediately west of the Afon Elwy. These sources are located above bedrock of the Warwickshire Group. These licensed abstractions are located a significant distance from the east end of the Mona Proposed Onshore Development Area. The abstractions are presumed to be down-hydraulic gradient from the Mona Onshore Substation option 7 as they are located at a low elevation relative to the Mona Proposed Onshore Development Area and are adjacent to the Afon Elwy. The Afon Elwy represents the local receptor for groundwater.

Private groundwater abstractions

16.4.5.58 Ordnance Survey mapping (1:25,000 scale) identifies multiple 'wells' across the GHGC study area, most notably in areas of high elevation that are underlain by the Silurian bedrock and commonly overlain by glacial till. The highest density of 'wells' fringe the north side of Moelfre Isaf, at comparatively high elevations of between 180m to 250m AOD. Nine of these wells are located within or adjacent to the Mona Proposed Onshore Development Area. Although there are no licensed abstractions in the low permeability Silurian bedrock, the presence of these wells suggest small private abstractions may be relatively common and the water is accessible.

16.4.5.59 The survey of private groundwater abstractions within the GHGC study area is yet to be undertaken. This survey and the associated abstraction source risk assessment shall be completed for inclusion in the Environmental Statement.

Groundwater and historical mining

16.4.5.60 The physical properties of minor aquifers in England (BGS, 2000) confirms that mines were historically worked around Abergele and St Asaph. Information obtained during mining and the driving of drainage tunnels indicate that rock structures largely control the seaward movement of groundwater (Richards, 1959). Seven of the eight historical mines recorded by BGS, discussed in section 16.4.5.31 are located within the Clwyd Limestone Group. Subsequently, the rock structures influencing groundwater flow will be characteristic of karstic hydrogeological flow regimes. Studies have shown that variation in limestone permeability result in highly variable groundwater levels, which can result in the so-called 'chessboard and staircase' drainage pattern of Smith (1921).

16.4.5.61 Gravity drainage was used in lead-zinc mines, with several schemes involving drainage tunnels (know as adits) undertaken since 1818. These adits encountered many natural solution caverns. By providing zones of high permeability the drainage tunnels and shafts also affected natural flow systems of the area. Flows from drainage tunnels can be substantial, for example a discharge of approximately 2,900m^3/day was recorded from an adit at Bodelwyddan on 19 May 1998 [NGR SJ 0048 7506]. Information provided with the BGS geological records for a borehole at Bodelwyddan Mine (BGS Ref. SJ07NW94) in Appendix 1 of volume 7, annex 16.1: Aquifers, groundwater abstraction and ground conditions of the PEIR, confirmed the historical monitoring of groundwater and groundwater discharge from the now flooded sections of the mine.

16.4.5.62 It is also noted that historical licensed abstraction source GWA_03 was stated to be a mine adit. Given its position approximately 600m east of Bodelwyddan it is likely to be associated with the former Bodelwyddan Mine.

Groundwater Source Protection Zones

16.4.5.63 There are no groundwater SPZs within the Mona GHGC study area. The closest SPZs are:

- Llannerch Park abstraction borehole situated approximately 2.6km east of the Mona Proposed Onshore Development Area. It is above the Permo-Triassic sandstone aquifer of the Kinnerton Sandstone Formation. It has a capture zone that extends southeast away from the GHGC study area and is considered to be outside the area of potential influence
- Trofarth Farm abstraction borehole located more than 8km west southwest of the Mona Proposed Onshore Development Area and above Silurian bedrock aquifer of the Elwy Formation. It is considered outside the area of potential influence.

Summary of groundwater receptors

16.4.5.64 Private and licensed groundwater abstractions represent important and sensitive groundwater receptors within the GHGC study area.

16.4.5.65 The surface watercourses that cross the Mona Proposed Onshore Development Area also constitute potential groundwater receptors, where they are in hydraulic continuity with aquifers in the underlying bedrock and/or superficial deposits. Groundwater within these aquifer units will tend to flow towards, and discharge to, these watercourses. However, the discontinuous nature of groundwater in the glacial till and its limited resource potential suggests that the groundwater contribution to these small watercourses will be of limited importance to their flow regime.

16.4.5.66 The desktop study has not identified any groundwater dependent protected sites within the GHGC study area.

16.4.5.67 Despite the importance of the Carboniferous limestone aquifers, springs are not a common feature on Ordnance Survey mapping for the GHGC study area. Springs are most commonly observed at relatively high elevation on the north side of Moelfre Isaf in the areas underlain by Silurian bedrock of the Elwy Formation.

16.4.5.68 The ultimate receptor of groundwater in aquifers underlying the GHGC study area is the coastline to which all watercourses ultimately flow and groundwater is discharged.

Ground conditions

16.4.5.69 A preliminary assessment of ground conditions with the GHGC study area has been undertaken and presented in volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR. In addition to historical mining operations and safeguarded mineral operations described above, other activities that

may represent potential risk to land or groundwater quality have been assessed and summarised below.

Landfill sites

16.4.5.70 The historical NRW Llanddulas Beach landfill and licensed waste site (annex 16.1 reference LF_01A, LF_01B and WS_01 in volume 7, Annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR) extends from west to east, along the ridge of Storm Beach Deposits immediately north of the A55 and coastal railway line. This closed landfill site crosses the Mona Proposed Onshore Development Area. The landfill site is a narrow, raised feature formed by the historical disposal of a range of waste types that include household waste and possible industrial waste. The landfill has been subject to historical leachate and gas monitoring.

16.4.5.71 Ty Mawr Ucha Farm landfill is the only active landfill identified within the GHGC study area (reference LF_02 in volume 7, Annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR). The landfill and licensed waste site is situated immediately west of the A548, near Abergele Hospital. The site is located approximately 620m from the Mona Proposed Onshore Development Area, on the opposite side of a local topographic high, in an area that is underlain by glacial till and Silurian bedrock of the Elwy Formation. Given this setting it is considered to represent a low soil and groundwater contamination risk with regards to the Mona Proposed Onshore Development Area.

16.4.5.72 A small historical landfill site that received inert and household waste is identified at Moelfre and is situated immediately north of the Mona Proposed Onshore Development Area (reference LF_03 in volume 7, Annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR). This site is considered to represent a low soil and groundwater contamination risk in relation to the Mona Proposed Onshore Development Area given it is a small, historical landfill site, that is underlain by low permeability glacial till and Silurian bedrock of the Elwy Formation.

16.4.5.73 The Ffordd Las historic landfill (reference LF_05 in volume 7, Annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR) is located approximately 600m north of the Mona Proposed Onshore Development Area. This small historical landfill site represents a low soil and groundwater contamination risk in relation to the proposed transmission assets given its size, age and position on the opposite side of Nant y Creigiau at a lower elevation relative to the Mona Proposed Onshore Development Area.

16.4.5.74 The historical Plas Newydd Cefn landfill site (reference LF_04 in volume 7, Annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR) is the most easterly landfill site identified in the GHGC study area. This small landfill site is recorded as receiving industrial and commercial waste. It located approximately at a central point within the Mona Proposed Onshore Development Area. The landfill is shown to be located above a small window in the superficial deposits and is directly underlain by the Clwyd Limestone Group. Despite its size and age, it is considered to represent a possible soil or groundwater contamination risk with respect to the Mona Proposed Onshore Development Area.

Other recent and historical land-uses

16.4.5.75 The Waterloo Service Station is the only active petrol station within the Mona GHGC study area. It is located on the B5381, near the Penreefail crossroads with the A548 and is situated above glacial till and Silurian bedrock of the Elwy Formation. Given its proximity to the Mona Proposed Onshore Development Area, it does represent a possible soil or groundwater contamination risk with respect to the transmission assets. There is also a former petrol station in St Asaphs, however it is located some distance from the Mona Proposed Onshore Development Area.

16.4.5.76 Several licensed industrial activities have been identified at the east end of the GHGC study area at St Asaph business park (ref. HA_01 to HA_04). These sites operate inorganic processes within the former Pilkington's Special Glass site (that ceased manufacturing in 2008) and the active Qioptiq Ltd site. The sites are situated between 100m to 200m outside Mona Proposed Onshore Development Area. Although this area is underlain by glacial till, these sites could represent a possible soil or groundwater contamination risk with respect to the transmission assets.

16.4.5.77 Many other recent and historical land-uses have been identified within the GHGC study area (as shown in Figure 1.5 volume 7 annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR). Recent or current land uses include, unspecified tanks, slurry stores or beds, hoppers and silos). Recent industrial land uses are most common in the east end of the Mona Proposed Onshore Development Area around St Asaphs and considered to be a low soil or groundwater contamination risk in relation to the Mona Onshore Cable Corridor, Mona Onshore Substation and 400kV Grid Connection Corridor.

16.4.5.78 Historical land uses include small unspecified quarries, old tanks and old mine shafts. These historical features were identified from OS mapping and are typically very old. When considering recent industrial land uses, comparatively few historical land uses have been identified in or near the Mona Proposed Onshore Development Area, with the exception of the area around Cefn Meriadog and Glascoed. These features are generally related to the historical metal mining and are considered likely to represent a relatively low soils or groundwater contamination risk in relation to the Mona Proposed Onshore Development Area although geotechnical considerations will be required.

Pollution incidents

16.4.5.79 Five pollution incidents (of category 1 or 2) were identified within the GHGC study area and are shown in Figure 1.5 of volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR. These incidents principally affected land and are all located around St Asaph outside the Mona Proposed Onshore Development Area. Given their location they are considered likely to represent a low contamination risk for soils and groundwater in relation to the Mona Onshore Cable Corridor, Mona Onshore Substation and 400kV Grid Connection Corridor.

Licensed discharges to groundwater

16.4.5.80 All eleven licensed discharges to groundwater are situated more than 100m outside of the Mona Proposed Onshore Development Area. As described in volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR, none of these sites are considered to represent a high risk to groundwater quality in relation

to the transmission assets given the characteristics of the treated effluent within the consented discharges. However, certain measures may be required should groundwater management be required in relation to the Mona Onshore Cable Corridor, Mona Onshore Substation and 400kV Grid Connection Corridor.

16.4.6 Designated sites

16.4.6.1 Designated geological, geomorphological or groundwater dependant sites identified for the GHGC study area are described in volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR. There are four SSSIs within the GHGC study area; two of which fall within the Mona Proposed Onshore Development Area. These sites are designated for ecological features, however Llanddulas Limestone and Gwrych Castle Wood SSSI includes caves, which represent features of geological and geomorphology interest.

16.4.7 Future baseline scenario

16.4.7.1 The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (as amended) requires that as well as a description of the current baseline, the Environmental Statement must include "*an outline of the likely evolution thereof without implementation of the development as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge*". In the event that 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.

16.4.7.2 The baseline conditions associated with geology, hydrogeology and ground conditions are not subject to significant change should the Mona Offshore Wind Project not come forward. In the absence of construction and operations of the transmission assets little change is expected with regards to the following:

- Geology
  - Designated and non-designated sites and features of geological or geomorphological significance
- Hydrogeology
  - Groundwater bodies/aquifer units
  - Groundwater levels and groundwater flow patterns
  - Groundwater recharge rates
  - Groundwater quality and the level of groundwater abstraction
  - Groundwater discharge to groundwater dependent receptors
- Ground Conditions
  - Areas of potentially contaminated land/groundwater relating to historical or recent land-use
  - Operation of permitted landfill sites/ waste facilities.

16.4.7.3 Climate change represents the only possible mechanism that could potentially result measurable changes to hydrogeology, through changes to the amount and distribution of recharge to aquifers. The Meteorological Office provide UK Climate Projections (UKCP) the most recent being for 2018 (UKCP18). The projected climate change impacts on rainfall and river flow for Wales could involve decreasing summer rainfall and increasing winter rainfall resulting in more severe low flow events in rivers and high peak river flows.

16.4.8 Data limitations

16.4.8.1 The assessments presented in this chapter are largely based on the results of a desktop study of baseline conditions. At this stage no site-specific geological, hydrogeological or ground condition survey data has been gathered. The use of publicly available data sources is considered sufficient, given the rural setting of the site and conservative nature of the assessments undertaken, particularly with respect to mitigating possible effects. Where there is high level of uncertainty in desktop assessment further works may be required. Additional works may include:

- A site-specific survey and assessment of private water abstraction sources within the GHGC study area
- Intrusive ground investigation works at specific locations to inform the detailed design.

16.5 Impact assessment methodology

16.5.1 Overview

16.5.1.1 The geology, hydrogeology and ground condition impact assessment has followed the methodology set out in volume 1, chapter 5: EIA methodology of the PEIR. Specific to the geology, hydrogeology and ground condition impact assessment, the following guidance documents have also been considered:

- Welsh Local Government Association (WLGA) and NRW (2017) Development of land affected by contamination: A Guide for developers, version 3
- Environment Agency (2020) Land contamination risk management (LCRM)
- Construction Industry Research and Information Association (CIRIA) (2006) Technical Guidance C648: Control of Water Pollution from Linear Construction Projects
- Environment Agency (2018) The Environment Agency's approach to groundwater protection, version 1.2
- NetRegs (2022) Guidance for Pollution Prevention (GPPs)
- CIRIA (2001) Contaminated land risk assessment: A guide to good practice (C552)
- Design Manual for Roads and Bridges (DMRB) (October 2019) Sustainability and Environment Appraisal: LA 109 - Geology and soils, Revision 0
- DMRB (March 2020) Sustainability and Environment Appraisal: LA 113 - Road drainage and the water environment, Revision 1
- British Standards Institute (BSI) (2013) BS10175: Code of Practice for Investigation of Potentially Contaminated Sites.

16.5.1.2 In addition, the geology, hydrogeology and ground condition chapter impact assessment has considered the legislative framework as defined by:

- Part IIA of the Environmental Protection Act 1990
- Environment Act 1995
- Contaminated Land (Wales) Regulations 2006
- Environmental Permitting (England and Wales) Regulations (2016)
- Water Resources Act 1991
- Water Act 2003
- Water Environment (Water Framework Directive) (England and Wales) Regulations 2003, which transpose the WFD into UK law
- Waste (England and Wales) Regulations 2011, which transpose the Waste Framework Directive (Directive 2008/98/EC of the European Parliament and of the Council on waste into UK law.

16.5.2 Impact assessment criteria

16.5.2.1 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.

16.5.2.2 The criteria for defining magnitude in this chapter are outlined in Table 16.9 below.

Table 16.9: Definition of terms relating to the magnitude of an impact.

* The assessment of impacts on groundwater dependent, surface water receptors (i.e. rivers or streams) or ecological receptors will be considered in Chapter 17: Hydrology and flood risk and Chapter 18: Onshore ecology of this PEIR respectively.

Magnitude of impact	Definition
High	**Geology** A large change from baseline conditions, that results in the large-scale loss or deterioration in condition of the geological feature, site or resource affected. The impact is typically of wide spatial extent, long term duration (i.e. up to 10 years) and low reversibility (Adverse). **Groundwater/Hydrogeology** A large change from baseline conditions in an aquifer unit, that results in severe deterioration of groundwater quality, groundwater levels, groundwater flow and/or resource utility, for example: • a deterioration in overall WFD status for a groundwater body • rendering the groundwater in an aquifer unit non-potable through the introduction of hazardous substances into groundwater, failure against prescribed concentrations for pollutants (i.e statutory Drinking Water Standards), or reduction in resource availability • render existing groundwater sources of supply (borehole, well or spring) non-viable • cause a large impact on groundwater dependent watercourse in terms of flow, overall WFD status of the water body or failure against statutory Environmental Quality Standards* • cause statutory monitoring targets for ecological site to be failed*. These impacts are likely to be of wide spatial extent, of long term duration (i.e. up to 10 years) and of low reversibility (Adverse),
	Geology A large change from baseline conditions, that results in major improvement in the condition of the geological feature or site affected. The impact will be of wide extent and of long-term duration (Beneficial), **Groundwater/Hydrogeology** A large change from baseline conditions in an aquifer unit, that results in significant improvement in groundwater quality, groundwater levels, groundwater flow and/or resource utility, for example: • an improvement in the overall WFD status for a groundwater body • rendering a previously contaminated aquifer potable or increasing resource availability • rendering existing groundwater sources of supply viable • cause a large beneficial impact on a groundwater dependent receptor (e.g. watercourse in terms of flow, or water quality, or WFD status; achieving statutory monitoring targets for ecological site)*. These impacts are likely to be of wide spatial extent and of long term duration (Beneficial).
Medium	**Geology** A moderate change from baseline conditions, that results in the loss or deterioration in condition of part of the geological feature, site or resource affected. The impact is typically of local to wide spatial extent, medium duration (i.e. up to five years) and of low reversibility (Adverse), **Groundwater/Hydrogeology** A moderate change from baseline conditions in an aquifer unit, that results in the deterioration of groundwater quality, groundwater levels, groundwater flow and/or resource utility, for example: • a deterioration in WFD criteria for certain parameters, although the overall WFD status may not change • a deterioration in groundwater quality in an aquifer and/or possible failure against certain prescribed concentrations (i.e statutory Drinking Water Standards) • deterioration in quality, quantity, or reliability of groundwater source of supply (borehole, well or spring) • cause a moderate impact on groundwater dependent watercourse in terms of flows, or WFD status or failure relative to statutory Environmental Quality Standards* • cause statutory monitoring targets for ecological site to be failed*. These impacts are likely to be of local to wide spatial extent, or of medium duration (i.e. up to five years) and/or of low reversibility (Adverse).
	Geology A moderate change from baseline conditions, that results in improvement in the condition of part of the geological feature or site affected. The impact is typically of local to wide spatial extent, medium duration and of low reversibility (Beneficial). **Groundwater/Hydrogeology**

Magnitude of impact	Definition
	A moderate change from baseline conditions in an aquifer unit, that results in the improvement in groundwater quality, groundwater levels, groundwater flow and/or resource utility. These impacts are likely to be of local to wide spatial extent, of medium duration (Beneficial).
Low	**Geology** Some measurable change from baseline conditions, that results in a small deterioration in condition of part of the geological feature, site or resource affected. The impact is typically of limited spatial extent and may be of short duration (i.e. up to two years) and/or reversible (Adverse) **Groundwater/Hydrogeology** Some measurable change from baseline condition, that results in a small deterioration of groundwater quality, groundwater levels, groundwater flow and/or resource utility but does not change its regulatory status (e.g. overall WFD status) or utility of resource given. The impacts are small, likely to be of limited spatial extent, or of short duration (i.e. up to two years) and/or reversible (Adverse).
	Geology Some measurable change from baseline conditions, that results in a small improvement in condition of part of the geological feature, site or resource affected. The impact is typically of limited spatial extent and may be of short duration and/or reversible (Beneficial) **Groundwater/Hydrogeology** Some measurable change from baseline condition, that results in a small improvement of groundwater quality, groundwater levels, groundwater flow and/or resource utility. This may result in measurable effects on groundwater dependent receptors. These impacts are likely to be of limited spatial extent, or short duration and/or reversible (Beneficial).
Negligible	**Geology** A small measurable change from baseline conditions of short duration (i.e. up to one year), but **no material change** to the status or condition of the geological feature, site or resource affected (Adverse or Beneficial.) **Groundwater/Hydrogeology** A small measurable change from baseline condition of short duration (i.e. up to one year), but no change in the status of groundwater quality, quantity or flow within the aquifer unit affected or its utility (adverse or beneficial), A small measurable change from baseline condition of short duration (i.e. up to one year), but no change in the status of groundwater dependent receptor affected (e.g. river, stream, borehole, well, spring or wetland) (Adverse or Beneficial) and their utility.
No change	**Geology and Groundwater/Hydrogeology** No change from baseline conditions. No measurable impact either adverse or beneficial.

16.5.2.3 The criteria for defining sensitivity in this chapter are outlined in Table 16.10 and are based criteria presented in Design Manual for Roads and Bridges (DMRB) LA 104 Environmental assessment and monitoring (HE, 2020).

Table 16.10: Definition of terms relating to the sensitivity of the receptor.

Sensitivity	Definition
Very High	Very high importance and rarity, international scale and very limited potential for substitution. **Geology** UNESCO World Heritage Sites, UNESCO Global Geoparks and GCR where citations indicate features of international importance. Geology meeting international designation citation criteria which is not designated as such **Groundwater/Hydrogeology** Principal aquifer providing a nationally important water resource and/or supporting a groundwater dependant site protected under international/EC legislation. Groundwater within an inner source protection zone (SPZ1) **Contamination** Human health: very high sensitivity land use such as residential or allotments.
High	High importance and rarity, national scale and limited potential for substitution **Geology** Geological site of national importance (e.g. GCR or SSSI or National Nature Reserves (NNR)). Geology meeting national designation citation criteria which is not designated as such. **Groundwater/Hydrogeology** Principal aquifer providing locally important water resource and/or supporting a groundwater dependent site of national importance or a river ecosystem. Groundwater supports a Groundwater Dependent Terrestrial Ecosystem defined for the WFD Groundwater within an outer source protection zone (SPZ2) **Contamination** Human health: high sensitivity land use such as public open space
Medium	High or medium importance and rarity, regional scale, limited potential for substitution **Geology** Geological site of regional importance (e.g. RIGS, LNR). Geology meeting regional designation citation criteria which is not designated as such **Groundwater/Hydrogeology** Secondary aquifer unit providing a locally important water resource and/or groundwater dependent sites of local importance. Groundwater within the total catchment source protection zone (SPZ3) **Contamination** Human health: medium sensitivity land use such as commercial or industrial
Low	Low or medium importance and rarity, local scale **Geology** Non-designated geological features of local interest (e.g. non designated geological exposure, former quarry's/mining sites). **Groundwater/Hydrogeology** Secondary aquifer unit of providing water resource of limited local importance with little connection to surface water **Contamination**

Sensitivity	Definition
	Human health: low sensitivity land use such as highways and rail
Negligible	Very low importance and rarity, local scale **Geology** No geological exposures, little/no local interest. **Groundwater/Hydrogeology** Unproductive strata **Contamination** human health: undeveloped surplus land/no sensitive land use proposed

16.5.2.4 The significance of the effect upon geology, hydrogeology and ground conditions 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 16.11. Where a range of significance of effect is presented in Table 16.11, the final assessment for each effect is based upon expert judgement.

16.5.2.5 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 (as amended).

Table 16.11: 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

16.6 Key parameters for assessment

16.6.1 Maximum design scenario

16.6.1.1 The maximum design scenario (MDS) identified in Table 16.12 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 Design Envelope 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, based on details within the Project Design Envelope (e.g. different infrastructure layout), to that assessed here be taken forward in the final design scheme.

Table 16.12: MDS considered for the assessment of potential impacts on geology, hydrogeology and ground conditions.

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

Potential impact	Phase[a] C	O	D	MDS	Justification
The impact of loss of, or damage to, designated sites of geological and geomorphological interest.	✓	×	✓	**Construction phase** <u>Open cut trenching along the Onshore Cable Corridor</u>: • The area of the permanent Onshore Cable Corridor is up to 540,000m^2 based on a corridor measuring 30m wide and 18km in length. The temporary working corridor requires an additional 70m wide corridor (making the total width of the Onshore Cable Corridor (temporary and permanent requirements) 100m wide. The total temporary area of disturbance for the Onshore Cable Corridor is up to 1,800,000m^2 • There are up to four cable trenches within the permanent Onshore Cable Corridor, each trench measures up to 2.5m wide at the top, 1.5m at the base and the depth is 1.8m • The maximum number of joint bays along the Onshore Cable Corridor is 96 (based on a minimum distance of 750m between each joint bay on up to four trenches). The area of each joint bay is up to 200m^2 and each joint bay is 2m deep; the volume of material excavated per joint bay is 400m^3 (a total of 38,400m^3 of material excavated for the joint bays) • The maximum number of link boxes along the Onshore Cable Corridor is 96 (based on a distance of 750m between each link box on up to four trenches). The area of each link box is up to 6m^2 and each link box is 1m deep; the volume of material excavated per link box is 6m^3 (a total of 576m^3 of material excavated for the link boxes). <u>Open cut trenching along the 400kV Grid Connection Cable Corridor:</u> • The area of the permanent 400kV Grid Connection Cable Corridor is up to 48,000m^2 based on a corridor measuring 16m wide and 3km in length. The temporary working corridor requires an additional 44m wide corridor (making the total width of the route to grid connection (temporary and permanent requirements) 60m wide. The total area of temporary disturbance for the 400kV Grid Connection Cable Corridor is up to 180,000m^2 • There are up to two cable trenches within the permanent 400kV Grid Connection Cable Corridor, each trench measures up to 2.5m wide at the top, 1.5m at the base and the depth is 1.8m • The maximum number of joint bays along the 400kV Grid Connection Cable Corridor is 10 (based on a minimum distance of 500m between each joint bay on up to two trenches). The area of each joint bay is up to 200m^2 and each joint bay is 2m deep; the volume of material excavated per joint bay is 400m^3 (a total of 4,000m^3 of material excavated for the joint bays) • The maximum number of link boxes along the 400kV Grid Connection Cable Corridor is 10 (based on a distance of 500m between each link box on up to two trenches). The area of each link box is up to 6m^2 and each link box is 1m deep; the volume of material excavated per link box is 6m^3 (a total of 60m^3 of material excavated for the link boxes). <u>Haul road</u> • There is one haul road within the Onshore Cable Corridor and 400kV Grid Connection Cable Corridor along the length of the corridor; it is 6m wide excluding passing places. It will be constructed using imported engineered granular fill with geotextile style layers with a nominal thickness of 400mm and a maximum thickness of up to 1,000mm. <u>Trenchless techniques</u> • The maximum number of HDD locations along the Onshore Cable Corridor is 72 and 12 along the 400kV Grid Connection Cable Corridor. Primary HDD operations will require a compound, these will measure up to 150m x 100m. Secondary HDDs will require a smaller compound (measuring up to 30m x 20m) and will be located within the 100m temporary construction corridor. <u>Construction compounds</u> • Two primary construction compounds (each measuring 150m x 150m) and up to 10 secondary construction compounds (each measuring 150m x 100m) will be located within the Mona Proposed Onshore Development Area. Soils ls will be removed and stored; crushed stone or other suitable material will be used across the entire area to create hardstanding. **Decommissioning phase** • The onshore cable and 400kV Grid Connection Cable would remain in situ but the link boxes would be removed.	The use of open cut trenching methods along the Onshore Cable Corridor and 400kV Grid Connection Cable Corridor represent the greatest potential for damage to designated geological resources and change the natural processes of erosion. The maximum area of disturbance required for the construction of the Onshore Cable Corridor and 400kV Grid Connection Cable Corridor and the associated infrastructure increases the likelihood of interaction with areas of geological and geomorphological interest and increases the potential for damage to occur.
Loss of, or damage to non-designated sites of geological and geomorphological interest (Drumlins).	✓	×	✓		
Sterilisation of safeguarded limestone mineral resources.	✓	✓	✓	**Construction phase** <u>Onshore Cable Corridor</u> • The area of the permanent Onshore Cable Corridor is up to 540,000m^2 based on a corridor measuring 30m wide and 18km in length • There are up to four cable trenches within the permanent Onshore Cable Corridor, each trench measures 2.5m wide at the top, 1.5m at the base and the depth is 1.8m.	The maximum area occupied by the Onshore Cable Corridor, 400kV Grid Connection Cable, Onshore Substation and the associated infrastructure represents the

Potential impact	Phase[a] C	O	D	MDS	Justification
				400kV Grid Connection Cable Corridor • The area of the permanent 400kV Grid Connection Cable Corridor is up to 48,000m² based on a corridor measuring 16m wide and 3km in length • There are up to two cable trenches within the permanent 400kV Grid Connection Cable Corridor, each trench measures 2.5m wide at the top, 1.5m at the base and the depth is 1.8m. Onshore Substation • The maximum footprint of the Onshore Substation will measure 125,000m² and will be located within the Onshore Substation Zone: this area will include the substation buildings and the earthworks to create the platform. The Onshore Substation will comprise up to four buildings. The maximum dimensions of the main building are 20m high, 40m wide and 90m long • Access to the substation will be via a new permanent access road measuring up to 8m wide and 1.2km in length • The maximum search area for landscape planting around the Onshore Substation is 469,732.83m². This area includes the footprint of the Onshore Substation, landscape planting and the attenuation pond. **Operations and maintenance phase** • The expected lifetime of the Mona Offshore Wind Project is 35 years. **Decommissioning phase** • The Onshore Cable Corridor and 400kV Grid Connection Cable Corridor will remain in situ but the link boxes will be removed • The Onshore Substation and access road will be removed.	maximum area of safeguard mineral resources that could be affected. The Onshore Cable Corridor and 400kV grid connection cable shall remain in situ in decommissioning phase.
Alteration to groundwater quantity or quality in the glacial till superficial aquifer (Secondary undifferentiated).	✓	✓	✓	**Construction phase** Open cut trenching along the Onshore Cable Corridor: • The area of the permanent Onshore Cable Corridor is up to 540,000m² based on a corridor measuring 30m wide and 18km in length. The temporary working corridor requires an additional 70m wide corridor (making the total width of the Onshore Cable Corridor (temporary and permanent requirements) 100m wide representing an area of up to 1,800,000m² • There are up to four cable trenches within the permanent Onshore Cable Corridor, each trench measures 2.5m wide at the top, 1.5m at the base and the depth is 1.8m • The depth of stabilised backfill in each of the four onshore cable trenches is up to 600mm. Surplus material excavated from the trenches will be spread on site • The maximum number of joint bays along the Onshore Cable Corridor is 96 (based on a minimum distance of 750m between each joint bay on up to four trenches). The area of each joint bay is up to 200m² and each joint bay is 2m deep; the volume of material excavated per joint bay is 400m³ (a total of 38,400m³ of material excavated for the joint bays) • The maximum number of link boxes along Onshore Cable Corridor is 96 (based on a distance of 750m between each link box on up to four trenches). The area of each link box is up to 6m² and each link box is 1m deep; the volume of material excavated per link box is 6m³ (a total of 576m³ of material excavated for the link boxes) • Dewatering of cable trenches, joint bays and link boxes will be required. Open cut trenching along the 400kV Grid Connection Cable Corridor: • The area of the permanent 400kV Grid Connection Cable Corridor is up to 48,000m² based on a corridor measuring 16m wide and 3km in length. The temporary working corridor requires an additional 44m wide corridor (making the total width of the route to grid connection (temporary and permanent requirements) 60m wide representing an area of up to 180,000m² • There are two cable trenches within the permanent 400kV Grid Connection Cable Corridor, each trench measures 2.5m wide at the top, 1.5m at the base and the depth is 1.8m • The depth of stabilised backfill in each of the two onshore cable trenches is up to 600mm. Surplus material excavated from the trenches will be spread on site • The maximum number of joint bays along the 400kV Grid Connection Cable Corridor is 10 (based on a minimum distance of 500m between each joint bay). The area of each joint bay is up to 200m² and each joint bay is 2m deep; the volume of material excavated per joint bay is 300m³ (a total of 4,000m³ of material excavated for the joint bays)	The maximum area required for the construction of the Onshore Cable Corridor, 400kV Grid Connection Cable, Onshore Substation and the associated infrastructure represents the greatest area of glacial till that could be affected in terms of recharge capability. The number of cable trenches, link boxes and joint bays represents the maximum numbers of structures that may require dewatering.
Alteration to groundwater quantity or quality in the Clwyd Limestone Group bedrock aquifer (Principal aquifer).	✓	✓	✓		The depth of the Onshore Cable and 400kV Grid Connection Cable trench represents the MDS for affecting groundwater quality of Principal and Secondary A aquifers by open cut trench construction as in some locations of the Onshore Cable and 400kV Grid Connection Cable superficial deposits may be locally thin and there is the potential for the cable trenches to intersect the Principal and Secondary A aquifers and therefore, create a pathway. HDD methods represent the MDS for affecting groundwater quality and flow of the Principal and Secondary A aquifers as these methods go deep below the ground (bypassing lower permeability superficial deposits) and may create a pathway for
Alteration to groundwater quantity or quality in the bedrock aquifers of the Ffernant Formation and Warwickshire Group (Secondary A aquifers).	✓	✓	✓		

Potential impact	Phase[a] C	O	D	MDS	Justification
				• The maximum number of link boxes along the 400kVGrid Connection Cable Corridor is 10 (based on a distance of 500m between each link box). The area of each link box is 6m^2 and each link box is 1m deep; the volume of material excavated per link box is 6m^3 (a total of 60m^3 of material excavated for the link boxes) • Dewatering of cable trenches, joint bays and link boxes will be required. <u>Haul road</u> • There is one haul road within the 400kV Grid Connection Cable Corridor for the length of the corridor; it is 6m wide excluding passing places. It will be constructed using imported engineered granular fill with geotextile style layers with a nominal thickness of 400mm and a maximum thickness of up to 1000mm. <u>Trenchless techniques</u> • The maximum number of HDD locations along the Onshore Cable Corridor is 72 and 12 on the 400kV Grid Connection Cable Corridor. Primary HDD operations will require a compound, these will measure up to 150m x 100m. Secondary HDDs will require a smaller compound (measuring up to 30m x 20m) and will be located within the 100m temporary construction corridor. <u>Onshore Substation</u> • The maximum footprint of the Onshore Substation will measure 125,000m^2 and will be located within the Onshore Substation zone: this area will include the substation buildings and the earthworks to create the platform. The Onshore Substation will comprise up to four buildings. The maximum dimensions of the main building are 20m high, 40m wide and 90m long • Access to the substation will be via a new permanent access road will be created measuring up to 8m wide and 1.2km in length • A construction compound will be required to support the construction of the substation extending to 250,000m^2 • The maximum search area for landscape planting around the Onshore Substation is 469,732.83m^2. This area includes the footprint of the Onshore Substation, landscape planting and the attenuation pond. **Operations and maintenance phase** • The expected lifetime of the Mona Offshore Wind Project is 35 years. **Decommissioning phase** • The Onshore Cable Corridor and 400kV Grid Connection Cable would remain in situ but the link boxes will be removed • The Onshore Substation and access road will be removed.	contaminants to the groundwater resource within the principal aquifer with minimal potential for attenuation. The dimensions of the main buildings at the Onshore Substation represent the MDS as the largest area of disturbance to the Principal and Secondary A aquifers from the construction of foundations.
Impact on private groundwater abstractions in terms of abstraction quantity, abstraction reliability and abstraction quality.	✓	✓	✓	**Construction phase** <u>Open cut trenching along the Onshore Cable Corridor</u>: • The area of the permanent onshore cable corridor is up to 540,000m^2 based on a corridor measuring 30m wide and 18km in length. The temporary working corridor requires an additional 70m wide corridor (making the total width of the Onshore Cable Corridor (temporary and permanent requirements) 100m representing an area of up to 1,800,000m^2 • There are up to four cable trenches within the permanent Onshore Cable Corridor, each trench measures up to 2.5m wide at the top, 1.5m at the base and the depth is 1.8m • The maximum number of joint bays along the Onshore Cable Corridor is 96 (based on a minimum distance of 750m between each joint bay). The area of each joint bay is up to 200m^2 and each joint bay is 2m deep; the volume of material excavated per joint bay is 400m^3 (a total of 38,400m^3 of material excavated for the joint bays) • The maximum number of link boxes along the Onshore Cable Corridor is 96 (based on a distance of 750m between each link box). The area of each link box is up to 6m^2 and each link box is 1m deep; the volume of material excavated per link box is 6m^3 (a total of 576m^3 of material excavated for the link boxes) • Dewatering of cable trenches, joint bays and link boxes will be required. <u>Open cut trenching along the 400kV Grid Connection Cable Corridor:</u> • The area of the permanent 400kV Grid Connection Cable corridor is up to 48,000m^2 based on a corridor measuring 16m wide and 3km in length. The temporary working corridor requires an additional 44m wide corridor (making the total width of the route to grid connection (temporary and permanent requirements) 60m wide representing an area of up to 180,000m^2 • There are up to two cable trenches within the permanent 400kV Grid Connection Cable corridor, each trench measures up to 2.5m wide at the top, 1.5m at the base and the depth is 1.8m	The maximum area required for the construction of the Onshore Cable Corridor, 400kV Grid Connection Cable, Onshore Substation and the associated infrastructure represents the greatest area that could be affected in terms of recharge capability. The number of cable trenches, link boxes and joint bays represents the maximum numbers of structures that may require dewatering.

Potential impact	Phase[a] C	O	D	MDS	Justification
				• The maximum number of joint bays along the 400kV Grid Connection Cable corridor is 10 (based on a minimum distance of 500m between each joint bay) • The area of each joint bay is up to 200m^2 and each joint bay is 2m deep; the volume of material excavated per joint bay is 400m^3 (a total of 4,000m^3 of material excavated for the joint bays) • The maximum number of link boxes along the 400kV Grid Connection Cable Corridor is 10 (based on a distance of 500m between each link box) • The area of each link box is up to 6m^2 and each link box is 1m deep; the volume of material excavated per link box is 6m^3 (a total of 60m^3 of material excavated for the link boxes) • Dewatering of cable trenches, joint bays and link boxes will be required. <u>Haul road</u> • There is one haul road within the 400kV Grid Connection Cable Corridor for the length of the corridor; it is up to 6m wide excluding passing places. It will be constructed using imported engineered granular fill with geotextile style layers with a nominal thickness of 400mm and a maximum thickness of up to 1000mm. <u>Onshore Substation</u> • The footprint of the Onshore Substation will measure up to 125,000m^2 and will be located within the Onshore Substation zone: this area will include the substation buildings and the earthworks to create the platform. The Onshore Substation will comprise up to four buildings. The maximum dimensions of the main building are 20m high, 40m wide and 90m long • Access to the substation will be via a new permanent access road will be created measuring up to 8m wide and 1.2km in length • A construction compound will be required to support the construction of the substation extending to 250,000m^2 • The maximum search area for landscape planting around the Onshore Substation is 469,732.83m^2. This area includes the footprint of the Onshore Substation, landscape planting and the attenuation pond. **Operations and maintenance phase** • The expected lifetime of the Mona Offshore Wind Project is 35 years. **Decommissioning phase** • The Onshore Cable and 400kV Grid Connection Cable would remain in situ but the link boxes would be removed • The Onshore Substation and access road would be removed.	
Deterioration of groundwater quality in the Clwyd Limestone Group bedrock aquifer by the mobilisation of contamination associated with the historical Llanddulas Beach Landfill site	✓	×	×	**Construction phase** <u>Open trenching in the intertidal area between MLWS and MHWS:</u> • The area required for the trenches is 18,000m^2 based on four trenches each measuring 3m wide, 3m deep and 1.5km long • A total of up to 54,000m^3 of material will be excavated from the trenches based on the area and depth required for the trenches • The working area required to undertake the open trenching is up to 25m wide on each side of the trench and will extend along the 1.5km length (between MHWS and MLWS) • The maximum total area that will be disturbed for the construction of the trenches (including the working areas) will be 318,000m^2. <u>Trenchless techniques in the intertidal area</u> • Maximum HDD burial depth landward of MHWS is up to 30m • Maximum HDD burial depth between MHWS and MLWS is up to 25 • There will be up to four HDD exit pits • The HDD working compound area measures 100m x 150m.	Mobilisation of contamination largely relates to disturbance through construction activities associated with the creation of migration pathways created during construction.
Deterioration of groundwater quality in the glacial till aquifer by the	✓	×	×	**Construction phase**	Mobilisation of contamination largely relates to disturbance through

Potential impact	Phase[a] C	O	D	MDS	Justification
disturbance and mobilisation of existing areas of contamination associated with recent or historical land-use				Open cut trenching along the Onshore Cable Corridor: • The area of the permanent Onshore Cable Corridor is up to 540,000m^2 based on a corridor measuring 30m wide and 18km in length. The temporary working corridor requires an additional 70m wide corridor (making the total width of the Onshore Cable Corridor (temporary and permanent requirements) 100m wide representing an area of up to 1,800,000m^2 • There are up to four cable trenches within the permanent Onshore Cable Corridor, each trench measures up to 2.5m wide at the top, 1.5m at the base and the depth is 1.8m • The maximum number of joint bays along the Onshore Cable Corridor is 96 (based on a minimum distance of 750m between each joint bay). The area of each joint bay is up to 200m^2 and each joint bay is 2m deep; the volume of material excavated per joint bay is 400m^3 (a total of 38,400m^3 of material excavated for the joint bays) • The maximum number of link boxes along the Onshore Cable Corridor is 96 (based on a distance of 750m between each link box). The area of each link box is up to 6m^2 and each link box is 1m deep; the volume of material excavated per link box is 576m^3 (a total of 60m^3 of material excavated for the link boxes) • Dewatering of cable trenches, joint bays and link boxes will be required.	construction activities associated with the creation of migration pathways created during construction. No new effects anticipated during the decommissioning of assets. In terms of contamination to the groundwater in the glacial till both crossing options may create pathways for contaminants, however HDD methods represent the MDS as they go deeper below the ground, increasing the likelihood of hydraulically connecting with groundwater in secondary aquifers.
Deterioration in groundwater quality in bedrock aquifers through the disturbance and mobilisation of existing areas of contaminated land associated with recent or historical land-use.	✓	×	×	Open cut trenching along the 400kV Grid Connection Cable Corridor: • The area of the permanent 400kV Grid Connection Cable Corridor is up to 48,000m^2 based on a corridor measuring 16m wide and 3km in length. The temporary working corridor requires an additional 44m wide corridor (making the total width of the route to grid connection (temporary and permanent requirements) 60m wide representing an area of up to 180,000m^2 • There are up to two cable trenches within the permanent 400kV Grid Connection Cable Corridor, each trench measures up to 2.5m wide at the top, 1.5m at the base and the depth is 1.8m • The maximum number of joint bays along the 400kV Grid Connection Cable Corridor is 10 (based on a minimum distance of 500m between each joint bay). The area of each joint bay is up to 200m^2 and each joint bay is 2m deep; the volume of material excavated per joint bay is 400m^3 (a total of 4,000m^3 of material excavated for the joint bays) • The maximum number of link boxes along the 400kV Grid Connection Cable Corridor is 10 (based on a distance of 500m between each link box). The area of each link box is up to 6m^2 and each link box is 1m deep; the volume of material excavated per link box is 6m^3 (a total of 60m^3 of material excavated for the link boxes) • Dewatering of cable trenches, joint bays and link boxes will be required. Haul road • There is one haul road within the 400kV Grid Connection Cable Corridor for the length of the corridor; it is up to 6m wide excluding passing places. It will be constructed using imported engineered granular fill with geotextile style layers with a nominal thickness of 400mm and a maximum thickness of up to 1000mm. Trenchless techniques • The maximum number of Horizontal Directional Drilling (HDD) locations along the Onshore Cable Corridor is 72 and 12 on the 400kV Grid Connection Cable Corridor. Primary HDD operations will require a compound, these will measure up to 150m x 100m. Secondary HDDs will require a smaller compound (measuring up to 30m x 20m) and will be located within the 100m temporary construction corridor. Onshore substation • The maximum footprint of the Onshore Substation will measure 125,000m^2 and will be located within the Onshore Substation zone: this area will include the substation buildings and the earthworks to create the platform. The Onshore Substation will comprise up to four buildings. The maximum dimensions of the main building are 20m high, 40m wide and 90m long. • Access to the substation will be via a new permanent access road will be created measuring up to 8m wide and 1.2km in length • A construction compound will be required to support the construction of the substation extending to 250,000m^2	Mobilisation of contamination largely relates to disturbance through construction activities associated with the creation of migration pathways created during construction. No new effects anticipated during the decommissioning of assets. In terms of contamination to the groundwater in the bedrock aquifers both crossing options may create pathways for contaminants, however HDD methods represent the MDS scenario as they go deeper below the ground, increasing the likelihood of hydraulically connecting with groundwater in bedrock aquifers.
Deterioration in groundwater quality as a result of accidental release or spillage of potentially polluting substances, during the construction and decommissioning phase	✓	×	✓	**Construction phase** Construction compounds • Up to two primary construction compounds (each measuring 150m x 150m) and up to 10 secondary construction compounds (each measuring 150m x 100m) will be located along the Onshore Cable Corridor. Soils will be removed and stored; crushed stone or other suitable materials will be used across the entire area to create hardstanding	Fuels and chemicals will be stored at construction compounds and HDD compounds. The maximum number of construction compounds and HDD compounds represents the MDS scenario for the risk of spillages.

Potential impact	Phase[a] C	O	D	MDS	Justification
				• A construction compound will be required to support the construction of the substation extending to 250,000m^2. HDD compounds • Primary HDD operations will require a compound, these will measure up to 150m x 100m. Secondary HDDs will require a smaller compound (measuring up to 30m x 20m) and will be located within the 100m temporary construction corridor. **Decommissioning phase** • The onshore cable and 400kV Grid Connection Cable Corridor will remain in situ but the link boxes will be removed • The Onshore Substation and access road will be removed.	
Ground stability issues associated with areas of historical deep mining operations	✓	×	×	**Construction phase** Onshore substation • The footprint of the Onshore Substation will measure up to 125,000m^2 and will be located within the Onshore Substation zone this area will include the substation buildings and the earthworks to create the platform. The Onshore Substation will comprise up to four buildings. The maximum dimensions of the main building are 20m high, 40m wide and 90m long • Access to the substation will be via a new permanent access road will be created measuring up to 8m wide and 1.2km in length • A construction compound will be required to support the construction of the substation extending up to 250,000m^2. Trenchless techniques • The maximum number of HDD locations along the Onshore Cable Corridor is 72 and 12 on the 400kV Grid Connection Cable Corridor. Primary HDD operations will require a compound, these will measure up to 150m x 100m. Secondary HDDs will require a smaller compound (measuring up to 30m x 20m) and will be located within the 100m temporary construction corridor.	In terms of ground stability issues associated with areas pf historical deep mining, the greatest footprint of the onshore substation and HDD methods represent the MDS as they go deeper below the ground, increasing the likelihood of interacting with historical mining activities. .

16.6.2 Impacts scoped out of the assessment

16.6.2.1 On the basis of the baseline environment and the description of development outlined in volume 1, chapter 5: Project description of the PEIR, a number of impacts are proposed to be scoped out of the assessment for geology, hydrogeology and ground conditions. These impacts are outlined, together with a justification for scoping them out, in Table 16.13.

Table 16.13: Impacts scoped out of the assessment for geology, hydrogeology and ground conditions.

Potential impact	Justification
Loss of, or damage to, designated sites of geological and geomorphological interest (GCR & RIGS).	No impact predicted as locally important designated sites are all situated outside of Mona Proposed Onshore Development Area.
Temporary or permanent alteration to the hydrogeological regime of groundwater dependent designated sites, in terms of levels, discharge rates, flow, temperature or water quality.	The construction of the onshore transmission assets has the potential to impact the hydrogeological regime at sites that are dependent on groundwater. Designated sites identified within the GHGC study area are not considered to have a direct groundwater dependence contributing to their designation. Impacts on the ecology of these designated sites are considered in chapter 18: Onshore ecology of the PEIR.
Temporary or permanent alteration to the quantity or quality of groundwater discharge to surface waters fed by groundwater discharge (baseflow) from underlying aquifer units.	Small surface watercourses present within study area and crossed by the cable route corridor do not receive significant groundwater discharge (baseflow) given their position above glacial till or localised areas of exposed bedrock where groundwater is expected to present at significant depth. Flow in these watercourses is dependent on surface runoff as opposed to groundwater discharge. Any direct impacts on surface watercourses during the construction, operational and maintenance and decommissioning phase will be assessed in the chapter 17: Hydrology and flood risk of the PEIR.
Temporary or permanent impact on groundwater quantity or quality in the Secondary A glaciofluvial sand and gravel aquifer due to the construction, operations and decommissioning of the Mona Onshore Cable Corridor, Mona Onshore Substation and 400kV Grid Connection Corridor.	BGS geological mapping suggests that glaciofluvial deposits rarely occur within the cable route corridor and will be limited extent where present. This suggests groundwater in glaciofluvial deposits is unlikely to be of resource value, nor will it support important groundwater dependent receptors. A review of risk to private water abstractions will however be undertaken following the completion of land-owner consultation and site walkover surveys.
Temporary or permanent impact on groundwater quantity or quality in the Secondary B bedrock aquifer of the Silurian Elwy Formation due to the construction, operations and maintenance and decommissioning of Mona Onshore Cable Corridor, Mona Onshore Substation and 400kV Grid Connection Corridor.	The impact on groundwater in the Clwyd Limestone Group Principal aquifer has been shown to be not significant in EIA terms. No assessment is therefore required for the Elwy Formation aquifer given it has a lower receptor sensitivity as it is a Secondary B aquifer. A review of risk to private water abstractions will however be undertaken following the completion of land-owner consultation and site walkover surveys.
Direct impact on licensed groundwater abstractions within the GHGC study area.	All active, licensed, groundwater abstractions are at very low risk of any impact resulting from the construction, operations and maintenance and decommissioning of the transmission assets, given: • They are located a significant distance (approximately 950m) from the east end of the Mona Proposed Onshore Development Area • They are situated in a presumed down-hydraulic gradient position from the Mona Proposed Onshore Development Area and Onshore Substation at a lower elevation, adjacent to the Afon Elwy which represents the likely local groundwater receptor and hydraulic minimum • The east end of the Mona Proposed Onshore Development Area is situated above glacial till, which is likely to be thick • The east end of the Mona Proposed Onshore Development Area is situated above bedrock of Clwyd Limestone Group which dips east beneath the aquifers of the Warwickshire Group to the northeast.
Direct impact on groundwater Source Protection Zones within the GHGC study area.	<u>*Trofarth Farm SPZ*</u> Located over 8km from the Mona Proposed Onshore Development Area and above Silurian bedrock aquifer of the Elwy Formation. Given the low permeability of this Secondary B aquifer and the large distance from the Mona Proposed Onshore Development Area it is not considered to be at any risk from the construction, operations and maintenance and decommissioning of the Mona Onshore Cable Corridor, Mona Onshore Substation and 400kV Grid Connection Corridor. <u>*Llannerch Park SPZ*</u> This abstraction source is unlikely to be at any risk as it is considered to be located in a different groundwater catchment from the transmission assets, given: • It is situated on the opposite (east) side of the Afon Elwy, with a capture zone that extend to the southeast away from the Mona Proposed Onshore Development Area • It is located approximately 2.3km east of the Mona Proposed Onshore Development Area.
The impact of ground gas generation on human health and other environmental receptors, during the construction, operations and maintenance and decommissioning phases.	The desk top study did not identify deposits that may produce significant quantities of ground gas. The only exception is Llandulas Beach Landfill site which was shown to have had included gas and leachate control (Lle Geo-Portal for Wales). That former landfill site has been assessed separately herein.
Deterioration of groundwater quality in the Clwyd Limestone Group bedrock aquifer by the mobilisation of contamination associated with the historical Llanddulas Beach Landfill site during the operations and maintenance and decommissioning phases.	Any impact on groundwater quality in the Clwyd Limestone Group bedrock aquifer will be avoided during construction by the use of HDD drilling techniques and implementation of the associated method statement for drilling under the Llanddulas Beach landfill Site.

16.7 Measures adopted as part of the Mona Offshore Wind Project

16.7.1.1 For the purposes of the EIA process, the term 'measures adopted as part of the project' is used to include the following 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 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).

16.7.1.2 A number of measures (primary and tertiary) have been adopted as part of the Mona Offshore Wind Project to reduce the potential for impacts on GHGC. These are outlined in Table 16.14 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 16.8 below (i.e. the determination of magnitude and therefore significance assumes implementation of these measures).

Table 16.14: 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		
Use of trenchless techniques for the construction of the Onshore Cable Corridor across the Llanddulas Limestone and Gwrych Castle Wood SSSI. A method statement for the crossing would be prepared in discussion with NRW.	To avoid disturbance to the limestone caves of the Llanddulas Limestone and Gwrych Castle Wood SSSI.	These measures would be secured as a requirement of the DCO.
Tertiary measures: Measures required to meet legislative requirements, or adopted standard industry practice		
Production of an Outline Code of Construction Practice (CoCP) to ensure effective management of environmental risk during the construction phase of onshore transmission assets and supporting infrastructure. The CoCP shall include regulatory guidance and industry best practice guidance including: • The CoCP shall provide include a surface water and groundwater protection plan that outline the methods for managing surface water runoff and groundwater, to protect the local environment and sensitive receptors • The CoCP shall ensure that routine pollution prevention measures shall be adhered to during the construction phase • The CoCP shall provide emergency response plan for accidents and spillages • Restoration of drumlins using the retained glacial material as part of the soil management plan.	To manage the potential construction impacts.	These measures would be secured through a requirement in the DCO.
Preparation of a contamination discovery strategy that defines the approach for the management of unforeseen areas of soil or groundwater contamination should they be identified during the construction of Mona Onshore Cable Corridor, Mona Onshore Substation and 400kV Grid Connection Corridor and supporting infrastructure.	To help to deal with potentially contaminated land or groundwater and reduce the risk of creating additional/preferential pathways.	This measure would be secured as a requirement of the DCO.
Where the Onshore Cable Corridor and 400kV Grid Connection Cable Corridor cross areas with Secondary A or Principal aquifers, best practice measures will be included in the detailed design to that groundwater does not use the trenches as a conduit to convey groundwater elsewhere.	To ensure that the construction of the cable does not adversely affect regional groundwater flows and any local changes in flow direction are minimal.	This measure would be secured through the detailed design process.
Private groundwater source risk assessment for all private groundwater supply sources identified on or near the Mona Onshore Cable Corridor, Mona Onshore Substation and 400kV Grid Connection Corridor and supporting construction phase infrastructure.	To identify mitigation measures for each private water supply source. The measures will be based on a hierarchy depending on the supply source risk: • Supply source at high risk: Provision of alternative source of supply (e.g. borehole or mains water connection) • Supply source at moderate risk: Monitoring during construction phase, with contingency measures in place should supply source be affected during construction (e.g temporary or permanent provision of alternative supply) • Supply source at low risk: Contingency measures in place should supply source be affected during construction (e.g. temporary or permanent provision of alternative supply) • Supply source at negligible risk: No mitigation required.	These measures would be secured through the Outline CoCP.

Measures adopted as part of the Mona Offshore Wind Project	Justification	How the measure will be secured
	The nature of monitoring requirements and contingency measures shall be outlined in the CoCP.	
Site investigations will be undertaken at each primary HDD location during the detailed design stage to confirm local geological conditions,	To confirm suitability of geology for HDD techniques. To determine the absence of localised impacted soils and groundwater.	These measures would be secured as a requirement of the DCO.
Method statement for drilling under the Llanddulas Beach landfill Site	To avoid the deterioration of groundwater quality from mobilisation of contaminants	These measures would be secured as a requirement of the DCO.
Preparation of a piling risk assessment should piled foundations be considered as part of the detailed design.	To demonstrate that the construction of piled foundations would not create a pathway for pollutants.	This measure would be secured as a requirement of the DCO.
Historical mining activity assessment in areas potentially affected by deep historical mining.	To demonstrate the construction activity in areas of historic mining would not lead to ground stability issues,	This measure would be secured as a requirement of the DCO.

16.8 Assessment of significant effects

16.8.1.1 The impacts of the construction, operations and maintenance, and decommissioning phases of the Mona Offshore Wind Project have been assessed on geology, hydrogeology and ground conditions. The potential impacts arising from the construction, operations and maintenance and decommissioning phases of the Mona Offshore Wind Project are listed in Table 16.12, along with the MDS against which each impact has been assessed.

16.8.1.2 A description of the potential effect on geology, hydrogeology and ground conditions receptors caused by each identified impact is given below.

16.8.2 Loss of, or damage to, designated sites of geological and geomorphological interest.

16.8.2.1 The only designated site of geological and geomorphological interest within the Mona Proposed Onshore Development Area is the Llanddulas Limestone and Gwrych Castle Wood SSSI. The construction of the Mona Onshore Cable Corridor and associated haul roads may have an impact on designated geological and geomorphological features present.

16.8.2.2 Whilst the Traeth Pensarn SSSI also falls within the Mona Proposed Onshore Development Area it does not contain any geological or geomorphological features as part of its designation.

Construction phase

Magnitude of impact

16.8.2.3 The Mona Proposed Onshore Development Area crosses the Llanddulas Limestone and Gwrych Castle Woodland SSSI, and there is the potential that the construction of the Mona Onshore Cable Corridor will lead to temporary or permanent damage to the limestone features on the site. Through the implementation of the mitigation of trenchless crossing techniques, a method statement for this technique and micro-siting (see Table 16.14) some minor deterioration in condition of part of the site may occur, but that direct impact is predicted to be of limited spatial extent albeit long-term or permanent. The magnitude is therefore, considered to be **low.**

16.8.2.4 All other impacts on the SSSI will be considered in volume 3, chapter 18: Onshore ecology of the PEIR.

Sensitivity of the receptor

16.8.2.5 The Carboniferous Limestone bedrock, topography (i.e. the Carboniferous Limestone escarpments) and soil conditions have given rise to a complex and interesting range of plant communities of national importance. The sensitivity of the receptor is therefore, considered to be **high**.

Significance of the effect

16.8.2.6 The impact on the SSSI is largely mitigated by the application of trenchless crossing techniques. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be high. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

16.8.3 Loss of, or damage to non-designated features or sites of geological and geomorphological interest

16.8.3.1 The construction of the Mona Onshore Cable Corridor and 400kV Grid Connection Corridor and associated haul roads have the potential to directly impact non-designated features of geological and geomorphological interest. Numerous drumlins have been identified in the GHGC study area, most notably around Moelfre Isaf where up to ten are located partially or wholly within the Mona Proposed Onshore Development Area. These features are not present in the vicinity of the Onshore Substation option locations. No other non-designated features or sites of geological or geomorphological interest are located within the Mona Proposed Onshore Development Area.

Construction phase

Magnitude of impact

16.8.3.2 The construction of the Mona Onshore Cable Corridor and 400kV Grid Connection Corridor and associated haul roads across the non-designated drumlins will result in the deterioration in condition of some of these geological features. The direct impact on certain drumlins will be of local spatial extent, medium term duration, and of

medium reversibility. With the implementation of the soil management plan to restore the drumlins (see Table 16.14) the magnitude is considered to be **low**.

Sensitivity of receptor

16.8.3.3 Given that the drumlins are not designated, they are deemed to be of low rarity but of local importance, and are vulnerable to impacts of Mona Onshore Cable Corridor and 400kV Grid Connection Corridor construction. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

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

Decommissioning phase

Magnitude of impact

16.8.3.5 During decommissioning, the Onshore Cable Corridor and 400kV Grid Connection Cable Corridor will remain in place however there will be localised areas where link boxes are removed. Where the link boxes coincide with the location of drumlins the impact will be direct, of local spatial extent, medium term duration and medium reversibility. With the implementation of soil restoration measures similar to those in the soil management plan the magnitude is considered to be **negligible**.

Sensitivity of receptor

16.8.3.6 Drumlins are deemed to be of low rarity but of local importance and are vulnerable to impacts of Mona Onshore Cable Corridor and 400kV Grid Connection Corridor construction. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

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

16.8.4 Sterilisation of safeguarded limestone mineral resources

16.8.4.1 Minerals can only be extracted (or 'worked') where they naturally occur. Sterilisation of mineral resources is when a resource cannot be extracted or 'worked' due to the presence of non-mineral development.

16.8.4.2 Approximately 5.2km of the east and west ends of the Mona Proposed Development Area are situated above safeguarded limestone mineral resources of the Clwyd Limestone Group.

16.8.4.3 The MDS for geology, hydrogeology and ground conditions (summarised in Table 16.12) assumes that the onshore export cables will remain in place after decommissioning. The assessment of the Mona Offshore Wind Project for the construction phase will therefore apply to the operations and maintenance and decommissioning phases also.

Construction, Operations and maintenance and Decommissioning phases

Magnitude of impact

16.8.4.4 Despite the narrow width of the permanent Onshore Cable Corridor and 400kV Grid Connection Cable Corridor (i.e. up to 30m) up to 156,000m^2 of safeguarded limestone could be impacted by the construction of the onshore transmission assets. However, the limestone is commonly concealed by a considerable depth of glacial till: the borehole log reference SH97NE 175 (in appendix A of volume 7, annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR) measures the limestone is locally encountered at depths exceeding 40m. The depth of overburden material suggests that the extraction of this limestone resource would be commercially unviable. Given the large area of safeguarded limestone in the local area relative to that affected by the permanent Onshore Cable Corridor and 400kV Grid Connection Cable Corridor, the magnitude of the impact on the safeguarded resource is considered to be **low**.

Sensitivity of the receptor

16.8.4.5 The mineral safeguarded area defined for limestone is of local importance. Given the large area safeguarded limestone in the local area, the sensitivity of the receptor is therefore, considered to be **medium**.

Significance of effect

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

16.8.5 Alteration to groundwater quantity or quality in the glacial till superficial aquifer (Secondary undifferentiated)

16.8.5.1 The MDS for the construction and decommissioning phases is summarised in Table 16.12. Glacial till underlies the majority of Onshore Cable Corridor and 400kV Grid Connection Cable Corridor and is thickest in areas of lower elevation at the east end of the Mona Proposed Onshore Development Area e.g. in the vicinity of the Onshore Substation locations. The construction, operations and maintenance, and decommissioning of the Onshore Cables, 400kV Grid Connection Cables and the Onshore Substation locations may therefore have an impact on groundwater in the secondary undifferentiated aquifer formed by the glacial till, in terms of its quantity and quality.

Construction phase

16.8.5.2 Temporary dewatering of cable trenches during construction of the export and grid connection cables, may locally lower groundwater level, resulting in changes to flow directions, and/or reduction in the quantity of groundwater within localised water-bearing units in the till. Construction may also adversely impact water quality, although

these potential effects are considered separately in Section 16.8.12 in relation to accidental releases and spillage of hazardous substances.

Magnitude of impact

16.8.5.3 With the implementation of tertiary measures of the Outline CoCP, the impact on localised, discontinuous groundwater within the glacial till will be a small and localised change to groundwater levels, groundwater flow and resource utility. This direct impact on the glacial till aquifer is predicted to be of limited, local spatial extent, will be of short duration and high reversibility. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

16.8.5.4 The glacial till aquifer underlying most of the Onshore Cable Corridor, 400kV Grid Connection Cable Corridor and Onshore Substations is designated a Secondary undifferentiated aquifer. It is characterised by localised groundwater occurrence that is of limited resource potential, limited utilisation at a local scale and with limited connection to other potentially groundwater dependant receptors. The sensitivity of this receptor is therefore considered to be **low**.

Significance of effect

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

Operations and maintenance phase

16.8.5.6 The inert granular fill within the onshore export and grid connection cables, may create new shallow pathways for groundwater flow in the glacial till. This may provide increased localised connectivity of water bearing horizons at shallow depth within the glacial till aquifer, although a large increase in connectivity with potential groundwater dependent receptors (groundwater supply sources, watercourses or ecological sites) is considered unlikely to occur.

Magnitude of impact

16.8.5.7 The impact on groundwater within the glacial till will be a small and localised change but there will be no change in the status of groundwater quality, quantity or flow. This direct impact on the glacial till aquifer is predicted to be of limited, albeit long term to permanent duration. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

16.8.5.8 The glacial till aquifer underlying most of the Onshore Cable Corridor and 400kV Grid Connection Cable Corridor is designated a Secondary undifferentiated aquifer that is characterised by localised groundwater occurrence that is of limited resource potential, limited utilisation at a local scale and with limited connection to other potentially groundwater dependant receptors. The sensitivity of this receptor is therefore considered to be **low**.

Significance of effect

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

Decommissioning phase

16.8.5.10 As summarised in the MDS Table 16.12, it is proposed to leave the Onshore Cables and 400kV Grid Connection Cables in situ after decommissioning, however the link boxes and Onshore Substation will be removed. The impact of decommissioning phase will therefore largely reflect that described for the operations and maintenance phase. Localised dewatering may only be required during the removal of link boxes and the Onshore Substation. The removal of these structures may locally lower groundwater levels resulting in changes to flow directions and quantity within localised groundwater bearing units in the till.

Magnitude of impact

16.8.5.11 The impact on groundwater within the glacial till will be a small and localised change to groundwater levels, groundwater flow and resource utility. This direct impact on the glacial till aquifer is predicted to be of limited, local spatial extent albeit long term to permanent duration. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the shallow glacial till aquifer receptor

16.8.5.12 The glacial till aquifer underlying most of the Onshore Cable Corridor, 400kV Grid Connection Cable Corridor and the Onshore Substation is designated a Secondary undifferentiated aquifer that is characterised by localised groundwater occurrence that is of limited resource potential, limited utilisation at a local scale and with limited connection to other potentially groundwater dependant receptors. The sensitivity of this receptor is therefore considered to be **low**.

Significance of effect

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

16.8.6 Alteration to groundwater quantity or quality in the Clwyd Limestone Group bedrock aquifer (Principal aquifer)

16.8.6.1 The east and west end of the Mona Proposed Onshore Development Area is situated above limestone of the Clwyd Limestone Group, which is designated a Principal aquifer unit. This Principal aquifer is generally concealed beneath a thick layer of glacial till, except for small windows in those deposits in localised areas of high ground, principally in the west. Groundwater in the limestone aquifer is expected be located at considerable depth in the areas of high elevation or confined by thick till at lower elevation at the east end of the route corridor.

16.8.6.2 The MDS for the construction, operations and maintenance and decommissioning phases is summarised in Table 16.12. The construction, operations and maintenance, and decommissioning of the Onshore Cable Corridor, 400kV Grid Connection Cable Corridor and Onshore Substation option 2 (southwest corner) can only have a potential impact on groundwater within the Principal aquifer formed by limestones of the Clwyd Limestone Group, where they are situated directly above the limestone bedrock or they penetrate through thin glacial till.

Construction phase

Magnitude of impact

16.8.6.3 Where the Clwyd Limestone Group is concealed beneath significant depth of till, principally in the east of the Mona Proposed Onshore Development Area, no pathways are expected to be created and hence **no change** to groundwater is expected to the bedrock Principal aquifer during the construction of Onshore Cable Corridor, 400kV Grid Connection Cable Corridor and Onshore Substation option 2.

16.8.6.4 Elsewhere, where the overlying glacial till is expected to be thinner or absent, the creation of small, localised pathways to the underlying bedrock aquifer may occur during construction. These pathways could increase recharge to the underlying aquifer. Given these pathways will be of limited local extent, the considerable depth to groundwater in the Principal aquifer and the fact the additional recharge will generally be of reasonable quality, a small localised change from baseline conditions could potentially occur but no change to the status of groundwater quality, quantity or flow within the aquifer or its utility is predicted. The magnitude of the impact on groundwater in the Principal aquifer of the Clwyd Limestone Group is therefore, considered to be **negligible**.

Sensitivity of the receptor

16.8.6.5 Given its designation as a Principal aquifer but limited utilisation as a source of groundwater supply, the sensitivity of the Clwyd Limestone Group aquifer is considered to be **high**.

Significance of effect

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

Operations and maintenance phase

Magnitude of impact

16.8.6.7 An increase in recharge to the underlying Principal aquifer may occur during the operations and maintenance phase where new pathways to the Principal aquifer have been created (see above). However, any increase in recharge to Principal aquifer via these pathways is considered unlikely to have a have measurable effect on groundwater quantity or quality, given the localised nature of the effect, the good water quality expected for that recharge and depth to groundwater in the underlying aquifer in these areas. The magnitude of this impact is also considered to be **negligible**.

Sensitivity of receptor

16.8.6.8 Given its designation as a Principal aquifer, the sensitivity of the Clwyd Limestone Group aquifer is considered to be **high**.

Significance of effect

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

Decommissioning phase

Magnitude of impact

16.8.6.10 As for construction, no measurable impact on groundwater quantity or quality in the Principal aquifer is predicted during the decommissioning phase. The magnitude of the impact on groundwater in the principal aquifer of the Clwyd Limestone Group is therefore, considered to be **negligible**.

Sensitivity of receptor

16.8.6.11 Given its designation as a Principal aquifer, the sensitivity of the Clwyd Limestone Group aquifer is considered to be **high**.

Significance of effect

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

16.8.7 Alteration to groundwater quantity or quality in the bedrock aquifers of the Ffernant Formation and Warwickshire Group (Secondary A aquifers)

16.8.7.1 The east end and west ends of the Mona Proposed Onshore Development Area is situated above Secondary A bedrock aquifers of the Ffernant Formation and Warwickshire Group. In the east, these Secondary A sandstone aquifers are concealed and potentially confined beneath a thick layer of glacial till. In the west, the sandstone aquifers are concealed beneath glacial till that is expected to be thinner. Groundwater levels in these bedrock aquifers are uncertain, but are likely to be situated at depth beneath areas of high ground in the west and confined at depth beneath thick till in the east.

16.8.7.2 The MDS for the construction and decommissioning phases is summarised in Table 16.12. The construction, operations and maintenance, and decommissioning of the Onshore Cable Corridor and 400kV Grid Connection Cable Corridor and Onshore Substation sites can only have an impact on groundwater quality or quantity in the Ffernant Formation and Warwickshire Group aquifers, where they are situated directly above the sandstones in areas of high-ground or new pathways are created through the glacial till during construction.

Construction phase

Magnitude of impact

16.8.7.3 Where the sandstone bedrock aquifers are concealed beneath significant depth of till in the east (e.g. under the Onshore Substation), no pathways are expected to be created and the **no change** is expected on groundwater quality, level or flow.

16.8.7.4 Elsewhere, where the overlying glacial till is expected to be thinner, small, localised pathways to the underlying aquifer may be created during construction. These pathways could result in increased recharge to underlying aquifer. Given these pathways will be of limited local extent and the recharge will generally be of reasonable quality, some change from baseline conditions may potentially occur, although no change to the aquifers regulatory status or resource utility is predicted. To reflect uncertainty regarding the depth to groundwater in the sandstone bedrock aquifers, the magnitude of the impact on groundwater in the Secondary A aquifers is therefore, considered to be **low**.

Sensitivity of receptor

16.8.7.5 Given the Ffernant Formation and Warwickshire Group are designated Secondary A aquifers of possible local importance, the sensitivity of the receptor is considered to be **medium**.

Significance of effect

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

Operations and maintenance phase

Magnitude of impact

16.8.7.7 An increase in recharge to the underlying Secondary A aquifer may occur during the operations and maintenance phase where new pathways to the Secondary A aquifer have been created along the Onshore Cable Corridor and 400kV Grid Connection Cable Corridor and Onshore Substation site (see above).

16.8.7.8 Given these pathways will be of limited local extent and the recharge can be expected to be of reasonable quality, some change from baseline conditions may potentially occur, although no change to the aquifers regulatory status or resource utility is predicted. To reflect uncertainty regarding the depth to groundwater in the sandstone bedrock aquifers the magnitude is also considered to be **low**.

Sensitivity of receptor

16.8.7.9 Given the designation of the Ffernant Formation and Warwickshire Group as Secondary A aquifers of possible local importance, the sensitivity of the receptor is considered to be **medium**.

Significance of effect

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

Decommissioning phase

Magnitude of impact

16.8.7.11 As for construction and operations and maintenance, the magnitude of long term impacts on groundwater quantity or quality in the Secondary A sandstone aquifers via new pathways created during construction is considered to be **low**.

Sensitivity of receptor

16.8.7.12 Given the designation of the Ffernant Formation and Warwickshire Group as Secondary A aquifers, the sensitivity of the receptor is considered to be **medium**.

Significance of effect

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

16.8.8 Impact on private groundwater abstractions in terms of abstraction quantity, abstraction reliability and abstraction quality.

16.8.8.1 The construction, operations and maintenance, and decommissioning of the Onshore Cable Corridor, 400kV Grid Connection Cable Corridor and Onshore Substation have the potential to have a direct impact on private groundwater supply sources. Groundwater dewatering, new pathway creation, accidental releases of hazardous substances and/or the mobilisation of contamination all have the potential to affect groundwater supply sources situated near or down hydraulic gradient from the Onshore Cable Corridor, 400kV Grid Connection Cable Corridor and Onshore Substation. The location and nature of private groundwater supply sources will be determined through consultation with relevant landowners and associated site visits (refer to section 16.14 for further information). Given the level of uncertainty in private supply source locations, precautionary thresholds have been used for the assessment of significance for this possible impact.

Construction phase

Magnitude of impact

16.8.8.2 The construction of the Onshore Cable Corridor, 400kV Grid Connection Cable Corridor and Onshore Substation, most notably dewatering of cable trenches, could impact proximal private groundwater supply sources, most notably those situated in down hydraulic gradient position. That impact has the potential to be direct and continuous. However, with the implementation of the mitigation of the private groundwater abstraction risk assessment (see Table 16.14) the magnitude of impact is considered to be **low**.

Sensitivity of private groundwater supply sources

16.8.8.3 Private supply sources are of local importance to the properties they supply. These groundwater receptors have a sensitivity considered to be **medium**.

Significance of effect

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

Operations and maintenance phase

Magnitude of impact

16.8.8.5 The backfill of cable trenches and/or the interception of underlying permeable bedrock has the potential to create new groundwater flow pathways that could impact the flow and/or quality of groundwater to proximal private groundwater supply sources, most notably those situated in down hydraulic gradient position. That impact has the potential to be direct and continuous. With the implementation of the mitigation measures as identified (see Table 16.14) the potential impact on private groundwater abstractions and the magnitude of the impact is therefore considered to be **low**.

Sensitivity of private groundwater supply sources

16.8.8.6 Private supply sources are of local importance to the properties they supply. These groundwater receptors have a sensitivity considered to be **medium**.

Significance of effect

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

Decommissioning phase

Magnitude of impact

16.8.8.8 As summarised in the MDS Table 16.12, it is proposed to leave the Mona Onshore Cables and 400kV Grid Connection Cables in situ after decommissioning; the Onshore Substation, associated infrastructure and link boxes will be removed. The impact of decommissioning phase will therefore, largely reflect that described for the operations and maintenance phase. However, there is the potential for new groundwater flow pathways to be created in localised areas as a result of the removal of link boxes and the Onshore Substation sub-surface features. The impact is considered to be **low**.

Sensitivity of private groundwater supply sources

16.8.8.9 Private supply sources are of local importance to the properties they supply. These groundwater receptors have a sensitivity considered to be **medium**.

Significance of effect

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

16.8.9 Deterioration of groundwater quality in the Clwyd Limestone Group bedrock aquifer by the mobilisation of contamination associated with the historical Llanddulas Beach Landfill site

16.8.9.1 The construction of the Mona Onshore Cable Corridor could result in the disturbance of the Llanddulas Beach Landfill site. If the integrity of the basal liner of the landfill site were compromised this could lead to the mobilisation of contamination (i.e. leachate) during the construction and decommissioning. This has the potential to result in the deterioration of groundwater quality in the underlying Clwyd Limestone Group Principal aquifer.

Construction phase

Magnitude of impact

16.8.9.2 The MDS summarised in Table 16.12 states that a trenchless drilling approach, such as HDD will be adopted to cross the landfill site. By careful design (to be described in the Llanddulas Landfill method statement) and drilling beneath the Llanddulas Landfill Site, the mobilisation of contamination (i.e. leachate) within the landfill can be avoided and the risk of any deterioration in groundwater quality in the underlying Principal aquifer of the Clwyd Limestone Group avoided. By adopting trenchless drilling approach the magnitude is therefore, considered to be **negligible**.

Sensitivity of the receptor

16.8.9.3 Given its designation as a Principal aquifer, the sensitivity of the Clwyd Limestone Group aquifer is considered to be **high**.

Significance of effect

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

16.8.10 Deterioration of groundwater quality in the glacial till aquifer by the disturbance and mobilisation of existing areas of contamination associated with recent or historical land-use

16.8.10.1 Recent or historical land-use has the potential to result in localised areas of soil and groundwater contamination. That contamination can be disturbed and mobilised during construction of the Onshore Cable Corridor, 400kV Grid Connection Corridor and Onshore Substation and supporting infrastructure.

16.8.10.2 As shown in Figure 1.5 and Figure 1.6 of annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR, few high-risk sites of potential contamination have been identified within the Onshore Cable Corridor, 400kV Grid

Connection Corridor and Onshore Substation given the rural site setting. Where high risk sites are present in the Onshore Cable Corridor they are typically associated with the four former deep mining areas identified in the desktop study (see section 16.8.11). Llanddulas Beach Landfill site is the notable exception and is therefore assessed separately in section 16.8.9

16.8.10.3 Historical licensed industrial activity land-uses were identified around St Asaph Business Park to the north of the Onshore Substation option 7 at the east end of the Mona Proposed Onshore Development Area. However, as that area is underlain by thick glacial till there does not appear to be a significant pathway connecting these potentially contaminative historical industrial sources to soil and groundwater within the Mona Proposed Onshore Development Area. These possible contamination sources are unlikely to represent a risk to soil or groundwater quality during the construction and are not considered further in the assessment.

16.8.10.4 Most of the Onshore Cable Corridor, 400kV Grid Connection Corridor and Onshore Substation and supporting infrastructure are underlain by glacial till. Given the shallow nature of the proposed construction works it is the groundwater in the till that is most likely to be affected by any shallow contamination. However, the cohesive nature of the till and the discontinuous occurrence of groundwater therein, results in that contamination being localised and constrained with limited migration pathways.

Construction phase

Magnitude of impact

16.8.10.5 There are few areas recent or historical land-use with a high risk of causing shallow soil or groundwater contamination within the Mona Proposed Onshore Development Area. Given the low permeability nature of the superficial deposit and discontinuous nature of groundwater therein, possible disturbance of land contamination could result in small, measurable but localised change in groundwater quality albeit in very few places along the Onshore Cable Corridor, 400kV Grid Connection Corridor and the Onshore Substation option locations. By including a contamination discovery strategy and requirement for undertaking a piling risk assessment for deep foundation solutions in the CoCP, the risk from any contamination will be effectively managed and mitigated. The magnitude of this impact is predicted to be of local spatial extent, medium-term duration and medium reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the shallow glacial till aquifer

16.8.10.6 The glacial till aquifer underlying most of the Mona Proposed Onshore Development Areas designated a Secondary undifferentiated aquifer that is characterised by localised groundwater occurrence that is of limited resource potential, limited utilisation at a local scale and with limited connection to other receptors. The sensitivity of this receptor is therefore considered to be **low**.

Significance of effect

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

16.8.11 Deterioration in groundwater quality in bedrock aquifers through the disturbance and mobilisation of existing areas of contaminated land associated with recent or historical land-use

16.8.11.1 Recent or historical land-use has the potential to result in localised areas of soil and groundwater contamination. That contamination can be disturbed and mobilised during construction of the Onshore Cable Corridor, 400kV Grid Connection Corridor and Onshore Substation and supporting infrastructure.

16.8.11.2 As shown in Figure 1.5 and Figure 1.6 of annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR, few high-risk sites of potential contamination have been identified within the Onshore Cable Corridor, 400kV Grid Connection Corridor and Onshore Substations given the rural site setting. Where present in the Onshore Cable Corridor and 400kV Grid Connection Corridor, they are typically associated with the four former deep mining areas identified in the desktop study (See Section 16.8.11). Llanddulas Beach Landfill site is the notable exception and is therefore assessed separately in Section 16.8.8.

16.8.11.3 Historical licensed industrial activity land-uses were identified around St Asaph Business Park at the east end of the Mona Proposed Onshore Development Area and to the north of the Onshore Substation option 7 . However, as that area is underlain by thick glacial till these potentially contaminative historical industrial activities are considered unlikely to represent a risk to soil or groundwater quality during the construction of transmission assets.

16.8.11.4 Most of the Onshore Cable Corridor, 400kV Grid Connection Corridor and Onshore Substation and supporting infrastructure are underlain by glacial till. The underlying bedrock is exposed by small windows in the till, most notably in areas of high elevation in the west. Groundwater in the most important Carboniferous bedrock aquifers (i.e. of the Clwyd Limestone Group, Ffernant Formation and Warwickshire Group) are either located at considerable depth beneath the ground surface or are confined and/or concealed by thick glacial till. In both instances, this indicates long and/or complex pathways for shallow surface contamination to affect groundwater quality in the underlying limestone and sandstone aquifers.

Construction phase

Magnitude of impact

16.8.11.5 There are few areas of recent or historical land-use with a high risk of causing shallow soil or groundwater contamination within the Onshore Cable Corridor, 400kV Grid Connection Corridor and Onshore Substations . Given the depth to the groundwater and/or the presence of thick low permeability till, possible disturbance of land contamination could result in a small, measurable but localised change in groundwater quality albeit in localised areas. By including a contamination discovery strategy and requirement for undertaking piling risk assessment for deep foundation solutions in the CoCP the risk of mobilising existing contaminants from construction activities will be effectively managed and mitigated. The magnitude of this impact predicted to be of local spatial extent, medium-term duration and medium reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **negligible**.

Sensitivity of the bedrock aquifer receptor

16.8.11.6 The bedrock underlying the Mona Proposed Onshore Development Area is designated as a Principal aquifer (Clwyd Limestone Group), Secondary A aquifer (Ffernant Formation and Warwickshire Group) or Secondary B aquifer (Elwy Formation. The sensitivity of these bedrock aquifer receptors is therefore considered to be **medium** or **high**.

Significance of effect

16.8.11.7 Overall, the magnitude of the impact is deemed to be negligible and the sensitivity of the receptor is considered to be medium or high. The effect will, therefore, be of **negligible** or **minor** adverse significance, depending on which aquifer unit is potentially affected, which is not significant in EIA terms.

16.8.12 Deterioration in groundwater quality by the accidental release or spillage of potentially polluting substances during the construction and decommissioning phase

16.8.12.1 Potentially polluting substances will be stored, handled and used within the Mona Proposed Onshore Development Area during the construction phase and decommissioning phase. Notable substances include fuels, lubricants and hydraulic oils associated with plant and machinery. Oher substances such as foul water generated from welfare facilities will also require appropriate management. As outlined in Table 16.14 measures will be included in the Outline CoCP to ensure all controlled water receptors are protected during the proposed the proposed construction and decommissioning works. The Outline CoCP shall identify how potentially polluting substances will be stored, handled and used appropriately by:

- reference to relevant regulatory guidance and industry best practice
- consideration of groundwater, surface water and environmental receptors during the design of compounds and the management of surface water runoff thereon
- the design of material storage and refuelling areas
- production of method statements and emergency response plans for activities involving potentially polluting materials and associated training of the relevant personnel.

16.8.12.2 This assessment considers the significance of effect, with the delivery of the Outline CoCP and associated management plans included.

Construction phase

Magnitude of impact

16.8.12.3 The majority of the Onshore Cable Corridor, 400kV Grid Connection Corridor and Onshore Substation are situated upon glacial till. Given the low permeability of the till and discontinuous nature of groundwater therein, any accidental release to ground is likely to remain localised. The delivery of the CoCP will mean the magnitude for this impact on the glacial till aquifer will be local spatial extent, short-term duration and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

16.8.12.4 Groundwater in the bedrock aquifer units that underlie the Onshore Cable Corridor, 400kV Grid Connection Corridor and Onshore Substation is either located at considerable depth beneath the ground surface or are confined/concealed beneath glacial till. In either scenario the pathway for an accidental release to reach groundwater is either long or hydrogeologically complex. With the addition of the measures in the CoCP there will be no measurable impact on groundwater quality in the underlying bedrock aquifer. The magnitude of this impact is therefore, considered to be **negligible**.

Sensitivity of receptor

16.8.12.5 The sensitivity of groundwater receptors present within the GHGC study area have been defined in preceding sections as follows:

Superficial geology

- Glacial till (Secondary undifferentiated) aquifer – **Low** sensitivity.

Bedrock geology

- Limestones of the Clwyd Limestone Group (Principal) bedrock aquifer – **High** sensitivity
- Sandstones of the Ffernant Formation and Warwickshire Group (Secondary A) bedrock aquifers – **Medium** sensitivity
- Mudstones of the Elwy Formation (Secondary B) bedrock aquifer – **Low** sensitivity.

Significance of effect

16.8.12.6 Overall, the magnitude of the impact has been assessed for each aquifer unit as follows:

Superficial geology

- Glacial till (Secondary undifferentiated) aquifer - The magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Bedrock geology

- Limestones of the Clwyd Limestone Group (Principal) bedrock aquifer – The magnitude of the impact is deemed to be negligible and the sensitivity of the receptor is considered to be high. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms
- Sandstones of the Ffernant Formation and Warwickshire Group (Secondary A) bedrock aquifers – The magnitude of the impact is deemed to be negligible and

the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms

- Mudstones of the Elwy Formation (Secondary B) bedrock aquifer –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.

Decommissioning phase

Magnitude of impact

16.8.12.7 As summarised in the MDS Table 16.12, it is proposed to leave the Mona Onshore Cables and 400kV Grid Connection Cables in situ after decommissioning, however the link boxes and Onshore Substation and associated infrastructure will be removed. The impact is therefore considered to be **negligible**.

Sensitivity of receptor

16.8.12.8 The sensitivity of groundwater receptors present within the Mona GHCC study area have been defined in preceding sections as follows:

Superficial geology

- Glacial till (Secondary undifferentiated) aquifer – **Low** sensitivity

Bedrock geology

- Limestones of the Clwyd Limestone Group (Principal) bedrock aquifer – **High** sensitivity
- Sandstones of the Ffernant Formation and Warwickshire Group (Secondary A) bedrock aquifers – **Medium** sensitivity
- Mudstones of the Elwy Formation (Secondary B) bedrock aquifer – **Low** sensitivity.

Significance of effect

16.8.12.9 Overall, the magnitude of the impact has been assessed for each aquifer unit as follows:

Superficial geology

- Glacial till (Secondary undifferentiated) aquifer - 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.

Bedrock geology

- Limestones of the Clwyd Limestone Group (Principal) bedrock aquifer – The magnitude of the impact is deemed to be negligible and the sensitivity of the receptor is considered to be high. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms
- Sandstones of the Ffernant Formation and Warwickshire Group (Secondary A) bedrock aquifers – The magnitude of the impact is deemed to be negligible and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms
- Mudstones of the Elwy Formation (Secondary B) bedrock aquifer –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 or minor** adverse significance, which is not significant in EIA terms.

16.8.13 Ground stability associated with areas of historical deep mining operations

16.8.13.1 The following four areas within the Mona Proposed Onshore Development Area were identified in the desktop study as potentially being situated above or near historical deep mining operations (as shown in Figure 1.6 of annex 16.1: Aquifers, groundwater abstractions and ground conditions of the PEIR):

- Area to the west of Gwrych Castle (approximately 0.75km south of the Mona Landfall) associated with Cefn yr Ogof
- Area around Castell Cawr (approximately 1.2km south of the Mona Landfall), associated with Ffos-y-Bleiddiaid Mine
- Area around Nant Fawr (approximately 2.1km south of the Mona Landfall) associated with Nant Uchaf Mine
- Area around Glascoed and Cefn Meiriadog (approximately 2km south of Bodelwyddan and 3.5km from the east end of the Mona Onshore Substation option 2) that includes the Score (Cefn) Mine and Coed-Carreg-Dafydd Mine.

16.8.13.2 These very old areas of mining activity are typically associated with shafts or other associated features relating to deep mining operations. The construction of the Onshore Cable Corridor, Onshore Substation, 400kV Grid Connection Cable Corridor and associated infrastructure using heavy plant and machinery has the potential cause ground stability issues should they be situated above or near such structures. This in turn may represent a risk to the integrity of transmission assets and their operation, as well as a safety risk .

Construction phase

Magnitude of impact

16.8.13.3 The features associated with historical deep mining operations are likely to be either shafts or adits associated with the mines or localised areas of waste disposal. Although any impact will be of local spatial extent, the magnitude of the short-term impact would be large and may be of limited reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **medium.**

Sensitivity of the receptor

16.8.13.4 Ground stability issues could affect the integrity of the transmission assets themselves or safety of construction workers. For the purpose of this assessment the sensitivity of these receptors is therefore considered to be **high**.

Significance of effect

16.8.13.5 Overall, the magnitude of the impact is deemed to be medium and the sensitivity of the receptor is considered to be high. The effect will, therefore, be of **moderate** adverse significance, which is significant in EIA terms

Further mitigation and residual effect

16.8.13.6 To mitigate the impact of ground stability issues associated with historical deep mining operations a 'historical mining assessment' shall be undertaken. The assessment will include a site investigation to further characterise the mining features/structures and to identify any remedial works required to minimise the potential impact to the Onshore Cable Corridor, Onshore Substation and 400kV Grid Connection Cable Corridor. By completing that assessment and any resulting remedial work, the magnitude of impact shall be reduced to negligible hence the significance of effect will be **minor** adverse, which is not significant in EIA terms.

16.9 Cumulative effects assessment methodology

16.9.1 Methodology

16.9.1.1 The Cumulative Effects Assessment (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.

16.9.1.2 The geology, hydrogeology and ground conditions 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.

16.9.1.3 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
- Tier 2
  - Scoping Report has been submitted and is in the public domain
- Tier 3
  - Scoping Report has not been submitted or is not in the public domain
  - Identified in the relevant Development Plan
  - Identified in other plans and programmes.

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

16.9.1.2 The specific projects, plans and activities scoped into the CEA, are outlined in Table 16.15.

16.9.1.3 National Grid Electricity Transmission (NGET) are proposing to undertake upgrades to their Bodelwyddan substation; to facilitate the connection of multiple projects (e.g. Awel Y Mor). The upgrades will comprise works to the existing substation, an extension to the substation and associated works and infrastructure (e.g. new overhead gantries).

16.9.1.4 It is understood that works to the existing substation will be undertaken via NGET's permitted development rights. The proposed extension to Bodelwyddan substation will require planning consent. At the time of writing, an application had not been submitted to Denbighshire County Council but the anticipated timeframe is early 2024. Given that an application has not been submitted, the potential cumulative impacts of the Bodelwyddan upgrade have not been assessed within the PEIR. This will be re-visited in the application for consent for the Mona Offshore Wind Project should further information become available.

Table 16.15: List of other projects, plans and activities considered within the CEA.

Project/Plan	Status	Distance from the Mona Onshore Proposed Development Area (km)	Distance to Onshore Substation (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Mona Offshore Wind Project
Awel y Môr Offshore Wind farm (Onshore Infrastructure)	Application Submitted	0	0.1 (option 2) 0.7 (option 7)	Application for the construction of a 500MW offshore windfarm. Applicant expects consent in Q3 2023.	Construction to commence in 2026.	Site to be commissioned by 2030.	Yes
Major Developments 40/2021/0309	Approved within last 5 years	0.8	1.6 (option 2) 1.8 (option 7)	Erection of a 198 bed Registered Care Home (Use Class C2), landscaping, parking facilities and associated works (Resubmission)	Construction to commence in 2024.	N/A	Yes

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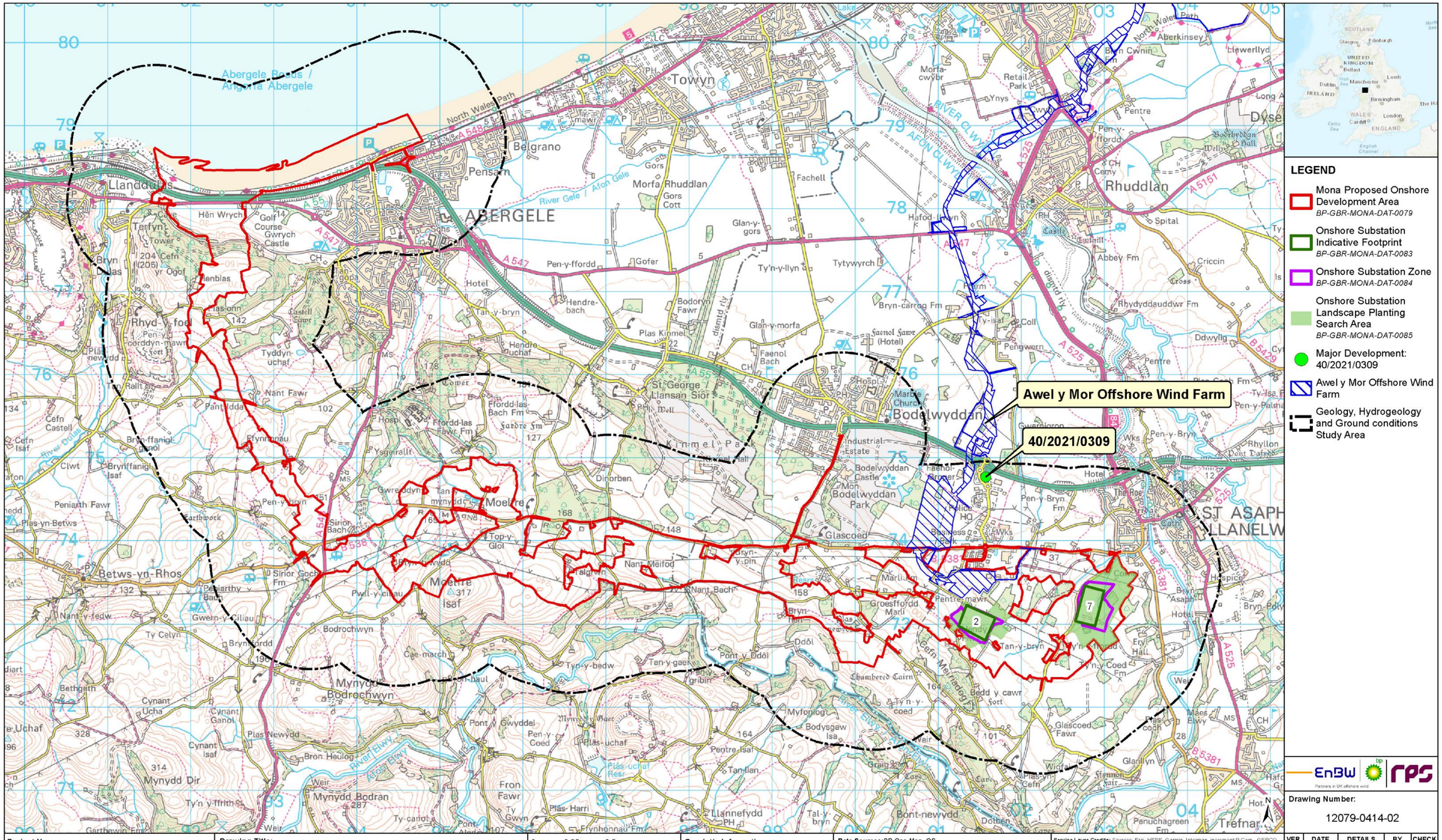

Figure 16.2: Other projects, plans and activities screened into the cumulative effects assessment.

16.9.2 Maximum design scenario

16.9.2.1 The MDS identified in Table 16.16 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 5: 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 turbine layout), to that assessed here, be taken forward in the final design scheme.

Table 16.16: MDS considered for the assessment of potential cumulative effects on geology, hydrogeology and ground conditions.

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

Potential cumulative impact	Phase[a] C	O	D	MDS	Justification
Alteration to groundwater quantity or quality in the glacial till superficial aquifer.	✓	✓	✓	MDS as described for the Mona Offshore Wind Project (Table 16.12) assessed cumulatively with the following other projects/plans: **Tier 1** • Awel y Môr Offshore Wind farm (Onshore Infrastructure) – Assumed that construction works to occur concurrently with the Mona Offshore Wind Project – Assumed that MDS for the construction phase of Awel y Môr Offshore Wind farm is equivalent to that for the Mona Offshore Wind Project as described in Table 16.12 – Assumed that operations and maintenance phase impacts will be equivalent, given the construction MDS is same as described for the Mona Offshore Wind Project – Assumed that during decommissioning phase the onshore infrastructure for Awel y Môr will be removed • Major Developments 40/2021/0309T – Assumed that construction works to occur concurrently with the Mona Offshore Wind Project – The magnitude of construction phase impacts on the Mona Proposed Onshore Development Area will be negligible – The magnitude of operational and maintenance phase and decommissioning phase impacts on the Mona Proposed Onshore Development Area will be smaller than construction phase impacts.	• Baseline conditions will be shared for projects • Outcome of the CEA will be greatest when projects are constructed concurrently • Construction approach and methodology for the Awel y Môr Offshore Wind farm (Onshore Infrastructure) are likely to be similar and will share equivalent operations and maintenance phase and decommissioning phase effects which is it is assumed will overlap • The magnitude of effects expected for the construction phase of Major Developments 40/2021/0309T are considered negligible given that: – the Major Developments site is situated approximately 750m outside of Mona Proposed Onshore Development Area – the Major Developments site is situated on significant depth of low permeability glacial till that is an aquifer characterised by limited hydraulic continuity – the planning permission for the 198 bed Registered Care Home will require a full assessment of risk associated with ground conditions on the site and development of remediation plan to manage those risks if required • Operational and maintenance phase and decommissioning phase impacts will be smaller than construction phase impacts, following delivery of the required risk assessment and remediation should it be required.
Alteration to groundwater quantity or quality in the bedrock aquifers of the Ffernant Formation and Warwickshire Group (Secondary A aquifers).	✓	✓	✓		
Impact on private groundwater abstractions in terms of abstraction quantity, abstraction reliability and abstraction quality.	✓	✓	✓		
Deterioration in groundwater quality as a result of accidental release or spillage of potentially polluting substances, during the construction and decommissioning phase.	✓	×	✓		
Deterioration of groundwater quality in the glacial till aquifer by the disturbance and mobilisation of existing areas of contamination associated with recent or historical land-use.	✓	×	×	MDS as described for the Mona Offshore Wind Project (Table 16.12) assessed cumulatively with the following other projects/plans: **Tier 1** • Awel y Môr Offshore Wind farm (Onshore Infrastructure) – Only considering construction phase impacts – Assumed that construction works to occur concurrently with the Mona Offshore Wind Project – Assumed that MDS for the construction phase of Awel y Môr Offshore Wind farm is equivalent to that for the Mona Offshore Wind Project as described in Table 16.12 • Major Developments 40/2021/0309T – Only considering construction phase impacts – Assumed that construction works to occur concurrently with the Mona Offshore Wind Project – The magnitude of construction phase impacts on the Mona Proposed Onshore Development Area will be negligible.	• Baseline conditions will be shared for projects • Outcome of the CEA will be greatest when projects are constructed concurrently • Construction approach and methodology for the Awel y Môr Offshore Wind farm (Onshore Infrastructure) are likely to be similar and will share equivalent operations and maintenance phase and decommissioning phase effects which is it is assumed will overlap • The magnitude of effects expected for the construction phase of Major Developments 40/2021/0309T are considered negligible given that: – the Major Developments site is situated approximately 750m outside of Mona Proposed Onshore Development Area – the Major Developments site is situated on significant depth of low permeability glacial till that is an aquifer characterised by limited hydraulic continuity – the planning permission for the 198 bed Registered Care Home will require a full assessment of risk associated with ground conditions on the site and development of remediation plan to manage those risks if required.
Deterioration in groundwater quality in bedrock aquifers through the disturbance and mobilisation of existing areas of contaminated land associated with recent or historical land-use.	✓	×	×		

16.10 Cumulative effects assessment

16.10.1.1 A description of the significance of cumulative effects upon geology, hydrogeology and ground condition receptors arising from each identified impact is given below.

16.10.2 Alteration to groundwater quantity or quality in the glacial till superficial aquifer (Secondary undifferentiated).

Tier 1

Construction phase

Magnitude of impact

16.10.2.1 The Awel y Môr project involves the construction of cable trenches. Temporary dewatering of the cable trenches may be required during construction. This may locally lower groundwater level, resulting in changes to flow directions, and/or reduce the quantity of groundwater within localised water-bearing units in the till within the cumulative GHGC study area. The cumulative impact is predicted to be of limited local spatial extent, short term duration and of and moderate reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

16.10.2.2 The glacial till is a Secondary undifferentiated aquifer, characterised by localised groundwater occurrence, limited resource potential and limited utilisation at a local scale and with limited connection to other groundwater dependant receptors. The sensitivity of this receptor is therefore considered to be **low**.

Significance of effect

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

Operations and maintenance phase

Magnitude of impact

16.10.2.4 The inert granular fill within the onshore export cables, may create new shallow pathways for groundwater flow in the glacial till. This may provide increased localised connectivity between water bearing horizons at shallow depth in the glacial till aquifer within the cumulative GHGC study area. However, a large increase in connectivity with potential groundwater dependent receptors is considered unlikely to occur. The cumulative effect is predicted to be of limited local spatial extent albeit long term to permanent duration. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

16.10.2.5 The glacial till is a Secondary undifferentiated aquifer, characterised by localised groundwater occurrence, limited resource potential and limited utilisation at a local scale and with limited connection to other groundwater dependant receptors. The sensitivity of this receptor is therefore considered to be **low**.

Significance of effect

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

Decommissioning phase

Magnitude of impact

16.10.2.7 The impact of the decommissioning phase will largely reflect that described for the operations and maintenance phase given onshore export cables will be left in situ within the cumulative GHGC study area. However, the link boxes and Onshore Substation will be removed. The impact on groundwater within the glacial till will be a small and localised change to groundwater levels, groundwater flow and resource utility. The cumulative effect is predicted to be of limited local spatial extent albeit long term to permanent duration. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

16.10.2.8 The glacial till is a Secondary undifferentiated aquifer, characterised by localised groundwater occurrence, limited resource potential and limited utilisation at a local scale and with limited connection to other groundwater dependant receptors. The sensitivity of this receptor is therefore considered to be **low**.

Significance of effect

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

16.10.3 Alteration to groundwater quantity or quality in the bedrock aquifers of the Ffernant Formation and Warwickshire Group (Secondary A aquifers).

Tier 1

Construction phase

Magnitude of impact

16.10.3.1 The sandstone bedrock aquifer of the Warwickshire Group within the cumulative GHGC study area are concealed beneath a significant depth of glacial till. As no pathways to the bedrock are expected to be created during construction within the CEA the magnitude of the cumulative effect is therefore considered to be **negligible**.

Sensitivity of the receptor

16.10.3.2 The Warwickshire Group sandstones are designated Secondary A aquifer of possible local importance. The sensitivity of the receptor is therefore, considered to be **medium**.

Significance of effect

16.10.3.3 Overall, the magnitude of the cumulative impact is deemed to be no change and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be **minor** adverse, which is not significant in EIA terms.

Operations and maintenance phase

Magnitude of impact

16.10.3.4 In the absence of new pathways to the concealed bedrock aquifer being created during constriction within the CEA and given local recharge can be expected to be of reasonable quality the magnitude of the cumulative effect is considered to be negligible.

Sensitivity of the receptor

16.10.3.5 The sandstones of the Warwickshire Group are designated a Secondary A aquifer of possible local importance. The sensitivity of the receptor is therefore, considered to be **medium**.

Significance of effect

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

Decommissioning phase

Magnitude of impact

16.10.3.7 As for the operations and maintenance phase the magnitude of long term cumulative effect on the Warwickshire Group bedrock aquifer is considered to be **negligible.**

Sensitivity of the receptor

16.10.3.8 The sandstones of the Warwickshire Group are designated a Secondary A aquifer of possible local importance. The sensitivity of the receptor is therefore, considered to be **medium**.

Significance of effect

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

16.10.4 Impact on private groundwater abstractions in terms of abstraction quantity, abstraction reliability and abstraction quality.

Tier 1

Construction phase

Magnitude of impact

16.10.4.1 The construction of transmission assets could have short to long term direct impact on proximal private groundwater supply sources through dewatering, pathway creation or accidental spillages within the cumulative GHGC study area However, the implementation of a private groundwater abstraction risk assessment for all developments with the CEA area will ensure private water sources are protected or effects mitigated. The magnitude of cumulative effect is therefore considered to be **low**.

Sensitivity of the receptor

16.10.4.2 Private supply sources are of local importance to the properties they serve. These groundwater receptors have a sensitivity considered to be **medium**.

Significance of effect

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

Operations and maintenance phase

Magnitude of impact

16.10.4.4 The creation of new, shallow groundwater pathways during construction could result in a long term impact on proximal private groundwater supply sources during the operations and maintenance phase. However, the implementation of a private groundwater abstraction risk assessment for all developments within the cumulative GHGC study area will reduce ensure private water sources are protected or effects mitigated. The magnitude of the cumulative effect is therefore considered to be **low**.

Sensitivity of the receptor

16.10.4.5 Private supply sources are of local importance to the properties they serve. These groundwater receptors have a sensitivity considered to be **medium**.

Significance of effect

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

Decommissioning phase

Magnitude of impact

16.10.4.7 As for the operations and maintenance phase the magnitude of this cumulative effect is considered to be **low**.

Sensitivity of the receptor

16.10.4.8 Private supply sources are of local importance to the properties they serve. These groundwater receptors have a sensitivity considered to be **medium**.

Significance of effect

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

16.10.5 Deterioration in groundwater quality as a result of accidental release or spillage of potentially polluting substances, during the construction and decommissioning phase

Tier 1

Construction phase

Magnitude of impact

16.10.5.1 The storage, transportation and use of potentially polluting substances during the construction phase for developments with the cumulative GHGC study area has the potential to directly impact groundwater in the shallow underlying aquifer. This risk is managed by measures outlined in the CoCP that will accompany all such developments within the cumulative GHGC study area. By implementing those measures the magnitude of this cumulative effect will be minimised. The magnitude of the cumulative impact on the glacial till aquifer is considered to be **low.**

16.10.5.2 The magnitude of the cumulative impact on the is therefore considered to be **low**.

Sensitivity of the receptor

16.10.5.3 The cumulative GHGC study area is directly underlain by a thick sequence of glacial till that is classified a Secondary undifferentiated aquifer unit. The sensitivity of this receptor is considered to be **low**.

Significance of effect

16.10.5.4 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 **negligible**, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

16.10.5.5 The cumulative effect for the decommissioning phase is considered to have the same magnitudes as defined for the construction phase. By implementing those measures in the CoCP for decommissioning the magnitude of cumulative effect will be minimised. The magnitude of impact is therefore considered to be **low**.

Sensitivity of the receptor

16.10.5.6 The cumulative GHGC study area is directly underlain by a thick sequence of glacial till that is classified a Secondary undifferentiated aquifer unit. The sensitivity of this receptor is considered to be **low**.

Significance of effect

16.10.5.7 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 **negligible**, which is not significant in EIA terms.

16.10.6 Deterioration of groundwater quality in the glacial till aquifer by the disturbance and mobilisation of existing areas of contamination associated with recent or historical land-use

Tier 1

Construction phase

Magnitude of impact

16.10.6.1 Historical licensed industrial activity land-uses have been identified around St Asaph Business Park in the vicinity of the cumulative GHGC study area, albeit largely outside of the Mona Onshore Development Area. The potential risk associated with soil and groundwater conditions within these areas shall mitigated through the implementation of a contamination discovery strategy and investigations as part of the CoCP for Awel y Môr Offshore Wind farm and as a planning condition for other major developments considered in the cumulative GHGC study area. Given the low permeability of the till and discontinuous nature of groundwater therein, it is also reasonable to expect the magnitude of this impact will not be greater than for the CEA than for Mona in isolation. The magnitude of this cumulative effect is therefore, considered to be **low**.

Sensitivity of the receptor

16.10.6.2 The glacial till is Secondary undifferentiated aquifer, characterised by localised groundwater occurrence, limited resource potential, limited utilisation at a local scale and with limited connection to other groundwater dependant receptors. The sensitivity of this receptor is therefore considered to be **low**.

Significance of effect

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

16.10.7 Deterioration in groundwater quality in bedrock aquifers through the disturbance and mobilisation of existing areas of contaminated land associated with recent or historical land-use.

Tier 1

Construction phase

Magnitude of impact

16.10.7.1 Historical licensed industrial activity land-uses have been identified around St Asaph Business Park in the vicinity of the cumulative GHGC study area, albeit largely outside of the Mona Onshore Development Area. The potential risk associated with soil and groundwater conditions within these areas shall mitigated through the implementation of a contamination discovery strategy and requirement for undertaking a piling risk assessment for deep foundation solutions as part of the CoCP for all developments considered in the cumulative GHGC study area. Given the bedrock aquifer in the cumulative GHGC study area is concealed beneath deep glacial till, the magnitude of this impact is therefore, considered to be **negligible**.

Sensitivity of the receptor

16.10.7.2 The Warwickshire Group sandstones are designated Secondary A aquifer of possible local importance. The sensitivity of the receptor is therefore considered to be **medium**.

Significance of effect

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

16.11 Transboundary effects

16.11.1.1 A screening of transboundary impacts has been carried out and has identified that there was no potential for significant transboundary effects with regard to geology, hydrogeology and ground conditions from the Mona Offshore Wind Project upon the interests of other states.

16.12 Inter-related effects

16.12.1.1 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 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 geology, hydrogeology and ground conditions , such as deterioration of groundwater, 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.

16.12.1.2 A description of the likely interactive effects arising from the Mona Offshore Wind Project on geology, hydrogeology and ground conditions is provided in volume 3, chapter 25: Inter-related effects of the PEIR.

16.13 Summary of impacts, mitigation measures and monitoring

16.13.1.1 Information on geology, hydrogeology and ground conditions within the GHGC study area was collected through a review of desktop information.

- Table 16.17 presents a summary of the potential impacts, measures adopted as part of the project and residual effects in respect to geology, hydrogeology and ground conditions. The impacts assessed include:
  - The impact of loss of, or damage to, designated sites of geological and geomorphological interest
  - Loss of, or damage to non-designated sites of geological and geomorphological interest
  - Sterilisation of safeguarded limestone mineral resources
  - Alteration to groundwater quantity or quality in the glacial till superficial aquifer (Secondary undifferentiated)
  - Alteration to groundwater quantity or quality in the Clwyd Limestone Group bedrock aquifer (Principal aquifer)
  - Alteration to groundwater quantity or quality in the bedrock aquifers of the Ffernant Formation and Warwickshire Group (Secondary A aquifers)
  - Impact on private groundwater abstractions in terms of abstraction quantity, abstraction reliability and abstraction quality
  - Deterioration of groundwater quality in the Clwyd Limestone Group bedrock aquifer by the mobilisation of contamination associated with the historical Llanddulas Beach Landfill site
  - Deterioration of groundwater quality in the glacial till aquifer by the disturbance and mobilisation of existing areas of contamination associated with recent or historical land-use
  - Deterioration in groundwater quality in bedrock aquifers through the disturbance and mobilisation of existing areas of contaminated land associated with recent or historical land-use

  - Deterioration in groundwater quality as a result of accidental release or spillage of potentially polluting substances, during the construction and decommissioning phase
  - Ground stability issues associated with areas of historical deep mining operations
- Overall it is concluded that there will be the following significant effects arising from the Mona Offshore Wind Project during the construction, operations and maintenance or decommissioning phases:
  - Ground stability issues associated with areas of historical deep mining operations
- Table 16.18 presents a summary of the potential cumulative impacts, mitigation measures and residual effects. The cumulative impacts assessed include:
  - Alteration to groundwater quantity or quality in the glacial till superficial aquifer (Secondary undifferentiated)
  - Alteration to groundwater quantity or quality in the Clwyd Limestone Group bedrock aquifer (Principal aquifer)
  - Alteration to groundwater quantity or quality in the bedrock aquifers of the Ffernant Formation and Warwickshire Group (Secondary A aquifers)
  - Impact on private groundwater abstractions in terms of abstraction quantity, abstraction reliability and abstraction quality
  - Deterioration of groundwater quality in the glacial till aquifer by the disturbance and mobilisation of existing areas of contamination associated with recent or historical land-use
  - Deterioration in groundwater quality in bedrock aquifers through the disturbance and mobilisation of existing areas of contaminated land associated with recent or historical land-use
  - Deterioration in groundwater quality as a result of accidental release or spillage of potentially polluting substances, during the construction and decommissioning phase
- 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 16.17: Summary of potential environmental effects, mitigation and monitoring.

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

Description of impact	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							
The impact of loss of, or damage to, designated sites of geological and geomorphological interest.	✓	×	×	Trenchless crossing techniques, a method statement for this technique and micro-siting of Onshore Cable Corridor and 400kV Grid Connection Corridor	C:Low	C:High	C: Minor adverse	N/A	C: Minor adverse	N/A
Loss of, or damage to non-designated sites of geological and geomorphological interest.	✓	×	✓	Micro-siting of Onshore Cable Corridor and 400kV Grid Connection Corridor. Restoration of drumlins as part of soil management plan	C:Low D: Negligible	C: Low D: Low	C: Minor adverse D: Negligible	N/A	C:Minor adverse D:Negligible	N/A
Sterilisation of safeguarded limestone mineral resources.	✓	✓	✓	Refinement of Onshore Cable Corridor	C:Low O:Low D:Low	C:Medium O:Medium D:Medium	C:Minor adverse O: Minor adverse D: Minor adverse	N/A	C:Minor adverse O: Minor adverse D: Minor adverse	N/A
Alteration to groundwater quantity or quality in the glacial till superficial aquifer.	✓	✓	✓	Outline CoCP	C:Low O:Low D:Low	C:Low O:Low D:Low	C:Minor adverse O: Minor adverse D: Minor adverse	N/A	C:Minor adverse O: Minor adverse D: Minor adverse	N/A
Alteration to groundwater quantity or quality in the Clwyd Limestone Group bedrock aquifer (Principal aquifer).	✓	✓	✓	None	C: Negligible O: Negligible D: Negligible	C:High O:High D:High	C:Minor adverse O: Minor adverse D: Minor adverse	N/A	C:Minor adverse O: Minor adverse D: Minor adverse	N/A
Alteration to groundwater quantity or quality in the bedrock aquifers of the Ffernant Formation and Warwickshire Group (Secondary A aquifers).	✓	✓	✓	None	C: Negligible O: Negligible D: Negligible	C:Medium O:Medium D:Medium	C:Minor adverse O: Minor adverse D: Minor adverse	N/A	C:Minor adverse O: Minor adverse D: Minor adverse	N/A
Impact on private groundwater abstractions in terms of abstraction quantity, abstraction reliability and abstraction quality.	✓	✓	✓	Private water supply risk assessment	C:Low O:Low D:Low	C:Medium O:Medium D:Medium	C:Minor adverse O: Minor adverse D: Minor adverse	N/A	C:Minor adverse O: Minor adverse D: Minor adverse	N/A
Deterioration of groundwater quality in the Clwyd Limestone Group bedrock aquifer by the mobilisation of contamination associated with the historical Llanddulas Beach Landfill site.	✓	×	×	Method statement for the trenchless cross technique	C: Negligible	C: High	C:Minor adverse	N/A	C:Minor adverse	N/A
Deterioration of groundwater quality in the glacial till aquifer by the disturbance and mobilisation of existing areas of contamination associated with recent or historical land-use.	✓	×	×	Piling risk assessment for deep foundations, contamination discovery strategy	C:Low	C:Low	C:Negligible	N/A	C: Negligible	N/A
Deterioration in groundwater quality in bedrock aquifers through the disturbance and mobilisation of existing areas of contaminated land associated with recent or historical land-use.	✓	×	×	Piling risk assessment for deep foundations, contamination discovery strategy	C: Negligible	C:Medium or High	C:Negligible	N/A	C: Minor adverse	N/A
Deterioration in groundwater quality as a result of accidental release or spillage of potentially polluting substances, during the construction and decommissioning phase.	✓	×	✓	Measures within the CoCP	C: Low to Negligible D:Negligible	C:Low to High D:Low to HIgh	C:Negligible to Minor adverse D:Negligible to Minor adverse	N/A	C: Negligible to Minor adverse D: Negligible to Minor adverse	N/A
Ground stability issues associated with areas of historical deep mining operations.	✓	×	×	None	C:Medium	C:High	C:Moderate adverse	Historical mining risk assessment	C:Minor adverse	N/A

Table 16.18: Summary of potential cumulative environmental effects, mitigation and monitoring.

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

Description of effect	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
Tier 1										
Alteration to groundwater quantity or quality in the glacial till superficial aquifer.	✓	✓	✓	Outline CoCP	C:Low O:Low D:Low	C:Low O:Low D:Low	C:Minor adverse O: Minor adverse D: Minor adverse	N/A	C:Minor adverse O: Minor adverse D: Minor adverse	N/A
Alteration to groundwater quantity or quality in the bedrock aquifers of the Ffernant Formation and Warwickshire Group (Secondary A aquifers).	✓	✓	✓	None	C: Negligible O: Negligible D: Negligible	C:Medium O:Medium D:Medium	C:Minor adverse O: Minor adverse D: Minor adverse	N/A	C:Minor adverse O: Minor adverse D: Minor adverse	N/A
Impact on private groundwater abstractions in terms of abstraction quantity, abstraction reliability and abstraction quality.	✓	✓	✓	Micro-siting of Onshore Cable Corridor and 400kV Grid Connection Corridor, private water supply risk assessment	C:Low O:Low D:Low	C:Medium O:Medium D:Medium	C:Minor adverse O: Minor adverse D: Minor adverse	N/A	C:Minor adverse O: Minor adverse D: Minor adverse	N/A
Deterioration in groundwater quality as a result of accidental release or spillage of potentially polluting substances, during the construction and decommissioning phase.	✓	×	×	Measures within the CoCP	C: Low	C:Low	C:Negligible	N/A	C:Negligible	N/A
Deterioration of groundwater quality in the glacial till aquifer by the disturbance and mobilisation of existing areas of contamination associated with recent or historical land-use.	✓	×	×	Piling risk assessment for deep foundations, contamination discovery strategy	C:Low	C:Low	C:Negligible	N/A	C: Negligible	N/A
Deterioration in groundwater quality in bedrock aquifers through the disturbance and mobilisation of existing areas of contaminated land associated with recent or historical land-use.	✓	×	×	Piling risk assessment for deep foundations, contamination discovery strategy	C: Negligible	C:Medium/	C:Minor adverse	N/A	C: Minor adverse	N/A

16.14 Next steps

16.14.1.1 Following the refinement of the Onshore Cable Corridor and 400kV Grid Connection Cable Corridor and the selection of the Onshore Substation option, the following groups will be consulted:

- Landowners, to determine the location and details of any Private Water Supply Sources (PWSSs) present within the GHGC study area that may be affected by the Onshore Cable Corridor, 400kV Grid Connection Corridor and Onshore Substation.
- NRW and the local EHOs at CCBC and DCC, to agree the level of information required to characterise the baseline with regards to ground conditions.

16.14.1.2 A private water supply risk assessment will be completed, and the hierarchy of mitigation measures will be identified.

16.15 References

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