8. LAND SOILS AND GEOLOGY

8.1 Introduction

8.1.1 Background and Objectives

Fehily Timoney and Company (FT) was engaged by MKO to carry out an assessment of the potential impacts of the Glenora wind farm including its grid connection at Glenora, Co. Mayo (the 'Proposed Development') on the land, soil and geological environment.

The Proposed Development is described in full in Chapter 4 of this EIAR.

This report provides a baseline assessment of the environmental setting of the Proposed Development and all other associated works, as described in Chapter 4 of the EIAR, in terms of land, soils and geology and discusses the potential likely significant, direct, indirect and cumulative effects that the construction, operation and decommissioning of the Proposed Development will have. Where required, appropriate mitigation measures to avoid any identified effects to land, soils and geology are recommended and the residual effects of the Proposed Development post-mitigation are assessed.

8.1.2 Statement of Authority

FT is a civil and environmental engineering, scientific and planning consultancy. Set-up in 1990, FT has grown to be one of the largest Irish-owned independent consultancies. FT have offices in Cork, Dublin and Carlow. FT deliver projects in Ireland and internationally in our core competency areas of Waste Management, Environment and Energy, Civils Infrastructure, Planning and GIS and Data Management. FT have been involved in over 100 wind farm developments in both Ireland and the UK at various stages of development i.e. preliminary feasibility, planning, design, construction and operational stage and have established themselves as one of the leading engineering consultancies in peat stability assessment, geohazard mapping in peat land areas, investigation of peat failures and site assessment of peat.

The chapter of the EIAR was prepared by Ian Higgins and Emily Archer.

Ian Higgins (BSc Engineering Geology, MSc Geotechnical Engineering, FGS, MIEI) is a Geotechnical Engineer with 25 years consultancy experience in Ireland. Ian has completed numerous peat stability assessment and geological impact assessment for wind farms. In addition, he has significant experience in the geotechnical design of wind energy projects at construction stage.

Emily Archer (BSc Geology, MSc Applied Environmental Geology) is a Geotechnical Engineer with 5 years' experience and has been involved in the preparation of several peat stability reports and Land, Soils & Geology Chapters for EIAR's for wind farm developments.

Site visits were also undertaken by Alan Whelan and Gary Lawlor. Alan is a Project Engineer with Fehily Timoney and has two years' experience in geotechnical engineering. Gary is a Project Engineer with FT and has two years' experience.

8.1.3 Relevant Guidance

The land, soils and geology chapter of this EIAR was prepared in accordance with the legislation and guidance outlined in Chapter 1: Introduction and the following documents:

- NRA (2009), Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes
- IGI (2013), Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements
- Scottish Executive (2017) Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments, 2nd Edition.
- EPA (2003), Towards Setting Guideline Values for the Protection of Groundwater in Ireland.
- Environmental Protection Agency (2022). Guidelines on the Information to be Contained in Environmental Impact Assessment Reports

8.2 Schedule of Works

8.2.1 Desk Study

A desk study for the Proposed Development and the surrounding area was completed in advance of undertaking the walkover survey and site investigations (July 2021) and was reviewed prior to completion of this Chapter (August 2023). This involved collecting all relevant geological data for the site and surrounding area. This included consultation of the following:

- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 6 (Geology of North Mayo);
- Geological Survey of Ireland (GSI, 1996);
- General Soil Map of Ireland 2nd edition (www.epa.ie)

8.2.2 Baseline Monitoring and Site Investigation

Detailed walkover surveys, geological mapping and peat probing for the Proposed Development was undertaken by FT during July and August 2021.

Trial pit investigations (13 no. trial pits) were completed by Irish Drilling Ltd. (IDL) under the supervision of FT in October 2021. The trial pits were strategically placed to get an understanding of the soil and bedrock conditions across the Proposed Development.

The objectives of the intrusive site investigations included mapping the distribution and depth of blanket peat at the site along with assessing the mineral subsoil / bedrock interface beneath the peat at key development locations (i.e. proposed turbines & met mast, substation, temporary construction compounds, existing and proposed access roads, peat and peat placement areas and borrow pit location).

These thorough investigations allowed the development of a geological conceptual model of the site.

In summary, site investigations to address the land, soil and geology section of the EIAR included the following:

- A total of 520 no. peat probe depths were carried out by FT, in July and August 2021, and MKO in May 2022, to determine the depth and geomorphology of the blanket peat at the site;
- A geotechnical assessment of peat stability by FT (August 2022);
- Logging and supervision of 13 no. trial pits across the site (October 2021) and laboratory testing of bulk samples from trial pits;
- Logging of bedrock outcrops and subsoil exposures; and,
- Mineral subsoils and peat were logged according to BS: 5930 and Von Post Scale respectively.

The Geotechnical and Peat Stability Assessment Report prepared by FT is included as Appendix 8-1 of this EIAR.

8.2.3 Scoping and Consultation

The scope for this assessment has been informed by consultation with statutory consultees, bodies with environmental responsibility and other interested parties. This consultation process is outlined in Section 2.6 of this EIAR. Certain issues and concerns highlighted with respect land, soils and geology are summarised in Table 8-1 below.

Table 8-1 Summary of Scoping Responses relating to Land, Soils & Geology

Source	Description	Addressed in Chapter Section
Inland Fisheries Ireland (IFI)	A detailed geotechnical survey must be carried out and the potential for soil movement and landslides should be assessed fully for all areas of the site and all proposed activities including borrow pits, peat deposition sites, settlement ponds, turbines and access roads. The impact these works will have either directly or by vibration on the stability of the soils.	Section 8.3.11
Irish Peatland Conservation Council (IPCC)	The IPCC would advise any developer planning construction in, or within close proximity to peatland habitat to be familiar with the Environmental Protection Agency funded project BOGLAND (www.ucd.ie/bogland). This project recommends the best practice guidelines to ensure no damaging development occurs on, or affects peat soils and peatlands of conservation value. Its overall objective was to develop guidance in the development of strategies for the sustainable future management of peatlands in Ireland. To this effect, the report aimed to provide a synthesis of knowledge on this key natural resource, the important functions and roles that peatland ecosystems perform, their various utilisations and how attitudes and policies affect them. Looking at the Geological Survey of Ireland's Landslide Events Map it is possible to see that there are a number of historic peat slide events recorded in the area. Also, the GSI's Landslide Susceptibility	Section 8.3.11, Appendix 8.1 "Peat and

Source	Description	Addressed in Chapter Section
	Map shows that the locations for turbines 2,7,11,15,18,20,21,22 are in zones graded to be of a "Moderately High" chance of a landslide event. The proposed turbine locations are a cause for concern and need to be extensively reviewed. It has come to IPCC's attention that current best-practice methods for assessing the probability and/or risk assessment for peat slippage and bog bursts/flows may not be fit for purpose. There has been a number of peat events in recent times, such as the Meenbog bog flow, Boleybrack Mountain peat slide and the Knockanefune Mountain bog slide and there is uncertainty over what caused them as there are confounding variables such as afforestation, developments (such as access roads), overgrazing, drainage, turbuary and rainfall. Peat has an exceptionally high water content, is a low density material with low compressive strength. Disturbed peat also has a low shear strength. These parameters allow long runouts to develop when there is a peat failure with the potential to destroy aquatic wildlife directly and downstream. The possibility and extent of runouts could be examined further to ascertain where these might occur, what paths they would take and what would be at risk environmentally. This of course has to be dove-tailed with proper contingency and management plans in the event of an actual peat-slide. There is a high possibility that if there is a peat slide event it would affect neighbouring designated sites which would be unacceptable and disastrous. If there is a possibility of any more damage occurring to the designated sites and ANNEX habitats as a result of this development then the project should not go ahead.	Geotechnical Stability Assessment Report" There is considered to be a low risk of peat instability on the Glenora site, based on the peat stability assessment undertaken. The runout distance for a low potential event is considered to be beyond the scope of a peat stability report. Appendix 8.2 includes information on the procedure should a peat failure occur, which involves the construction of check barrages downstream.
Health Services Executive (HSE)	A detailed assessment of the current ground stability of the site for the proposed wind farm development together with all mitigation measures should be included in the EIAR. This assessment should include the impact construction work will have on the future stability of ground conditions taking into consideration extreme weather events, site drainage and the potential for soil erosion. The scoping document states " A Peat and Spoil Management	Section 8.3.11

Source	Description	Addressed in Chapter Section
	Plan will cover peat stability, with reference to the construction phase of the wind farm". The Environmental Health Service recommends that the EIAR should include provision for a peat stability monitoring programme to identify early signs of potential bog slides (pre-failure indicators, see the Scottish Governments 'Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Developments 2017)	See Appendix 8.2 for notes on where monitoring will be required.
Department of Tourism, Culture, Arts, Gaeltacht, Sports and Media	The EIAR should give specific consideration to the mobilisation of silt and changes to the stability of peat. The proposed windfarm has the potential for significant changes in patterns of surface water flow and may desiccate the peat allowing pathways to open up resulting in subsurface water losses. It should be noted that in 2020 a number of major upland peatland (blanket bog) landslides occurred across Ireland, most notably on Shass Mountain near Drumkeeran in County Leitrim and Meenbog, near Ballybofey in County Donegal. The Peat Stability Risk Assessment must be considered in light of these occurrences with consideration of climate change predictions (e.g. rainfall level) in the hazard rating and should thoroughly assess risk with regard to change in weather patterns due to climate change such as more frequent and intense storms and rainfall events, increased likelihood and magnitude of river flooding, prolonged periods of dry conditions which may increase the likelihood of unstable peat. Detailed consideration should be given to the amount of peat to be excavated, stored, and disposed/recovered. A detailed plan for the safe storage, disposal and rehabilitation of excavated or disturbed peat should form part of the EIAR. The associated impacts of quarrying or extraction should be included among the considerations at the earliest stages of project planning and design and should be assessed fully in the EIAR. Reinstatement or restoration plans will be required for any quarries or borrow pits on-site and should be included in the EIAR. As with any other part of the development, all borrow pits (existing or proposed) to be used in construction should be included within the application area for the Proposed Development.	Section 8.3.11, Appendix 8.1 "Peat and Geotechnical Stability Assessment Report" Section 8.4, Appendix 8.2 "Peat and Spoil Management Plan", CEMP Sections through the proposed borrow pits are included in Appendix 8.2.

Source	Description	Addressed in Chapter Section
Geological Survey of Ireland (GSI)	Landslides are common in areas of peat, rock near surface and in fine to coarse range materials (such as glacial tills), areas which are found within the proposed area. Landslide susceptibility in the area of the proposed wind energy development is variable and is classed from Moderately Low / Moderately High to High. There have been previous landslide events in the vicinity of the proposed wind energy development	Section 8.3.11, Appendix 8.1.

8.2.4 Impact Assessment Methodology

Using information from the desk study and data from the site investigation, an estimation of the importance of the land, soil and geological environment within the study area is assessed using the criteria set out in Table 8-2 (NRA, 2008).

Table 8-2-Estimation of Importance of Soil and Geology Criteria (NRA, 2008).

Importance	Criteria	Typical Example
Very High	Attribute has a high quality, significance or value on a regional or national scale. Degree or extent of soil contamination is significant on a national or regional scale. Volume of peat and/or soft organic soil underlying attributes significant on a national or regional scale.	Geological feature rare on a regional or national scale (NHA). Large existing quarry or pit. Proven economically extractable mineral resource
High	Attribute has a high quality, significance or value on a local scale. Degree or extent of soil contamination is significant on a local scale. Volume of peat and/or soft organic soil underlying site is significant on a local scale.	Contaminated soil on site with previous heavy industrial usage. Large recent landfill site for mixed wastes. Geological feature of high value on a local scale (County Geological Site). Well drained and/or highly fertility soils. Moderately sized existing quarry or pit Marginally economic extractable mineral resource.
Medium	Attribute has a medium quality, significance or value on a local scale. Degree or extent of soil contamination is moderate on a local scale. Volume of peat and/or soft organic soil underlying site is moderate on a local scale.	Contaminated soil on site with previous light industrial usage. Small recent landfill site for mixed Wastes. Moderately drained and/or moderate fertility soils. Small existing quarry or pit. Sub-economic extractable mineral Resource.
Low	Attribute has a low quality, significance or value on a local scale. Degree or extent of soil contamination is minor on a local scale.	Large historical and/or recent site for construction and demolition wastes.

Importance	Criteria	Typical Example
	Volume of peat and/or soft organic soil underlying site is small on a local scale.	Small historical and/or recent landfill site for construction and demolition wastes. Poorly drained and/or low fertility soils. Uneconomically extractable mineral Resource.

The guideline criteria (EPA, 2022) for the assessment of impacts require that likely impacts are described with respect to their extent, magnitude, complexity, probability, duration, frequency, reversibility and trans frontier nature (if applicable). The descriptors used in this environmental impact assessment are those set out in EPA (2022) Glossary of Impacts as shown in Chapter 1 of this EIAR. In addition, the two impact characteristics proximity and probability are described for each impact and these are defined in Table 8-3.

In order to provide an understanding of this descriptive system in terms of the geological/hydrological environment, elements of this system of description of impacts are related to examples of potential impacts on the hydrology and morphology[1] of the existing environment, as listed in Table 8-4.

Table 8-3: Additional Impact Characteristics.

Impact Characteristic	Degree/ Nature	Description
Proximity	Direct	An impact which occurs within the area of the proposed project, as a direct result of the proposed project.
	Indirect	An impact which is caused by the interaction of effects, or by off-site developments.
Probability	Low	A low likelihood of occurrence of the impact.
	Medium	A medium likelihood of occurrence of the impact.
	High	A high likelihood of occurrence of the impact.

Table 8-4: Impact descriptors related to the receiving environment.

Impact Characteristics		Potential Geological, Hydrogeological and Hydrological Impacts
Quality	Significance	
Negative Only	Profound	Widespread, permanent impact on: › The extent or morphology of a cSAC. › Regionally important aquifers. › Extents of floodplains. Mitigation measures are unlikely to remove such impacts.
Positive or Negative	Significant	Local or widespread, time dependent impacts on: › The extent or morphology of a cSAC / ecologically important area. › A regionally important hydrogeological feature (or widespread effects to minor hydrogeological features). › Extent of floodplains. Widespread permanent impacts on the extent or morphology of an NHA/ecologically important area. Mitigation measures (to design) will reduce but not completely remove the impact – residual impacts will occur.

Impact Characteristics		Potential Geological, Hydrogeological and Hydrological Impacts
Quality	Significance	
Positive or Negative	Moderate	Local, time dependent impacts on: › The extent or morphology of a cSAC / NHA / ecologically important area. › A minor hydrogeological feature. › Extent of floodplains. Mitigation measures can mitigate the impact OR residual impacts occur, but these are consistent with existing or emerging trends
Positive, Negative or Neutral	Slight	Local, perceptible, time dependent impacts not requiring mitigation.
Neutral	Imperceptible	No impacts, or impacts which are beneath levels of perception, within normal bounds of variation, or within the bounds of measurement or forecasting error.

8.3 Existing Environment

8.3.1 Site Description

The Proposed Development site (EIAR Site Boundary) is located approximately 6 kilometres south-west of Ballycastle, Co. Mayo. The site setting is forested upland blanket bog which is owned by Coillte. The site is accessible via a network of existing forestry tracks. The intended grid connection cabling route will connect the on-site substation to the existing 110kV Tawnaghmore substation. The grid connection route measures approximately 28km and runs within existing forestry access roads and local and public roads (within the EIAR Site Boundary) for its entire length. All elements of the Proposed Development (as described in Chapter 4) have been considered in this assessment.

There is 1 no. proposed grid route, along with 1 no. proposed substation. The proposed substation is located approximately 200 metres north of Turbine No. 15 along an existing access road.

The topography of the Proposed Development ranges between 115mOD (southwest side) to 330mOD (northeast side). The centre and west of the site is drained by a series of drains and watercourses running roughly north to south. The eastern side of the site is drained by a combination of north-south drains/streams and a river (Keerglen River) running west to east. In addition, accommodation works along the intended turbine delivery route (TDR) are proposed at a location along the Ballyglass local road and a proposed link road between this local road and the R314. All elements of the Proposed Development are described in full in Chapter 4 of this EIAR have been considered in the following assessment.

8.3.2 Soils and Subsoils

The Quaternary Geology (Figure 8.1) underlying the site predominantly comprises blanket peat with areas of till derived from Devonian and Carboniferous sandstones and areas of bedrock outcrop or subcrop also present in the centre of the site. A map showing the overburden types present is included as Figure 8-1.

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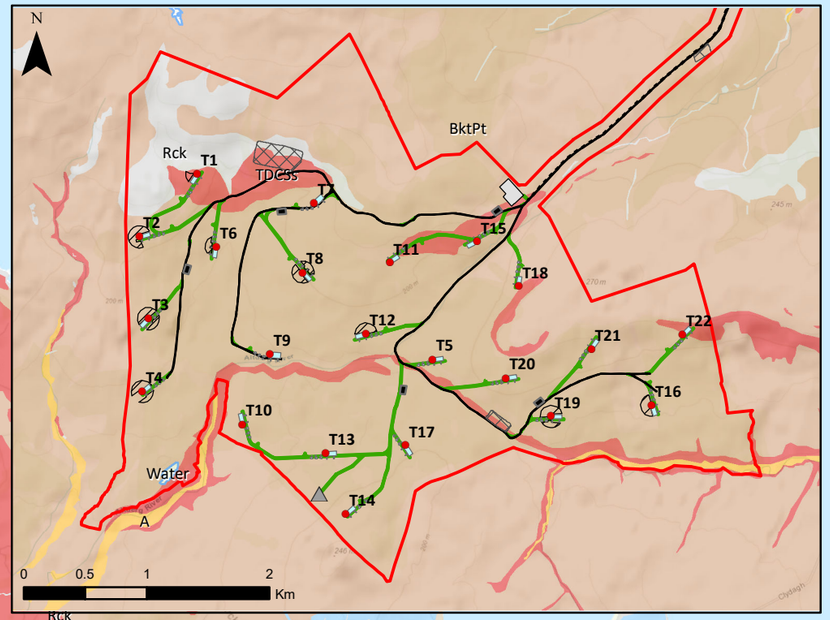

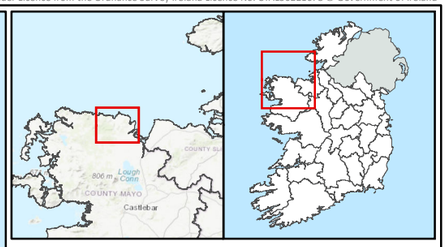

Legend

- Turbine Layout
- Turbine Foundation & Crane Hardstands
- Peat Placement
- Site Boundary
- Met Mast
- Grid Connection Route
- Proposed Borrow Pit
- Proposed Construction Compound
- Proposed Substation
- Existing Site Internal Roads
- Proposed New Roads
- A,
- BktPt, Blanket Peat
- Cut, Cut over raised peat
- GLPDSs, Gravels derived from Lower Palaeozoic and Devonian sandstones
- GLs, Gravels derived from Limestones
- GlMar, Glaciomarine sediments
- Industrial
- MGs, Marine gravel and sands (often raised)
- Mbs, Marine beach sands
- Mesc, Esturine silts and clays
- Pier
- Rck, Bedrock outcrop or subcrop
- TDCSs, Till derived from Devonian and Carboniferous sandstones
- TLs, Till derived from
- TMp, Till derived from Metamorphic
- TdlMr, Tidal Marsh
- Urban
- Water
- Ws, Windblown sands

TITLE: Quaternary Geology

PROJECT: Peat Stability Assessment
Glenora Wind Farm

FIGURE NO:	8.1		
CLIENT:	MKO		
SCALE:	1:70000	**REVISION:**	0
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Peat depths recorded across the site by FT and MKO varied from 0.1m to 4.6m, with an average of 1.85m. Approximately 99 percent of peat depth probes recorded peat depths of less than 3.0m. The peat depths recorded at the turbine locations varied from 0.5 to 3.3m with an average depth of 1.9m.

8.3.3 Bedrock Geology

The Geological Survey of Ireland (GSI) 1:100,000 scale bedrock geology map (Figure 8.2) shows that the Proposed Development site (including grid connection and TDR) is predominantly underlain by the Downpatrick Formation, the Minnaun Sandstone Formation and the Glencullin River Formation. Also present in a limited area in the northwest of the site are the Kanfinalte Formation, the Lugnalettin Black Schist Member, the Glenagh River Limestone Member and the Glencalry Schist Member.

Figure 8-2 shows the bedrock geology of the area. Three faults are mapped by the GSI as running through the site in a general northeast to southwest direction. An unconformity is shown on the GSI mapping as being present along the northern boundary of the Kanfinalta Formation with the Minnaun Formation.

The Downpatrick Formation is described as cross bedded sandstone and siltstone. The Minnaun Sandstone Formation is described as comprising cross bedded sandstone and siltstone beds. The Glencullin River Formation is described as comprising red pebbly sandstone with siltstone and mudstone.

There are no karst features on the site or within 10km of the site.

8.3.4 Geological Resource Importance

The bedrock underlying the site could be classified as “Medium” importance as per the NRA (now TII) Guidance. The bedrock has the potential to be used on a “sub-economic” local scale for construction purposes.

The glacial subsoils within site (i.e. sands and gravels where present) could be classified as “Medium” importance. The glacial subsoils have the potential to be used on a “sub-economic” local scale for construction purposes. There is no evidence within the site that this material was used in the past.

The overlying peat deposits at the site could be classified as “Low” importance as the peat is not designated in this area and is significantly degraded in most places at the site as a result of land use and drainage. Refer to Table 8.2 for definition of these criteria.

8.3.5 Geological Heritage and Designated Sites

The GSI - Irish Geological Heritage Section (IGH) and NPWS (National Parks and Wildlife Service) have undertaken a programme to identify and select important geological and geomorphological sites throughout the country for designation as NHAs (Natural Heritage Areas) – the Irish Geological Heritage Programme. This is being addressed under 16 different geological themes. For each theme, a larger number of sites (from which to make the NHA selection) are being examined, to identify the most scientifically significant. The criterion of designating the minimum number of sites to exemplify the theme means that many sites of national importance are not selected as the very best examples. However, a second tier of County Geological Sites (CGS) (as per the National Heritage Plan) means that many of these can be included in County Development Plans and receive a measure of recognition and protection through inclusion in the planning system.

There are no recorded Geological Heritage sites, mineral deposit sites or mining sites (current or historic) within 3km of the Proposed Development area. However, the Brookhill Delta, a sand and

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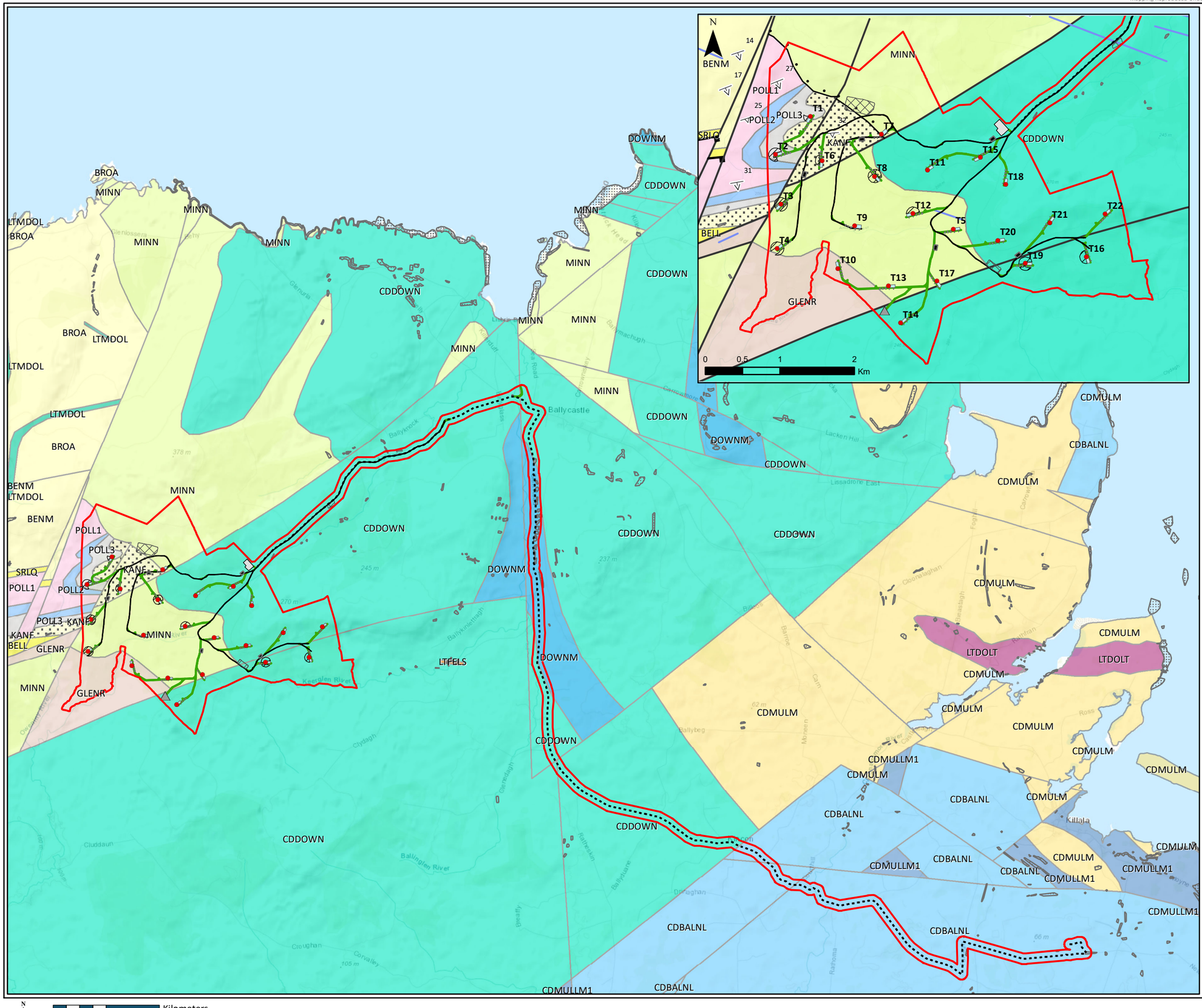

Legend

- Turbine Layout
- Turbine Foundation & Crane Hardstands
- Peat Placement Areas
- Site Boundary
- Met Mast
- Grid Connection Route
- Proposed Borrow Pit
- Proposed Construction Compound
- Proposed Substation
- Existing Site Internal Roads
- Proposed New Roads
- Bedrock Outcrop
- Bellagarvaun Formation
- Benmore Formation
- Broad Haven Formation
- Ballina Limestone Formation (Lower)
- Downpatrick Formation
- Killala Oolite Member
- Mullaghmore Sandstone Formation
- Moyny Point Limestone Member
- Glencullin River Formation
- Kanfinalta Formation
- Dolerite and Gabbro
- Felsite
- Metadolerite
- Minnaun Sandstone Formation
- Glencalry Schist Member
- Glenagh River Limestone Member
- Lugnalettin Black Schist Member
- Srahlaghy Quartzite Formation

TITLE:	Bedrock Geology		
PROJECT:	Peat Stability Assessment Glenora Wind Farm		
FIGURE NO:	8.2		
CLIENT:	MKO		
SCALE:	1:70000	**REVISION:**	0
DATE:	24/04/2023	**PAGE SIZE:**	A3

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gravel pit on the crest of a ridge near Ballycastle, is located approximately 5km north-east of the site boundary. The Geological Heritage sites are shown on Figure 8-3.

8.3.6 Soil Contamination

There are no known areas of soil contamination on the site of the Proposed Development. During the site walkovers, no areas of contamination concern were identified.

According to the EPA online mapping (http://gis.epa.ie/Envision), there are no licensed waste facilities on or within the immediate environs of the site of the Proposed Development.

There are no historic mines at or in the immediate vicinity of the site of the Proposed Development that could potentially have contaminated tailings.

8.3.7 Economic Geology

The GSI online Aggregate Potential Mapping Database shows that the Proposed Development site is located within an area mapped as being typically Very Low to Low in terms of granular aggregate potential and with low to moderate potential for crushed rock aggregate potential. Aggregate Potential is included as Figure 8-4.

8.3.8 Landslide Susceptibility

The GSI online Landslide Susceptibility mapping indicates that the Proposed Development site ranges from a low to high landslide susceptibility. The Landslide Susceptibility for the site and surrounding area is included on Figure 8-5. A Peat Stability Assessment has been undertaken and is included in Appendix 8.1 and summarised in Section 8.3.11 below.

There are no recorded historical peat failures within the Glenora wind farm site (GSI, 2023). The nearest recorded failure is located in open peat land 1km to the southeast of the Proposed Development site (Keerglen), and is believed to have occurred during the 1950's. An additional three or four failures have been recorded approximately 3km to the southeast of the Proposed Development. One of these (Cluddaun) is believed to be over 100 years old, with another (Shanettra) occurring in 2000. A further five landslides have been recorded approximately 2.5km to the west of the Proposed Development and are associated with an area of shallow bedrock on the northern flanks of Benmore.

A small scale peat failure was recorded on the site during November 2022. This failure occurred on the eastern side of the site in an area of forestry. An inspection of the failure by FT indicates that this is a 'peat slide' with a failure plane at the base of the peat, likely triggered by heavy rainfall. The peat depths in the area ranged from 1.0-1.5m, with slope angles of 10 to 14 degrees within the failure area. The failure comprised an estimated 3,750m^3 of material. No material entered any watercourses or damaged any existing infrastructure within the Proposed Development site.

8.3.9 Site Investigation - Results

As outlined in Section 8.2.2 site walkovers and peat stability assessments were undertaken by Engineering Geologists working for FT during July and August 2021 to determine the baseline characteristics of the Proposed Development site. Intrusive site investigations were undertaken by Irish Drilling Ltd (IDL) under the supervision of an Engineering Geologist from FT (Emily Archer) during October 2021.

Intrusive investigations were undertaken at the proposed borrow pit locations, at selected proposed turbine locations, and along the proposed access tracks. The purpose of the intrusive works was to confirm the geological succession underlying the site. The site investigations comprised the excavation

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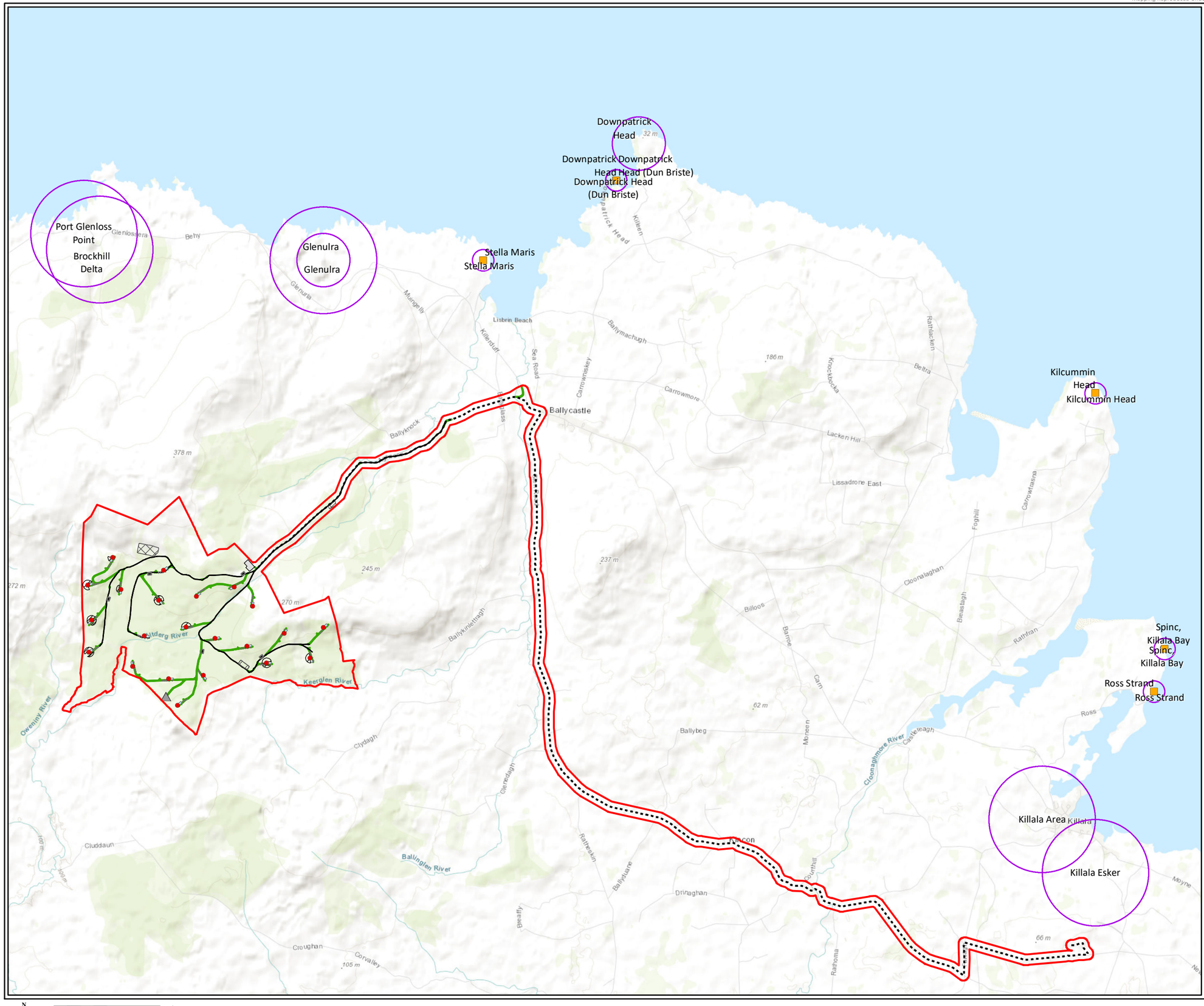

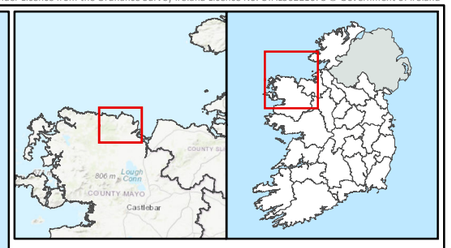

Legend

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- Peat Placement Areas
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- Proposed Borrow Pit
- Proposed Construction Compound
- Proposed Substation
- Existing Site Internal Roads
- Proposed New Roads
- Geological Heritage Sites
- Geological Heritage Sites (Unaudited)

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TITLE: Geological Heritage			
PROJECT: Peat Stability Assessment Glenora Wind Farm			
FIGURE NO:	8.3		
CLIENT:	MKO		
SCALE:	1:70000	**REVISION:**	0
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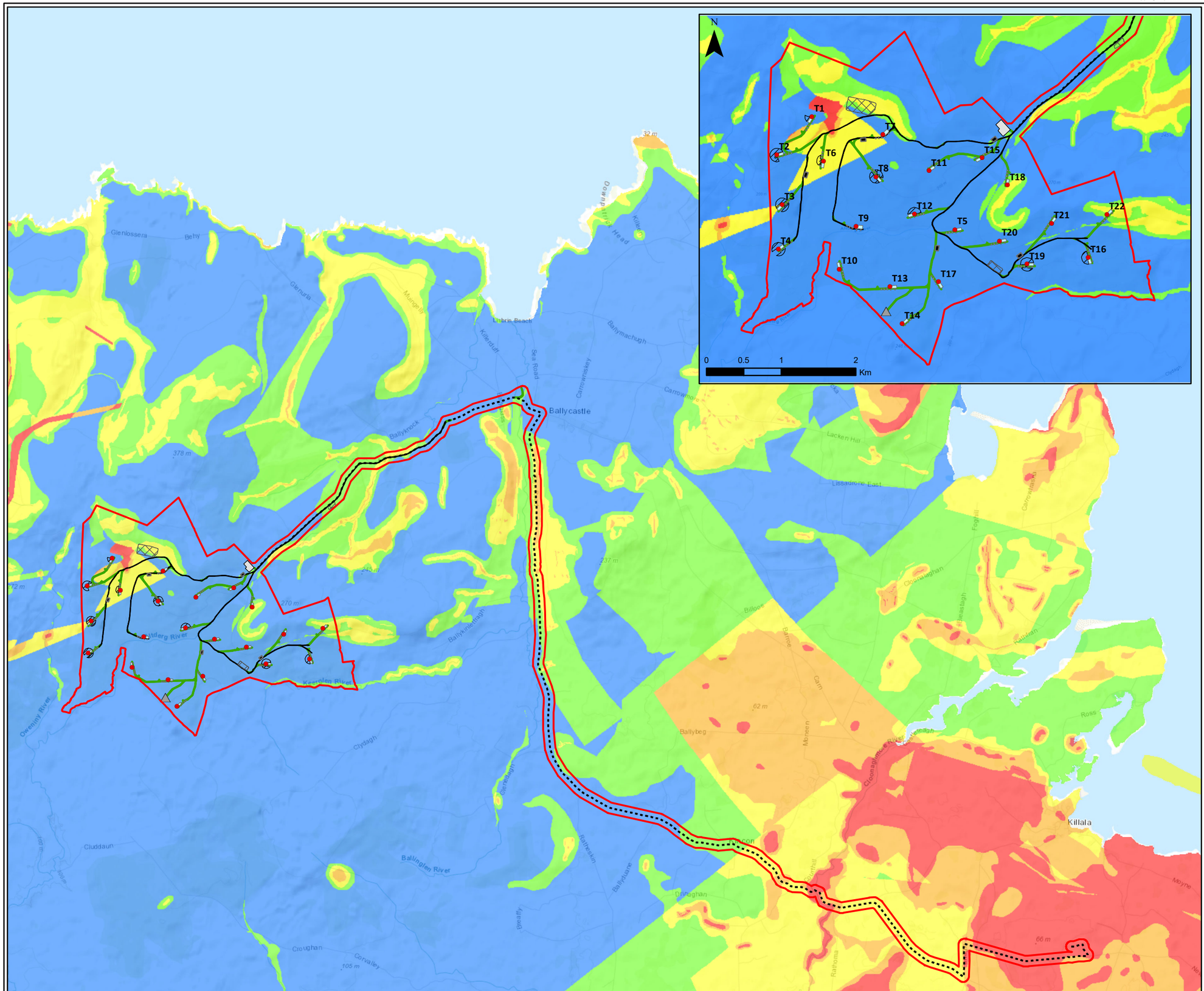

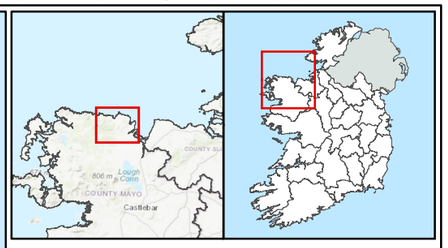

Legend

- Turbine Layout
- Turbine Foundation & Crane Hardstands
- Peat Placement
- Site Boundary
- Met Mast
- Grid Connection Route
- Proposed Borrow Pit
- Proposed Construction Compound
- Proposed Substation
- Existing Site Internal Roads
- Proposed New Roads

Crushed Rock Aggregate

Potential

- Very High potential
- High potential
- Moderate potential
- Low potential
- Very Low potential

N W E S

0 0.5 1 2 Kilometers

TITLE: Crushed Rock Potential			
PROJECT: Peat Stability Assessment Glenora Wind Farm			
FIGURE NO:	8.4		
CLIENT:	MKO		
SCALE:	1:70000	**REVISION:**	0
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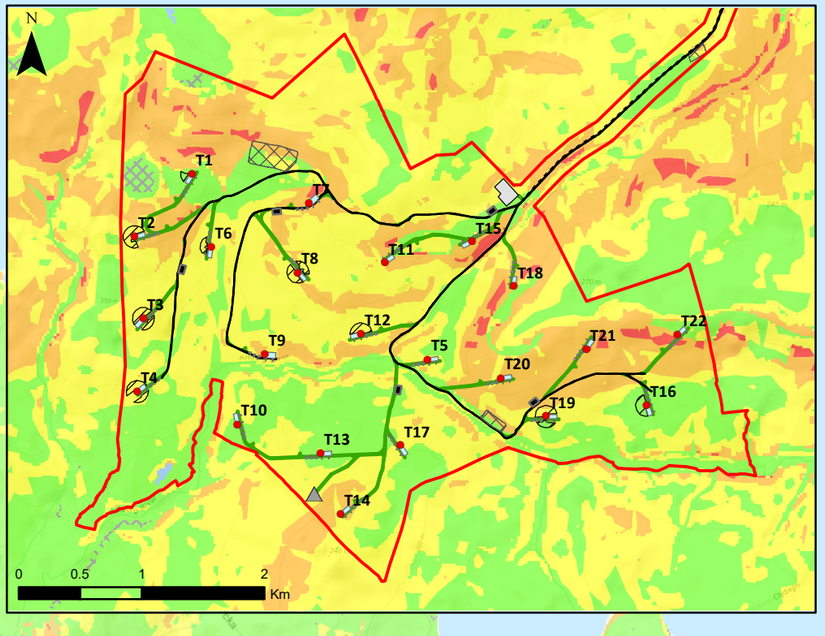

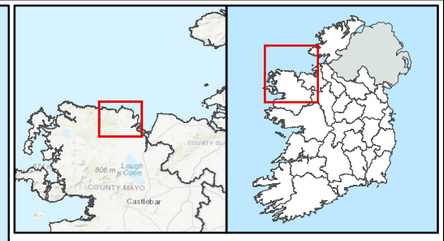

Legend

- Turbine Layout
- Turbine Foundation & Crane Hardstands
- Peat Placement Areas
- Site Boundary
- Met Mast
- Grid Connection Route
- Proposed Borrow Pit
- Proposed Construction Compound
- Proposed Substation
- Existing Site Internal Roads
- Proposed New Roads

Landslide Susceptibility:

Classification

- Low
- Low (inferred)
- Moderately Low
- Moderately High
- Moderately High (inferred)
- High
- High (inferred)
- Made
- Water

TITLE:	Landslide Susceptibility		
PROJECT:	Peat Stability Assessment Glenora Wind Farm		
FIGURE NO:	8.5		
CLIENT:	MKO		
SCALE:	1:70000	**REVISION:**	0
DATE:	24/04/2023	**PAGE SIZE:**	A3

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of 13 no. trial pits to a maximum depth of 4.5m bgl. These locations are considered representative of the ground conditions on the site and will be supplemented by additional confirmatory ground investigation prior to construction.

Peat was recorded in all trial pits across the site during the intrusive investigations. The peat deposits were found to generally overlie cohesive glacial deposits, typically described as firm grey sandy gravelly SILT.

Weathered Bedrock of the Downpatrick Formation and Minaun Formation was encountered during site investigations at a depth of between 1.9 and 2.7m bgl, recorded in three of the trial pits where it was described as angular gravel and cobble sized clasts of Schist and Mudstone.

During trial pit excavations shallow groundwater seepage at moderate ingress was noted below the peat deposits in trial pits. Table 8.5 shows the groundwater strikes encountered during the intrusive site investigations. The remainder of site investigation locations were noted as being dry during the works. A site walkover assessment summary is displayed below in Table 8.6.

Table 8-5: Summary of Groundwater Encountered.

Location	Groundwater Strike (m bgl)
TP03	2.1
TP05	2.6
TP09	1.3 and 3.0
TP12	2.3
TP15	1.0 and 4.2
TP16	1.0
TP17	3.2

Table 8-6: Summary of Ground Conditions.

Proposed Infrastructure	Land use	Quaternary Deposits (GSI Online Mapping)	Ground conditions encountered	Average Peat Depth (m)	Slope (degrees)	Overburden Encountered from Site Investigations	Depth to Bedrock (m) from Site Investigations	Groundwater Vulnerability (GSI Online Mapping)
T1	Forestry	Till derived from Devonian and Carboniferous Sandstone	Soft peat with moderate slopes	2.1	5	-	-	Extreme
T2	Forestry	Blanket Peat	Soft peat with moderate slopes	2.3	4	-	-	Moderate
T3	Forestry	Blanket Peat	Soft peat with moderate slopes	2.4	4	-	-	Moderate
T4	Forestry	Blanket Peat	Soft peat with moderate slopes	3.0	3	-	-	Moderate
T5	Forestry	Blanket Peat	Soft peat with moderate slopes	2.5	4	-	-	Moderate
T6	Forestry	Blanket Peat	Soft peat with moderate slopes	2.0	3	-	-	Moderate
T7	Forestry	Blanket Peat	Soft peat with moderate slopes	1.1	7	Peat to 1.9m underlain by Boulders to 2.6m and soft to stiff Silt	-	Moderate

Proposed Infrastructure	Land use	Quaternary Deposits (GSI Online Mapping)	Ground conditions encountered	Average Peat Depth (m)	Slope (degrees)	Overburden Encountered from Site Investigations	Depth to Bedrock (m) from Site Investigations	Groundwater Vulnerability (GSI Online Mapping)
						to 4.5m (base of trial pit).		
T8	Forestry	Blanket Peat	Soft peat with moderate slopes	2.5	3	-	-	High
T9	Forestry	Blanket Peat	Soft peat with moderate slopes	1.5	5	Peat to 1.98m underlain by Sand and stiff slightly sandy Silt to 4.1m (base of trial pit)	-	Moderate
T10	Forestry	Blanket Peat	Soft peat with moderate slopes	1.4	3	-	-	Moderate
T11	Forestry	Blanket Peat	Soft peat with moderate slopes	1.8	8	-	-	Moderate
T12	Forestry	Blanket Peat	Soft peat with moderate slopes	1.5	4	Peat to 1.6m underlain by firm to stiff slightly gravelly sandy Silt to 4.5m (base of trial pit).	-	Moderate
T13	Forestry	Blanket Peat	Soft peat with moderate slopes	1.6	4	-	-	Moderate

Proposed Infrastructure	Land use	Quaternary Deposits (GSI Online Mapping)	Ground conditions encountered	Average Peat Depth (m)	Slope (degrees)	Overburden Encountered from Site Investigations	Depth to Bedrock (m) from Site Investigations	Groundwater Vulnerability (GSI Online Mapping)
T14	Forestry	Blanket Peat	Soft peat with moderate slopes	1.9	9	-	-	High
T15	Forestry	Till derived from Devonian and Carboniferous Sandstone	Soft peat with moderate slopes	0.7	6	-	-	High
T16	Forestry	Blanket Peat	Soft peat with moderate slopes	2.2	4	-	-	High
T17	Forestry	Blanket Peat	Soft peat with moderate slopes	1.9	6	-	-	High
T18	Forestry	Till derived from Devonian and Carboniferous Sandstone	Soft peat with moderate slopes	1.0	6	-	-	Extreme
T19	Forestry	Blanket Peat	Soft peat with moderate slopes	2.4	3	Peat to 2.7m underlain by soft slightly sandy gravelly Silt to 4.5m (base of trial pit).	-	High

Proposed Infrastructure	Land use	Quaternary Deposits (GSI Online Mapping)	Ground conditions encountered	Average Peat Depth (m)	Slope (degrees)	Overburden Encountered from Site Investigations	Depth to Bedrock (m) from Site Investigations	Groundwater Vulnerability (GSI Online Mapping)
T20	Forestry	Blanket Peat	Soft peat with moderate slopes	2.1	4	-	-	High
T21	Forestry	Blanket Peat	Soft peat with moderate slopes	1.85	10	-	-	High
T22	Forestry	Till derived from Devonian and Carboniferous Sandstone	Soft peat with moderate slopes	0.95	11	-	-	Extreme
Met Mast	Forestry	Blanket Peat	Soft peat with moderate slopes	2.1	4	-	-	High
Substation	Forestry	Blanket Peat	Soft peat with moderate slopes	0.9	5	-	-	High
Temporary Construction Compound 1	Forestry	Blanket Peat	Soft peat with moderate slopes	1.35	3	-	-	High
Temporary Construction Compound 2	Forestry	Blanket Peat	Soft peat with moderate slopes	1.8	3	-	-	High

Proposed Infrastructure	Land use	Quaternary Deposits (GSI Online Mapping)	Ground conditions encountered	Average Peat Depth (m)	Slope (degrees)	Overburden Encountered from Site Investigations	Depth to Bedrock (m) from Site Investigations	Groundwater Vulnerability (GSI Online Mapping)
Temporary Construction Compound 3	Forestry	Blanket Peat	Soft peat with moderate slopes	1.0	4	-	-	Moderate
Temporary Construction Compound 4	Forestry	Blanket Peat	Soft peat with moderate slopes	2.5	3	-	-	Moderate
Temporary Construction Compound 5	Forestry	Blanket Peat	Soft peat with moderate slopes	2.75	3	-	-	High
BP1	Forestry	Blanket Peat	Soft peat with moderate slopes	0.65	10	Gravelly Sand over weathered bedrock at 1.9m.	1.9m	High
BP2	Forestry	Blanket Peat	Soft peat with moderate slopes	1.3	6	Stiff gravelly Clay and silty Gravel over bedrock at 2.2m.	2.2m	High
BP3	Forestry	Blanket Peat	Soft peat with moderate slopes	1.5	5	-	-	High

8.3.10 Peat Stability Assessment

8.3.10.1 Peat Stability Assessment Methodology

This section summarises the report on assessment of peat stability undertaken by FT. The peat stability assessment report is included as Appendix 8-1of this EIAR.

Stability of a peat slope is dependent on several factors working in combination. The main factors that influence peat stability are slope angle, shear strength of peat, depth of peat, pore water pressure and loading conditions. The slope angle and peat depth from site observations are used in combination with a lower-bound shear strength value to undertake the assessment. It is noted that the GSI mapping indicates the possible presence of faults within the site, however these are not considered to be a significant factor in peat stability.

The hand vane results indicate undrained shear strengths in the range 5 to 75kPa, with an average value of about 25kPa. The strengths recorded would be typical of well-drained peat as is present on the Glenora site.

Peat strength at sites of known peat failures (assuming undrained (short-term stability) loading failure) are generally very low, for example, the undrained shear strength at the Derrybrien failure (AGEC, 2004) as derived from essentially back-analysis, though some testing was carried out, was estimated at 2.5kPa. The recorded undrained strengths at the Glenora site are significantly greater than the lower bound values for Derrybrien indicating that there is no close correlation to the peat conditions at the Derrybrien site.

An adverse combination of the factors listed above could potentially result in peat sliding. An adverse condition of one of the above-mentioned factors alone is unlikely to result in peat failure. The infinite slope model (Skempton and DeLory, 1957) is used to combine these factors to determine a factor of safety for peat sliding (See Table 8-7 below). This model is based on a translational slide, which is a reasonable representation of the dominant mode of movement for peat failures.

To assess the factor of safety for a peat slide, an undrained (short-term stability) and drained (long-term stability) analysis has been undertaken to determine the stability of the peat slopes present on-site where development is proposed. In both conditions below the groundwater level is taken to be at ground level, in other words the peat layer is fully saturated.

- The undrained loading condition applies in the short-term during construction and until construction induced pore water pressures dissipate.
- The drained loading condition applies in the long-term. The condition examines the effect of, in particular, the change in groundwater level as a result of rainfall on the existing stability of the natural peat slopes.

The minimum required Factor of Safety (FoS) is 1.3 based on BS6031:1981: Code of Practice for Earthworks (BSI, 2009). The assigned probability of instability associated with a given FoS value is described in Table 8.7 below.

Table 8-7: Probability Scale for Factor of Safety.

Scale	Factor of Safety	Probability
1	1.30 or greater	Negligible/ None
2	1.29 to 1.20	Unlikely
3	1.19 to 1.11	Likely

Scale	Factor of Safety	Probability
4	1.19 to 1.11	Probable
5	<1.0	Very Likely

For the stability analysis two load conditions were examined, namely:

- Condition (1): no surcharge loading
- Condition (2): surcharge of 10 kPa, equivalent to 1m of stockpiled peat assumed as a worst case.

8.3.11 Peat Failures – Lessons Learned

This peat stability assessment has been undertaken taking into account peat failures that have occurred on peatland sites (such as recent failures at Shass Mountain 2020, Co. Leitrim and Meenbog 2020, Co. Donegal). The lessons learned from both peat slide events have been incorporated into the design of this project and the construction methodologies to be implemented. The Meenbog failure occurred during the construction of a section of floating road on sidelong ground in an area of weak peat. This construction technique is not proposed on sidelong ground on the Glenard site. It is important that the existing site drainage is maintained during construction to avoid a similar failure to that on Shass Mountain, which occurred following heavy rainfall, and this is referenced in the Risk Assessments for the turbines/access roads (FT, November 2023).

8.3.12 Existing Slope Stability – Grid Connection Route

During the site walkovers a series of hand-held probes were undertaken to determine the presence/depth of peat and/or soft soils within the proposed Glenora Wind Farm site. From a desk top review of the proposed grid connection route, the majority of the proposed route is situated within existing forestry access and public roadway. As such and given the limited extent of lateral (<1.0m) and vertical (1.2m) excavations, it is not considered a risk is posed to slope stability along the grid connection route.

8.3.13 Peat Stability Assessment Results

To assess the factor of safety for a peat slide, an undrained (short-term stability) and drained (long-term stability) analysis has been undertaken to determine the stability of the peat slopes on site.

The analysis of peat stability was carried out at the turbine locations, roads, substation compound, construction compounds and met mast for both the undrained and drained conditions. The purpose of the analysis was to determine the Factor of Safety (FoS) of the proposed peat slopes during construction and operation.

The undrained loading condition applies in the short-term during construction and until construction induced pore water pressures dissipate. For the undrained stability assessment, a peat shear strength of 6kPa and 8kPa (using 6kPa on slopes <8 degrees, and 8kPa on steeper slopes, reflecting in-situ peat strengths recorded on the site) has been used.

The drained loading condition applies in the long-term. The condition examines the effect of in particular, the change in groundwater level as a result of rainfall on the existing stability of the natural peat slopes. The results in Table 8-8 and 8-9 below are based on a groundwater level at ground level, which is a worst-case as it assumes that the peat is fully saturated.

Undrained analysis results are presented in Table 8-8. As outlined above the undrained loading condition applies in the short-term during construction and until construction induced pore water pressures dissipate.

Table 8-8: Factor of Safety Results (undrained condition)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T01	502518	834923	**2.88**	**2.03**
T02	502047	834410	**3.19**	**2.33**
T03	502119	833745	**3.19**	**2.33**
T04	502069	833148	**3.48**	**2.67**
T05	504436	833410	**2.87**	**2.16**
T06	502673	834328	**4.59**	**3.28**
T07	503470	834687	**3.82**	**2.16**
T08	503379	834119	**4.25**	**3.10**
T09	503111	833456	**3.29**	**2.23**
T10	502887	832881	**6.38**	**4.10**
T11	504089	834197	**2.76**	**1.87**
T12	503894	833620	**5.07**	**3.19**
T13	503565	832645	**4.31**	**2.87**
T14	503732	832150	**2.47**	**1.67**
T15	504802	834370	**6.41**	**3.04**
T16	506225	833037	**3.45**	**2.46**
T17	504216	832709	**2.40**	**1.70**
T18	505141	834006	**4.81**	**2.62**
T19	505406	832947	**3.70**	**2.80**
T20	505036	833259	**3.19**	**2.33**
T21	505736	833494	**2.73**	**1.79**
T22	506474	833610	**2.67**	**1.46**
Met Mast	503515	832315	**4.11**	**2.78**
Substation (1)	505146	834797	**4.94**	**2.88**
Construction Compound (1)	502430	834183	**6.38**	**4.10**
Construction Compound (2)	503395	834636	**4.59**	**3.28**
Construction Compound (3)	504987	834672	**5.75**	**3.45**
Construction Compound (4)	504180	833199	**3.59**	**2.73**
Construction Compound (5)	505128	832881	**3.70**	**2.80**
Borrow Pit 1	503286	835059	**5.85**	**2.19**
Borrow Pit 2	505251	833102	**4.44**	**2.51**
Borrow Pit 3	506655	835876	**3.10**	**1.91**

Peat Placement Area T01	502450	834910	**2.88**	**2.03**
Peat Placement Area T02	502018	834453	**3.19**	**2.33**
Peat Placement Area T03	502090	502090	**3.19**	**2.33**
Peat Placement Area T04	502045	833192	**3.48**	**2.67**
Peat Placement Area T06	502610	834340	**4.59**	**3.28**
Peat Placement Area T08	503342	834100	**2.31**	**1.65**
Peat Placement Area T12	503888	833670	**3.14**	**2.10**
Peat Placement Area T16	506180	833026	**3.45**	**2.46**
Peat Placement Area T19	505395	832999	**3.70**	**2.80**

Drained analysis results are presented in Table 8-9. As outlined above, the drained loading condition applies in the long-term. The condition examines the effect of in particular, the change in groundwater level as a result of rainfall on the existing stability of the natural peat slopes.

Table 8-9: Factor of Safety Results (drained condition)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T01	502518	834923	**1.92**	**2.92**
T02	502047	834410	**2.13**	**3.36**
T03	502119	833745	**2.13**	**3.36**
T04	502069	833148	**2.32**	**3.85**
T05	504436	833410	**1.92**	**3.10**
T06	502673	834328	**3.06**	**4.73**
T07	503470	834687	**2.54**	**3.09**
T08	503379	834119	**2.83**	**4.47**
T09	503111	833456	**2.19**	**3.21**
T10	502887	832881	**4.25**	**5.91**
T11	504089	834197	**1.38**	**2.01**
T12	503894	833620	**3.38**	**4.60**
T13	503565	832645	**2.87**	**4.14**
T14	503732	832150	**1.30**	**1.89**
T15	504802	834370	**4.28**	**4.36**
T16	506225	833037	**2.30**	**3.55**
T17	504216	832709	**1.60**	**2.44**
T18	505141	834006	**3.21**	**3.77**
T19	505406	832947	**2.47**	**4.04**
T20	505036	833259	**2.13**	**3.36**
T21	505736	833494	**1.36**	**1.91**

T22	506474	833610	**1.78**	**2.06**
Met Mast	503515	832315	**2.74**	**4.01**
Substation	505146	834797	**3.29**	**4.24**
Construction Compound (1)	502430	834183	**4.25**	**6.21**
Construction Compound (2)	503395	834636	**3.06**	**5.09**
Construction Compound (3)	504987	834672	**3.83**	**5.47**
Construction Compound (4)	504180	833199	**2.39**	**4.55**
Construction Compound (5)	505128	832881	**2.47**	**4.77**
Borrow Pit 1	503286	835059	**3.90**	**3.11**
Borrow Pit 2	505251	833102	**2.96**	**3.60**
Borrow Pit 3	506655	835876	**2.07**	**2.73**
Peat Placement Area T01	502450	834910	**7.49**	**6.93**
Peat Placement Area T02	502018	834453	**9.42**	**8.84**
Peat Placement Area T03	502090	502090	**9.73**	**9.16**
Peat Placement Area T04	502045	833192	**12.90**	**12.36**
Peat Placement Area T06	502610	834340	**14.08**	**13.20**
Peat Placement Area T08	503342	834100	**7.26**	**6.82**
Peat Placement Area T12	503888	833670	**8.59**	**7.89**
Peat Placement Area T16	506180	833026	**11.59**	**10.93**
Peat Placement Area T19	505395	832999	**15.34**	**14.74**

The findings of the peat stability assessment showed that the site has an acceptable margin of safety and is suitable for the Proposed Development. The findings include recommendations and specific control measures (Section 13 of Appendix 8-2 of this EIAR) for construction work in peatlands to ensure that all works adhere to an acceptable standard of safety.

An undrained analysis was carried out, which applies in the short-term during construction. For the undrained condition, the calculated FoS for load conditions (1) & (2) for the locations analysed, show that all locations have an acceptable FoS of greater than 1.3, indicating a low risk of peat failure. The undrained analysis would be considered the most critical condition for the peat slopes.

The peat stability risk assessment (see Appendix 8.1) at each infrastructure location (as listed above) identified a number of specific mitigation/control measures to reduce the potential risk of peat failure. Sections of access roads to the nearest infrastructure element will be subject to the same mitigation/control measures that apply to the nearest infrastructure element.

In summary, the findings of the peat stability assessment showed that the site has an acceptable factor of safety, is suitable for the Proposed Development and is at **low** risk of peat failure, provided appropriate control measures for construction work in peatlands are implemented in full to ensure that all works adhere to an acceptable standard of safety.

8.4 Characteristics of the Proposed Development

The Proposed Development will involve removal of peat, subsoil and bedrock for turbine foundations. hardstanding emplacement and access road construction Crushed rock for construction will be sourced from 3 no. proposed borrow pits. It is proposed that these borrow pits will be reinstated with peat and spoil excavated as part of the construction phase of the Proposed Development.

Estimated volumes of peat, subsoil and bedrock to be removed are shown in Table 8-9 and Table 8-10 respectively. Not all of the peat and soil excavated will be sent to the borrow pit and repository areas for reinstatement, the remaining portion will be locally cast to one side and used for reinstatement and landscaping works around the site. Any bedrock excavated during cut and fill works will be used for filling along the development footprint. Further details are provided in the Peat and Spoil Management Plan for the works which is included as Appendix 8-2 of this EIAR.

Table 8-10: Estimated Peat and Mineral Soil Excavation Volumes

Infrastructure Element	Peat Volume (m^3)	Soil (non-peat) Volume (m^3)
Turbines and Hardstands	309,000	135,000
Access Roads	212,000	30,500
Borrow Pits	60,200	25,800
Substation Temporary Construction Compounds Met Mast	74,200	13,300
Sub-total	655,400	204,600
Total peat and spoils volumes	860,000	

Table 8-11: Estimated Borrow Pit Rock Resource Volumes

Borrow Pit No.	Volume (m^3)
3	805,000

Table 8-12: Summary of Peat and Spoil Placement Areas on Site

Location	Peat & Spoil Volume (m^3)	Comment
Borrow Pits	744,000	Backfill of borrow pits within excavated peat and spoil.
Peat Storage Areas at Turbines	134,000	1.3m in height across specific areas within clearfell around turbines, see Section 7.3 of the Peat & Spoil Management Report (Appendix 8.2).
Landscaping	44,000	It is estimated that approximately 2,000m^3 of peat will be required for landscaping purposes at each of the 22 no. turbines
Total =	922,000	

The Proposed Development will be constructed in phases, which each phase comprising 5-7 turbines and associated hardstands and access roads. This will allow for the borrow pits to be developed and backfilled in stages. An outline of the Phasing is provided below:

a. Phase 1: Construction of link road, widening of public road, upgrade of private access road between the local road and the on-site substation and the substation and primary construction compound (100,000m^3 of peat and spoil).
   i. All fill material will come from BP3
   ii. All excavated material will be transferred to BP3 once cells have been created

b. Phase 2: Upgrade of all existing roads within the main wind farm site and construction of all other construction compounds (180,000m^3 of peat and spoil).
   i. Fill material to be taken from BP1 and BP2.
   ii. All excavated material to be transferred to BP3 until cells open up in BP1

c. Phase 3: Construction of new access roads, hardstands and foundation bases for Turbines 1, 2, 3, 4, 6 (150,000m^3 of peat and spoil).
   i. Fill material to be taken from BP1
   ii. Excavated material to be transferred to BP1 and peat placement areas around those turbines

d. Phase 4: Construction of new access roads, hardstands and foundation bases for Turbines 7, 8, 9, 11, 12, 15, 18 (170,000m^3 of peat and spoil).
   i. Fill material to be taken from BP1
   ii. Excavated material to be transferred to BP1 and the peat placement areas around T8 and T12

e. Phase 5: Construction of new access roads, hardstands and foundation bases for Turbines 5, 16, 19, 20, 21, 22 (130,000m^3 of peat and spoil).
   i. Fill material to be taken from BP2
   ii. Excavated material to be transferred to BP 2 until full and then to BP1

f. Phase 6: Construction of new access roads, hardstands and foundation bases for Turbines 10, 13, 14, 17 and met mast (130,000m3 of peat and spoil).
   i. Fill material to be taken from BP1
   ii. Excavated material to be transferred to BP1

8.5 Likely Significant Effects and Associated Mitigation Measures

8.5.1 Do Nothing Scenario

If the Proposed Development were not to proceed, commercial forestry operations would continue at the site.

Surface water drainage carried out in areas of existing access road and coniferous plantations will continue to function and may be extended in the case of coniferous plantation. Coniferous forestry will be felled as forestry compartments reach maturity. Re-planting of these areas with more coniferous trees is likely to occur. Plantations will be reploughed where necessary to facilitate afforestation.

The land, soils and geology would remain largely unaltered as a result of the Do-Nothing Scenario.

8.5.2 Construction Phase – Likely Significant Effects and Mitigation Measures

The likely impacts of the Proposed Development and mitigation measures that will be put in place to eliminate or reduce them are described below.

8.5.2.1 Peat, Subsoil Excavation and Bedrock Excavation

The Proposed Development will require construction phase earthworks associated with the excavation of turbine bases, removal of overburden deposits for the construction of turbine foundations, turbine

hardstandings, temporary site compounds, substations, grid connection trenches, turbine hard standings, borrow pits, internal access roads and a met mast. Temporary accommodation works, including road widening at existing junctions will also be required along the proposed turbine delivery route.

Excavation of peat, subsoil and bedrock will be required for site levelling and for the installation of infrastructure and foundations for the access roads and turbines. This will result in a permanent removal of peat, subsoil and bedrock at excavation locations. There is no loss of peat or subsoil, it will just be relocated within the site. Estimated volumes of peat and bedrock to be removed are shown in Table 8-10 and Table 8-11 above.

Mechanism: Extraction/excavation.

Receptor: Peat, subsoil and bedrock

Pre-Mitigation Potential Impact: Negative, slight/moderate, direct, likely, permanent impact on peat, subsoil and bedrock due to relocation within the site.

Mitigation Measures:

- Placement of turbines and associated infrastructure in areas with shallower peat has been achieved during the design phase;
- Maximum use of the existing road network to reduce peat excavation and borrow pit volumes;
- The minimum possible volume of peat 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;
- Construction of the Proposed Development will be undertaken in Phases, where each Phase comprises works around 5-7 turbines at any one time, allowing borrow pits to be developed and backfilled in stages.
- A suitable drainage system to be constructed to ensure continuity of the site hydrology (EIAR Chapter 9).
- All temporary cuts/excavations will be carried out such that they are stable or adequately supported. Gravel/rock fill will be used to provide additional support to temporary cuts/excavations where appropriate, as determined by the Project Geotechnical Engineer. Unstable temporary cuts/excavations will not be left unsupported. Where appropriate and necessary, temporary cuts and excavations will be protected against the ingress of water or erosion.
- To mitigate against the compaction of soil at the site, prior to the commencement of any earthworks, the work corridor will be pegged, and machinery will stay within this corridor so that peatland / soils outside the work area is not damaged. Excavations will then be carried out from access tracks as they are constructed in order to reduce the compaction of soft ground.
- Soil excavated from trenches along the proposed grid connection route will be taken to a licenced facility for disposal or recycling where required. If feasible, the upper layers of tarmac and asphalt will be excavated separately to the lower engineered fill layers.

Residual Effect Assessment: The granular and cohesive soils and peat deposits at the site are classified as of "Low" importance as they are already degraded by forestry and drainage. The impact is the disturbance and relocation of c 830,000m^3 of soil and subsoil during construction. The design measures incorporated into the project as described above in particular the avoidance of deeper peat areas combined with the 'low' importance of the deposits means that the residual effect is- negative, slight, direct, high probability, permanent effect on peat and subsoils due to disturbance and relocation within the site.

Significance of Effects: For the reasons outlined above, no significant effects on land, soils, subsoils or bedrock will occur.

8.5.2.2 Contamination of Soil by Leakages and Spillages

Accidental spillage during refuelling of construction plant with petroleum hydrocarbons is a pollution risk. The accumulation of small spills of fuels and lubricants during routine plant use can also be a significant pollution risk. Hydrocarbon has a high toxicity to humans, and all flora and fauna, including fish, and is persistent in the environment. Large spills or leaks have the potential to result in significant effects (i.e. contamination of peat, subsoils and pollution of the underlying aquifer) on the geological and water environment.

Pathway: Peat, subsoil and underlying bedrock pore space.

Receptor: Peat, subsoil and bedrock.

Pre-Mitigation Potential Impact: Negative, direct, slight, short term, unlikely impact on peat, subsoil and bedrock.

Proposed Mitigation Measures

- Minimal refuelling or maintenance of construction vehicles or plant will take place on site. Off-site refuelling will occur at a controlled fuelling station;
- On site re-fuelling will be undertaken using a double skinned bowser with spill kits on the ready for accidental leakages or spillages;
- On site re-fuelling will be undertaken by suitably trained personnel only under a permit to refuel system;
- Fuels stored on site will be minimised. Storage areas located at the temporary compounds where required will be bunded appropriately for the fuel storage volume for the time period of the construction and fitted with a storm drainage system and an appropriate oil interceptor;
- The electrical substation will be bunded appropriately to the volume of oils likely to be stored, and to prevent leakage of any associated chemicals and to groundwater or surface water. The bunded area will be fitted with a storm drainage system and an appropriate oil interceptor;
- The plant used during construction will be regularly inspected for leaks and fitness for purpose;
- All waste tar material arising from the chipping and resurfacing of the public road portion of the temporary construction access road will be removed off-site and taken to licenced waste facility;
- An emergency plan for the construction phase to deal with accidental spillages is contained within the Construction and Environmental Management Plan (Appendix 4- 4 of this EIAR). Spill kits will be available to deal with and accidental spillage in and outside the re-fuelling area.

Residual Effect Assessment: The use and storage of hydrocarbons and small volumes of chemicals is a standard risk associated with all construction sites. Proven and effective measures to mitigate the risk of spills and leaks have been proposed above and will break the pathway between the potential source and the receptor. The residual effect is considered to be - Negative, imperceptible, direct, short-term, low probability effect on peat and subsoils and bedrock.

Significance of Effects: For the reasons outlined above, no significant effects on land, soils, subsoils or bedrock will occur.

8.5.2.3 Erosion of Exposed Subsoils and Peat During Tree Felling and Construction Work

There is a high likelihood of erosion of peat and spoil during its excavation and during landscaping works. The main impacts associated with this aspect is to the water environment, and therefore this aspect is further assessed in detail in Chapter 9.

Pathway: Vehicle movement, surface water and wind action.

Receptor: Peat and subsoil.

Pre-Mitigation Potential Impact: Negative, slight, direct, short-term, high probability effect on peat and subsoils by erosion and wind action.

Proposed Mitigation Measures:

Peat removed from turbine locations and access roads will be used for landscaping, spread within the proposed peat placement areas around certain turbines and used to reinstate the 3 no. proposed borrow pits. The acrotelm will be stored with the vegetation part of the sod facing the right way up to encourage growth of plants and vegetation at the surface of the stored peat within the borrow pits. Reseeding and spreading/planting of heather and moss cuttings will also be carried out in these areas. These measures will prevent erosion of stored peat in the long term. A full Peat and Spoil Management Plan for the Proposed Development is included as Appendix 4-2 of this EIAR.

Any excess temporary mounded peat in storage for long periods will be sealed using the back of an excavator bucket. This will minimise erosion of soil. Silt fences will be installed around stockpiles to limit movement of entrained sediment in surface water runoff. The use of bunds around earthworks and mounds will prevent egress of water from the works.

To mitigate against erosion of the exposed soil or rock, all excavations will be constructed and backfilled as quickly as possible, although this will depend on the nature of the excavation – a hardstand excavation can be backfilled immediately, however a turbine base excavation will remain open for a prolonged period of time as the base is constructed. Excavations will stop during or prior to heavy rainfall events. To mitigate against possible contamination of the exposed soils and bedrock, refuelling of machinery and plant will only occur at designated refuelling areas.

In order to minimise erosion of mineral subsoils stripping of peat will not take place during extremely wet periods as defined in the Chapter 9 of this EIAR (to prevent increased silt rich runoff). Drainage systems (as described in Section 4.7 of Chapter 4 of this EIAR) will be required to limit runoff impacts during the construction phase.

During tree felling, brash mats will be used to support vehicles on soft ground, reducing peat and mineral soil erosion and avoiding the formation of rutted areas, in which surface water ponding can occur. Brash mat renewal will take place when they become heavily used and worn. Provision will be made for brash mats along all off-road routes, to protect the soil from compaction and rutting.

Residual Effect Assessment: Peat soils and spoil can be eroded by vehicle movements, wind action and by water movement. To prevent this all excavation works will be completed in accordance with the detailed Peat and Spoil Management Plan (Appendix 4-2), material will be moved the least possible distance, and reseeding and planting will be completed to bind landscaped peat and spoil together. Following implementation of these measures the residual effected is considered - Negative, slight, direct, short term, medium probability effect on peat and subsoils by erosion and wind action.

Significance of Effects: For the reasons outlined above, no significant effects on land, soils, subsoils or bedrock will occur.

8.5.2.4 Peat Instability and Failure

A peat stability risk assessment was carried out for the main infrastructure elements at the wind farm. This approach uses guidelines for geotechnical/peat stability risk assessments as given in PLHRA (2017) and MacCulloch (2005).

Peat instability or failure refers to a significant mass movement of a body of peat that would have an adverse impact on the Proposed Development, proposed construction access road and the surrounding environment. Peat failure excludes localised movement of peat that could occur below an access road, creep movement or erosion type events. The consequence of peat failure at the study area may result in:

- Death or injury to site personnel;
- Damage to machinery;
- Damage or loss of access tracks;
- Drainage disrupted;
- Site works damaged or unstable;
- Contamination of watercourses, water supplies by soil particulates;
- Degradation of the environment.

Mechanism: Vehicle movement and excavations.

Receptor: Peat subsoils.

Pre-Mitigation Potential Impact: Negative, significant, direct, low probability permanent effect on peat and subsoils. The findings of the peat stability assessment showed that the Proposed Development has an acceptable margin of safety, is suitable for the proposed wind farm development and is considered to be at low risk of peat failure. The findings include control measures which will be implemented for construction work in peatlands to ensure that all works adhere to an acceptable standard of safety.

Mitigation Measures:

Firstly, the key mitigation with regard peat stability risk at the Proposed Development site was the carrying out of a robust, multidisciplinary site investigation and peat stability risk assessment carried out in accordance with best practice guidance (PLHRAG, Scottish Government, 2017).

Also, the lessons learned from historical peat slide events have been incorporated into the design of this project and the construction methodologies to be implemented. These lessons show that it is important that the existing site drainage is maintained during construction to avoid a similar failure to that on Shass Mountain, which occurred following heavy rainfall, and this is referenced in the Risk Assessments for the turbines/access roads (Appendix 8-1).

Based on the control measures given in the FT Peat Stability Assessment (Appendix 8-1) report being strictly adhered to during construction and the detailed stability assessment carried out for the peat slopes which showed that the site has an acceptable margin of safety, there is a low risk of peat instability/failure at the Proposed Development site.

The risk assessment at each turbine and infrastructure location identified a number of control measures to reduce further the potential risk of peat failure. Access roads to turbines will be subject to the same relevant control measures that apply to the nearest turbine as detailed in the FT Peat Stability Assessment Report.

The following measures which will be implemented during the construction phase of the project will assist in the management of the risks for this site.

- Appointment of experienced and competent contractors;
- The site will be supervised by experienced and qualified personnel, including a Project Geotechnical Engineer;
- Allocate sufficient time for the project (be aware that decreasing the construction time has the potential to increase the risk of initiating a peat movement);
- Prevent undercutting of slopes and unsupported excavations. All temporary cuts/excavations will be carried out such that they are stable or adequately supported. Gravel/rock fill will be used to provide additional support to temporary cuts/excavations where appropriate, as determined by the Project Geotechnical Engineer. Unstable temporary cuts/excavations will not be left unsupported. Where appropriate and necessary, temporary cuts and excavations will be protected against the ingress of water or erosion. Open excavations will be inspected on a daily basis.
- Excavation will be carried out from access roads or hardstanding areas to avoid tracking of construction plant across areas of soft ground/peat.
- Excavations which could have the potential to undermine the up-slope component of an existing slope will be sufficiently supported to resist lateral slippage and careful attention will be given to the existing drainage.
- Maintain a managed robust drainage system;
- Prevent placement of loads/overburden on marginal ground as detailed in the peat stability assessment report;
- Set up, maintain and report findings from monitoring systems (as described in the Peat & Spoil Management Plan, Appendix 8.2);
- Undertake strength testing of peat directly prior to access road construction for new access roads, both founded and floating.
- Earthworks will not be commenced when heavy or sustained rainfall is forecast. A rainfall gauge will be installed on site to provide a record of rainfall intensity. An inspection of site stability and drainage by the Project Geotechnical Engineer will be carried out on site when a daily rainfall of over 15mm is recorded on site, works will only recommence after heavy rain with the prior approval of the Project Geotechnical Engineer following an inspection.
- Engineer and Contractor to ensure that construction method statements are followed; and,
- Revise the Geotechnical Risk Register, as necessary as construction progresses.

Residual Effects Assessment: A detailed Geotechnical and Peat Stability Assessment has been completed for the Proposed Development. The findings of that assessment have demonstrated that there is a low risk of peat failure at the site as a result of the Proposed Development. With the implementation of the control measures outlined above the residual effect is - Negative, slight, direct, low probability, permanent effect on peat and subsoils.

Significance of Effects: For the reasons outlined above, no significant effects on land, soils, subsoils or bedrock will occur.

8.5.2.5 Proposed Turbine Delivery Route Accommodation Works

A new roadway will be required to allow abnormal load delivery vehicles to bypass the junction of the R314 and Ballyglass local road. Temporary widening will be required along the Ballyglass local road to facilitate the delivery of turbine components and other abnormal loads. This widening will be reinstated with clay once the Proposed Development has been completed.

Mechanism: Excavation of peat/subsoil.

Receptor: Soils and subsoils.

Pre-Mitigation Potential Impact: Negative, significant, direct, low probability permanent effect on peat and subsoils.

Proposed Mitigation Measures: Mitigation measures in respect of peat and subsoil excavation are outlined at Section 8.5.2.1.

Mitigation measures to prevent soil / subsoil contamination (leaks / spills) are dealt with in Section 8.5.2.2 above and measures dealing with soil erosion are dealt with in Section 8.5.2.3. The residual effects of soil / subsoil contamination from leaks / spills is assessed in Section 8.5.3.2, and the residual effects of soil erosion are assessed in Section 8.5.2.3.

Residual Effects Assessment: The proposed TDR works footprint is small (7,500m2), and there will be minimal disturbance to the local geology. As such the residual effects are considered as - Negative, slight, direct, high probability, permanent effect on local subsoils.

Significance of Effects: No significant effects on soils and subsoils will occur.

8.5.3 Operational Phase - Likely Significant Effects and Mitigation Measures

Very few potential direct impacts are envisaged during the operational phase of the Proposed Development. These may include:

- Some construction vehicles or plant necessary for maintenance of turbines which could result in minor accidental leaks or spills of fuel/oil; and,
- The transformer in the substation and transformers in each turbine are oil cooled. There is potential for spills / leaks of oils from this equipment resulting in contamination of soils and groundwater.

In relation to indirect impacts a small amount of granular material will be required to maintain access tracks during operation which will place intermittent minor demand on local quarries. Please note the onsite borrow pit will have been reinstated with excavated peat and spoil following the construction stage and will not be available to source aggregate during the operational phase.

None of these potential impacts are considered to be significant, as they are of such small scale and also of an intermittent nature.

Mitigation measures for soils and geology during the operational stage include the use of aggregate from authorised quarries for use in road and hardstand maintenance. Oil used in transformers (at the substation and within each turbine) and storage of oils in tanks at the substation could leak during the operational phase and impact on ground/peat and subsoils and groundwater or surface water quality. The substation transformer, and oil storage tanks will be in a concrete bund capable of holding 110% of the stored oil volume. Turbine transformers are located within the turbines, so any leaks would be contained within the turbine. These mitigation measures are sufficient to reduce risk to ground/peat/soils and subsoils, and groundwater and surface water quality.

8.5.4 Decommissioning Phase - Likely Significant Effects and Mitigation Measures

The potential impacts associated with decommissioning of the Proposed Development will be similar to those associated with construction but of reduced magnitude.

During decommissioning, it may be possible to reverse or at least reduce some of the potential impacts caused during construction by rehabilitating construction areas such as turbine bases, hard standing areas, and the substation. This will be done by covering hard surfaces with peatland vegetation/scraw or poorly humified peat from the site to encourage vegetation growth and reduce run-off and sedimentation. Other impacts such as possible soil compaction and contamination by fuel leaks will remain but will be of reduced magnitude due to the reduced scale of the works. However, as noted in the Scottish Natural Heritage report (SNH) Research and Guidance on Restoration and Decommissioning of Onshore Wind Farms (SNH, 2013) reinstatement proposals for a wind farm are made approximately 30 years in advance, so within the lifespan of the wind farm, technological advances and preferred approaches to reinstatement are likely to change. According to the SNH guidance, it is therefore:

> *"best practice not to limit options too far in advance of actual decommissioning but to maintain informed flexibility until close to the end-of-life of the wind farm".*

Mitigation measures applied during decommissioning activities will be similar to those applied during construction where relevant.

Some of the impacts will be avoided by leaving elements of the Proposed Development in place including turbine bases which will be rehabilitated by covering with local topsoil/peat in order to regenerate vegetation which will reduce runoff and sedimentation effects. Mitigation measures to avoid contamination by accidental fuel leakage and compaction of soil by on-site plant will be implemented as per the construction phase mitigation measures.

No significant impacts on the soils and geology environment are envisaged during the decommissioning stage of the Proposed Development.

8.5.5 Indirect Effects

There are no likely significant Indirect Effects from the construction of the Proposed Development.

8.5.6 Cumulative Effects

A list of developments within 20km of the site boundary considered in relation to cumulative effects is shown in Figure 2.3.

Due to the localised nature of the proposed construction works which will be kept within the Proposed Development site boundary, there is no potential for **significant** cumulative effects in-combination with other local developments on the land, soils and geology environment as all effects are direct within the Proposed Development site. Other Developments outside the Proposed Development site do not have the potential to reduce or increase the magnitude of effects of the Proposed Development on Land, Soils and Geology. The potential cumulative impacts from the developments shown in Figure 2.3 of Chapter 2 are considered to be **Imperceptible**.

The only way the Proposed Development can have cumulative effects with other off site projects and plans is via the drainage and off site surface water network, and this hydrological pathway is assessed in Chapter 9. The construction of the grid connection works will only require relatively localised excavation works within the site boundary and therefore will not contribute to any significant cumulative effects.

8.5.7 Post Construction Monitoring

None proposed. There are not considered to be any significant long term impacts that require monitoring.