8. LAND SOILS AND GEOLOGY

8.1 Introduction

8.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by MKO Ireland (MKO) to carry out an assessment of the potential likely and significant effects of the proposed Knockshanvo Wind Farm in Co. Clare on the land, soils and geological aspects of the receiving environment.

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

The Proposed Development includes 9 no. proposed turbines, an on-site 110kV electrical substation, new site access roads, upgrade of existing roads, 1 no. meteorological mast, 3 no. temporary construction compounds, 5 no. onsite borrow pits, amenity proposals and biodiversity enhancement areas, an underground grid connection and works along the turbine delivery route including a temporary compound. The proposed Wind Farm Site is located ~11km north of Limerick City and ~4km northeast of Sixmilebridge, Co. Clare.

This chapter provides a baseline assessment of the environmental setting of the Proposed Development, as described in Chapter 4, in terms of land, soils and geology and discusses the potential likely significant effects that the construction, operation and decommissioning phases of the Proposed Development will have. Where required, appropriate mitigation measures to avoid any identified significant effects to land, soils and geology (i.e. natural resources) are prescribed and the residual effects of the Proposed Development post-mitigation are assessed.

Please note that in this chapter we refer to specific elements of the Proposed Development such as the Wind Farm Site, the Grid Connection route and the Turbine Delivery Route (TDR). The Proposed Development site (as defined by the EIAR Study Boundary) includes both the Wind Farm Site (including the biodiversity enhancement lands), the Grid Connection route and the location of the proposed TDR compound.

8.1.2 Statement of Authority

Hydro-Environmental Services (HES) are a specialist geological, hydrological, hydrogeological and environmental practice which delivers a range of water and environmental management consultancy services to the private and public sectors across Ireland and Northern Ireland. HES was established in 2005, and our office is located in Dungarvan, County Waterford.

Our core areas of expertise and experience includes soils, subsoils and geology. We routinely complete impact assessments for land, soils and geology, hydrology and hydrogeology for a large variety of project types including wind farms and renewable energy projects.

This chapter of the EIAR was prepared by Michael Gill and Conor McGettigan.

Michael Gill P.Geo (BA, BAI, Dip Geol., MSc, MIEI) is an Environmental Engineer and Hydrogeologist with over 22 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms and renewable projects in Ireland. In addition, he has substantial experience in geological characterisation, peatland morphology, and surface water drainage design and SUDs design and surface water/groundwater interactions. Michael has worked on the EIS/EIAR for Oweninny WF, Cloncreen WF, Derrinlough WF and over 100 other wind farm related projects across the country.

Conor McGettigan (BSc, MSc) is an Environmental Scientist with 3 years' experience in the environmental sector in Ireland. Conor holds an M.Sc. in Applied Environmental Science (2020) and a B.Sc. in Geology (2016) from University College Dublin. Conor routinely prepares the land, soils and geology chapters of environmental impact assessment reports for wind farm development on peatlands.

8.1.3 Relevant Legislation

The EIAR is prepared in accordance with the requirements of European Union Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (the 'EIA Directive') as amended by Directive 2014/52/EU. The requirements of the following legislation are complied with:

- Planning and Development Acts, 2000 (as amended);
- Planning and Development Regulations, 2001 (as amended);
- Directives 2011/92/EU and 2014/52/EU on the assessment of the effects of certain public and private projects on the environment;
- S.I. No. 296/2018 European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018; and,
- The Heritage Act 1995, as amended.

8.1.4 Relevant Guidance

The Land, Soils and Geology chapter of this EIAR was completed using the following relevant good practice guidance:

- Environmental Protection Agency (2022): Guidelines on the Information to be contained in Environmental Impact Assessment Reports;
- Institute of Geologists Ireland (2013): Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements;
- National Roads Authority (2008): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment (DoHPLG, 2018); and,
- Guidance on the preparation of the EIA Report (Directive 2011/92/EU as amended by 2014/52/EU), (European Commission 2017).

8.2 Methods

8.2.1 Desk Study

A desk study of the Proposed Development site was completed in the Summer of 2022 to collect all relevant geological data for the Proposed Development site and the surrounding area. The desk study was completed to supplement site walkovers surveys and site investigations. The desk study information has been checked and updated, where necessary to ensure any updates were captured, in August and November 2023.

The desk study involved consultation with the following data sources:

- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - Groundwater and Geology Databases (www.gsi.ie);
- Geological Survey of Ireland – Geological Heritage site mapping (www.gsi.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 17 (Geology of the Shannon Estuary). Geological Survey of Ireland (GSI, 1997);
- Geological Survey of Ireland – 1:25,000 Field Mapping Sheets;

- General Soil Map of Ireland 2nd edition (www.epa.ie); and,
- Aerial Photography, 1:5000 and 6 inch base mapping.

8.2.2 Baseline Monitoring and Site Investigations

Site walkover surveys, including geological mapping and investigation of the Proposed Development site were undertaken by Michael Gill and Conor McGettigan of HES (refer to Section 8.2.1 above for qualifications and experience) on 7th December 2022, 13th July 2023, 15th August, 13th September, 12th October and 26th October 2023.

Geotechnical ground investigations and a peat stability assessment was undertaken by Fehily Timoney (FT) (Appendix 8-1). The combined geological and hydrogeological dataset collated by HES, MKO and FT has been used in the preparation of this EIAR Chapter.

The objectives of the intrusive site investigations included mapping the distribution and depth of peat at the Wind Farm Site along with assessing the mineral subsoil / bedrock conditions beneath the peat at key development locations (refer to Chapter 4 for a full description of the Proposed Development). This data was used to inform the final layout design.

In summary, site investigations to address the Land, Soils and Geology chapter of the EIAR included the following:

- HES completed site walkover surveys of the Proposed Development site on 7th December 2022, 13th July 2023, 15th August, 13th September, 12th October and 26th October 2023;
- During these walkover surveys observations were made on near surface geological features and included geological mapping of bedrock exposures, peat probing investigations and the logging of subsoil exposures and peat profiles where exposed;
- All mineral subsoils and peat were logged according to BS: 5930[1] and Von Post Scale[2] respectively;
- FT completed detailed walkover surveys and peat probing investigations (5 no. peat probes at each turbine locations) at the Proposed Development site from 7th to the 9th June 2023. During these surveys particular attention was paid to slope and peat stability. In addition to peat probing, in-situ shear van testing was completed, using a Geonor H-60 Hand-Field Vane Tester, at proposed turbine locations and other selected location across the site to provide a representative coverage of indicative peat strengths. Slope angles at infrastructure locations were obtained using handheld equipment, such as the Silva Clino Master. The methodology is detailed in full in Appendix 8-1;
- Site walkover surveys and peat probing investigations were also undertaken by MKO in September and October 2021;
- A total of 569 no. peat probe depths/investigations points were carried out by FT and MKO to determine the depth and geomorphology of the blanket peat within the Proposed Development site;
- A total of over 25 no. gouge core sample points were undertaken by HES at proposed infrastructure locations to investigate peat and underlying mineral soil lithology;
- Irish Drilling Limited (IDL) completed ground investigations at the Proposed Development site, under the supervision of FT in August and September 2023. These site investigations included;

[1] *BS 5930:2015+A1:2020: Code of Practice for Ground Investigations (BSI Knowledge) provides guidelines for conducting ground investigation on construction sites and provides recommendations for the investigation of sites to assess their suitability.*
[2] *The Von Post scale is a field test to rank organic soils by degree of humification (i.e. decomposition) using parameters such as fibre integrity, colour and viscosity of exudate and presence of colloidal particles. It creates a descriptive framework across a wide range of organic soils.*

- The excavation of a total of 13 no. trial pits between 28th and 30th August 2023 to investigate underlying mineral soil lithology and the subsoil/bedrock interface; and,
- The drilling of a total of 3 no. boreholes within the Wind Farm Site between 11th and 13th September 2023 to investigate the nature of the underlying bedrock. These investigations were considered to be appropriate given the excellent bedrock exposures within several watercourse channels and, from a hydrogeological perspective, significant effects on groundwater not being anticipated (refer to Chapter 9).

The Geotechnical and Peat Stability Assessment Report and Peat and Spoil Management Plan prepared by FT are included as Appendix 8-1 and Appendix 4-2 of this EIAR respectively. The methodology associated with the Peat Stability Assessment is detailed in Section 2.3 of Appendix 8-1.

The site investigation factual report prepared by IDL (IDL, 2023) is attached as Appendix E to the Geotechnical and Peat Stability Report (Appendix 8-1).

8.2.3 Scope and Consultation

The scope for this EIAR 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.

The Geological Survey of Ireland (GSI), Inland Fisheries Ireland (IFI) and the National Parks and Wildlife Services (NPWS) were the only consultees to respond with respect to Land, Soils and Geology and their responses are summarised in Table 8-1 below.

Table 8-1 Summary of Scoping Responses

Consultee	Description	Addressed in Section
Geological Survey of Ireland (GSI)	*"Ballyvorgal South, Co. Clare (GR 151261, 168493), under IGH theme: IGH 2 Precambrian to Devonian Palaeontology. The Ballyvorgal site is an unusual Irish occurrence of an assemblage of deep-water fossils now found all over the world in rocks of Upper Ordovician age. Ballyvorgal is an important site for understanding and dating the rocks of the Slieve Bernagh Inlier. This site is the type locality for five species of trilobite. The gorse, bramble and other vegetation overgrowing the stream banks means there are currently only three small exposures of the brown mudstones, and no clear section of the trilobite bed. Whilst it would be necessary for some clearance to take place for any future study, if the landowner was to undertake any drainage work in the immediate vicinity of the stream, then a geological investigation should be made at the same time. Equally any major forestry work (felling/gripping/planting) in the adjacent western bank of the stream (not included within the site boundary) should be notified so that investigation may also occur of fresh exposures".*	Section 8.3.6

Consultee	Description	Addressed in Section
	"With the current plan, although the Ballyvorgal South CGS is on the margins of the wind farm site boundary, there may be potential impacts on the integrity of current CGSs envisaged by the proposed wind farm development, should these sites not be assessed as constraints. Ideally, the sites should not be damaged or integrity impacted or reduced in any manner due to the proposed development. However, this is not always possible, and in this situation appropriate mitigation measures should be put in place to minimize or mitigate potential impacts.".	
	"Geohazards can cause widespread damage to landscapes, wildlife, human property and human life. In Ireland, landslides, flooding and coastal erosion are the most prevalent of these hazards. We recommend that geohazards be taken into consideration, especially when developing areas where these risks are prevalent, and we encourage the use of our data when doing so." *"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 wind farm area".* *"The Landslide Susceptibility Map indicates there are some areas of Moderately High to High Landside Susceptibility in the wind farm site boundary area."*	Section 8.3.8.
Inland Fisheries Ireland (IFI)	*"We are concerned about soils, their structure and types around all the turbines, turbine pads, associated access roads and site development. In particular we have concerns about the stability of the soils and the impact that works on both the turbines and access roads may have either directly or by vibration on the stability of the soils. IFI are particularly concerned where it is proposed to construct wind turbines on peat soils especially if these peat soils are located on upland areas. This would appear to be the case in the current application. Extra caution will be required to prevent deleterious discharges to waters".*	Section 8.3.8 & 8.5.2.5

Consultee	Description	Addressed in Section
	"IFI strongly recommends that specialist personnel are employed to assess soil strength and suitability of the ground at each site and along any proposed access road. This is particularly important in relation to peat soils. From our experiences we will have serious difficulties with developments on peat soils where there is excessive slope and/or where the peat depth exceeds one metre. Excessive slopes will be an issue with all wind farm proposals regardless of soil type. The potential for soil movement and landslides should be assessed fully within the EIS".	Section 8.3.8
	"The use of sedimentary rocks, such as shale, in road construction should be avoided. This type of material has poor tensile strength and is liable to be crushed by heavy vehicles thereby releasing fine sediment materials into the drainage system which are difficult to precipitate and may give rise to water pollution. We recommend that specialist expertise should advise on the type of material required for road construction bearing in mind the pressures that will arise during the construction phase and the necessity to avoid pollution due to fines washing out into the roadside drainage."	Refer to Section 8.5.3. All material used in the surfacing of the access roads will comply with the Travel Infrastructure Ireland (TII) standards (TII, 2013). Some aggregate material due to a requirement for specific grade, quality or quantity may be sourced from suitable licenced quarries around the site.
National Parks and Wildlife (NPWS)	*"Peat stability should be assessed where required".*	Section 8.3.8

8.2.4 Impact Assessment Methodology

The EPA's Guidelines on the Information to be contained in Environmental Impact Assessment Reports (EPA, 2022) states that there are 7 no. steps in the preparation of the EIAR. The initial steps relate to screening, scoping, the consideration of alternatives and the description of the project. Step 5 relates to the description of the baseline environment which is presented in Section 8.3 for the land, soils and geological environment. Step 6 relates to the assessment of impacts and is presented in Section 8.5.

The guideline criteria (EPA, May 2022) require that the baseline environment is described in terms of the context, character, significance and sensitivity of the existing environment. In addition, using information from the desk study and data from the site investigations, an estimation of the importance of the land, soil and geological environment within the study area and Proposed Development site 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	Geological feature rare on a regional or national scale (NHA).

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

The assessment of effects follows the description of the baseline environment and is Step 6 of the information which must be included in an EIAR. The guideline criteria for the assessment of effects states that the purpose of an EIAR is to identify, describe and present an assessment of the likely significant effects. The likely effects are described with respect to their quality (positive, neutral or negative), significance (imperceptible to profound), extent (i.e. size of area or number of sites effected), context (is the effect unique of being increasingly experienced), probability (likely or unlikely), duration (momentary to permanent), frequency and reversibility. The descriptors used in this environmental impact assessment are those set out in the EPA (2022) glossary of effects as shown in Chapter 1 of this EIAR.

In order to provide an understanding of this descriptive system in terms of the geological/hydrological environment, elements of this system of description of effects are related to examples of potential likely significant effects on the geology and morphology of the existing environment, as listed in Table 8-3.

Table 8-3: Effect descriptors related to the receiving environment.

Impact Characteristics		Potential Geological and Hydrological Effects
Quality	Significance	
Negative only	Profound	Widespread permanent impact on: › The extent or morphology of a SAC. › 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 SAC / 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.
Positive or Negative	Moderate	Local time-dependent impacts on: › The extent or morphology of a SAC / 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.
Positive, Negative or Neutral	Not Significant	An effect which causes noticeable changes in the character of the environment but without significant consequences.
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.

8.2.5 Study Area

The study area for the land, soils and geological impact assessment is limited to within the Proposed Development site boundary (i.e. the EIAR Study Boundary). Due to the localised nature of the construction works, effects on the land, soils and geological environment will not extend beyond the immediate vicinity of the Proposed Development footprint. Therefore, the Proposed Development has no potential to impact the land, soils and geological environment outside of the Proposed Development site.

8.2.6 Limitations and Difficulties Encountered

No limitations or difficulties were encountered during the preparation of the Land, Soils and Geology Chapter of the EIAR.

8.3 Existing Environment

8.3.1 Site Description and Topography

8.3.1.1 Wind Farm Site

The proposed Wind Farm Site is located ~4km northeast of the village of Sixmilebridge, ~3km south of the small village of Broadford and ~3.5km southeast of Kilkishen in southeast Co. Clare. The Wind Farm Site is situated ~11km north of Limerick City. The Wind Farm Site is elongated along the crest of a hill and is located in the townland of Knockshanvo and adjacent townlands. The Grid Reference co-ordinates for the approximate centre of the site are E554266 N669733. The Wind Farm Site has a total area of 1,072 hectares (ha).

The Wind Farm Site is comprised of existing commercial forestry plantations, dominated by Sitka Spruce and Lodgepole Pine. The Wind Farm Site also contains areas which are unplanted and comprises of wet heath habitats or unplanted areas along riparian buffer zones. Other areas of the Wind Farm Site have been felled and are reverting naturally to wet heath.

The Wind Farm Site is served by an existing network of forestry roads. The Wind Farm Site is accessed via local roads from the R465 Regional Road, which travels in a north-south direction between Broadford and Ardnacrusha, the R471 Regional Road which travels east-west between Sixmilebridge and Clonlara and the Crag Local Road, which travels in a northeast-southwest direction between Sixmilebridge and Broadford.

Topography of the Wind Farm Site is highly variable, ranging from ~160 to 310mOD (metres above Ordnance Datum). The Wind Farm Site is located in the Slieve Bernagh Mountain Range in east, Co. Clare and is located on an elevated east-west orientated ridge. The Wind Farm Site contains several local peaks, the highest of which is Knockanuarha (~310mOD). The north of the Wind Farm Site slopes to the north and northwest while the south slopes to the south and southeast away from this elevated ridge.

8.3.1.2 Grid Connection

The Grid Connection to Ardnacrusha is ~9.2km in length. This Grid Connection will originate from the proposed onsite 110kV electrical substation in the townland of Drumsillagh Co. Clare. This underground Grid Connection travels to the south along a local road as far as Ardnacrusha. Elevations along Grid Connection range from ~180mOD at the proposed onsite 110kV electrical substation to ~20mOD in the vicinity of Ardnacrusha 110kV Electrical Substation. The Grid Connection will utilise

the existing public local road networks, existing Coillte forestry access tracks, private forestry access tracks and private agricultural lands.

8.3.1.3 Turbine Delivery Route

The Turbine Delivery Route (TDR) begins at Foyne Port and travels along the N69 passing through Limerick City. To the north of Limerick City, the TDR follows Corbally Road, the R463 and the R465 before entering the Wind Farm Site in the townland of Kilmore, Co Clare.

Minor works, comprising road widening, are required along the R465 to the south of the Wind Farm Site. Meanwhile, a temporary compound will also be constructed along the N69 in the townland of Court, Co. Limerick.

8.3.2 Land and Land Use

8.3.2.1 Wind Farm Site

Corine land cover maps (2018) show that the Wind Farm Site comprises coniferous forestry with smaller areas of transitional woodland scrub and peat bogs. On the lower ground surrounding the Wind Farm Site, land cover is mapped by Corine predominantly as agricultural pastures. Historic Corine land cover maps (1990-2018) do not record any significant land cover changes at the Wind Farm Site apart from the progressive replacement of peat bogs with coniferous forestry plantations.

Land cover at the Wind Farm Site has been verified during site walkover surveys completed by HES and from the inspection of recent aerial imagery. During walkover surveys the Wind Farm Site was noted to comprise largely of coniferous forestry plantations, with some recently felled areas and some smaller areas of wet heath.

A total of 5 no. turbines are located in coniferous forestry (T1, T2, T3, T6 and T7). 2 no. turbines are located on the boundary between forested areas and recently felled areas (T4 and T5). Meanwhile, 2 no. turbines are located in areas which contain a mosaic of forestry and open ground with wet heath habitats (T8 and T9).

8.3.2.2 Grid Connection

According to Corine land cover maps (2018) the northernmost section of the Grid Connection, in the immediate vicinity of the Wind Farm Site, is mapped by Corine as forestry and peat bogs. According to Corine mapping, the Grid Connection then passes through agricultural lands before passing through urban lands near Ardnacrusha. During the site walkover surveys it was noted that the proposed onsite substation is located in an area of coniferous forestry. In the vicinity of the proposed onsite substation the Grid Connection will be located along an existing forestry road while the majority of the Grid Connection will be located in the corridor of the existing public road network.

8.3.2.3 Turbine Delivery Route

The works areas along the R465 and the temporary compound along the N69 are located in areas mapped by Corine as agricultural pastures.

8.3.3 Soils and Subsoils

8.3.3.1 Wind Farm Site

The published Teagasc soils map (www.gsi.ie) for the local area shows that the Wind Farm Site is overlain by a mosaic of soil types. Mapped soils within the Wind Farm Site comprise of blanket peat (BktPt), acid shallow well drained mineral soils (AminSW), acid deep well drained mineral soils (AminDW) and acid shallow poorly drained mineral soils (AminSP).

The published subsoils map (www.gsi.ie) shows that the Wind Farm Site is underlain by bedrock outcrop or subcrop (Rck), blanket peat (BktPt) and till derived from Devonian sandstones (TDSs). The GSI also map some till derived from Lower Palaeozoic sandstones and shales (TLPSsS) within the Wind Farm Site. In terms of the proposed turbine locations, a total of 7 no. turbines are mapped in areas of bedrock outcrop or subcrop. Meanwhile, T8 is mapped in an area of blanket peat and T7 is mapped to be underlain by tills derived from Devonian sandstones.

A subsoil geology map for the Wind Farm Site and Grid Connection is shown as Figure 8-1.

The soils and subsoils present at the Wind Farm Site have been confirmed by site investigations comprising peat probes, trial pits and boreholes.

A total of 569 no. peat probes (combined FT, MKO and HES) have been completed at the Wind Farm Site. The peat depths ranged from 0 to 3.9m with an average peat depth of 0.55m. 97% of peat probes recorded peat depths of less than 2. A number of localised readings showed peat depths were between 2m and 3.9m (FT, 2024). The areas of deeper peat are remote from proposed infrastructure locations. The deepest recorded peat (~4m deep) is located in an area of open bog ~120m southeast of BP02.

Meanwhile, peat depths at the proposed turbine locations ranged from 0.2 to 0.9m. The average peat depth at the proposed turbine locations was recorded as 0.4m (FT, 2024). A summary of the peat depths and subsoil lithologies recorded at the Proposed Development locations are included in Table 8-4 below.

Table 8-4: Peat Depth Data at Key Infrastructure Locations

Proposed Development Location	HES Peat Depth (m)	FT and MKO Peat Depth (m)	Summary of Underlying Mineral Subsoil Lithologies (HES)
T01	0.42 – 0.6	0.6 – 0.9	Grey slightly gravelly silty CLAY with increasing sand and gravel content with depth
T02	0.1 – 0.26	0.1 – 0.3	Hard base – boulder/rock
T03	0.15 - 0.22	0.2 – 0.3	Firm grey CLAY
T04	0.15 - 0.58	0.3 – 0.5	Light brown slightly gravelly clayey medium SAND
T05	0	0.1 – 0.3	Mineral TOPSOIL over grey clayey SAND over hard base
T06	0	0.1 – 0.2	Mineral TOPSOIL over grey silty CLAY over brown gravelly CLAY
T07	0.02 – 0.05	0.1 – 0.2	Grey SILT/CLAY
T08	0.17 – 0.52	0.1 – 0.3	Hard base – boulder/rock
T09	0.32 – 0.43	0.2 – 0.5	Hard base – boulder/rock

Proposed Development Location	HES Peat Depth (m)	FT and MKO Peat Depth (m)	Summary of Underlying Mineral Subsoil Lithologies (HES)
Met Mast		0.2 – 0.4	Hard base – no returns
Construction Compound (CC1)	0.35	0.3 – 0.4	Hard base – no returns
Construction Compound (CC2)	0.15	0 – 0.2	Hard base – no returns
Construction Compound (CC3)	0.45	0.1 – 0.4	Hard base – no returns
Substation	0.15 - 0.45	0.2 – 0.6	Hard base – no returns
Borrow Pit (BP01)	0.32 – 0.45	0. – 0.4	Hard base – no returns
Borrow Pit (BP02)	0.05 – 0.4	0.6 – 1.2	Grey clayey SAND or hard base
Borrow Pit (BP03)	0.01 - -0.3	0.1 – 0.2	Hard base – boulder/rock
Borrow Pit (BP04)	0.1 – 0.4	0.2 – 0.5	Sandy mineral soil or hard base
Borrow Pit (BP05)	0.24	0.1 – 0.2	Hard base – boulder/rock

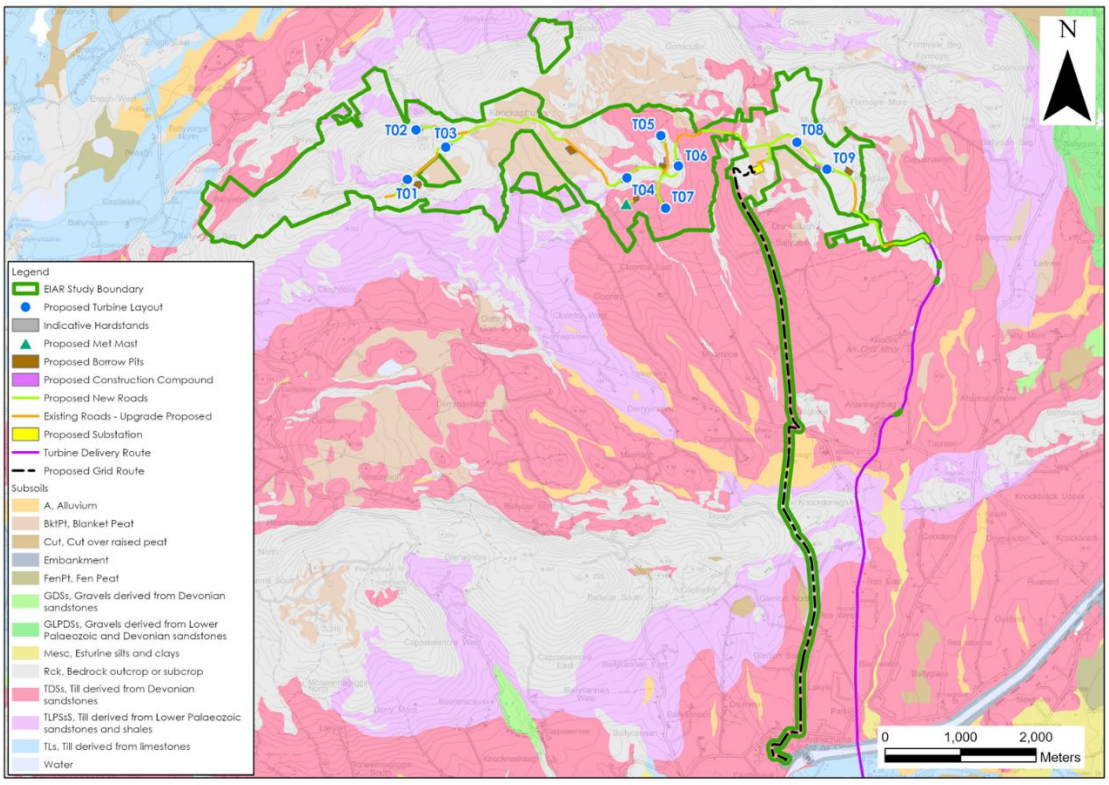

Figure 8-1 Local Subsoils Map (www.gsi.ie)

Trial pit investigations were carried out at the Wind Farm Site by IDL between 28th and 30th August 2023 (refer to Figure 8-2 for locations). A total of 13 no. trial pits were completed across the Wind Farm Site. These trial pit excavations were completed adjacent existing forestry roads and as close to Proposed Development infrastructure insofar as possible. In some instances, access and slope made it difficult to complete the site investigations at the location of the key proposed infrastructures such as T04, T08 and T09. However, most trial pit investigations are situated immediately adjacent or within 50m of proposed infrastructure locations.

The trial pits extended to a maximum depth of 4mbgl (metres below ground level). These trial pit excavations encountered glacial tills overlying bedrock. The glacial tills generally consisted of slightly sandy slightly gravelly SILT/CLAY with cobbles and boulders and/or silty SAND and/or GRAVEL with cobbles and boulders. MADE GROUND (*i.e.* ground were natural soils have been replaced or altered by the introduction of man-made or artificial materials such as concrete or crushed brick) was also encountered in 3 no. trial pits (TP05, TP06 and TP07) due to their location adjacent existing forestry roads. The made ground deposits were described as brown silt mixed with yellowish silty sand with cobbles. The made ground deposits extended to depths of 0.5 to 0.6mbgl. Meanwhile, peat was encountered in TP05 from a depth pf 0.6 to 0.8mbgl.

The full subsoil profile was encountered in 12 of the 13 no. trial pits with depth to competent rock ranging from 0.7m to 3m. Competent bedrock was found to be overlain by weathered rock, recovered from the trial pit excavations as angular gravel and cobble sized clasts of mudstone and shale. No bedrock was encountered in TP07 with this trial pit terminating on boulders at a depth of 4mbgl.

The trial pit geological logs are presented in full in Appendix E to the Geotechnical and Peat Stability Risk Assessment (Appendix 8-1).

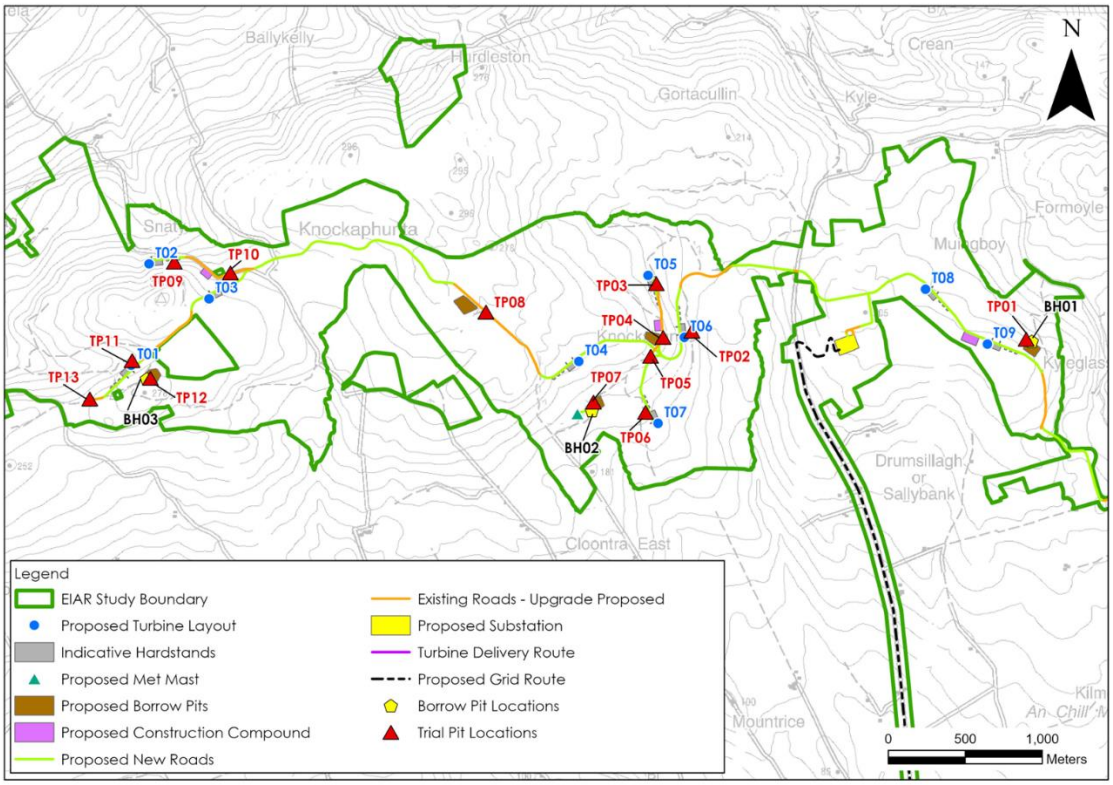

Figure 8-2: Site Investigation Locations (Trial Pits and Boreholes)

8.3.3.2 Grid Connection

According to the Teagasc soil mapping (www.gsi.ie), the majority of the Grid Connection is overlain by mainly acidic poorly drained mineral soils (AminPD). Meanwhile, the northern section, in the vicinity

of the Wind Farm Site is overlain by shallow, rocky, peaty mineral soils (AminSRPT). Alluvium is also mapped along the Blackwater River. Made ground is mapped in the south of the Grid Connection, in the vicinity of Ardnacrusha.

In terms of subsoils, the GSI (www.gsi.ie) map till derived from Devonian sandstones (TDSs) underlying much of the Grid Connection. Bedrock outcrop or subcrop (Rck) is mapped in the vicinity of the Wind Farm Site and further south in the townland of Knockdonagh. Other subsoils mapped along the Grid Connection include till derived from Lower Palaeozoic sandstones and shales (TLPSsS) and mineral alluvium along the Blackwater River.

8.3.3.3 Turbine Delivery Route

According to the Teagasc soil mapping (www.gsi.ie), the works areas along the R465 are overlain by acid poorly drained mineral soils. The mapped subsoils in this area comprise of till derived from Devonian sandstones.

The temporary compound along the N69 is overlain by alluvial soils and basic poorly drained mineral soils. This area is underlain by alluvium and till derived from limestones.

8.3.4 Bedrock Geology

8.3.4.1 Wind Farm Site

The Wind Farm Site is underlain by a total of 4 no. bedrock geological formations as shown on the GSI bedrock mapping (www.gsi.ie).

The centre and east of the Wind Farm Site is underlain largely by Old Red Sandstones (undifferentiated) which comprise of red mudstones, siltstones and sandstones, and poorly sorted, polymict pebble conglomerates and breccias. Meanwhile, the west of the Wind Farm Site is heavily faulted and, in addition to the Old Red Sandstones (undifferentiated), is underlain by the Broadford, Ballymalone and Cornagnoe bedrock geology formations. The Broadford Formation consists of fine to conglomeratic greywackes. Meanwhile, the GSI provide the following lithological description of the Ballymalone Formation: "*red to black coloured shales and buff grey coloured cherts. The shales locally contain graptolites*". The Cornagnoe Formations contains two principal lithologies, grey mudstones and mottled siltstones and mudstones.

In terms of the key Proposed Development infrastructure, a total of 6 no. turbines are underlain by the Old Red Sandstones (undifferentiated). Meanwhile, 2 no. turbines (T1 and T3) are underlain by the Cornagnoe Formation and 1 no. turbine (T2) is underlain by the Broadford Formation.

The Wind Farm Site is underlain by several mapped structural geological features. The geology of east Co. Clare has been strongly influenced by folding and faulting. The rocks in this area which comprise largely of Silurian mudstones, siltstones and sandstones and were originally deposited on an ocean floor but were swept up in the Caledonian orogeny. Some older, Ordovician rocks are also exposed in the faulted areas in the west of the Wind Farm Site. The west of the Wind Farm Site contains several faults of variable orientation, some of which extend eastwards towards the centre of the Wind Farm Site. Due to the age of the faulting (Ordovician to early Devonian), the mapped faults are not considered to be of significance with respect to the Proposed Development.

The GSI map the occurrence of bedrock exposures within the Wind Farm Site. These are largely concentrated towards the centre and east of the Wind Farm Site and along the elevated ground. Site walkover surveys and intrusive site investigations have shown that bedrock is exposed and/or close to the ground surface across much of the Wind Farm Site. Several historic borrow pits within the Wind Farm Site show excellent exposures of the underlying bedrock geology.

IDL drilled a total of 3 no. boreholes within the Wind Farm Site in September 2023 in order to verify the bedrock geology of the local area. The location of the boreholes are presented in Figure 8-2 above. The borehole logs are summarised in Table 8-5 below and are presented in full in Appendix E to the Geotechnical and Peat Stability Risk Assessment (Appendix 8-1).

Based on the site investigations (trial pits and boreholes), the depth to competent rock (unweathered) is shallow across the Wind Farm Site, ranging from 0.7 at TP08 to 4.6m at BH02. The top of the bedrock is noted to be weathered, recovered as angular, fine to coarse grained gravel sized clasts of siltstone. The competent bedrock encountered in the 3 no. boreholes was described as strong, thinly laminated, dark reddish brown SILTSTONE and SANDSTONE.

Table 8-5: Summary borehole Logs (from IDL, 2023)

Trial Pit ID	Total Depth (m)	Depth Interval (m)	Summary Geological Description
BH01	10.10	0 – 2.3	Overburden (sandy gravelly SILT)
		2.3 – 4.4	Strong, thinly laminated, reddish brown, fine to medium grained SILTSTONE
		4.4 – 10.10	Strong, thinly laminated, reddish brown, fine to coarse grained SANDSTONE
BH02	10.10	0 – 1.6	Overburden (GRAVEL)
		1.6 – 4.6	Weathered rock – clasts of dark reddish brown siltstone
		4.6 – 10.10	Strong, thinly bedded, dark reddish brown, fine grained SILTSTONE
BH03	10	0 – 1.3	Overburden (gravelly SILT)
		1.3 – 3.2	Weathered rock – clasts of dark reddish brown siltstone
		3.2 - 10	Strong, thinly laminated , reddish brown, fine to medium grained SILTSTONE

8.3.4.2 Grid Connection

Much of the Grid Connection is mapped by the GSI to be underlain by Old Red Sandstones (undifferentiated) (www.gsi.ie). Meanwhile, in the townland of Knockdonagh, the Grid Connection is mapped to be underlain by the Cratloes Formation. The southern section is underlain by the Lower Limestone Shales and the Ballysteen Formation to the north of Ardnacrusha. The Waulsortian Limestones underlie Ardnacrusha and the southernmost section of the Grid Connection.

The Cratloes Formation is noted by the GIS to be comprised of laminated siltstone and sandstones. The Lower Limestone Shale is comprised of sandstones, mudstone and thin limestones, while the Ballysteen Formation is described as irregularly bedded and nodular bedded argillaceous bioclastic limestones, interbedded with fossiliferous calcareous shales. Finally, the Waulsortian Limestones are described as massive, unbedded lime mudstones.

This GSI map shows some small areas of bedrock outcrop in the vicinity of the Wind Farm Site and further south in the townland of Knockdonagh.

A large, approximately east-west orientated fault is mapped to underlie the Grid Connection in the townland of Trough and separate the Old Red Sandstones (undifferentiated) to the north from the Cratloes Formation to the south.

A bedrock geology map is shown as Figure 8-3 below.

8.3.4.3 Turbine Delivery Route

The temporary compound along the N69 is underlain by Waulsortian Limestones. Meanwhile, bedrock geology underlying the works areas along the R465 is mapped as Old Red Sandstone.

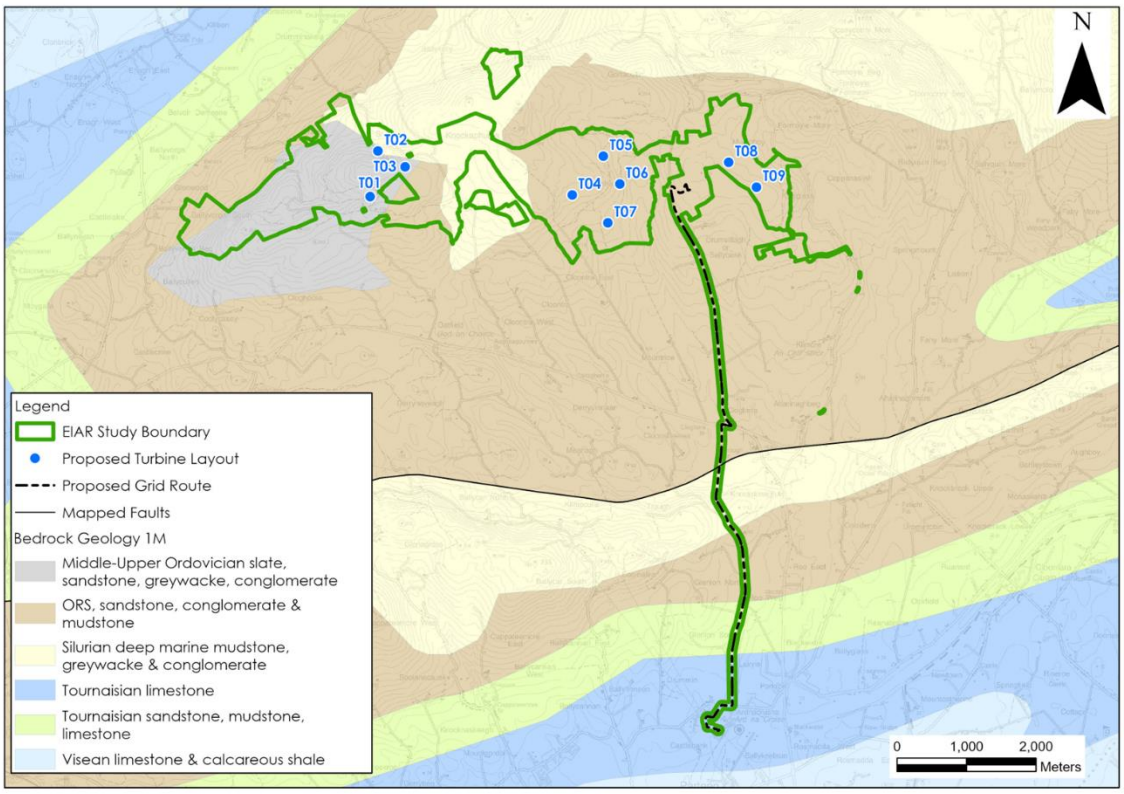

Figure 8-3: Bedrock Geology Map

8.3.5 Geological Resource Importance

8.3.5.1 Wind Farm Site

The GSI Online Database accessed via the Public Data Viewer (www.gsi.ie) does not record the presence of any active quarries or pits within the Wind Farm Site. The closest mapped active sand and gravel pit is Ballyquin Pit, operated by Roadstone Ltd, is located ~3.4km west of the Wind Farm Site in the townlands of Ballyquin and Woodpark. Meanwhile, the closest mapped active bedrock quarry is located ~5km south of the Wind Farm Site. This bedrock quarry, Ballycar Quarry, is located in the townland of Ballycar South in the Cratloes Formation. According to the GSI the main deposit at the quarry location is greywacke.

Furthermore, the GSI do not record the presence of any historic quarries or pits within the Wind Farm Site. The closest mapped historic quarries are a series of slate quarries to the southwest of Broadford village.

The GSI record several mineral localities within the Wind Farm Site and in the surrounding lands (www.gsi.ie). In the townland of Knockshanvo, the GSI record the presence of impure iron, where a trial shaft has been made in purple shales. Meanwhile, in the townland of Oatfield, to the south of the Wind Farm Site, the GSI record the presence of gold stating that "*very anomalous gold values were noted in streams here during 1989-1990 stream sediment sampling*". Other mineral deposits in the surrounding lands include haematite, quartz and jasper.

The GSI online Aggregate Potential Mapping Database (www.gsi.ie) shows that the crushed rock aggregate potential of the Wind Farm Site ranges from Low to Very High. The greatest potential is found in the east of the Wind Farm Site with the majority of the site having Moderate potential for a bedrock quarry. The bedrock at the Wind Farm Site could be used on a "sub-economic" local scale for construction purposes. The bedrock at the Wind Farm Site has been extracted previously, with several small borrow pits encountered during site walkover surveys.

The Wind Farm Site is not located within an area mapped for granular aggregate potential (i.e., potential for gravel reserves). The closest mapped area of granular aggregate potential are mapped near the village of Broadford.

The peat and subsoil deposits at the Wind Farm Site can be considered to be of "Low" importance due to the largely thin occurrence, given the fact that peat is not designated in this area (*i.e.* does not form part of a designated site i.e. a Special Area of Conservation), and is significantly degraded in most places as a result of forestry plantations and associated drainage.

8.3.5.2 Grid Connection

There are no active quarries or pits mapped along the Grid Connection.

The GSI online Aggregate Potential Mapping Database (www.gsi.ie) shows that the crushed rock aggregate potential along the Grid Connection ranges from Low to Very High. The greatest potential is found in the north of the Grid Connection, in the vicinity of the Wind Farm Site.

The majority of the Grid Connection is not mapped in an area for granular aggregate potential. However, a small section of the route, along the Blackwater River is mapped as having moderate potential for gravel reserves.

8.3.5.3 Turbine Delivery Route

There are no active quarries or active sand and gravel pits or mineral occurrences mapped in the area of the proposed works (www.gsi.ie).

The GSI online Aggregate Potential Mapping Database (www.gsi.ie) shows that the crushed rock aggregate potential at the temporary compound along the N69 ranges from moderate to very high. This area is also mapped as having moderate potential for granular aggregate.

The works areas along the R465 are not mapped in an area of granular aggregate potential and are mapped as having moderate potential for crushed rock.

8.3.6 Geological Heritage Sites

There are no geological heritage sites located within the Wind Farm Site, along the Grid Connection or in the vicinity of the TDR work areas.

The closest mapped geological heritage site is Ballyvorgal South (Site Code: CE006). This site is designated as a County Geological Site (CGS) and is recommended for designation as a geological national heritage area. This CGS is located immediately to the southwest of the Wind Farm Site and is designated due to stream bank exposures which reveal an unusual Irish occurrence of an assemblage of deep-water fossils now found all over the world in rocks of Upper Ordovician age. The fauna has been well described and contains small trilobites and tiny brachiopod shells (GSI, Ballyvorgan South – County Geological Site Report). The closest proposed turbine to this CGS is T01, located ~2km to the east/northeast.

Meanwhile, the Ballycar South CGS (Site Code: CE002) is located ~5km south of the Wind Farm Site and ~2.2 km west of the Grid Connection. This site is designated as a County Geological Site (CGS) and is recommended for designation as a geological national heritage area. Ballycar South is an important site as the rocks here, which are not exposed at the surface, have yielded a very diverse assemblage of brachiopods, corals, gastropods, trilobites and bryozoans of Silurian age (GSI, Ballycar South – County Geological Site Report).

There are no other geological heritage sites within 5km of the Wind Farm Site or Grid Connection.

A map of local geological heritage sites is attached as Figure 8-4.

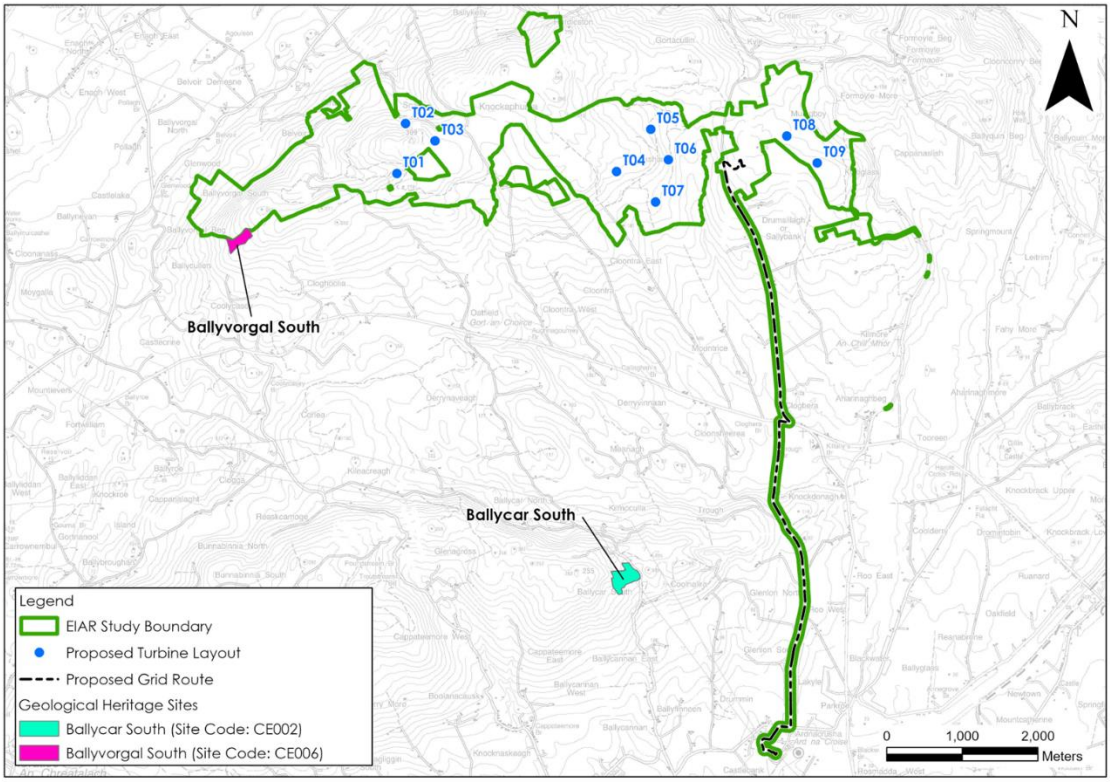

Figure 8-4 Geological Heritage Sites

8.3.7 Soil Contamination

There are no known areas of soil contamination within the Wind Farm Site, along the Grid Connection or in the vicinity of the TDR work areas. During the site walkovers and investigations, no areas of contamination concern were identified within the Proposed Development site. Several historic borrow pits are located within the Wind Farm Site. The trial pit excavation encountered MADE GROUND at 3 no. locations adjacent existing forestry roads. These deposits are associated with the construction of the existing roads at the Wind Farm Site and do not constitute contaminated soil/land as they are not hazardous to the environment.

According to the EPA online mapping (www.epa.ie), there are no licensed waste facilities or dump sites located within the Wind Farm Site, along the Grid Connection or in the vicinity of the TDR work areas.

The closest EPA mapped waste facility is Longpavement landfill, located ~9km south of the Wind Farm Site and ~2.6km south of the Grid Connection.

8.3.8 Peat Stability Assessment

8.3.8.1 Introduction

A constraints study was initially undertaken by the Environmental (MKO), Hydrological (HES) and Ecological (MKO) members of the project design team to determine the developable area on the Wind Farm Site, prior to the site reconnaissance by engineering geologists/geotechnical engineers from FT.

Fehily Timoney and Company (FT) was engaged to undertake a geotechnical and peat stability assessment of the Wind Farm Site. A Geotechnical and Peat Stability Assessment Report (FT, 2024) is attached in Appendix 8-1.

FT undertook the assessment following the principles in Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (2nd edition, PLHRAG, 2017). The Peat Landslide Hazard and Risk Assessment Guide (PLHRAG) was used in the assessment as it provides best practice methods to identify, mitigate and manage peat slide hazards and associated risks in respect of consent applications for electricity generation projects

Hydrological, hydrogeological and ecological factors were also assessed in the Geotechnical and Peat Stability Assessment Report, and interaction between FT, HES and MKO were undertaken throughout the iterative design process. The assessment was done in accordance with guidance contained in Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (PLHRAG, Scottish Government, 2017).

8.3.8.2 Hydrological Considerations

The hydrological factors with regard to peat stability were assessed using a combination of desk study data, aerial photography (historical and contemporary), topographic lidar data flow path drainage analysis, site walkovers, field drainage mapping and gouge coring. The full methodology used in the completion of the Geotechnical and Peat Stability Assessment report is detailed in Section 2.3 of Appendix 8-1. Detailed drainage maps were prepared along with hydrological constraints mapping for on-site drainage features and wet areas.

Many of the pre-conditions for peat failure as described by (PLHRAG, Scottish Government, 2017) are hydrological in nature and are listed in the guidance as follows:

- Impeded drainage caused by a peat layer overlying an impervious clay or mineral base (hydrological discontinuity, especially an iron pan at the base of the peat deposit);
- A convex slope or a slope with a break of slope at its head (concentration of
- subsurface flow);
- Proximity to local drainage, either from flushes, pipes or streams (supply of
- water); and
- Connectivity between surface drainage and the peat/impervious interface (mechanism for generation of excess pore pressures).

Identifying the above pre-conditions at the Wind Farm Site was a key part of the hydrological constraints assessment carried out in conjunction with project design team.

8.3.8.3 Peat Slides – Lessons Learned

The peat stability assessment for the proposed Knockshanvo wind farm has been undertaken taking into account peat failures that have occurred on peatland sites in Ireland. These include recent failures such as Shass Mountain 2020, Co. Leitrim and Meenbog 2020, Co. Donegal. The Meenbog failure occurred during the construction of a section of floating road on sidelong ground in an area of weak peat. 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). The lessons learned from both peat slide events have been incorporated into the design of this project and the construction methodologies for the Proposed Development include measures to implement the lessons learned.

8.3.8.4 Peat Stability - Desk Study

The GSI do not record the occurrence of any historic landslides within the Wind Farm Site. The closest recorded peat slide is located on the northeastern slopes of Slieve Bernagh, ~8.5km northeast of the Wind Farm Site.

The GSI Landslide Susceptibility Map (www.gsi.ie) classifies the probability of a landslide occurring based on the soil type and the slope. The landslide susceptibility of the Wind Farm Site was classified by the GSI (2023) as ranging from "low" to "high" susceptibility, with the higher risk areas corresponding to steeper slopes within the Wind Farm Site. A total of 4 no. turbines (T1, T2, T3, T5 and T6) are located in the vicinity of areas which are mapped by the GSI as having a "high" susceptibility to landslides. However, this map is to the scale of 1:50,000 and is therefore superseded by site-specific stability assessments at the proposed infrastructure locations.

8.3.8.5 Peat Stability - Site Walkover Surveys and Investigations

FT completed detailed site surveys and walkover inspections of the Wind Farm Site from 7th to the 9th June 2023. The observations made during the site surveys were supplemented by observations recorded by MKO and HES during separate walkover surveys. During these site walkover surveys a total of 569 no. peat probes were completed. Intrusive site investigations comprising 13 no. trial pits and 3 no. boreholes were also completed by IDL under the supervision of FT.

The findings of the walkover surveys and intrusive site investigations are as follows:

- The Wind Farm Site is covered in a layer of thin peat (0 – 3.9m) with undulating terrain open peatland.
- Shear vane testing of the peat shows that undrained shear strengths range from 10 to 29kPa, which an average of 20kPA, which is typical of shallow, well drained peat. Peat strengths at sites of known peat failures are generally very low, for example the undrained shear strength at the Derrybrien failure was estimated to be 2.5kPa.
- A construction buffer zone plan has been produced for the Wind Farm Site and highlights areas on the site with an elevated or higher construction risk. No development is proposed in these areas. The above identified buffer areas are based on qualitative factors identified during the walkover survey e.g. areas of relatively deep peat.
- The results of the peat depth probing, shear strength testing of the peat and qualitative factors identified on site have been used in the stability and risk assessments, see below.
- No peat failures/landslides are recorded in the Wind Farm Site.
- No areas of quaking peat were recorded during the site walkover surveys.
- Walkover surveys and peat probing of the Grid Connection, TDR work areas and the TDR temporary compound identified no peat stability issues and therefore there was no requirement to carry out the detailed analysis as described below for the Wind Farm Site (FT, 2024).

8.3.8.6 Peat Stability Analysis and Assessment

An analysis of the risk of a peat slide occurring was carried out at all the main proposed infrastructure locations across the Wind Farm Site (*i.e.* proposed turbine, construction compound, borrow pit, met mast and access roads locations). The purpose of the analysis was to determine the Factor of Safety (FoS) of the peat slopes. The FoS is a numerical value of the stability on individual areas of a peatland. The FoS is calculated by a combination of geotechnical information and site characteristics which are

obtained from desk study and site walkovers including the property of the peat, shear strength, depth, slope geometry underlying strata and groundwater etc. The factor of safety provides a direct measure of the degree of stability of a slope and is the ratio of the shear resistance over the downslope destabilising force. Provided the available shear resistance is greater than the downslope destabilising force then the factor of safety will be greater than 1.0 and the slope will remain stable. If the factor of safety is less than 1.0 the slope is unstable and liable to fail. The acceptable range for factor of safety is typically from 1.3 to 1.4. 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 8-6 below.

Interaction between FT and HES was undertaken throughout the iterative design process, with the Geotechnical and Peat Stability Assessment Report also incorporating hydrological and hydrogeological factors.

Table 8-6: 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
4	1.01 to 1.10	Probable
5	<1.0	Very Likely

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.

An adverse combination of the factors mentioned in the preceding sentence 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. 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[3] (short-term stability) and drained (long-term stability) analysis has been undertaken to determine the stability of the peat slopes on site.

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.

[3] *For the stability analysis two load conditions were examined, namely*

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

As mentioned above, the Geotechnical and Peat Stability Assessment Report (FT, 2024) is attached in Appendix 8-1.

8.3.8.6.1 *Undrained Analysis*

Undrained analysis results are presented in Table 8-7. As outlined above the undrained loading condition applies in the short-term during construction and until construction induced pore water pressures dissipate.

The calculated FoS for Condition 1 and Condition 2 are in excess of 1.30 for all Proposed Development locations assessed, indicating a low risk of peat instability.

Table 8-7: Factor of Safety Results (undrained condition)

Turbine No./Waypoint	Factor of Safety for Load Condition	
	Condition (1)	Condition (2)
T1	4.73	2.24
T2	11.34	2.62
T3	30.71	7.09
T4	15.39	5.13
T5	30.71	7.09
T6	19.35	4.47
T7	57.48	9.58
T8	38.27	10.93
T9	15.39	5.13
Met Mast	30.71	7.09
Construction Compound (1)	3.43	1.8
Construction Compound (2)	57.48	9.58
Construction Compound (3)	22.99	7.66
Substation	10.24	4.85
Borrow Pit (1)	51.78	4.71
Borrow Pit (2)	7.26	3.22
Borrow Pit (3)	38.48	6.41
Borrow Pit (4)	15.36	5.76

Turbine No./Waypoint	Factor of Safety for Load Condition	
	Condition (1)	Condition (2)
Borrow Pit (5)	38.48	6.41
Access Roads (Range)	2.75 – 42.6	1.79 – 5.15
Settlement Ponds (Range)	3.43 – 51.78	1.8 – 9.58

8.3.8.6.2 *Drained Analysis*

Drained analysis results are presented in Table 8-8. 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.

The calculated FoS for Condition 1 and Condition 2 are in excess of 1.30 for all Proposed Development locations assessed, indicating a low risk of peat instability.

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

Turbine No./Waypoint	Factor of Safety for Load Condition	
	Condition (1)	Condition (2)
T1	1.89	1.88
T2	4.54	2.15
T3	15.36	4.64
T4	7.70	5.52
T5	15.36	7.64
T6	9.67	4.78
T7	28.74	10.35
T8	19.13	11.82
T9	7.70	5.52
Met Mast	20.69	8.87
Construction Compound (1)	3.0	2.35
Construction Compound (2)	28.74	10.35

Turbine No./Waypoint	Factor of Safety for Load Condition	
	Condition (1)	Condition (2)
Construction Compound (3)	11.50	8.28
Substation	10.45	7.75
Borrow Pit (1)	28.83	5.3
Borrow Pit (2)	6.95	4.93
Borrow Pit (3)	23.68	7.64
Borrow Pit (4)	11.21	6.46
Borrow Pit (5)	23.68	7.64
Access Roads (Range)	2.95 – 19.0	2.15 – 6.92
Settlement Ponds (Range)	3.0 – 28.83	2.42 – 10.5

8.3.8.7 Conclusions

The findings of the Geotechnical and Peat Stability Assessment Report showed that the Wind Farm Site has a low risk of peat failure and is suitable for the proposed wind farm development. The findings include recommendations and control measures for construction work in peatlands, all of which will be implemented in full to ensure that all works adhere to an acceptable standard of safety.

The Wind Farm Site is typically covered in a shallow layer of blanket peat with undulating terrain of commercial forestry and open peatland. Peat thicknesses recorded from 569 probes ranged from 0.0 to 3.9m with an average depth of 0.55m. Slope inclinations at the main infrastructure locations range from 3 to 18 degrees.

An analysis of peat sliding was carried out at the main infrastructure locations across the Wind Farm Site for both the undrained and drained conditions. The purpose of the analysis was to determine the Factor of Safety (FoS) of the peat slopes.

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 and 2 for the locations analysed showed that all locations have an acceptable FoS of greater than 1.3, indicating a low risk of peat failure. The undrained analysis is considered the most critical condition for the peat slopes.

A drained analysis was also carried out, which examined the effect of in particular, rainfall on the existing stability of the natural peat slopes on site. For the drained condition, the calculated FoS for load conditions (1) & (2) for the locations analysed, showed that all locations have an acceptable FoS of greater than 1.3. The peat stability risk assessment at each infrastructure location, along access roads, in peat placement areas and at settlement pond locations identified a number of mitigation/control measures to reduce the potential risk of peat failure (included in Appendix B of the PSRA).

A stability analysis was also completed to demonstrate the stability of the proposed berms around the proposed borrow pits. The perimeter berm is considered to be more critical than any internal buttress,

as peat is only present on one side of the berm. The stability analysis, undertaken for both the undrained and drained conditions shows that the proposed berms are stable.

In summary, the findings of the Geotechnical and Peat Stability Assessment Report showed that the Wind Farm Site has a low risk of peat failure and is suitable for the Proposed Development.

8.3.9 Receptor Importance and Sensitivity

Based on the criteria set out in Table 8-2 above, the soils and peat at the Wind Farm Site can be classed as being of low importance as the overlying peat deposits are not designated in this area and are significantly degraded as a result of the commercial forestry operations and associated drainage. The bedrock geology underlying the Wind Farm Site can be classed as being of medium importance where the bedrock could be used on a sub-economic scale. The Ballyvorgal South CGS, immediately to the southwest of the Wind Farm Site can be considered as being of high importance due to its designation as a county geological heritage site.

The land, peat, soils and bedrock geological formations underlying the Wind Farm Site, the Grid Connection and the TDR compound will be included in the impact assessment due to their proximal location to the Proposed Development and the potential effects that the Proposed Development may have on these receptors.

The Ballyvorgal South CGS is not included in the impact assessment despite its proximal location to the Proposed Development. This CGS is located outside of the Proposed Development site boundary and there is no potential for effects to occur on the land, soils and geological environment outside of the site. Furthermore, as detailed in Chapter 9: Hydrology and Hydrogeology, there are no works proposed upstream of this CGS which is located in the Owenogarney_040 WFD river sub-basin (refer to Table 9-8). Therefore, the Proposed Development has no potential to effect this CGS.

In addition, all other geological heritage sites have been screened out due to their distal location from the Proposed Development. There is no potential for effects to occur on these geological heritage sites.

8.4 Characteristics of the Proposed Development

The Proposed Development is defined in full in Chapter 4.

In summary the Proposed Development includes:

- 9 no. turbines and associated foundations and hardstand areas. The range of turbine diameters assessed in this chapter are as follows;
  - Turbine tip height range between 179.5 and 185m
  - Hub hight range between 102.5 and 110.5m
  - Rotor diameter range between 149 and 163m
- 1 no. permanent meteorological mast;
- 3 no. temporary construction compounds;
- Opening of the 5 no. proposed on-site borrow pits;
- 1 no. onsite 110kV substation including 2 no. control buildings, welfare facilities, security fencing, wastewater holding tank and all associated ancillary works;
- Underground cabling between the turbines and the onsite substation;
- Construction of new access roads and upgrades of existing roads;
- Insertion of the Proposed Development drainage network;
- Felling of coniferous forestry;
- Biodiversity enhancement;
- Amenity trails including 2 no. amenity viewing areas;

- Grid Connection (9.2km in length) from the proposed onsite substation to the existing Ardnacrusha 110kV electrical substation. The Grid Connection will be located entirely within the public road corridor and forestry tracks; and,
- Works along the TDR including a temporary compound.

The Proposed Development will involve removal of peat, subsoils and in places bedrock for access roads, internal access road networks, internal cable network, hardstanding emplacement, turbine foundations, substation, crane hardstands, construction compounds, drainage works and met mast installation. Rock for construction purposes will be sourced from the proposed onsite borrow pits.

Generally, for constructing any structure or platform foundation, such as a turbine base, hardstand or substation, removing all soft material is required to a depth where a suitable bearing material is encountered. Hardcore materials will be extracted from the borrow pit (and some turbine locations, if necessary), principally by means of rock breaking. Depending on the hardcore volume requirements, blasting may also be used as a more effective rock extraction method. The material excavated is required to be properly managed and stored and will be re-used in other elements of the proposed wind farm design.

During turbine construction, peat will be permanently excavated to the substrate to make room for the concrete turbine foundation and a small working area surrounding the foundation footprint. Breaking and excavation of bedrock may be required where it is encountered at shallow depths to achieve the reduced foundation level and level surface required by design. Turbine bases in the range of 25m in diameter are proposed, with detailed foundation design dictated by the local ground conditions and the requirements of the turbine supplier. The plan area of the material to be removed will be dictated by the enabling temporary works design, allowable excavation angle and the mean peat and overburden depths across each turbine location. The design of the turbine base foundations is subject to further ground investigation and the detailed design designer's assessment.

Similarly, all turbine crane hardstands will be required to be founded on a suitable bearing material requiring the excavation of all peat and other soft ground materials, where present. The platform will be constructed in the excavated area using a suitable specified engineered stone fill. Following the placement of the platform, the excavated peat can be re-used to batter the platform edges and landscape the platform back into the existing topography.

The total volume of spoil (peat and non-peat superficial deposits) requiring placement/reinstatement on Wind Farm Site is estimated to be 211,100m^3 (refer to Table 8-9 below).

There is the capacity to store a total of 205,000m^3 of peat and spoil at the borrow pits, whilst 18,000m^3 will be used for landscaping (it is estimated that ~2,000m^3 will be required for landscaping purposes at each of the 9 no. turbine locations) (refer to Table 8-10). Therefore, the capacity of the placement/reinstatement areas (223,000m^3) is greater than the volume of material which will be generated by the Proposed Development.

It is proposed to obtain ~60% of all rock and hardcore material that will be required during the construction phase of the Proposed Development from the 5 no. on-site borrow pits. Usable rock may also be won from other infrastructure. For example, at certain turbine foundation and hardstand locations, depending on local ground conditions, the extraction of rock may be required in order to obtain a level construction area. Any rock obtained from a turbine location will be used to supply the hardcore materials requirement for that turbine's hardstand and access road. This estimated available rock volume of 251,000m^3 is detailed in Table 8-11. Some aggregate material due to a requirement for specific grade, quality or quantity may be sourced from suitable licenced quarries around the site.

Table 8-9: Estimated Peat, Mineral Soil and Rock Excavation Volumes

Infrastructure Element	Excavated Peat Volume (m^3)	Excavated Spoil Volume (m^3)	Excavated Rock Volume i.e. Cut (m^3)
9 no. turbines and associated hardstands	16,000	50,000	70,000
Access Roads	40,000	32,000	30,000
Temporary Construction Compounds	3,800	9,500	None
Substation	7,300	3,000	
Met Mast	300	300	
Borrow Pits	14,000	28,000	151,000
Grid Connection	100	6,800	None
Sub-Total Volume (m^3)	**81,500m^3**	**129,600m^3**	
Total Spoil	**211,100m^3**	**Total Rock**	**251,000 m^3**

Table 8-10: Summary of Peat and Spoil Placement/Reinstatement

Location	Peat and Spoil Volume (m^3)
Borrow Pits	205,000
Landscaping at Turbine locations	18,000
Total Volume (m^3)	**223,000m^3**

Table 8-11: Summary of Earthworks Stone Requirements

Location	Earthworks Stone Requirements (m^3)
9 no turbines and associated hardstands	145,000
Access Roads	70,000
Substation, 3 no. construction compounds and met mast	30,000
Borrow pits	6,000
Grid Connection	None
Total Volume (m^3)	**251,000m^3**

8.5 Likely Significant Effects and Associated Mitigation Measures

8.5.1 Do Nothing Scenario

If the Proposed Development was not developed, the site will continue to function as it does at present, with no changes made to the current land-use of commercial forestry. The impact of this is considered neutral in the context of the EIAR. If the Proposed Development were not to proceed, the opportunity to capture an even greater part of County Clare's valuable renewable energy resource would be lost, as would the opportunity to further contribute to meeting Government and EU targets for the production and consumption of electricity from renewable resources and the reduction of greenhouse gas emissions. The opportunity to generate local employment and investment and to diversify the local economy would also be lost.

If the Proposed Development were not to proceed the Wind Farm Site would continue to function as a coniferous forestry plantation. Currently felling operations are ongoing at Knockshanvo and, in the Do Nothing Scenario, such forestry operations would continue at the Wind Farm Site and may be extended in some areas. The forestry operations would comprise of felling and replanting of certain areas depending on the productivity of each area. All forestry operations would continue to conform with the current best practice Forest Service regulations, policies and guidance documents as well as Coillte and DAFM guidance documents.

8.5.2 Construction Phase - Likely Significant Effects and Mitigation Measures

The likely effects of the Proposed Development and mitigation measures that will be put in place during the construction phase to eliminate or reduce them are outlined below.

8.5.2.1 Effects on Land (Land-Take)

The Proposed Development includes the construction of 9 no. turbines, associated hardstand areas, temporary construction compounds, an onsite substation, new access roads and upgrades to the existing road network. The Proposed Development has a total footprint of 18.5ha within the Wind Farm Site.

These works will result in a change in the land environment within these areas. For example, the Proposed Development works will result in the loss of a total of ~107.65ha of coniferous forestry. The area of temporary felling to facilitate the construction phase is ~5.69ha while the permanent felling area for infrastructure is ~48.89ha. In addition, ~52.98ha will be felled as part of the Hen Harrier/Biodiversity Management and Enhancement Plan (the potential effect of the biodiversity enhancement works are discussed separately in Section 8.5.2.7).

There will be no effects on the lands adjoining the Wind Farm Site.

Furthermore, no effects on land will occur along the Grid Connection as all works will occur within the carriageway of the existing public road network.

With regards to the work areas along the TDR, there will be a loss of ~1.2ha of agricultural land which will be replaced by new roads and a temporary construction compound to facilitate the delivery of the turbine components.

Pathways: Excavation and infrastructure construction.

Receptors: Land.

Pre-Mitigation Potential Effect: Negative, slight, direct, permanent, likely effect on land (land-take).

Mitigation Measures / Impact Assessment: The Proposed Development layout has been designed to utilise the existing road network at the Wind Farm Site, therefore reducing the area of the site which will be altered from existing land covers to site access roads.

The loss of ~107.65ha of coniferous forestry will not have a significant effect on land at the Wind Farm Site. Following the construction phase, ~48.89ha of forestry will be replaced by hardstand areas and ~52.98ha will be replaced by Hen Harrier enhancement areas. Meanwhile, ~5.96ha will be temporarily felled to facilitate the construction phase. This represents a change in landcover of ~10% of the total Wind Farm Site area (~1,072ha).

Post-Mitigation Residual Effect: The Proposed Development will result in the loss of ~51.75ha of coniferous forestry and wet heath which will be replaced by turbine bases, hardstands and other proposed infrastructure. This will result in a permanent change to land at these locations. However, due to the relatively small footprint of the Proposed Development infrastructure on a site scale and even more so on a local scale the residual effect is considered to be negative, direct, slight, permanent, likely effect on land (land-take). Meanwhile, an additional ~50.41ha of forestry will be felled for the Hen Harrier enhancement areas. This will have a positive, direct, slight, permanent, likely effect on land within the Wind Farm Site.

Significance of Effects: For the reasons outlined above (small development footprint), no significant effects on land (land-take) will occur.

8.5.2.2 Peat, Subsoil and Bedrock Excavation

Excavation of peat, subsoil and bedrock will be required for the proposed works during the construction phase including:

- The installation of new proposed access roads and the upgrade of existing site access roads will require the excavation of 40,000m^3 of peat and 32,000m^3 of spoil materials (these volumes include works along TDR route);
- Construction of 9 no. turbine foundations and associated turbine hardstands will require the excavation of 16,000m^3 of peat and 50,000m^3 of spoil;
- Construction of 1 no. met mast will require the excavation of 300m^3 of peat and 300m^3 of spoil;
- Construction 1 no. onsite substation and associated hardstand area will require the excavation of 7,300m^3 of peat and 3,000m^3 of spoil;
- Excavation of the 5 no. proposed borrow pits will require the removal of 14,000m^3 of peat and 28,000m^3 of spoil;
- Construction of the 3 no. temporary construction compounds will require the removal of 3,800m^3 peat and 9,500m^3 spoil;
- Excavation of the Grid Connection will require the removal of 100m^3 of peat and 6,800m^3 of spoil; and,
- Insertion of the Proposed Development drainage network.

These construction phase activities will result in the permanent removal and relocation of in-situ peat and subsoil at most excavation locations. Estimated volumes of peat, subsoils and bedrock to be relocated are summarised above in Table 8-9. It is estimated that the total volume of peat and spoil excavated will be 211,100m^3. Meanwhile, it is estimated that 251,000m^3 of rock will also be excavated during the construction phase. We note that earthworks of this type, scale and magnitude have been granted permission and successfully completed at similar sites around the country. For example, the permitted Ardderroo Wind Farm required the removal of 227,370m^3 of peat and 281,550m^3 of spoil materials.

However, there will be no loss of peat or spoil, it will just be relocated within the Wind Farm Site. It is proposed to store the excavated material in the 5 no. proposed borrow pits. Peat materials will also be used for landscaping at the 9 no. turbine locations. Meanwhile, the excavated rock will be used to facilitate the construction of the Proposed Development.

Excavation of subsoils will also be required along the Grid Connection. However, these deposits will be reinstated back into the trench and there will be no requirement to store these materials elsewhere.

Excavation of material will also be required at the work areas along the TDR.

Pathway: Extraction/excavation.

Receptor: Peat and subsoil.

Pre-Mitigation Potential Effect: Negative, slight/moderate, direct, likely, permanent effect on peat, subsoil and bedrock due to relocation within the Wind Farm Site.

Proposed Mitigation Measures by Design:

- Placement of turbines and associated infrastructure in areas with shallower peat;
- The peat and subsoil which will be removed during the construction phase will be localised to the wind farm infrastructure turbine location, substation and temporary compounds and access roads;
- The Proposed Development has been designed to avoid sensitive habitats within the application area;
- A minimal volume of peat, subsoil and rock will be excavated and removed to allow for infrastructure works to take place in comparison to the total volume of these materials present on the site due to optimisation of the Proposed Development design;
- In general, excavated peat and spoil will be moved short distances from the point of excavation and will be used for landscaping or stored in the onsite borrow pits; and,
- Construction of settlement ponds will be volume neutral, and all excess material will be used locally to form pond bunds and surrounding landscaping.

Post-Mitigation-Residual Effect: The granular subsoils and peat at the Wind Farm Site can be classified as of "Low" importance and the bedrock of "Medium" importance.

The overall Wind Farm Site area is extensive (1,072ha) while the Proposed Development footprint (18.5ha) is approximately 1.7% of the overall area. The negative effect is the disturbance and relocation of ~211,100m^3 of peat and spoil and 251,000m^3 of bedrock during construction. The design measures incorporated into the Proposed Development as described above in particular the avoidance of deeper peat areas combined with the 'low' importance of the peat deposits and the 'medium' importance of the local bedrock means that the residual effect will be - Negative, slight, direct, likely, permanent effect on peat, subsoils and bedrock due to disturbance and relocation within the Wind Farm Site.

Significance of Effects: For the reasons outlined above, no significant effects on peat, subsoils and bedrock will occur.

8.5.2.3 Excavation and Reinstatement of the Borrow Pits

The excavation of 14,000m^3 of peat and 28,000m^3 of spoil will be completed at 5 no. proposed borrow pit locations. The peat depth at the proposed borrow pits locations is less than 1m. Once the overlying peat has been removed, bedrock will be excavated from the borrow pits to facilitate the construction of the Proposed Development. It is estimated that 151,000m^3 of rock (sandstone and siltstone) will be removed from the proposed borrow pits.

Upon removal of the rock from the individual cells within the borrow pits, it is proposed to reinstate the borrow pits using excavated peat and spoil.

Pathway: Extraction/excavation.

Receptor: Peat, subsoil and bedrock.

Pre-Mitigation Potential Effect: Negative, slight/moderate, direct, likely, permanent effect on peat, subsoil and bedrock due to relocation within the Wind Farm Site.

Proposed Mitigation Measures by Design:

The Peat and Spoil Management Plan (FT, 2024) attached as Appendix 4-2 sets out the guidelines for the construction and reinstatement of the on-site borrow pits. Upon the removal of the required volumes of material (for the construction of the infrastructure elements at the wind farm) from the borrow pits it is proposed to reinstate the pits using excavated peat and spoil. The borrow pits are designed and will be constructed in a way which will allow the excavated peat and spoil to be placed safely, with areas within the borrow pits designated for the storage of excavated peat. Other mitigation measures included in the design of the borrow pits are as follows:

- Excavation works will be undertaken and supervised by an experienced contractor and suitably qualified personnel;
- Rock will be removed by either breaking or blasting and will be determined by confirmatory ground investigations comprising of rotary core drilling;
- Borrow pits will be developed with stable ground inclinations;
- Exposed slopes will be left with irregular faces to promote re-vegetation;
- The stability of the rock faces will be inspected by the Project Geotechnical Engineer upon excavation to ensure stability;
- Rock buttresses will be constructed within the borrow pits to help retain placed peat and spoil. The founding stratum for each buttress will be inspected and approved by the Project Geotechnical Engineer;
- Infilling of peat and spoil should commence at the back of the borrow pit and progress towards the pit entrance.

Post Mitigation Residual Effect: The bedrock at the Wind Farm Site can be classified as of "Medium" importance, while the peat and spoil deposits can be classified as being of "Low" importance. The overall Wind Farm Site area is extensive (1,072ha) while the Proposed Development footprint of the borrow pits (3.4ha) is approximately0.3% of the overall Wind Farm Site area. The effect is the excavation of c 42,000m^3 of peat of spoil during construction and the relocation of bedrock (~151,000m^3) used for the construction of the Proposed Development. The design measures as described above in particular the avoidance of deeper peat areas combined with the 'Medium' and 'Low' importance of the deposits means that the residual effect is considered - Negative, slight, direct, likely, permanent effect on peat, subsoils and bedrock due to disturbance and relocation within the Wind Farm Site.

Significance of Effects: For the reasons detailed above, and with the implementation of the listed mitigation measures, no significant effects on peat, subsoils or bedrock will occur.

8.5.2.4 Contamination of Soil and Bedrock by Leakages and Spillages of Hydrocarbons

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 and subsoil and underlying bedrock pore space.

Receptor: Peat and subsoil, bedrock.

Pre-Mitigation Potential Effect: Negative, slight, direct, short-term, unlikely effect on peat, subsoils and bedrock.

Proposed Mitigation Measures:

- On-site re-fuelling will be undertaken using a double skinned bowser with spill kits kept on site for accidental leakages or spillages;
- Only designated trained operatives will be authorised to refuel plant on-site;
- Taps, nozzles or valves associated with refuelling equipment will be fitted with a lock system;
- All fuel storage areas will be bunded appropriately for the duration of the construction phase. All bunded areas will be fitted with a storm drainage system and an appropriate oil interceptor. Ancillary equipment such as hoses, pipes will be contained within the bunded area;
- Fuel and oil stores including tanks and drums will be regularly inspected for leaks and signs of damage;
- The electrical control building (at the substation) will be bunded appropriately to the volume of oils likely to be stored and to prevent leakage of any associated chemicals 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; and,
- An emergency response plan for the construction phase to deal with accidental spillages will be contained within the Construction Environmental Management Plan (which is contained in Appendix 4-3).

Post-Mitigation Residual Effect: 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 will be - Negative, imperceptible, direct, short-term, low unlikely effect on peat and subsoils and bedrock.

Significance of Effects: For the reasons outlined above, and with the implementation of the listed mitigation, no significant effects on peat, subsoils and bedrock will occur.

8.5.2.5 Erosion of Exposed Subsoils and Peat During Construction

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

Pathway: Vehicle movement, surface water and wind action.

Receptor: Peat and subsoil.

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

Proposed Mitigation Measures:

- Peat removed from the development locations and access roads will be reinstated within the Proposed Development site;
- The upper vegetative layer (where still present) 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 peat storage areas;
- Re-seeding and spreading/planting will also be carried out in these areas;
- Brash/bog mats will be put in place to support vehicles on soft ground, reducing peat and mineral soils erosion and avoiding the formation of rutted areas, in which surface water ponding can occur; and,
- A full Peat and Spoil Management Plan for the development is shown as Appendix 4-2 and details control measures for the removal, storage and general management of the materials to be excavated during construction.

Post-Mitigation Residual Effect: 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 a detailed Peat and Spoil Management Plan, material will remain within the Proposed Development site and reseeding and planting will be completed to bind landscaped peat and spoil together. Following implementation of these measures the residual effected will be - Negative, slight, direct, short-term, likely effect on peat and subsoils by erosion and wind action.

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

8.5.2.6 Erosion of Exposed Soils/Subsoils and Peat During Tree Felling

Tree felling is a component of the proposed works at the Wind Farm Site, with ~107.65ha of felling proposed. The area of temporary felling to facilitate the construction phase is ~5.69ha while the permanent felling area for infrastructure is ~48.89ha. In addition, ~52.98ha will be felled as part of the Hen Harrier/Biodiversity Management and Enhancement Plan.

During felling operations there is a high likelihood of erosion of peat and spoil due to the distance of soils and subsoils associated with vehicle and plant movements across the Wind Farm Site. This also has associated potential effects on the water environment; and therefore this aspect is assessed in further detail in Chapter 9 Hydrology & Hydrogeology.

Pathway: Vehicle movement, surface water and wind action.

Receptor: Peat, subsoil and weathered bedrock.

Pre-Mitigation Potential Effect: Negative, slight, direct, permanent, likely effect on peat, subsoil and weathered bedrock due to felling operations.

Proposed Mitigation Measures:

All proposed felling works will be completed in accordance with the best practice Forest Service regulation, policies and strategic guidance documents as well as Coillte and DAFM guidance documents to ensure that felling results in minimal potential negative effects on the local peat, soil and subsoil environment.

In addition, the following mitigation measures will be implemented during felling operations:

- Before any works are completed silt fences will be installed to limit the movement of entrained sediment in surface water runoff;
- The harvester and the forwarder are designed specifically for the forest environment and are low ground pressure machines;
- All machinery will be operated by suitably qualified personnel;
- These machines will traverse the Wind Farm Site along specified off-road routes (referred to as racks);
- Brash mats will be placed on the racks to support the vehicles on soft ground, reducing peat and mineral soil disturbance and erosion and avoiding the formation of rutted areas, in which surface water ponding can occur;
- As felling progresses, the harvester will collect brash produced by the felling and place it in front of the machine before it advances forward along the rack;
- The condition of the racks will be continually monitored and fresh brash will be applied when the brash mat becomes heavily used and worm, ensuring that the mat remains effective throughout the operational phase; and,
- The location of racks will be chosen to avoid wet and potentially sensitive areas.

Post-Mitigation Residual Effect: The proposed felling works will result in the disturbance and erosion of peat and subsoil within the Wind Farm Site. However, given the minimal footprint of the proposed felling areas combined with the mitigation measures above, the residual effect is - negative, imperceptible, direct, permanent, unlikely effect on peat, subsoils and weathered bedrock.

Significance of Effects: For the reasons outlined above, and with the implementation of the proposed mitigation measures, no significant effects on peat, soils/subsoils or bedrock will occur.

8.5.2.7 Effects due to Biodiversity Enhancement Proposals (Wind Farm Site)

The biodiversity enhancement proposals are summarised as follows:

- It is proposed to permanently fell ~52.98ha of forestry ad restore these lands to habitats which are suitable for foraging hen harrier. The proposed works include the removal of timber, brash and stumps from the felled area and to complete surface smoothing (removal of the ridge and furrow pattern) if ground conditions allow. The mechanical management of bramble, bracken and regenerating conifers will be completed and a hydrological study will be completed to inform the necessity or requirement for future drain blocking (note that any future drain blacking does not for part of the Proposed Development).
- The management of ~74.38ha of agricultural lands to improve this habitat for foraging hen harrier;
- Replanting of hedgerow habitats; and,
- The restoration of the TDR compound area, including the removal of culverts and replanting of trees.

Some of these proposals will disturb local peat, soil and subsoil deposits and increase the likelihood of erosion of peat and subsoils. However due to the largely non-invasive nature of the works the potential for effects on the soils and geological environment are limited. The works will have a positive effect on the land environment.

Pathway: Vehicle movement, restoration works, surface water and wind action.

Receptor: Land, peat/soil, subsoil and weathered bedrock.

Pre-Mitigation Potential Effect: Negative, direct, imperceptible, likely effect on peat, subsoils and weathered bedrock due to disturbance associated with proposed restoration works.

Positive, slight, direct, permanent effect on the land in the biodiversity enhancement areas.

Proposed Mitigation Measures:

All proposed bog restoration works will be in accordance with the best practice Forest Service regulation, policies and strategic guidance documents as well as Coillte, DAFM and NatureScot guidance documents to ensure minimal potential negative effects on the local peat, soil and subsoil environment.

Given the nature of the restoration measures the following mitigation measures are proposed:

- Before any works are completed silt fences will be installed to limit the movement of entrained sediment in surface water runoff;
- Proposed off-road routes will be walked in advance of any machinery;
- All machinery operators will be experienced;
- The site will be walked before a machine goes off-road;
- Bog mats will be used where the excavator is required to travel over wet ground; and,
- A low ground pressure excavator with wide tracks (1.9m or greater) will be used to reduce compaction of the peat and subsoils.

Post-Mitigation Residual Effect: The proposed biodiversity enhancement proposals will result in the disturbance and erosion of peat and subsoils. However, with the implementation of mitigation measures outlined above the residual effect is a Negative, direct, imperceptible, likely effect on peat, subsoils and weathered bedrock. There will be a slight, positive, permanent effect on land within the enhancement areas.

Significance of Effects: For the reasons outlined above, and with the implementation of the listed mitigation measures, no significant effects on peat, subsoils and weathered bedrock will occur.

8.5.2.8 Peat Instability and Failure

A Geotechnical and Peat Stability Risk Assessment was carried by FT for the main infrastructure elements at the Wind Farm Site. This approach is in compliance with the guidelines for geotechnical/peat stability risk assessments as given in PLHRA (2017) and MacCulloch (2005). The peat stability risk assessment is attached in full as Appendix 8-1.

Peat instability or failure refers to a significant mass movement of a body of peat that would have an adverse impact on the proposed wind farm development and the surrounding environment. The potential significant effects of peat failure at the study area may result in:

- Death or injury to site personnel;
- Damage to machinery;
- Damage or loss of infrastructure;
- Drainage disruption by blockage of drainage pathway by relocated peat and spoil;
- Site works damaged or unstable;
- Contamination of watercourses, water supplies by particulates; and,
- Degradation of the peat environment by relocation of peat and spoil.

However, the findings of the Geotechnical and Peat Stability Risk Assessment showed that the Proposed Development areas have an acceptable margin of safety and that the Wind Farm Site is suitable for the proposed wind farm development. Notwithstanding the above, the management of peat stability and appropriate construction practices will be inherent in the construction phase of the wind farm to ensure peat failures do not occur on site.

Pathway: Vehicle movement and excavations.

Receptor: Peat and subsoils.

Pre-Mitigation Potential Effect: The findings of the peat stability assessment showed that the proposed Wind Farm Site 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 pre-mitigation residual effect is considered to be - Negative, significant, direct, permanent, likely effect on peat and subsoils.

Proposed Mitigation Measures:

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

The findings of the Geotechnical and Peat Stability Risk Assessment, which involved analysis of 249no. locations, showed that the Proposed Development infrastructure locations within the Wind Farm Site have an acceptable margin of safety and that the site is suitable for the proposed wind farm development. Notwithstanding the above, the management of peat stability and appropriate construction practices will be inherent in the construction phase of the wind farm to ensure peat failures do not occur on site.

The following control measures incorporated into the construction phase of the project will ensure the management of the risks for this site:

- Appointment of experienced and competent contractors;
- The site will be supervised by experienced and qualified personnel;
- Allocate sufficient time for the project (be aware that decreasing the construction time has the potential to increase the risk of initiating a localised peat movement);
- Prevent undercutting of slopes and unsupported excavations;
- Maintain a managed robust drainage system;
- Prevent placement of loads/overburden on marginal ground;
- Set up, maintain and report findings from monitoring systems (as outlined in the Geotechnical and Peat Stability Assessment);
- Ensure construction method statements are developed and agreed before commencement of construction and are followed by the contractor. The method statements will be in compliance with all guidance and control measures prescribed in the Geotechnical and Peat Stability Risk Assessment. This will ensure that best practice guidance regarding the management of peat stability will be inherent in the construction phase;
- Revise and amend the Construction Risk Register as construction progresses to ensure that risks are managed and controlled for the duration of construction.
- Maintain hydrology of area by maintaining existing drains to prevent the build-up of water pressures in the peat, leading to the peat becoming “buoyant”;
- Use of experienced geotechnical staff for confirmatory site investigations; and,
- Use of experienced contractors and trained operators to carry out the work.

Please refer to **Appendix 8-1** for proposed turbine specific and road section design proposals.

Post-Mitigation Residual Effect: 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 will be - Negative, imperceptible, direct, unlikely, permanent effect on peat and subsoils.

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

8.5.2.9 Proposed Amenity Trails

Approximately 1.4km of internal amenity trails and 2 no. amenity viewing points will be provided as part of the construction of the Proposed Development. In addition, 1 no. existing viewing area will be upgraded. These trails and viewing points will be used as a public amenity during the operational phase and will have a gravel/crushed stone finish surface.

Pathway: Extraction/excavation of peat and soil/subsoils (spoil).

Receptor: Peat and underlying subsoil.

Pre-Mitigation Potential Effect: Negative, slight, direct, likely, permanent effect on peat and subsoil.

Proposed Mitigation Measures:

Mitigation measures in respect of peat and subsoil excavation are outlined at Section 8.5.2.2.

Mitigation measures to prevent soil / subsoil contamination (leaks / spills) are dealt with in Section 8.5.2.4 above and measures dealing with soil erosion are dealt with in Section 8.5.2.5. The residual effects of soil / subsoil contamination from leaks / spills is assessed in Section 8.5.2.4, and the residual effects of soil erosion are assessed in Section 8.5.2.5.

Post Mitigation Residual Effect: It is proposed to place amenity pathways on top of the existing ground. Ground disturbance and peat and/or spoil relocation during these works will be minimal. As such the residual effects of these works are considered - Negative, imperceptible, direct, likely, permanent effect on peat and subsoils by covering with 3m wide pathway.

Significance of Effects: For the reasons detailed above, and with the implementation of the proposed mitigation measures, no significant effects on peat, soils/subsoils or bedrock 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 may be necessary for maintenance of turbines which could result in minor accidental leaks or spills of fuel/oil;
- 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; and,
- In relation to indirect impacts a small amount of granular material may be required to maintain access tracks during operation which will place intermittent minor demand on local quarries.

8.5.3.1 Site Road Maintenance

In relation to indirect effects a small amount of granular material will be required to maintain access tracks/site roads during operation which will place intermittent minor demand on local quarries.

Pathway: Peat, subsoil and bedrock pore space.

Receptor: Peat, subsoil and bedrock.

Potential Pre-Mitigation Effect: Negative, indirect, imperceptible, short term, likely effect on peat, subsoil and bedrock.

Proposed Mitigation Measures:

- Use of aggregate from authorised quarries for use in road and hardstand maintenance.

Post-Mitigation Residual Effect: The use of aggregate for site road maintenance will be minor and infrequent, and all material will be imported to the Proposed Development site from local authorised quarries. The residual effect is considered to be - negative, imperceptible, indirect, short-term, unlikely effect on bedrock.

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

8.5.3.2 Site Vehicle/Plant Use

Plant and site vehicles used in site maintenance will be run on fuels and use hydraulic oils. Accidental spillage during refuelling of construction plant with petroleum hydrocarbons is a significant pollution risk to land, soils and associated ecosystems. The accumulation of small spills of fuels and lubricants during routine plant use can also be a pollution risk. Hydrocarbon has a high toxicity to humans, and all flora and fauna, and is persistent in the environment.

Pathway: Peat, subsoil and bedrock pore space.

Receptor: Peat, subsoil and bedrock.

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

Proposed Mitigation Measures:

- Vehicles used during the operational phase will be refuelled off site before entering the site;
- No fuels will be stored on-site during the operational phase; and
- Spill kits will be available in all site vehicles to deal with an accidental spillage and breakdowns; and,
- An emergency plan for the operational phase to deal with accidental spillages and breakdowns will be contained in the CEMP (Appendix 4-3).

Post-Mitigation Residual Effect: The use of hydrocarbons in plant and vehicles is a standard risk associated with all operational wind farm 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, unlikely effect on peat, subsoils, and bedrock.

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

8.5.3.3 Use of Oils in Transformers

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. Hydrocarbon has a high toxicity to humans, and all flora and fauna, and is persistent in the environment.

Pathway: Peat, subsoil and bedrock pore space.

Receptor: Peat, subsoil and bedrock.

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

Proposed Mitigation Measures:

- All transformers and substation areas will be bunded to 110% of the volume of oil used in each transformer/substation;
- An emergency plan for the operational phase to deal with accidental spillages will be contained in the Environmental Management Plan.

Post-Mitigation Residual Effect: The use of hydrocarbons in transformers and substations is a standard risk associated with all operational wind farm 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, unlikely effect on peat, subsoils, and bedrock.

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

8.5.4 Decommissioning Phase - Likely Significant Effects and Mitigation Measures

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

During decommissioning, it will 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. This will be done by covering with peatland vegetation/scraw or poorly humified peat to encourage vegetation growth and reduce run-off and sedimentation. Other impacts such as possible soil contamination by fuel leaks will remain but will be of reduced magnitude.

Mitigation measures applied during decommissioning activities will be similar to those applied during the construction phase (refer to Section 8.5.2) where relevant.

Some of the effects will be avoided by leaving elements of the Proposed Development in place where appropriate. The 110kV electrical substation and cabling will be retained by EirGrid. The turbine bases will be rehabilitated by covering with local topsoil/peat in order to regenerate vegetation which will reduce runoff and sedimentation effects. Internal roads will remain as amenity pathways and forestry access roads. 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 effects on the land, soils and geological environment will occur during the decommissioning stage of the Proposed Development.

8.5.5 Risk of Major Accidents and Disasters

Due to the nature of the Proposed Development site, *i.e.,* mountainous terrain with peat covered slopes, there is a risk of a landslide occurring.

A comprehensive Peat Stability Risk Assessment (FT, 2024) has been undertaken for all Proposed Development infrastructure locations, and it concludes that with the implementation of the proposed

control (mitigation) measures. The residual risk of a landslide occurring is determined to be Negligible/None.

Please refer to Chapter 16 Major Accidents and Natural Disasters for a full assessment relating to the risk of landslides.

8.5.6 Human Health Effects

Potential health effects arise mainly through the potential for soil and ground contamination. The Proposed Development is not a recognized source of pollution (e.g., it's not a waste management site, or a chemical plant), and so the potential for effects during the operational phase is very low.

Hydrocarbons will be used onsite during construction; however, the volumes will be small in the context of the scale of the Proposed Development and will be handled and stored in accordance with best practice mitigation measures. The potential residual effects associated with soil or ground contamination and subsequent health effects are imperceptible.

8.5.7 Potential Cumulative Effects

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. The only way the wind farm proposal can have in combination 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 Hydrology & Hydrogeology.

The construction of the Grid Connection and works along the TDR will only require relatively localised excavation works within the site boundary and therefore will not contribute to any significant cumulative effects.

8.5.8 Post Construction Monitoring

None required.