MWP

Chapter 09 Land and Soils

Ballynisky Wind Farm

Ballynisky Green Energy Ltd.

December 2025

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Project No.	Doc. No.	Rev.	Date	Prepared By	Checked By	Approved By	Acceptance Code / Status
22569	6006	A	Sept. 2025	JS	LL	AO'C	Final
22569	6006	B	Dec. 2025	JS	LL	AO'C	Final

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9. Land and Soil

9.1 Introduction

This chapter assesses any likely significant effects to the land and soils environment arising from the proposed development and also considers any indirect effects. A full description of the proposed development, development lands and all associated project elements is provided in **Chapter 03 Description of the Proposed Development** of this **EIAR**. The assessment comprises:

- A review of the existing receiving environment;
- Prediction and characterisation of likely effects;
- Evaluation of effects significance; and
- Consideration of mitigation measures, where appropriate.

9.1.1 Competency of Assessor

The assessment was completed by Jasmin Spoerri (BSc, MSc), an Engineering Geologist with over four years' experience in engineering geology, environmental geology, and geotechnical engineering. She holds an MSc in Applied Environmental Geoscience from University College Cork. Jasmin has been involved in geological investigation/interpretation, geotechnical investigation/interpretation, hydrogeological assessment and investigation, and environmental assessments.

Jasmin has written Land and Soils chapters for various projects such as wind farms, pharmaceutical developments: LEO Pharma, Little Island, Co. Cork and Abbott Kilkenny Facility, Abbott (Ireland), Co. Kilkenny, and housing developments: Castlelake Strategic Housing Development (SHD), Carrigtwohill, Co. Cork. This included assessment of environmental impacts on land, soils, geology, and hydrogeology as well as cumulative impacts with various other aspects of the environment. She has also worked on Geotechnical Interpretive Reports (GIRs) for several projects including Moanvane Wind Farm, Co. Offaly and Coole Wind Farm, Co. Westmeath, including respective substations and grid connections.

9.2 Scope of Assessment

'Land and soil' are considered geological terms and in current, historical, and planned land use. The subject matter of hydrogeology and hydrology are further addressed in **Chapter 08 Water** of this **EIAR.** However, they are referenced in this chapter given that the scope of the chapter overlaps between soils, geology hydrology and hydrogeology.

Accordingly, the scope of this assessment is made with respect to these topic areas and considers the effects of the construction, operation, and decommissioning of the proposed development in terms of how the proposal could affect the local land and soil environment, and how the soils on site have a bearing on the site layout, site selection, alternative locations of turbines, may give rise to significant effects on the overall definition of the site layout, and may also impact hydrology and surface water quality.

9.2.1 Assessment Criteria

The method of impact assessment and prediction follows the EPA (2022) *Guidelines on the Information to be contained in Environmental Impact Assessment Reports (EIAR).* The methodology and approach outlined in the EPA Guidelines was used to determine whether the proposed development had the potential to cause significant effects on the land and soils environment and is as set out in **Table 1-2**, **Chapter 01 Introduction**.

9.2.2 Study Area

The proposed development area is shown in **Figure 9-1**. The Study Area for Land and Soils focused on the footprint of the proposed development area, as well as the lands adjacent to the site.

The proposed development site is located in the townlands of Ballynisky, Graigoor, Ballyegny More, Kilbradran, Ballysteen, Dunmoylan, Lisbane and Carrons near Coolcappa, Co. Limerick. It lies approximately 9km north of Newcastle West and 6km northwest of Rathkeale. The proposed development will comprise six (6) turbines and associated infrastructure including grid connection on a site area of approximately 43.02ha. The site and surrounding area are in a rural setting with landcover comprising mainly agricultural land, farmsteads and one-off residential houses.

Features of note in the surrounding area include Carrons Wind Farm to the west and Creeves Quarry to the north.

The R521 between Foynes and Newcastle West is located to the west of the site. The R521 links the N21 National Primary Road to the southeast and the N69 to the north. The R521 can also be accessed at Ardagh from the R523 south of Rathkeale. Access to the site will be via the L1219 local road to the northwest of the site, which is connected to the R521.

9.3 Methodology

The assessment methodology included a desk-based study, a site visit, and a qualitative assessment of the potential effects. The assessment criteria for geology, land and soils are based on the following guidelines:

- Coillte (2009): Forest Operations & Water Protection Guidelines;
- Environmental Protection Agency (2015): Draft - Advice Notes on Current Practice (in the preparation of Environmental Impact Statements);
- Environmental Protection Agency (2022): Guidelines on the Information to be contained in Environmental Impact Assessment Reports;
- European Union (2017): Guidance on the preparation of the EIA Report (Directive 2011/92/EU as amended by 2014/52/EU);
- Institute of Geologists Ireland (2013): Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements;
- National Roads Authority (2005): Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment (DoHPLG, 2018);
- National Roads Authority (2009): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes; and
- Scottish Executive (2017): Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments, 2nd Edition.

9.3.1 Desk Study

The methodology used for this study included desk-based research of published information and site visits to assemble information on the local receiving environment. The desk study included the following activities:

- Review of Ordnance Survey Mapping and aerial photography to establish existing land use and settlement patterns within the study area;
- Review of LiDAR data provided by client, OSi contour data and identification of water features on site;
- Examination of the Geological Survey of Ireland (GSI) datasets pertaining to geological (bedrock, heritage, subsoil, etc.) and extractive industry data;
- Examination of EPA / Geohive / Teagasc online soil and subsoil maps;
- Review of local and regional development plans and planning policy in order to identify future development and identify any planning applications within the study area; and
- Review of Limerick City and County Council's Planning Register to identify relevant development proposals currently under consideration by the Council.

Following the desktop study, a set of geological and soils maps were generated in GIS using data acquired from the Geological Survey Ireland (GSI), the Environmental Protection Agency (EPA) and Geohive Online maps, and are included as figures in this chapter. A site survey was also undertaken on the 1st December 2021 and the 18th May 2023 to verify gathered information. The data collected is still valid for the purposes of this assessment as there has been no land change since the site visits.

9.3.2 Statement on Limitations and Difficulties Encountered

The information used for this assessment is suitable for environmental assessment and planning design purposes only. Further ground investigation consisting of trial pits, boreholes and laboratory testing will be undertaken prior to construction to define the nature of the soil, subsoil, ground truth the desk study. No limitations or difficulties were encountered in the production of this chapter.

9.4 Baseline Environment

9.4.1 Site Location and Description

The proposed development is located in the townlands of Ballynisky, Graigoor, Ballyegny More, Kilbradran, Ballysteen, Dunmoylan, Lisbane and Carrons, approximately 9km north of Newcastle West and 6km west of Rathkeale, Co. Limerick. Refer to **Figure 9-1** for the site location map.

The site is rural in nature, with landcover comprising mainly agricultural land, farm holdings and residential dwellings in the wider area. The topography of the area is relatively flat with elevations ranging between 46 to 56m AoD. The terrain gently slopes upwards towards the southwest.

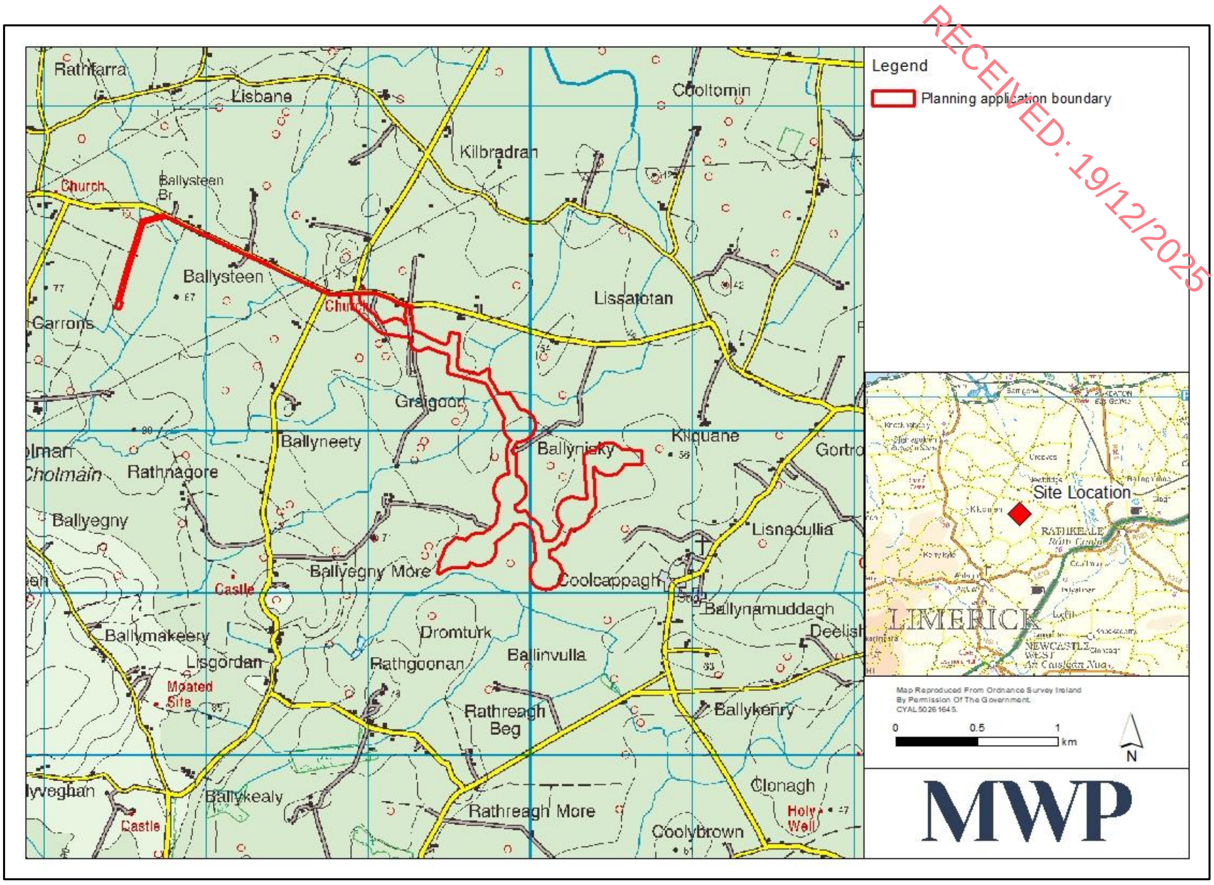

Figure 9-1: Site Location

9.4.2 Existing Land Use

The land use at the site has been mapped as shown in **Figure 9-2**. The land cover mapping was created using information from CORINE landcover and OSI. The proposed development is situated on lands primarily composed of *Improved Grassland*. **Figure 9-3** provides a photo showing the current land use on site.

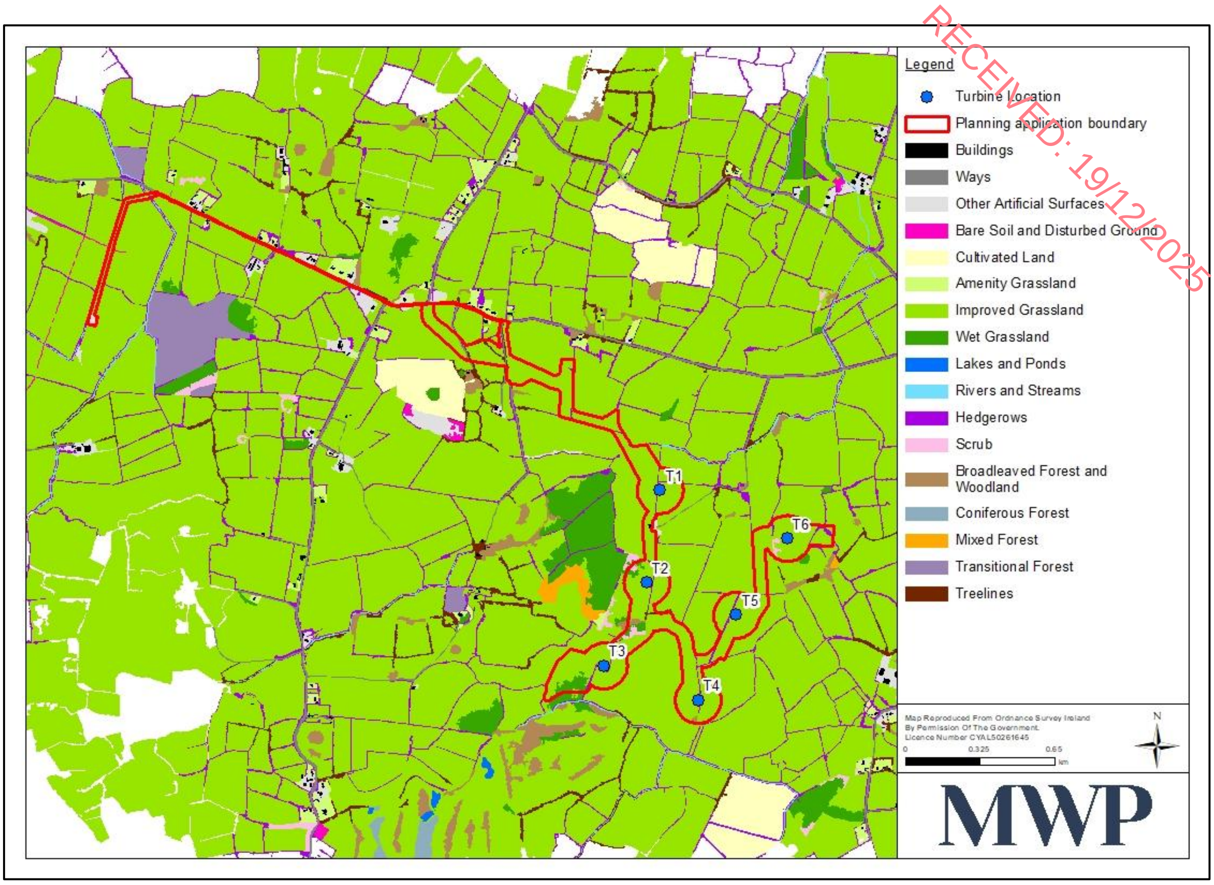

Figure 9-2: CORINE Landcover (Source: OSI)

Figure 9-3: Existing Land Use

As described in **Chapter 03 Description of the Proposed Development**, the final chosen locations of the main infrastructural components of the development are as follows:

- Turbines T1, T3, T4 and T5 are located in flat agricultural lands;
- Turbine T2 is located within wet grassland/scrub;
- Turbine T6 is located in flat agricultural lands bordered by scrub/woodland; and
- The 38kV Wind Farm Substation is located in improved grassland in the northwest corner of the site close to the permanent site entrance and adjacent to the temporary compound.
    - The soil deposition areas are located southwest of turbine T3 and east of the temporary compound respectively.
    - The Met Mast is located to the east of the substation.

9.4.3 Topography

The site is gently sloping upwards towards the southwest and dotted with small hills and depressions across the site (GSI 2m contour data). The maximum elevation of the study area is approx. 78m AOD. Elevations of the site range between approx. 46 - 56m AOD in areas where infrastructure will be developed (**Figure 9-4**).

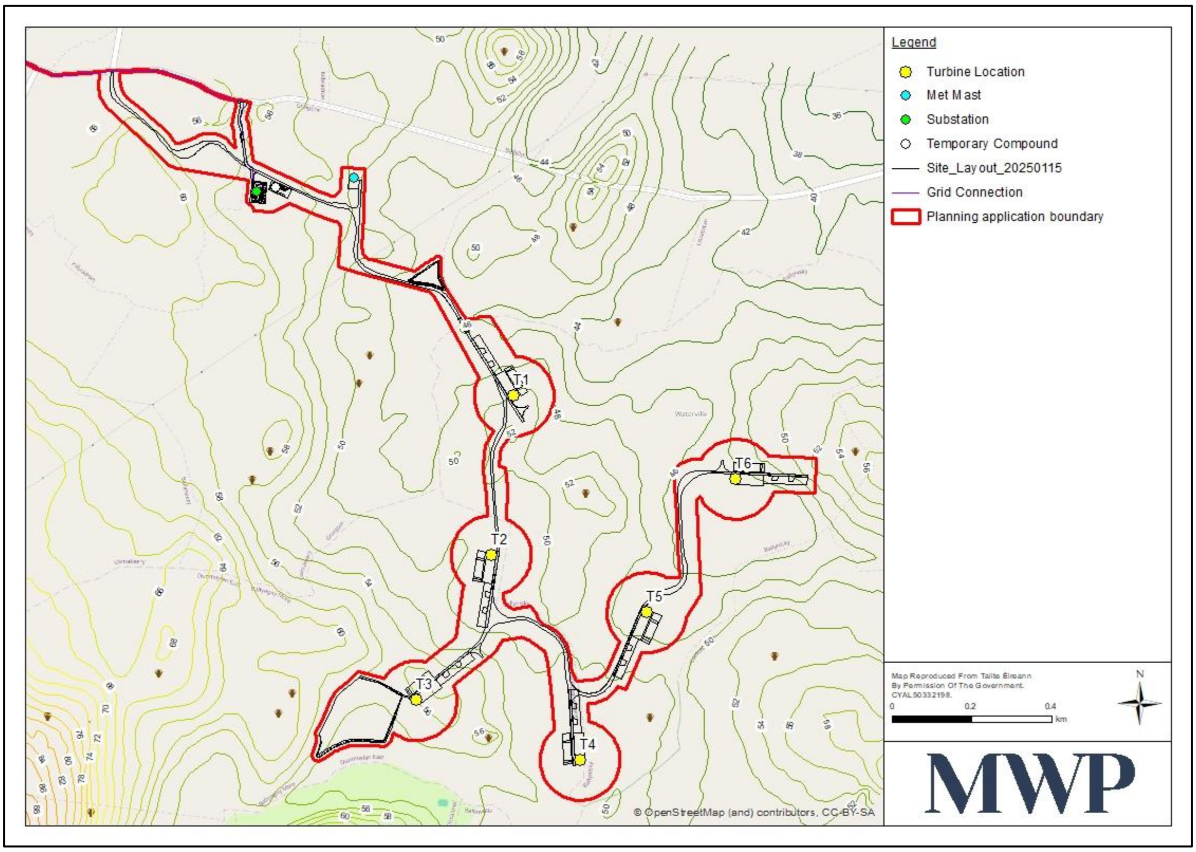

Figure 9-4: Topography (2m Contours)

9.4.4 Regional Geology

The proposed development is located in Co. Limerick. The lithology of Co. Limerick is primarily composed of Silurian marine turbidite sequences, sandstone and siltstone, Devonian sandstones and conglomerates, Carboniferous limestones, volcanics, shales and sandstones, and post-glacial sediments with associated geomorphological features (**Figure 9-5**).

The following is an excerpt of a summary of the Geology of County Limerick from 'the Geological Heritage of County Limerick': "*County Limerick has five main episodes in its geological story. The first of these is represented by rocks of the Ballyhoura, Slieve Felim and Galtee Mountains. Here, Silurian marine rocks, around 440 million years old, are found where erosion of the uplands has stripped off the younger Devonian sandstones and conglomerates. The Devonian rocks, of sediments deposited by rivers, form the second stage. They surround the Silurian rocks in these mountain ranges, as well as forming most of the upland area of Corronoher and Knockfeerina Ridges. The Carboniferous Period began around 360 million years ago and forms the third episode. Its limestone forms the bedrock to the lowland plains. These are limestones from open marine environments. Midway through this phase a period of volcanic activity saw basalt lava and other volcanic rocks deposited on the limestones. In the fourth episode, the Upper Carboniferous, deep-water marine shales and deltaic sandstones were deposited and these now form the Mullaghereirk Mountains and the adjacent Abbeyfeale Plateau. However, the most significant force to shape the county as we see it today was the fifth major episode, the Ice Age, which ended about 11,500 years ago. Large ice sheets covered the entire region and county, and eroded the surface rocks. As the ice eventually melted away, the meltwaters reorganised the sediments into iconic landforms like eskers, also with outwash terraces of sand and gravel*" (GSI, 2021).

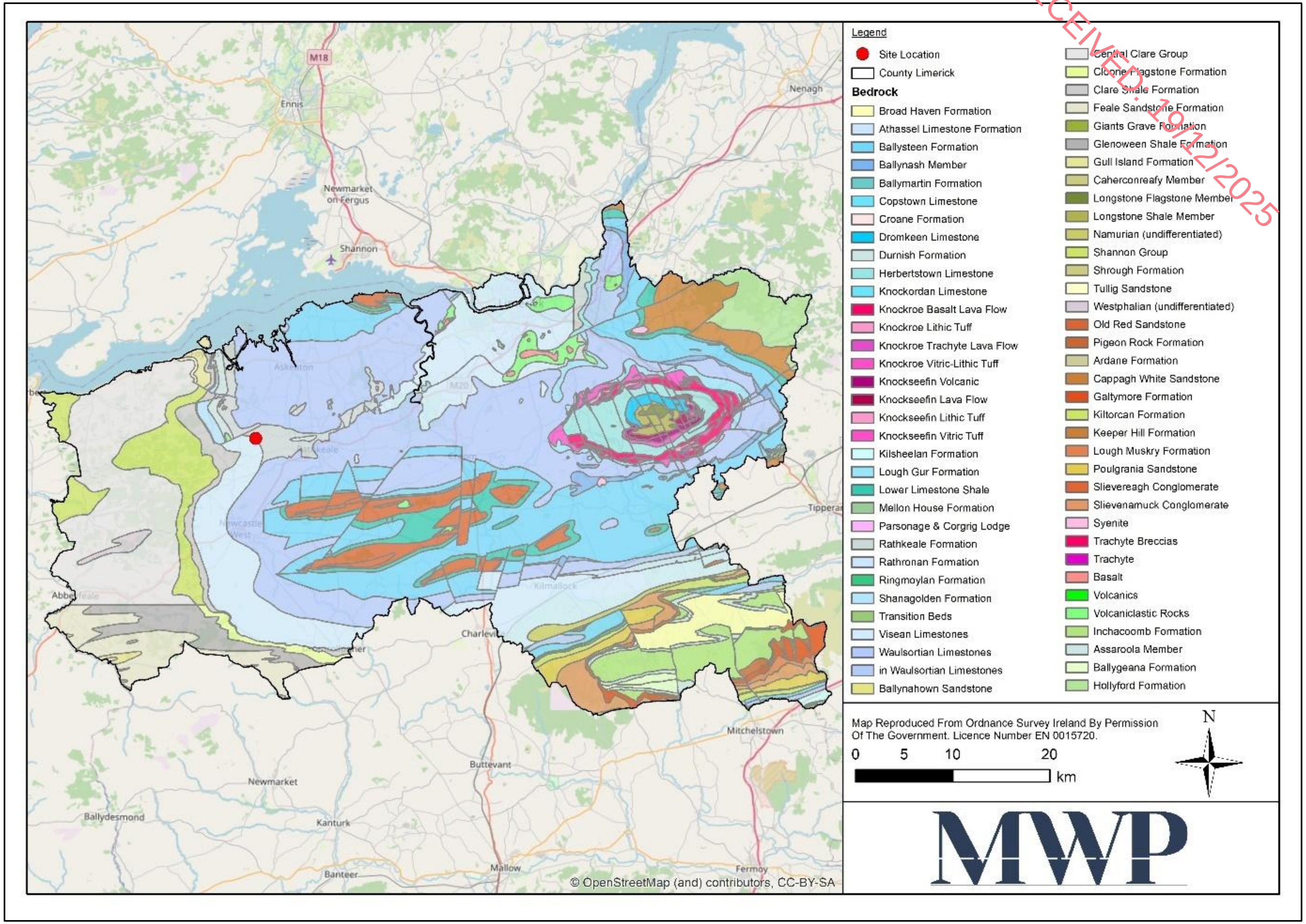

Figure 9-5: Bedrock Geology of Co. Limerick (Source: GSI)

9.4.5 Local Geology

The proposed development is underlain by the Upper Carboniferous rocks of the Shannon Group which were deposited in the extensional Shannon Basin. The two main rock formations are the Rathkeale Formation within the northern portion and the Visean Limestone (undifferentiated) within the southern portion of the proposed development study area. These rocks consist of limestones indicative of the phase of deposition when Ireland was covered in a warm, shallow sea. The northern and southern areas outside of the study area are dominated by Waulsortian Limestone which is known to be karstic. The area west of the study area is dominated by the Clare Shale Formation, while the area to the northwest of the study area is dominated by the Durnish Formation and Volcanic Rocks (**Figure 9-6**).

The rocks found within and immediately adjacent to the study area are described from literature below with the symbol for each formation given in brackets for cross-reference purposes with the GSI 1:100,000 scale bedrock geology map.

- Visean Limestones (undifferentiated)[CDVIS]: Described as Carboniferous, undifferentiated limestone. Known to be karstic in areas of Galway and Limerick;
- Rathkeale Formation (CDRAKE): Described as Carboniferous dark grey argillaceous limestones and shaly mudstones. The formation is unfossiliferous apart from trace fossils. The limestones are well-bedded and brittle and have a fracture cleavage. The lower part of the formation is dominantly shaly. Thickness is estimated to be 1500ft;
- Waulsortian Limestones (CDWAUL): Described as Carboniferous massive, unbedded limestones. Sometimes informally called "reef" limestones, although inaccurate. Dominantly pale grey, crudely bedded or massive limestone. Known to be moderately to intensely karstified. Typically 300 - 500 m thick;
- Clare Shale Formation (CNCLSH): Described as Carboniferous mudstone, cherty at base. The formation consists of a condensed sequence of black shales with closely spaced layers rich in goniatites, underlain by shales with many phosphatic horizons. Nodules and bands of clay ironstone occur near the top of the formation. P2 - E1 - R1b Goniatite Zones. It is 12-15m thick in the type area; and
- Durnish Formation (CDDURN): Described as Carboniferous, blue-black cherty bioclastic limestone. Uniform, blue-black, bioclastic limestones which commonly contain bands of chert nodules parallel to bedding. The limestones contain a coral - brachiopod fauna, the corals being chiefly large solitary Caniniid - Clisiophyllid types. Thickness is estimated to be 1000ft.

Evidence of faulting can be seen in the area. Two sets of cross-cutting faults has been mapped north of the site. The first strikes southwest to northeast and the second strikes approx. northwest to southeast. A fault line has been mapped beneath the footprint of the substation and runs southwest – northeast across a portion of the grid connection (Option A) and proposed access track. GSI fault mapping is however not precise and cannot be relied upon for on-site conditions. The presence of this fault beneath the substation is not considered to be hydro-geologically significant particularly given the depth of subsoil indicated by the aquifer vulnerability maps of 8-10m.

The presence of an unconformity trending north-south is mapped just to the west of the study area, approximately 2km southwest of T3 and acts as a contact for the Visean Limestones and the Clare Shale Formation, with the latter being the younger of the two formations.

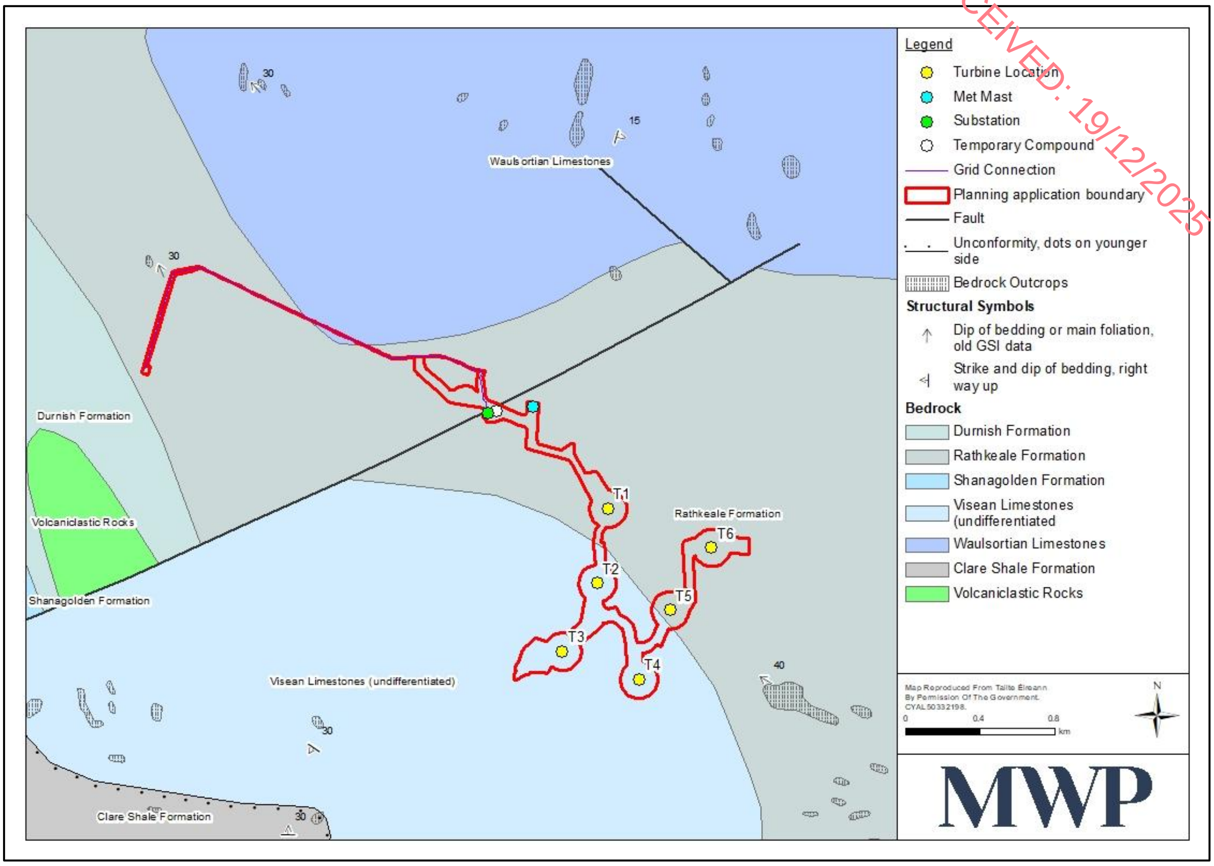

Figure 9-6: Local Geology (Source: GSI)

9.4.6 Soil and Subsoil

Soil includes the topsoil (soil) and subsoil, which together provide for the following important functions:

- Facilitate the hydrological cycle in the filtration/recharge, storage and discharge of rainwater;
- Support all terrestrial ecology, including all flora and fauna (and all food crops);
- Protect and enhance biodiversity;
- Holding or preserving archaeological remains; and
- Provision of raw materials and a base on which to build.

Soil (topsoil) and subsoil may derive from parent geological material and organic matter under the influence of processes including weathering and erosion.

The predominant soil type at the majority of the wind farm section of the study area is "*BminDW – Deep well drained mineral (Mainly basic)*" according to the Teagasc/EPA Soil Maps available on the Geological Survey of Ireland online mapping system. The characteristics of this soil type based on Teagasc data are defined as calcareous well drained mineral at deep depth (location of Turbines 1, 3, 4, 5). This is followed by *"BminPD - Mineral poorly drained (Mainly basic)"* - mapped across a few parts of the study area, mainly the central, north-eastern, and south-eastern portions (location of Turbine 2). *"AlluvMIN - Alluvial (mineral)"* can be found in the central, eastern (proximity to location of Turbine 6) and southern portions of the site, while *"BminSW - Shallow* *well drained mineral (Mainly basic)*" and "*Lac - Lacustrine type soils"* can be found in the northern portion of the wind farm section of the study area (**Figure 9-7**).

The predominant soil type at the end section of the grid connection (Option A) route of the study area comprises mainly *"BminPD - Mineral poorly drained (Mainly basic)''*, with a small section also located along the middle of grid connection route. The beginning (grid connection section closest to wind farm) and middle of the grid connection (option A) comprises "*BminDW – Deep well drained mineral (Mainly basic)"* and there is also a section of *"AlluvMIN – Alluval (mineral)"* on the grid connection at the end closest to Carrons Wind Farm Substation.

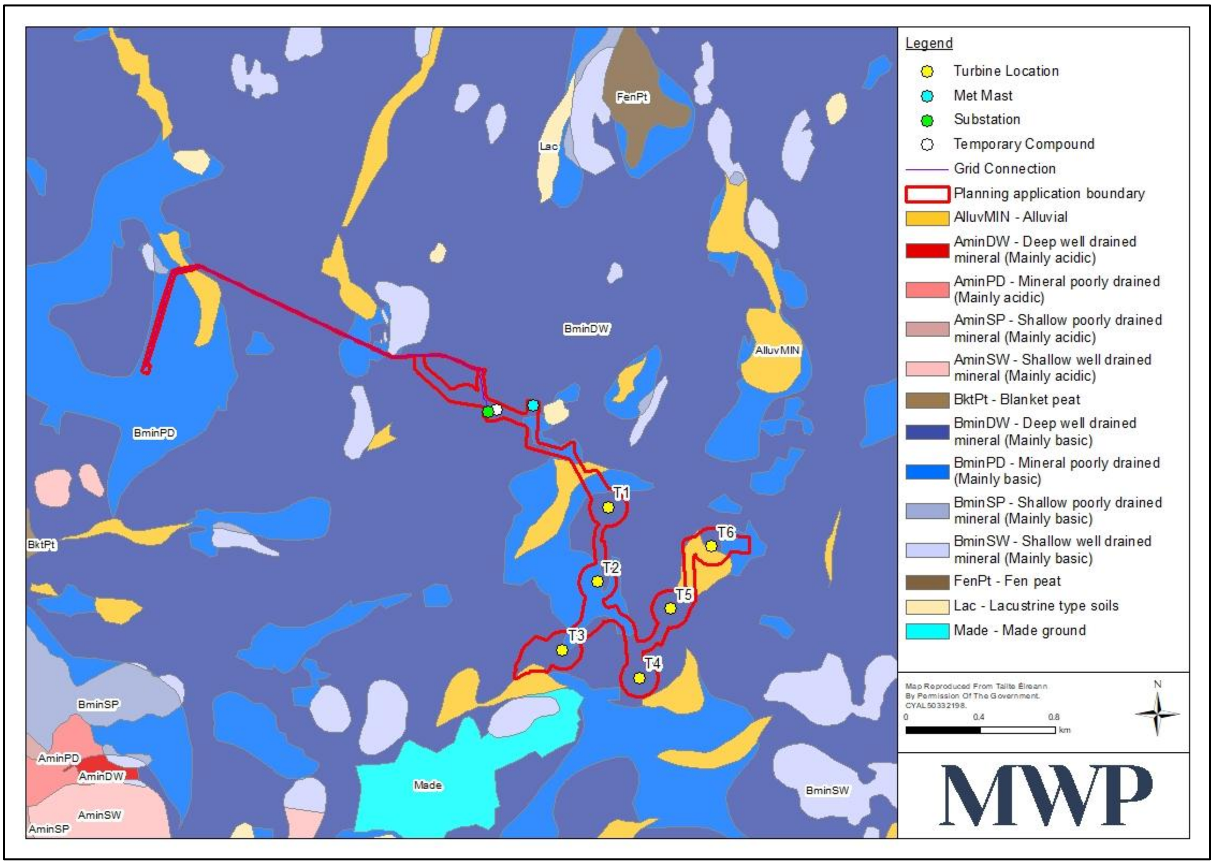

Figure 9-7: Teagasc Soils (Source: GSI)

The Quaternary Sediments at the study area shown on the Geological Survey of Ireland online mapping system include "*TLs, Till derived from limestones''* covering the majority of the study area (location of Turbines 1 – 5), and *"A, Alluvium*" covering central, eastern (proximity to location of Turbine 6) and southern portions of the study area. "*L, Lacustrine sediments*" and "*Rck, Bedrock outcrop or subcrop*" can be found along the northern boundary of the study area. The quaternary geomorphology of the area comprises features such as one drumlin feature and streamlined bedrock which strike northeast to southwest (**Figure 9-8**).

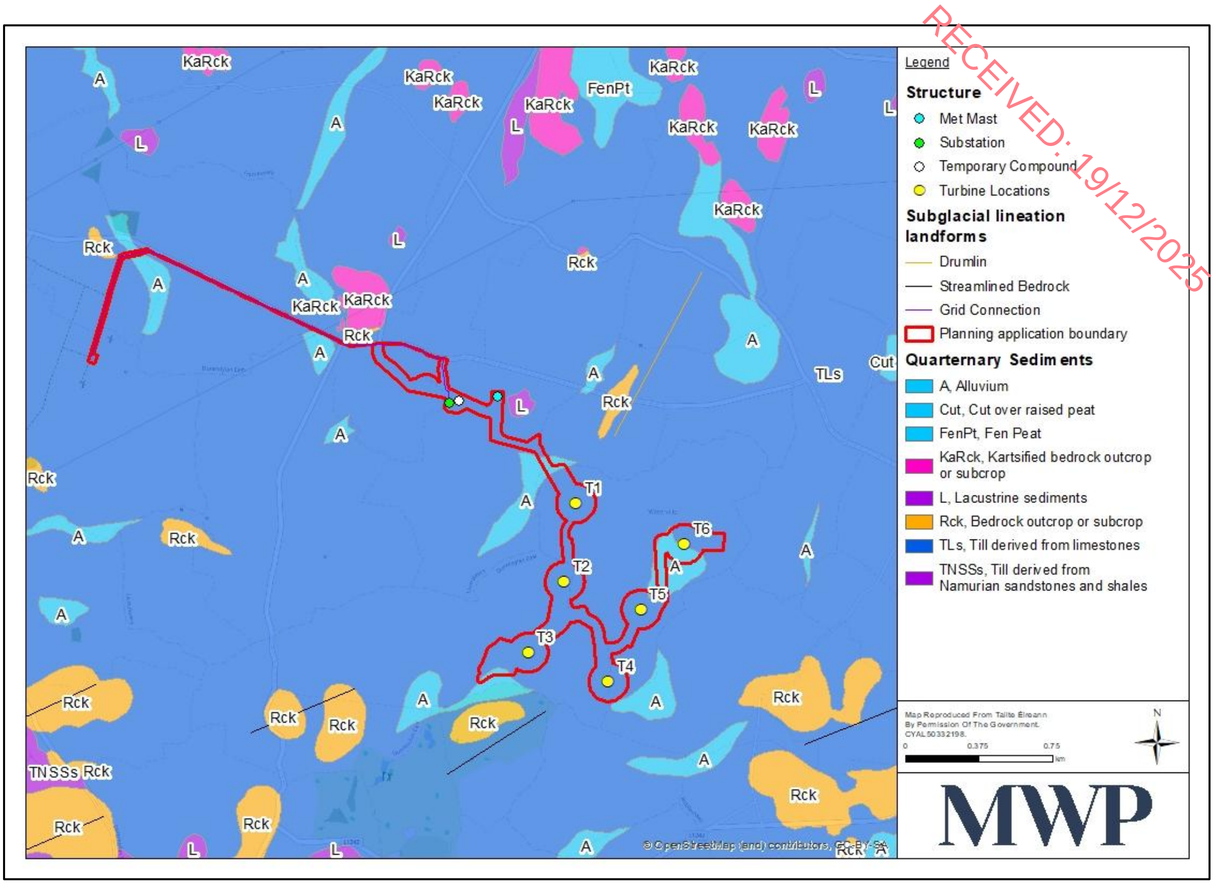

Figure 9-8: Quaternary Sediments and Geomorphology (Source: GSI)

9.4.7 Geological Heritage

The Geological Survey of Ireland (GSI) partnered with National Parks and Wildlife Service (NPWS) to identify, protect and promote the geologically important areas under the program of Irish Geological Heritage (IGH). These areas are protected and designated as National Heritage Areas (NHA) after audits carried out by local county authorities along with the heritage council. These protected areas are differentiated based on themes varying from Karst, Palaeontology, Quaternary, Hydrogeology, and many others.

A review of the GSI Geological Heritage Database available on the GSI online mapping system indicates that there is a Geological Heritage Site located approximately 5.47km south west of the proposed development, Carrigkerry Esker (**Figure 9-9**). The nearest mapped geological heritage sites are also detailed in **Table 9-1**. Given the distances to the proposed development, no effects to geological heritage are predicted as a result of the proposed development.

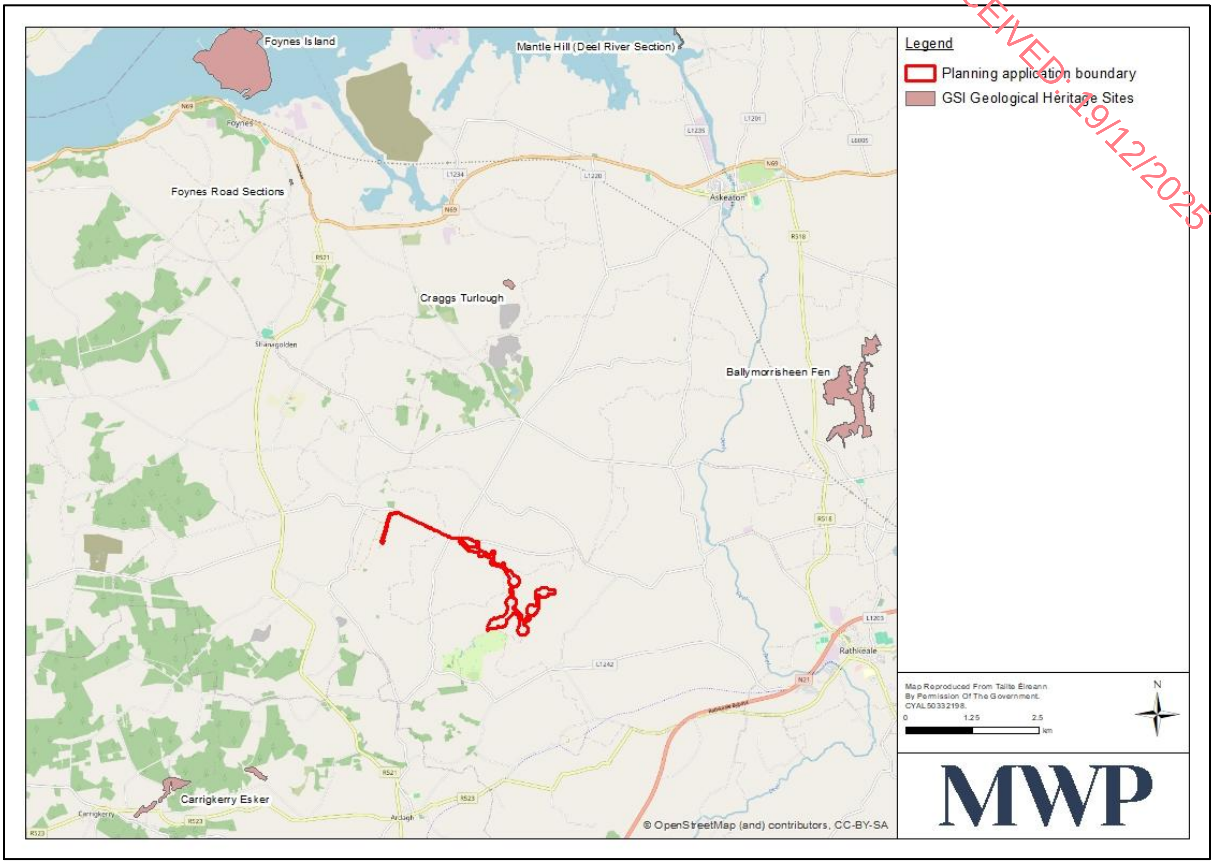

Figure 9-9: Geological Heritage (Source: GSI)

Table 9-1: Geological Heritage Sites in Proximity to Proposed Development

Feature Name	Feature Description	Distance
Carrigkerry Esker	The Carrigkerry Esker and surrounding sands and gravels includes a small accumulation of waterlain sediments deposited both under the ice sheet and at its margin at the end of the last Ice Age.	Ca.5.47km west
Craggs Turlough	This site comprises a small turlough in an area of abundant outcrop of limestone. This is the most impressive as well as the most pristine such feature from a landscape perspective.	Ca.5.83km north
Ballymorrisheen Fen	This site comprises a large fen, enclosing some small lakes, in an area with abundant limestone bedrock outcrop. There are few relatively intact fens left in Limerick, in a county where they were abundant and common historically, and this is one of the most impressive.	Ca.6.95km northeast
Cappagh Fen	This site comprises a small fen within an area with abundant limestone bedrock outcrop. This fen has local-scale geomorphological diversity present over a relatively small area.	Ca.8.46km northeast
Foynes Road Sections	Limestone exposures visible along roadsides. Bedrock comprises Lower Carboniferous Visean limestones of the Durnish Formation, Shanagolden Formation, and Parsonage Formation.	Ca.8.65km north
Gorteennamrock Fen	This site comprises a small fen in an area with abundant limestone bedrock outcrop. This fen has local-scale geomorphological diversity present over a relatively small area.	Ca.9.38km northeast

Feature Name	Feature Description	Distance
Foynes Island	A small island with coastal outcrops of Namurian rocks. Shannon Group rocks including Clare Shales Formation, Gull Island Formation and Tullig Formation.	Ca.10.5km north
Mantle Hill (Deel River Section)	Shoreline outcrops along low tidal mudflat estuarine shore at the mouth of the River Deel in the Shannon Estuary. Transitional sequence of carbonate muds up to 3 m thick immediately underlying Waulsortian mudbank rocks.	Ca.10.7km northeast

Source: GSI online database

9.4.8 Economic Geology

The closest quarry to the site is Knockbowheen Quarry which is located approximately 3km west from the site.

Recorded mineral locations have the potential to be used for future mineral extraction. According to the GSI, there are a number of recorded metallic and non-metallic mineral locations in the area, mainly composed of iron, lead and zinc (**Figure 9-10**). There are no records of any metallic or non-metallic mineral locations within the proposed development.

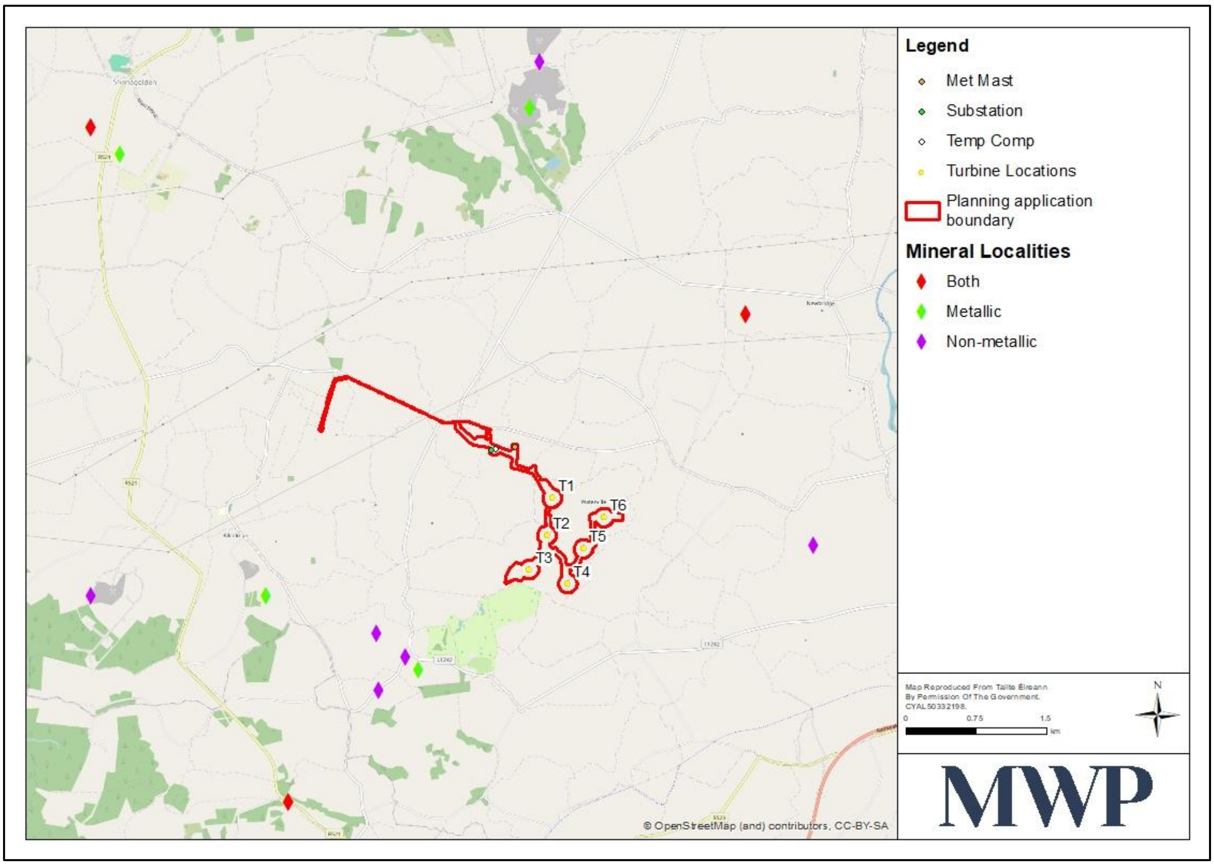

Figure 9-10: Mineral Localities (Source: GSI)

Most of the material delivered to the proposed development will consist of aggregate for the construction of access tracks and crane hardstands and concrete for the construction of the turbine bases. The following could supply these construction materials (**Figure 9-11**):

- Knockbowheen Quarry, Ardagh, Co. Limerick;

- Michael O'Donovan Quarries, Knockbowheen, Co. Limerick; and
- Roadstone Joseph Hogans (Creeves) Quarry;

Where possible, similar stone to that of the site will be used, i.e., limestone. The use of local quarries, where possible, will also reduce any impact on traffic and the environment. A detailed assessment of the possible delivery routes and junctions has been carried out. Further details are provided in **Chapter 14 Material Assets**.

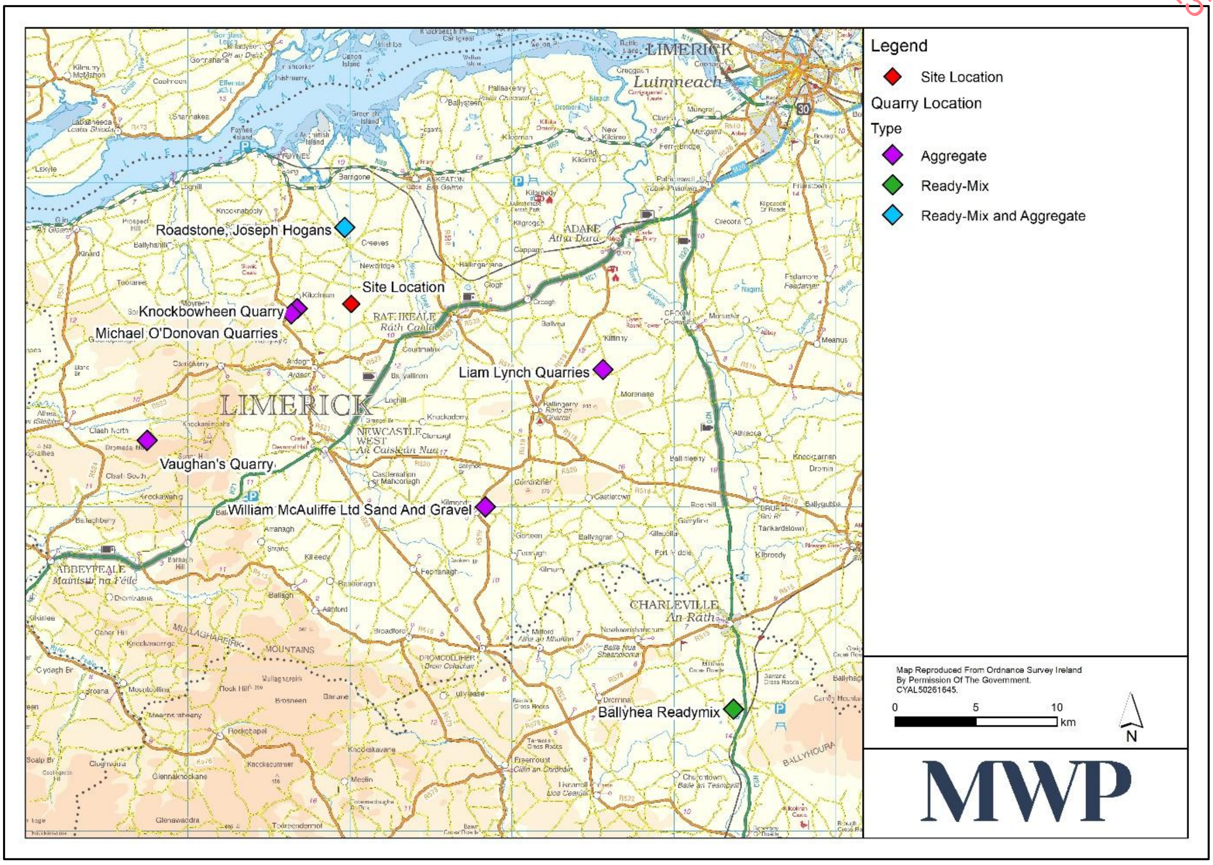

Figure 9-11: Local Quarries (Source: GSI)

9.4.9 Existing Slope Stability

From a desktop review, the GSI's Landslide Events database has no record of any landslides recorded within or in proximity to the proposed development. The nearest recorded landslide is located approximately 12km north west of the proposed development. The study area is located in an area of relatively flat topography with an approximate range in height of 46-56m AOD.

According to the GSI Landslide Susceptibility map (**Figure 9-12**), the proposed development is located in areas classified as being "Low" and "Low (inferred)". Given that there is no peat on the site, the site is considered to be low risk, thus stability issues are not envisaged.

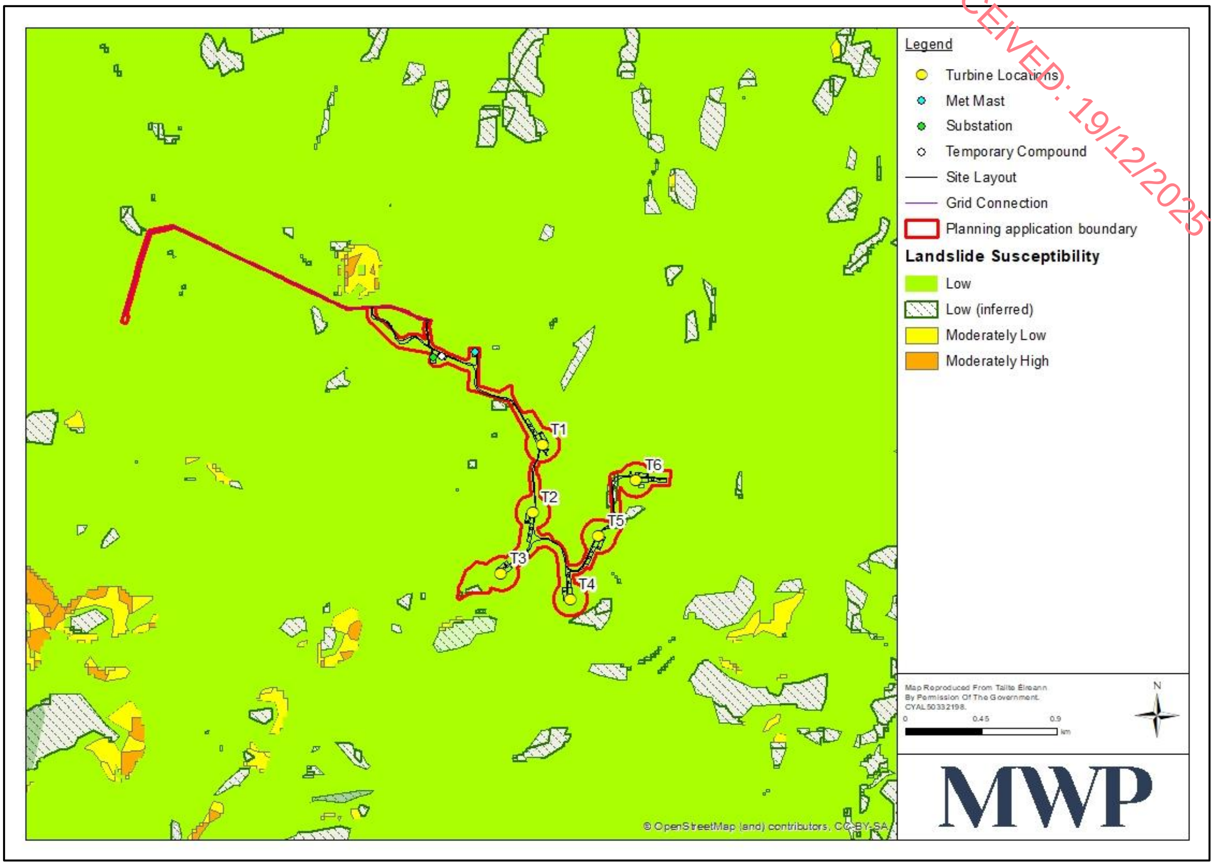

Figure 9-12: Landslide Susceptibility (Source: GSI)

9.4.10 Existing Borrow Pits

There are no existing borrow pits on site. There is also no proposed borrow pit location within the development due to the flat nature of the site. As there will be no on-site borrow pit, all construction materials, which will include stone and quarry-run material for various uses at the site, will be imported from local quarries. Graded crushed limestone will be used as a running course on all internal access tracks to assist in reducing sediment run-off during rainfall events.

9.4.11 Existing Geotechnical Conditions

Blasting at turbine locations and hardstands may be necessary to enable excavation of the rock if encountered at less than 3m depth. However, it is considered unlikely given that the depth of subsoil indicated by the aquifer vulnerability maps is 8-10m. In the unlikely event of rock being encountered, blasting will be carried out and will be carried out by a suitably qualified specialist under licence with a suite of mitigation measures in place. Blasting, and mitigation measures associated with the process, are discussed in further detail in Section 9.6 as well as Chapter 11 Noise and Vibration of this EIAR and in Appendix 3D of Volume III for the CEMP.

MWP produced the 2010 report "Soils and Geology Assessment for Carrons Wind Farm", located 2.5km west of the proposed development. It consisted of a desk study, a review of field work, trial pitting logs and a geological assessment for 2 no. turbines at Carrons Wind Farm, Co. Limerick. For reference, the following geotechnical conditions were uncovered:

- Bedrock is indicated as being *Rathkeale Formation - Dinantian Upper Impure Limestone* with a small area of basalts and other Volcanic Rocks approximately 1km to the south. There are no bedrock fault lines within the site but there is a fault line running from southwest to northeast approximately 1.1km south of the site; and
- 3 no. trial pits were dug on the 17th November 2009 (Keohane Geological & Environmental Consultancy) and 7 no. trial pits were dug on the 7th December 2009. Trial pits ranged from 2.05m to 4.2m bgl. In general, TOPSOIL ranged from 0.1 – 0.3m thick, followed by greyish-brown stiff, silty <u>or</u> sandy CLAY with limestone cobbles ranging from 0.3 to 1.8m bgl, followed by greyish-brown stiff to very stiff to hard slightly silty slightly sandy gravelly CLAY with limestone cobbles (in some case boulders) ranging from 0.95 – 2m bgl. Bedrock was not encountered at any of the trial pits. Groundwater was not noted during digging, but surface water ingress was strong.

There are 16 historic mineral exploratory boreholes located within 4km of the proposed development (**Figure 9-13**). A description of each borehole can be found in **Table 9-2.**

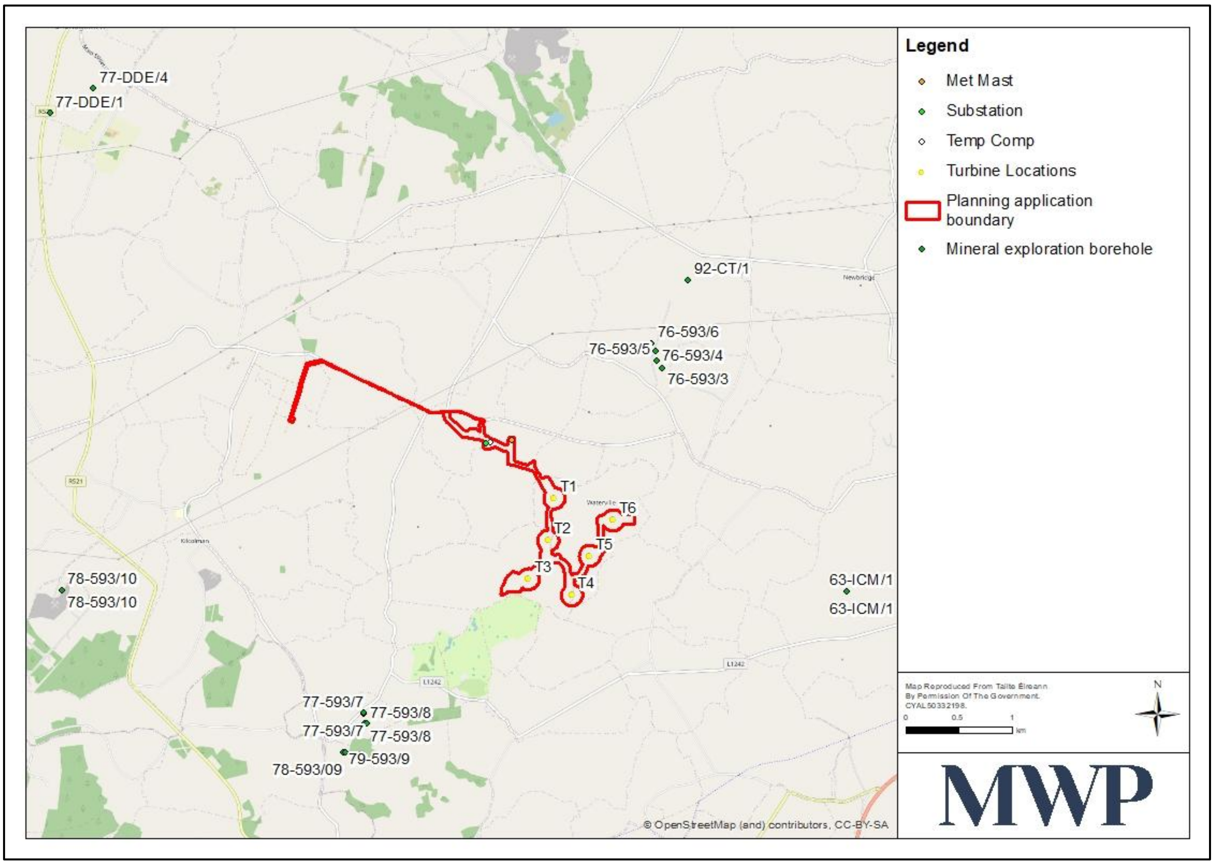

Figure 9-13: Historic Exploration Boreholes Drilled between 1957 – 2002 (Source: GSI)

Table 9-2: Description of Historic Exploration Boreholes Drilled between 1957 – 2002

Borehole ID	Number of Boreholes	Distance from Site	Overall Description
63-ICM	1	3km	3m overburden, residual soil. Followed by 120m dark grey, "Calp" limestone, dense, fine-grained, weakly fossiliferous (crinoids), minor calcite veining. Some hematite staining at 25m.
76-593	6	2.3km	593-1: 0-3.4m Limestone boulder clay. 42.5m largely massive bedded pale grey shale-free calcilutites and calcarenites. Partially dolomitised in places. Sedimentary structures persevered throughout. Coarser calcarenite is a wackestone with large crinoid ossicles. Reef breccia consisting of irregular unsorted fragment found from 10-14m. At 22.5m finely cross bedded silt. At 23m, finely bedded limestone with large, detached blocks dipping at 40'. 593-2: 2.5m boulder clay. 97m reef limestone. From 2.5-71m, pale grey shale-free calcilutites and calcarenites. Bedding undefined, non-fissile. Minor clay veining. Mineralisation and minor pyrite. 593-3: N/A 593-4: 1.5m boulder clay. 38m of interbedded calcilutite, calcisilite, calcarenite and fibrous crystalline calcite with dolomite, broken limestone, calcite veins and dolomite breccia inclusions found in the first 14m of the rock. 593-5: 1.5m boulder clay. 44m of interbedded calcilutite, calcisilite, calcarenite and fibrous crystalline calcite with fossil fragments. 593-6: 1.5m boulder clay. 62m reef limestone – pale grey micrite with fennistellid mat structure throughout. Fossils common. Evidence of calcite veins in upper 20m.
77-593	2	3.2km	593-7: 3m boulder clay. Followed by 35.4m black Namurian Shale. Described as hard black fissile thinly laminated shale. Soft white coating on fracture and bedding planes occur throughout. 25' dip. Pyrite found at 10.7m. 593-8: 2.1m boulder clay. Followed by 43m black Namurian Shale. Described as hard black fissile thinly laminated shale. Soft white coating on fracture and bedding planes occur throughout. Between 9.75 – 14m frequent occurrences of small nodules of soft silty material and dark soft laminae. 14-14.3m finds a band of dark soft unconsolidated earthy material. Pyrite found from 21.3m below.
78-593	1	5.2km	593-10: No overburden. 83.2m of hard, dark grey, vertical jointed Namurian shale. Soft beds, compact mud, occur at 1.5-2m, 14-14.5m, 16.2-19.5m. Hard beds occur at 26.5m, 39m, 40.5m, 44m, 46m, and 48.5m. Carboniferous limestone can be found from 83.2m.
79-593	1	3.4km	593-9: 6.1m limestone diamicton overburden. Followed by 43.9m black Namurian Sandstone, fine grained, homogenous, thin bedded hard shales, vertical joints, many joints, some coated with a soft white amorphous mineral, turquoise found at 12.5m. Abundant pyrite found at 41.5m. Core recovery % decreases with depth followed by 10m carboniferous limestone.
92-CT	1	2.65km	One borehole drilled to 357m BGL. Waulsortian Limestone. Dark grey micrite limestone. Stromataltis cavity development through core. 5cm vein of pyrite noted at 33m BGL.

9.4.12 Existing Access Tracks

Access to the site will be via L1219 to the north. The R521 is located to the west of the site running between Foynes and Newcastle West. The closest National primary road N21 is located to the southeast of the site.

There will be two site entrances. A permanent site entrance utilising an existing farm access track will be located on the L1219 local road to the north of the site for access during the operation of the wind farm. A temporary site entrance also on the L1219 further west of the permanent entrance will be used for the construction phase only. The proposed development will involve the upgrade of approximately 470m of existing tracks and approximately 3.4km of new tracks will be constructed within the development site, this includes approximately 490m of temporary access tracks which will be reinstated following construction. Full details are provided in **Chapter 03 Description of the Proposed Development** of this **EIAR**.

9.5 Assessment of Effects

This section details the potential effects on the land and soils environment from the proposed development. The changes proposed on-site comprise a number of elements including excavation for construction of the turbine hardstands, construction of a new access track system, construction of two deposition areas, construction of a met mast and construction of a substation. The relevant works are further discussed in the following sections. This section considers the phases of construction, operation and decommissioning of the proposed developments elements relevant to soil and geology.

9.5.1 Construction Phase

The predicted effects on soils and land from the proposed development are discussed in the following sections. The activities that have the potential to cause damage to the existing geological environment and surrounding receptors, as a result of effects to the geological environment, may also indirectly effect the aquatic environment if appropriate mitigation measures discussed in **Chapter 8 Water** are not implemented.

The proposed development will involve excavation of topsoil (20,042m^3), subsoil (28,064m^3), and bedrock for facilitating access tracks and hardstand emplacements. Large amounts of aggregates (42,543m^3), concrete (5,010m^3), and steel (480t) will be used during construction. The aggregates (rock, stone, gravel, sand) used during construction of the tracks, hardstands and substation will be imported. Concrete and additional aggregate materials will be sourced from authorised facilities listed in **Section 9.4.8**. The total volume of excavated material for the proposed development is approximately 48,107m^3.

Estimated volumes of material and spoil are presented in **Chapter 03 Description of the Proposed Development**. A portion will be used for reinstatement and landscaping works within the site. Bedrock excavated during cut-and-fill works will be used for filling along the development footprint. Excess material will be sent to the on-site material storage areas. Refer to **Figure 3-5** of **Chapter 03 Description of the Proposed Development** showing the location and extent of deposition areas and **Planning Drawing No. 22569-MWP-00-00-DR-C-5412**.

The evaluation of the most likely important effects are described below. Lands where the proposed development will be built will see the majority of the earthworks and excavations, therefore these are the main focus of the assessment. Where applicable, the grid route is included.

The predicted effects on soils and land for the proposed development are discussed in the following sections.

9.5.1.1 Change of Land Use

Land use is the term to describe the human activities which take place within a given area of space.

All new development proposals have the potential to affect the local area character and human environment by introducing a new incompatible land use activity which could result in physical disruption, severance, or exclusion of users' ability to continue existing activities or the sterilisation of lands, thus preventing any additional further land use potential.

The majority of the site consists of pastures. During the construction phase of the works, material will be excavated, moved, altered, or compacted and will influence the existing land use requirements. In this respect, land use associated with the required development footprint will change over the course of the construction phase from existing pastural activities to a functioning wind farm. The surrounding lands not required as part of the development footprint will remain in agricultural use.

The proposed works require the construction of turbine bases, hardstands, permanent met mast, substation, internal tracks, cable trenches, and grid connection. With the removal of soil and subsoil from the construction areas, there will be slight alteration to the site topography, but on a wider scale these changes will be imperceptible concerning the land and landscape of the proposed development. All the excavations will be reinstated to ground level/existing level. Similarly, as most of the grid route Option A is along an existing public road there are only very small, proposed changes to land, and imperceptible changes to topography. Along the grid connection route all excavations will be reinstated to existing ground/road level. If grid route Option B is selected, the grid connection route is substantially shorter and considered to result in similar imperceptible changes to land and imperceptible changes to surrounding topography.

The land use along the grid connection routes and surrounding areas comprises mainly of transport (roads), agriculture, and residential. In terms of effects to neighbouring lands and land uses, it is considered that the proposed development does not pose a significant risk to either existing or future land uses, given that land use in surrounding areas will be able to continue during the construction phase.

It is considered that without the implementation of mitigation measures, the alteration of land use has the potential to alter the character of land and soils (including geological) environmental. Without mitigation, the alteration of land use will have an ***adverse, moderate, short-term, direct effect*** within the proposed development site and along the grid connection route. Similarly, during decommissioning temporary disruptions to land uses and access are likely. Mitigation measures are outlined in Section 9.6.1.1.

9.5.1.2 Soil and Geology

9.5.1.2.1 Soil Erosion

Soil erosion is the process whereby agents, such as wind and water, gradually detach, remove, and transport soil particles, causing a breakdown in the soil resource. Soil erosion from wind, water and ice can occur when:

- Topsoil is removed, exposing the soil and subsoil;
- Soil levels from cut and fill practices are altered due to excavation and compaction;
- Soil deposition areas are exposed, prior to revegetation;
- Open excavations are left exposed for a period of time;
- Stockpiled and exposed soil is not maintained or stored incorrectly;
- Activities from earthworks leave soils exposed;
- Mismanagement of material transport, material alterations and waste disposal occurs;
- Other construction activities such as vehicular movement and heavy machinery with large tyre threads remove topsoil and soils from excavations; and
- Heavy rainfall causes soil to mobilise.

During the construction phase, volumes of soil, subsoil and bedrock will be excavated, moved, altered and/or removed from certain areas of the site in order to facilitate the construction of the proposed development. Topsoil and subsoil will be reused for landscaping. Excavated soil, subsoil and bedrock will be required for site levelling, construction of the wind farm site infrastructure, i.e., gravity foundations for turbine bases, crane hardstands, met masts, substation, internal cable network and tracks and drainage accommodation works. This will result in the permanent removal of material at excavation locations. Stone required for the construction of new access tracks, construction compound and drainage will be imported from local quarries, where feasible.

Excavation of soils, subsoils and bedrock will also be required along the grid route. These works will result in temporary and transient disturbance of the public road surface, subsoil, and bedrock. The majority of subsoil excavated along the grid cable connection will be reinstated following these works. The active construction area for grid connection option A will be small, ranging from 100 to 200 meters in length at any one time, and it will be transient in nature as it moves along the route. Grid connection option B does not require any works on the public road.

Construction works will have an ***adverse, slight, temporary, effect*** on soil in terms of erosion.

The total volume of excavated material for the proposed development is approximately 48,107m^3. All material volume estimates can be found in Table 3-3 in Chapter 03 Description of the Proposed Development of this EIAR.

Excavation, material management, and vehicular movement activities will be managed during construction as detailed in the CEMP (Refer to Appendix 3D).

9.5.1.2.2 Compaction/Loading

Soil compaction describes the reduction of pore space within the soil structure. This also causes the soil to have less total pore volume, an increase in bulk density, reduced rate of water infiltration and drainage, expulsion of air within the soil, and change in soil strength.

Soil compaction may occur due to movement of overland traffic, such as construction and maintenance vehicles and will also arise as a result of compaction of deposition areas. Regular movement of heavy vehicles and plant on off-alignment sections, greenfield areas and temporary works areas would result in an increased risk of soil and subsoil integrity during the construction phase of the proposed development. This could in turn lead to other effects such as a temporary increase in surface water runoff, and subsequently to an increase in erosion.

The effects in terms of soil compaction during the construction phase will be ***adverse, moderate and temporary***.

9.5.1.2.3 Slope Stability

A slope failure involves a mass movement of earth material under shear stress along one or several surfaces. The movement may be rotational or planar. A slip is defined as a small movement of soil, debris, earth, or rock down a slope. It can take the form as a minor landslide, a land slip, a soil slip, or soil creep. These can affect the land and soils environment during the construction phase of the proposed development, particularly in excavations, material movement, earthworks, and storage of material on site. This can cause several direct effects including erosion, contamination, sedimentation, instability of the land, and waste generation, as well as indirectly effecting other environments including water, biodiversity, material assets and landscape & visual.

Slippage can occur as a result of an increase in overburden load on slopes, earthworks that affect slope angles and embankments, unstable embankments, unstable excavations, cut-and-fill techniques from excavations, uncovered stockpiled materials, or unforeseen ground conditions not identified during geotechnical investigations. These can be exacerbated by adverse weather conditions from heavy rain, wind, and ice. Slips are more likely to occur on slopes >25° but have been known to occur on much gentler slopes.

Slips on the proposed development are considered low risk due to the gently sloping topography. However, excavation and earthworks will affect this. Deposition areas have potential for slippage if mitigation measures are not put in place. Similarly, stockpiled material is at risk of slipping if no mitigation measures are put in place. A desktop study of the site was undertaken, which included a review of LiDAR and OSi contour data and identification of water features on the site, all of which can have an impact on slope stability. During site visits, no areas were identified as prone to stability risk.

Soil erosion, compaction/loading and slope stability represent ***adverse moderate short-term effects*** on the land and soils environment, without the implementation of appropriate mitigation measures which can be found in Section 9.6.1.2.

The effects on the underlying bedrock geology, with respect to slope stability, arising from the construction phase are considered to be an ***adverse, not-significant, short-term effect***.

9.5.1.3 Accidental Spills & Contamination/Pollution

Contamination, or pollution, is the presence of human-made chemicals entering and altering the natural environment. It can occur as a result of waste-related activities, historical activities, leakages and accidental spillages of chemicals. Contamination can lead to the degradation and the physio-chemical alteration of the land and soils environment as well as cause indirect effects to the biodiversity, human health and material asset environments.

Construction materials, including any hazardous substances such as fuel and oil, have the potential to affect the soil and geological environment should a spill occur. The accumulation of spills of fuels and lubricants during routine plant use can also be a pollution risk. Construction plant and machinery will be run on hydrocarbon fuel and oil and activities relating to hydrocarbons (storage, bunding, refuelling) will be managed during the works. Any effect from a hydrocarbon spill to soil may also indirectly effect the hydrological/hydrogeological environment.

Cement / concrete will be transported to, stored, and used across the site. Without proper management, cement spills and other construction materials pose a threat to the land and soils environment (soil matrix) and may indirectly impact on the hydrological environment and groundwater environment as pH would likely be altered.

Wastewater from construction processes or leakage from poor welfare facilities can alter the nutrient and microbial balance of the land and soils environment.

Contaminated runoff arising from soil erosion on construction sites can pose a significant risk to the geological and hydrogeological environments, if allowed to percolate into the soil matrix and can also be deleterious to the surface water environment. Sedimentation can also affect safety on the site from build-up, flooding from drain blockage, and maintenance issues from soil erosion. Soil loss due to erosion will be affected if areas are left exposed.

Without appropriate mitigation measures, contamination from accidental spills of hydrocarbons, cement or contaminated waters represents an ***adverse, significant, short-term, 'Worst-case' effect*** on the land and soils environment, and an ***adverse, significant, short-term, indirect, cumulative effect*** to the geological and hydrogeological environment. Mitigation measures to limit this can be found in Section 9.6.1.3.

9.5.1.4 Rock Blasting

The depth of subsoil indicated by the aquifer vulnerability maps is of 8-10m so it is unlikely that blasting will be required for turbine foundations. If blasting of rock is required, it will result in some level of ground vibration and air overpressure. If uncontrolled and not properly mitigated, this could result in soil liquefaction in the vicinity of the blast hole and could contribute to slope instability. The intensity of vibration will depend on a number of factors including rock type and structure, weight/timing of explosive and distance from the blast site. The seismic wave parameters used for correlation with structural damage is the peak particle velocity (ppv). It has been found that the safe limit for ppv below which structural damage is unlikely to occur is 50mm/s. British Standard BS 7385

Part 2: 1993, which provides guidance on vibration measurement, states that loose/waterlogged/cohesionless soils start to become vulnerable to liquefaction at ppv values of about 10 mm/s. The publication "Rock Engineering Guides to Good Practice Road Rock Slope Engineering" (Transport Research Laboratory 2000) refers to the range of ppv experienced for a wide variety of civil engineering projects, and shows that a ppv of > 10 mm/s is generally only experienced within 20 m of the blast holes if not properly mitigated. Rock blasting also has the potential to result in excessive dust within the vicinity of the turbine bases which may affect the soils or nearby aquatic environment, without appropriate planning and mitigation. The potential impacts associated with noise and vibration are dealt with in **Chapter 11 Noise and Vibration**. Further associated impacts of blasting are discussed in **Chapter 05 Population and Human Health** and **Chapter 10 Air and Climate** of this **EIAR**.

Although it is envisaged that rock blasting will not be required given that there is 8-10m soil cover on site, it is considered that without the implementation of mitigation measures, rock blasting, in the unlikely event it is required, has the potential to alter a sensitive aspect of the land and soils environment by its structure (internal and external, which may involve landmass removal and replacement), extent, duration, or intensity. This represents an ***adverse, significant, short-term, direct effect*** on the soils and geological environment.

9.5.1.5 Piled Foundations

Each turbine will be supported by a reinforced concrete foundation with a central upstand, constructed after excavating to suitable ground bearing levels. Foundations will be placed directly on rock or another appropriate bearing stratum, as determined by pre-construction site and geotechnical investigations. If poor ground conditions are encountered during excavation and a signification depth to sub-formation is required, a piled foundation may be considered.

This process involves using a piling rig with an auger drill to bore multiple holes around the turbine base area to a specified depth. Steel reinforcement is placed in each hole, followed by concrete pouring. Piling can cause soil compaction and generate spoil, however, any piling (if required) will be limited and is not expected to produce significant spoil volumes. Any spoil generated will be reused on site and moved to the designated deposition areas.

Although current geotechnical data suggests that piling is unlikely to be necessary across the site, their use cannot be completely ruled out. If required, and without mitigation, these activities could temporarily alter the soil environment. As such, piling would represent an ***adverse, significant, short-term, direct effect*** on the land and soils environment.

9.5.2 Operational Phase

9.5.2.1 Change of Land Use

All potential effects to land and land use will occur during the construction phase. No additional effects to land and land use are anticipated to occur during the operational phase, as no further works are proposed.

The character of the land will be altered to include a renewable energy use, resulting in an increase in its economic output while continuing its current use. Once the proposed development is operational, all agricultural activities in adjacent lands will continue.

It is considered that during the operational phase, land use change will have an effect on the land and soils environment which causes noticeable changes in the character of the environment but without significant consequences. This represents an ***adverse, not significant, long-term direct effect***.

9.5.2.2 Soil and Geology

The potential effect on the land and soils of the proposed development due to excavations will be significantly lower during operation and maintenance, as the majority of excavations will have been reinstated. Some of the surplus excavated topsoil and subsoils will be re-used on-site in reinstatement, revegetation and landscaping works. Some erosion of soil will continue early into the operation phase, however as vegetation becomes established and equilibrium is achieved, erosion rates will reduce to pre-construction levels.

All vehicular movement during operation and maintenance will be restricted to the areas of hardstanding and existing/newly constructed access tracks. The effect on the hydrogeology will remain due to the risks associated with sedimentation and contamination of the aquifers due to erosion and runoff (see Chapter 08 Water), however as areas are reinstated and revegetated and construction traffic is stopped, these effects will also be reduced to minimal levels.

Traffic levels will be very low during the operational phase in comparison to the construction phase. Maintenance works on turbines will be carried out from the existing tracks and hardstands. All vehicular movement during operation and maintenance will be restricted to the areas of hardstanding and existing/newly constructed access tracks.

It is considered that without the implementation of mitigation measures, these effects on soil and geology will cause noticeable changes in the character of the land and soils environment without affecting its sensitivities. This represents an ***adverse, slight, long-term direct effect***.

Minor excavations of replaced soils, subsoils, trench backfill material could be required along the grid route if a fault occurred during the operational phase. These works would be temporary and short duration. Any material excavated during such works would however be reinstated back within the trench.

This represents an ***adverse, imperceptible, low probability, temporary, direct effect*** on the soils, subsoils, and bedrock environment.

9.5.2.3 Accidental Spills & Contamination/Pollution

There is the potential for accidental spillages to occur from plant and machinery operating at the proposed development, with the degree of effect depending on the nature of the emission. Some construction vehicles or plant may be necessary for the maintenance of turbines which could result in minor accidental leaks or spills of fuel/oil.

It is considered that without the implementation of mitigation measures, the above effects will have the potential to alter the character of land and soils environmental regime. This would occur over a long-term period covering the lifespan of the proposed development (35 years). This represents an ***adverse, moderate, direct, unlikely, long-term effect***.

9.5.2.4 Climate Change

Climate change is considered in a global rather than local context. The land and soils environment will be altered as climate change takes affect over the coming years and the area may be at risk of soil leaching/erosion, soil podzolisation, slope slippage, and effects to the hydrogeological regime. Declining soil moisture is expected due to increased temperatures and rainfall pattern changes during hotter periods.

The United Nations' Intergovernmental Panel on Climate Change (IPCC) has published "Special Report - Climate Change and Land", on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. In summary, the land and soils environment is at risk of being altered to such an extent that it will not be able to complete its primary functions or be used to its full potential, namely, to produce food and fresh water, to provide an ecosystem/habitats, to sequester carbon and methane, to retain heat and moisture, to control the climate and weather patterns, and so on.

The soil environment contains significant quantities of elements, chemicals, metals and minerals which harbour and nurture life on Earth. There is a potential for these chemicals to be released into the atmosphere by several means particularly through vegetation removal, excavation of soils, burning of fuels, poor farming techniques, and deforestation.

The changes in the local and global climate could affect the proposed development's material assets, the landscape's appearance and character, the geochemical processes that occur in the soils, the prospects for land use in the future, etc.

Without appropriate mitigation measures, during the operational phase of the proposed development, the effects from climate change will have an ***adverse, moderate long-term, cumulative effect*** on the land and soils environment. Mitigation measures to limit this can be found in **Section 9.6.2.4**. However, it is widely accepted that renewable energy projects such as the one proposed contribute towards limiting climate change effects due to the transition from fossil fuel-based electricity systems to those based on renewable energy.

9.5.3 Decommissioning Phase

The potential effects associated with decommissioning of the proposed development will be similar to those associated with construction (i.e. soils, subsoils and bedrock excavation, potential contamination by leaks and spills, erosion of exposed subsoils), but of significantly reduced magnitude as activities such as extensive excavation and wet concrete handling will not be required.

Turbine components will be removed at decommissioning stage, however it is envisaged that access tracks will remain in place. Hardstanding and foundation areas will be reinstated to match the surrounding landscape. As such, the decommissioning phase of the proposed development will require minimal earthworks. The turbine bases will be rehabilitated by covering with local topsoil in order to regenerate vegetation which will reduce runoff and sedimentation effects. Some of the effects will be avoided by leaving elements of the proposed development in place where appropriate. A return to the original land use practices will recommence. It is considered that without the implementation of mitigation measures, the effect of the development on land and soils at decommissioning phase would have an effect which causes noticeable changes in the character of the environment without affecting its sensitivities. This represents an ***adverse, slight, long-term effect***.

9.5.4 Do-Nothing

Under the do-nothing scenario, no development would take place on this site, the land and soils environment would remain unchanged, with the exception of future agricultural change or any effects due to climate change. If the proposed development were not to proceed, the opportunity to generate renewable energy and electrical supply to the national grid would be lost. The opportunity to further contribute to meeting EU, Government and Limerick City and County Council targets for the production and consumption of electricity from renewable sources and the reduction of greenhouse gas emissions would also be lost. Compliance with the Climate Change and Low Carbon Emissions Act 2015-2021 would be impeded.

If the proposed development is not carried out, there would be ***no direct*** *or* ***indirect significant effects*** on land, soils, or geology.

9.5.5 Cumulative Effects

Consideration has been given to the cumulative effects resulting from interactions with other surrounding developments and activities. With the exception of places where gravity is a role (on slopes) soils, geology, and land use have a largely static nature, which limits the possibility for cumulative consequences. Nonetheless, these effects may be increased by external causes, which could be organic or man-made, as was previously mentioned (wind, water, ice, etc.).

Evaluation of the cumulative effects must also assess the potential linkage/pathways with nearby permitted/operational developments relative to their shared receptors.

The bulk of the renewable energy production in Limerick comes from wind, with 15 wind farms in operation. The proposed development area (wind turbines) is located 4.5km east of the Grouse Lodge Wind Farm and 2.5km east of Carrons Wind Farm.

The Limerick City and County Council online planning databases and the An Coimisiún Pleanála website were consulted to identify solar energy developments within 20km of the proposed development.

Planning permission has been granted to Harmony Solar Rathkeale Ltd for the development of a solar farm on a 63.4 Ha site, located approximately 3.5 km northeast of the proposed development. The permission is valid for a 10-year period.

Within 20km of the proposed development, a battery storage application has been granted in Limerick (Planning Ref. No. 211702), and it is associated with the Kilathmoy wind farm.

Due to the localised nature of the proposed construction works, there is no potential for significant cumulative effects in-combination with any other local developments on the land, soils and geology environment. As erosion, sedimentation and contamination of the soils has the potential to enter watercourses and aquifers within the site, the cumulative effect with the adjacent developments is also be considered. The hydrological pathway is assessed in Chapter 08 Water.

The construction of the grid connection route will only require relatively localised excavation works, will be short duration, and will be linear and transient in nature and therefore, will not contribute to any significant cumulative effects.

Given the highly modified nature of the proposed development site and surrounding area, the potential for cumulative effects on the land and soils environment arising from the proposed development and developments on adjacent sites is considered to have an ***adverse, not-significant, long-term effect***.

9.5.6 Risk of Major Accidents and Disasters

This section presents an assessment of the vulnerability of the proposed development in relation to major accidents and disasters. It assesses the likelihood of the proposed development to cause an increased risk of major accidents and disasters.

Major accidents can relate to any incident, technological or otherwise, which has the potential to have a significant impact on the turbines, substation, cable route or on the receiving environment. Examples of major accidents which have such potential are fire, explosion, traffic collisions, contamination and pollution.

A natural disaster is an all-encompassing term which describes any severe natural event which has the potential to cause disturbance to an individual, development or population. The severity depends on the receptor and the type of disaster. Examples of natural disasters are earthquakes, flooding, tsunamis, lightning strikes, hurricanes or any other extreme natural event. This section has considered the potential increased risk of such events occurring as a result of climate change, such as sea-level rise and increased frequency in the occurrence of extreme weather events.

It is considered that there is low risk for the proposed development to cause a major accident or disaster. Furthermore, there is no increased risk to the development from a major accident or disaster.

9.6 Mitigation and Monitoring Measures

Appropriate mitigation measures to avoid or significantly reduce any potential effects of the proposed development are outlined in this section.

The primary mitigation measure employed has been the design of the proposed development in terms of locating the turbines, access tracks, and other proposed infrastructure in order to reduce the effects on land and soils. Mitigation measures for the land and soils environment during the construction, operational, and decommissioning phases of the proposed development are outlined in the following sections below.

9.6.1 Construction Phase

9.6.1.1 Land Use

To reduce the potential effect of changing the land use associated with the footprint of the proposed development, the footprint of the works has been minimised to avoid unnecessary soil sealing, disruption, etc. A minimal volume of soil and subsoil will be removed to allow for infrastructural work to take place in comparison to the total volume present on the site due to optimisation of the layout by mitigation by design. The proposed development will involve excavation of topsoil (20,042m^3), subsoil (28,064m^3), and bedrock for facilitating access tracks and hardstand emplacements. Large amounts of aggregates (42,543m^3), concrete (5,010m^3), and steel (480t) will be used during construction. Turbine locations, the alignment and rotation of the hardstands, and the routes of proposed new access tracks were designed to optimise the balance between access criteria and the required volumes of excavated and imported materials. The turbine foundation will be backfilled with a cohesive material, where possible using the material arising during the excavation, and landscaped using the vegetated soil set aside during the excavation.

The land associated with the footprint of the development will be reinstated at the end of the operational life of the proposed development such that it can be used again for pastural purposes. The land outside the development footprint, within the study boundary will not be affected by the development, and current land use practices will remain in place on these lands over the lifetime of the development. The area of land required to construct, operate, maintain and ultimately decommission the proposed development has been kept to the minimum reasonably practicable area as part of the design process. Existing access tracks have been utilised in the design as much as possible such that the existing land use does not change in these areas of the site during the operational life of the proposed development. This approach minimises the area temporarily altered from its current land use.

These measures are designed to reduce the effect of land use change by sequestering carbon, reducing waste (soil, subsoil, and rock materials), target limitations and controls on soil sealing, and not changing the use of the original lands where practicable.

Both grid route options under consideration have been designed to minimise impacts on existing land use as much as possible. Option A primarily follows the existing road network, thereby reducing the need to disturb adjacent lands. Option B, while located off-road, offers a substantially shorter route, which in itself helps to limit the extent of land use change as a result of the proposed development.

9.6.1.2 Soil and Geology

9.6.1.2.1 Soil Erosion

Materials used during the construction phase of the proposed development will be managed in line with the proposed **CEMP** which can be found in **Appendix 3D**. The **CEMP** includes site management controls to mitigate for soil erosion.

Due to the significant loads that will be imposed by the outriggers of the main lifting crane during the erection process for the installation of the wind turbines on site; it is intended that the proposed crane hardstands will be constructed using excavation methods over the footprint of the hardstand area / turbine base.

Excavations for turbine foundations will be the largest scale excavations onsite. These excavations will be completed to an approved temporary works design and carried out such that they are stable or adequately supported. This is likely to involve creating safe side slope angles, installation of drainage around and within the excavation, and installation of sediment control measures within the drainage system to prevent soil erosion. Sediment control measures and further measures to limit soil erosion and discharges to the drainage system are outlined in **Chapter 03 Description of the Proposed Development**.

Drainage will be constructed in parallel with access track construction and turbine excavation, including drains and stilling ponds, etc. A combination of new and upgraded drainage networks will be installed within the site. The existing drainage network will be utilised where possible and will be upgraded where necessary including the installation of settlement ponds and sediment traps at key locations. The drainage network has a twin system of water management separating out clean water from dirty water. This network and design approach is outlined in **Chapter 03 Description of the Proposed Development** of this **EIAR**. The proposed wind farm drainage design is illustrated on **Drawings 22569-MWP-00-00-DR-C-5006** and **22569-MWP-00-00-DR-C-5405**. Temporary works will be such that they do not adversely interfere with existing drainage channels/regimes.

Temporary stockpiles of excavated spoil, stored in the footprint of the excavation areas, will be directed for use in backfilling and restoration or placed in the deposition areas on site. Reusable excavated sub-soils and aggregate will be stored in temporary stockpiles at suitably sheltered areas to prevent erosion or weathering and shall be shaped to ensure rainfall does not degrade the stored material. Stockpiles will be stored away from any open surface water drains, managing height and slope of all stockpiles and minimising soil movement. Estimated volumes of material can be found in **Section 3.4.9** of the **Chapter 03 Description of the Proposed Development** of this **EIAR**. Excess spoil material will be stored on site in the two (2) designated deposition zones.

Whenever possible, existing access tracks have been utilised to access turbine locations. This reduces the volume of excavated material and imported crushed rock for track construction. Excavations and material removal that will take place during the construction phase will be localised to the turbine locations and access tracks.

Excavated material from the grid route will be used to reinstate the area around the cable trench following backfilling of the trench with approved materials. In the event that there is a requirement for soil to be exported from site, this will be treated as an Article 27 by-product (a non-waste) where practicable or treated to comply with Article 28, and recycled if possible. A Resource Waste Management Plan (RWMP) will be implemented by the appointed contractor, and included as **Appendix 9A** of **Volume III**.

The implementation of erosion and sediment controls will be made prior to the commencement of site clearance works. Silt traps, such as geotextile membrane, will be placed in the existing drainage network prior to construction work. These will be inspected weekly and in the event of major rain events to ensure their performance adequacy, by a suitably qualified and experienced civil / structural engineer and cleaned regularly as required.

The mitigation measures for the grid connection will be the same as those at the wind farm site. These include mitigation measures for soils and geology, drainage, siltation control, hydrocarbon release and general site management and will be fully in line with any requirements identified in the Environmental Management Plans found in the **CEMP** (**Appendix 3D**). The land use at these locations will not change.

In relation to Grid Connection Option A, use of the existing public road network will be used to reduce subsoil and bedrock excavation volumes. The subsoil and bedrock which will be excavated during the construction phase will be localised to the proposed grid connection route alignment. A minimal volume of subsoil and bedrock will be removed to allow for grid connection works, and suitable material will be reused in trench backfilling where possible. Excess excavated material will be removed to the deposition areas. Once in place, the grid connection will not affect existing or further land uses.

9.6.1.2.2 Compaction/Loading

The project **CEMP** (refer to **Appendix 3D**) includes site management controls to mitigate for compaction.

A traffic management plan has been developed for the construction phase (refer to **Appendix 14A**). This is to manage and control vehicular movement onsite. Measures will include the scheduling of HGVs during the construction phase to reduce the number of vehicles moving in, through and off site. This in turn will reduce the impact of soil compaction and erosion. Unscheduled vehicles will not have access to the site. Machinery will not operate directly on excavated/stockpiled soils. Heavy vehicles will only follow designated and newly constructed access tracks and avoid loading areas which are not contained within the footprint of the main works to minimise disturbance of the original soil and subsoil formations and to retain soil structure. This implies that machinery will be kept on tracks and aside from advancing excavations, will not move onto areas that are not permitted for the development. Buffers will also be created between tracks and monuments to prevent threat of disturbance.

The compound, vehicles, stockpiled materials and heavy machinery will be in place for the duration of the construction phase and will be removed once commissioning is complete.

Within excavations and around excavations, pore water pressure will be kept low by avoiding loading the soil/subsoil and giving careful attention to the existing drainage, as compaction would alter the surface drainage regime (see **Chapter 08 Water**).

9.6.1.2.3 Slope Stability

All temporary cuts/excavations will be carried out such that they are stable or adequately supported. Temporary works will be such that they do not adversely interfere with existing drainage channels/regimes.

All site excavations and construction will be supervised by a suitably qualified and experienced engineer. The Contractor's method statements for each element of work will be reviewed and approved by the engineer prior to site operations. Prior to excavation, drains will be established to effectively intercept overland flow prior to earthworks. The existing network of drainage within the site will be utilised whenever possible. From examination of factual evidence to date, the majority of landslides occur after an intense period of rainfall. An emergency response system will be developed for the construction phase of the proposed development, particularly during the early excavation phase. This, as a minimum, will involve 24 hour advance meteorological forecasting (Met Éireann download) linked to a trigger-response system. When a pre-determined rainfall trigger level is exceeded (1 in 100 year storm event or very heavy rainfall at >25mm/hr), planned responses are undertaken, refer to **CEMP** (**Appendix 3D**). These responses will include cessation of construction until the storm event including storm runoff has passed over.

From a desktop review, the GSI's Landslide Events database has no records of any landslide events recorded within or in proximity to the site. The two closest events include "Ballyhahill 1997" 11km northwest of the site with the collapse of a riverbank, and "Kapanihane 1697" 20km southeast of the site with a peat flow.

A project geotechnical engineer or engineering geologist will be employed during the construction phase of the works. As part of the detailed design and assessment, identification of potential planes of weakness will be made in the overburden such as discrepancies in the material type and foliation direction in the bedrock. Earthworks will be constructed to safe, stable angles in accordance with detailed design and best practice.

Plant and materials will be stored in approved locations only (such as the proposed site compound) and will not be positioned or trafficked in a manner that would surcharge existing or newly-formed slopes.

9.6.1.3 Accidental Spills & Contamination/Pollution

The **CEMP** (refer to **Appendix 3D** of **Volume III**) includes site management controls to mitigate for contamination/pollution.

The permanent access track works will require a drainage network to be in place for the construction and operation phases of the proposed development. Fundamental to any construction phase is the need to keep clean water (i.e. runoff from adjacent ground upslope of the permitted development footprint) clean and manage all other runoff and water from construction in an appropriate manner. Wheel wash facilities will be available onsite for the duration of the construction phase. These and other measures are outlined in the Construction Environmental Management Plan - **CEMP** (**Appendix 3D**). The proposed surface water drainage is summarised in **Chapter 03 Description of the Proposed Development** and **Chapter 08 Water**.

A bunded containment area will be provided within the compound for the storage of fuels, lubricants, oils etc.

Good site practice will be applied to ensure no fuels, oils or any other substance are stored in a manner on site in which they may spill and enter the ground, particularly when the initial top layer of made ground is excavated. Dedicated, bunded storage areas will be used for all fuels or hazardous substances. Spill kits will be maintained on site. The **CEMP** includes a management plan and can be seen in **Appendix 3D**.

The potential for hydrocarbons getting into the existing drains, local watercourses, and land and soils environment will be mitigated by only refuelling construction machinery and vehicles in designated refuelling areas using a prescribed re-fuelling procedure. A fuel management plan will be implemented incorporating the following elements:

- **Refuelling of Construction Plant On-Site** - Refuelling will be carried out using 110% capacity double bunded mobile bowsers. The refuelling bowser will be operated by trained personnel. The bowser will have spill containment equipment which the operators will be fully trained in using. Plant nappies or absorbent mats will be placed under refuelling points during all refuelling to absorb drips. Mobile bowsers, tanks and drums will be stored in secure, impermeable storage areas, over 50m away from drains and open water. To reduce the potential for oil leaks, only vehicles and machinery will be allowed onto the site that are mechanically sound. An up to date service record will be required from the main contractor. Should there be an oil leak or spill, the leak or spill will be contained immediately using oil spill kits, all oil and any contaminated material will be contained in a quarantined area and properly disposed of in a licensed facility. Immediate action will be facilitated by easy access to oil spill kits. An oil spill kit that includes absorbing pads and socks will be kept at the site compound and also in site vehicles and machinery. Correct action in the event of a leak or spill will be facilitated by training all vehicle/machinery operators in the use of the spill kits and the correct containment and cleaning up of oil spills or leaks. This training will be provided by the Environmental Manager at site induction. In the event of a major oil spill, a company who provide a rapid response emergency service for major fuel spills will be immediately called for assistance, their contact details will be kept in the site office and in the spill kits kept in site vehicles and machinery; and

- **Materials Handling, Fuels and Oil Storage** - Leakages of fuel/ oil from stores will be prevented by storing these materials in bunded tanks which have a capacity of 110% of the total volume of the stored oil. Ancillary equipment such as hoses and pipes will be contained within the bunded storage container. Taps, nozzles or valves will be fitted with a lock system. On-site washing of concrete truck barrels will not be allowed. A designated chute wash down area, which will retain the washout water and treat prior to discharge, will be located within the construction compound and there will be no other chute wash down activity on any other part of the site.

The drainage and treatment system will be managed and monitored and particularly before and after extreme rainfall events during the construction phase. Controls will be regularly inspected and maintained. A programme of inspection and maintenance will be designed and dedicated construction personnel assigned to manage this programme. A checklist of the inspection and maintenance control measures will be developed and records kept of inspections and maintenance works. The purpose of this management control is to ensure that the measures in place are operating effectively, prevent accidental leakages, and identify potential breaches in the protective retention and attenuation network during earthworks operations.

Stockpiles of stripped topsoil will be in locations with minimum trafficking to prevent damage and dusting.

The access track surface can become contaminated with clay or other silty material during construction. Access track cleaning will, therefore, need to be undertaken regularly during wet weather to reduce the volume of sediment runoff to the treatment system. This is normally achieved by scraping the track surface with the front bucket of an excavator and disposing of the material at designated locations within the site.

9.6.1.4 Rock Blasting

Rock blasting will only take place if extraction using rippers or hydraulic breakers is deemed impractical. Circumstances include where the rock strength is such that other means of extraction are not possible and excavation rates need to be increased to keep up with the construction programme. If rock blasting proves to be necessary, a detailed blasting design will be undertaken by a suitably qualified and experienced specialist for each location to ensure that a peak particle velocity (PPV) of 10 mm/s is not exceeded at a distance of greater than 20m from the blast holes as per BS 7385 Part 2: 1993. If this cannot be achieved, blasting will not be permitted at this location.

To mitigate against the risk of slope failure occurring, blasting will not be permitted at turbine locations unless robust mitigation measures are put in place. Blasting for the track cuttings and hardstands, if required, will be subject to the same rigorous controls as that proposed at turbine foundation locations.

Blasting mitigation measures, included within the **CEMP** (**Appendix 3D** of **Volume III**), will ensure compliance with the Explosives Acts 1875 and 2006 and BS 7385 in relation to blasting. Limerick City and County Council, An Garda Síochána, and adjoining landowners will be notified in advance of any blasting activities on the site. Additionally, the NPWS and any other required consultees will be consulted as part of the general consultation and blasting permitting process in order to keep them informed of any blasting proposals for the site.

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9.6.1.5 Piled Foundations

To minimise potential environmental impacts associated with piling activities, a range of mitigation measures will be implemented during the construction phase. Piling works will be carefully planned and limited to locations where geotechnical investigations confirm that conventional foundations are not feasible. Where piling is required, best practice construction methods will be employed to reduce disturbance to soils, groundwater and the surrounding environment.

All piling activities will be undertaken in accordance with the **CEMP** (**Appendix 3D**), which will include detailed method statements, site-specific risk assessments, and pollution prevention measures. Piling rigs will be operated by experienced contractors who will ensure that boreholes are installed and filled efficiently to avoid unnecessary delays or prolonged ground exposure.

To manage spoil generated during piling, excavated materials will be assessed for reusability on-site, with suitable material used for backfilling or landscaping. Any excess spoil will be transported to the designated deposition areas within the site. Measures will be taken to prevent silt-laden runoff from entering nearby watercourses, including the use of silt fences, settlement ponds, or other appropriate filtration systems.

9.6.2 Operation Phase

9.6.2.1 Change of Land Use

The potential effect on the land and soils of the site due to excavations will be lower during operation and maintenance, as the majority of excavations will have been reinstated. Some erosion of soil may continue into the operation phase, however as vegetation becomes established and equilibrium is achieved, erosion rates will reduce to normal levels. Ongoing track and drainage management will be required during operational phase. Stability of soil will be monitored by a qualified Geotechnical Engineer. No additional mitigation measures are required in relation to land use for soil and the geological environment during the operation of the proposed development.

Mitigations to minimise the land use footprint and land use change have been implemented into the engineering design of the proposed development. Only observation and monitoring measures are needed during maintenance. As such, no mitigations are considered necessary for the effects on land use during the operational phase of the proposed development.

9.6.2.2 Soil and Geology

All vehicular movement during operation and maintenance will be restricted to the areas of hardstanding and existing/newly constructed access tracks. The volume of traffic during the operational phase will be greatly reduced in comparison with the construction phase. The potential effect on slope stability will therefore be minimal.

The risks associated with sedimentation and contamination of the watercourses and aquifers due to erosion and runoff will be significantly reduced to minimal levels as areas are revegetated and construction traffic ceases. Refer to **EIAR Chapter 08 Water** for further details in relation to hydrology and hydrogeology.

No mitigation is required for the grid connection, unless repair works are undertaken. Should repair works be required, mitigation will include:

- Use of temporary excavations over the shortest distances possible;
- All excavated material will be stored and reused during reinstatement; and
- The works are likely to be completed over short periods of 1 to 2 days.

9.6.2.3 Accidental Spills & Contamination/Pollution

Mitigation measures for oils and fuels remain the same as the construction phase but will significantly reduce during the operation stage. Maintenance of the turbines, substation and maintenance vehicles is all that is required. Turbine transformers will be located within the turbines, so any leak of oil would be contained within or adjacent to the turbine. Minimal refuelling or maintenance of operational vehicles or plant will take place on site. Off-site refuelling will occur at a controlled fuelling station. Any on-site re-fuelling will be undertaken using a double skinned bowser with spill kits at the ready for accidental leakages or spillages. A minimal amount of fuels will be stored on site.

An emergency plan for the operational phase to deal with accidental spillages will be prepared and will be communicated to plant operatives. Spill kits will be available to deal with any accidental spillage in and outside the re-fuelling area.

The substation transformer oil storage tanks will be in a concrete bund capable of holding 110% of the oil in the transformer and storage tanks.

9.6.2.4 Climate Change

The installation of the proposed development will mitigate and offset some effects of climate change by producing renewable energy, reducing carbon-based emissions, and using the land in a sustainable way. Land use will change but not cause significant effects to the land and soils environment. However, climate change is still expected to trend negatively in the coming decades, with predicted and potential unforeseen worse-case effects. As such, no mitigation measures for climate change effects on the land and soils environment for the proposed development are likely at this time with a do-nothing approach recommended.

The United Nations' Intergovernmental Panel on Climate Change (IPCC) has published "Special Report - Climate Change and Land", on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Some of the key mitigations in this report are as follows:

- Scenarios and models are important tools to explore the trade-offs and co-benefits of land management decisions under uncertain futures;
- Large-scale implementation of mitigation response options that limit warming to 1.5°C or 2°C would require conversion of large areas of land for afforestation/reforestation and bioenergy crops, which could lead to short-term carbon losses. In high carbon lands such as forests and peatlands, the carbon benefits of land protection are greater in the short-term than converting land to bioenergy crops;
- Land degradation can be avoided, reduced or reversed by implementing sustainable land management, restoration and rehabilitation practices that simultaneously provide many co-benefits, including adaptation to and mitigation of climate change;
- Even with adequate implementation of measures to avoid, reduce and reverse land degradation, there will be residual degradation in some situations, e.g. extreme forms of soil erosion;
- The current global extent, severity and rates of land degradation are not well quantified. Land degradation is a serious and widespread problem, yet key uncertainties remain concerning its extent, severity, and linkages to climate change; and
- Coordinated action is required across a range of actors, including business, producers, consumers, land managers, and local communities and policymakers to create enabling conditions for adoption of response options. Delayed action will result in an increased need for response to land challenges and a decreased potential for land-based response options due to climate change and other pressures. The

potential for some land management options decreases as climate change increases; for example, climate alters the sink capacity for soil and vegetation carbon sequestration, reducing the potential for increased soil organic carbon. Some response options will not be possible if action is delayed too long; for example, peatland restoration might not be possible after certain thresholds of degradation have been exceeded, meaning that peatlands could not be restored in certain locations.

9.6.3 Mitigation Measures for Cumulative Effects

Based on the finding that the potential for significant cumulative effects on land and soils arising from the proposed development is considered to be not significant, no specific measures to mitigate against cumulative effects are considered necessary.

9.7 Decommissioning Phase

Where appropriate, mitigation measures used during decommissioning activities shall be comparable to those used during construction. By keeping some development components in place, when necessary, some of the effects will be avoided. In order to recover vegetation and lessen the effects of runoff and sedimentation, the turbine bases will be rehabilitated and covered with local topsoil. Access tracks that are not needed for farming purposes will also be allowed to naturally revert to vegetation. The proposed development's materials and equipment will all be removed from the site and disposed of or repurposed in a way that is environmentally responsible. There will be mitigation measures put in place to prevent potential pollution from fuel leaks and soil compaction.

9.8 Residual Effects

No significant residual effects on land and soils are likely.

Table 9-3: Residual Effects for Construction Phase and Operational Phase

EFFECT (PRE-MITIGATION)	RECEPTOR	EFFECT (PRE-MITIGATION)	MITIGATION MEASURES	RESIDUAL EFFECT (POST-MITIGATION)					
				QUALITY OF EFFECT	SIGNIFICANCE	SPATIAL EXTENT	DURATION	OTHER RELEVANT CRITERIA	LIKELIHOOD
CONSTRUCTION									
Land Use	Land, Soils	Adverse, moderate, short-term, direct effect	9.6.1.1	Adverse	Not significant	Localised	Short-term	Direct	Likely
Soil and Geology	Soil	Adverse, not significant-to-slight, short-term effect	9.6.1.2	Adverse	Not significant / Slight	Localised	Short-term	Direct	Likely
	Geology	Adverse, not-significant, short-term effect		Adverse	Imperceptible	Localised	Short-term	Direct	Unlikely
Accidental spills & contamination/pollution	Land and Soils	Adverse, significant, short-term, 'Worst-case' effect	9.6.1.3	Adverse	Slight	Localised	Short-term	Direct	Unlikely
	Geology and Hydrogeology	Adverse, significant, short-term, indirect, cumulative effect		Adverse	Not significant	Localised	Short-term	Indirect	Unlikely
Rock Blasting	Soils and Geology	Adverse, significant, short-term, direct effect	9.6.1.4	Adverse	Not significant	Localised	Short-term	Direct, Cumulative	Likely
Piled Foundations	Soils and Hydrogeology	Adverse, significant, short-term, direct effect	9.6.1.5	Adverse	Not significant	Localised	Short-term	Direct	Likely

EFFECT (PRE-MITIGATION)	RECEPTOR	EFFECT (PRE-MITIGATION)	MITIGATION MEASURES	RESIDUAL EFFECT (POST-MITIGATION)					
				QUALITY OF EFFECT	SIGNIFICANCE	SPATIAL EXTENT	DURATION	OTHER RELEVANT CRITERIA	LIKELIHOOD
OPERATIONAL									
Change of Land Use	Land	Adverse, not significant, long-term, direct effect	9.6.2.1	Positive	Not significant	Localised	Long-term	Direct, Cumulative	Likely
Soil and Geology	Land	Adverse, slight, long-term direct effect	9.6.2.2	Positive	Not significant	Localised	Long-term	Direct	Likely
	Soils and geology	Adverse, slight, long-term direct effect		Adverse	Not significant	Localised	Long-term	Direct	Likely
Accidental spills & contamination/pollution	Land, soils, geology, hydrogeology	Adverse, moderate, direct, unlikely, long-term	9.6.2.3	Adverse	Not significant	Localised	Long-term	Direct	Unlikely
Grid Connection – Effects Arising	Land and Soils	Adverse, imperceptible, direct, low probability temporary effect	9.6.2.1	Adverse	Imperceptible	Localised	Temporary	Direct	Likely
Climate Change	Land, soils, geology, hydrogeology	Adverse moderate long-term, cumulative effect	9.6.2.4	Adverse/Neutral	Slight	Localised	Long-term	Direct, Indirect	Likely

9.9 Conclusions

In conclusion, with the implementation of appropriate mitigation measures and correct procedures, no significant effects on the land, soil and geology of the site of the proposed development or along the grid route will occur during construction, operation, or during decommissioning phases.

The assessment also confirms that there will be no significant cumulative effects on the land, soil and geology environment as a result of the proposed development and other proposed projects.

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